Final Report

Consultancy for the Forest Carbon Partnership Facility Readiness Preparation Proposal

Development of a Reference Scenario & Design of a Monitoring System

Kampala, December 2010

NFA
National Forestry Authority

NFA World Bank Readiness Proposal Uganda

Development of a Reference Scenario & Design of a Monitoring, Reporting and Verification System

Client:

National Forest Authority

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COMPONENT 3: DEVELOPING A REFERENCE SCENARIO

Background

Uganda is the pearl of Africa located in Eastern Africa astride the equator between latitudes 4 degree 0' North and 1 degree 30' South. It is bordering Sudan, Kenya, Tanzania and the DR of Congo and has a total land area of approximately 20.5 million ha.

According to the last National Biomass Study, which was conducted in 2005, Uganda has a total forest area of 3.6 million hectares. The land use classification is distinguishing: Tropical high forests 744,000 ha (543,000 ha well stocked, 201,000 ha low stocked); Woodlands 2.8 million ha and forest plantations 34,000 ha (15,000 ha broad leaved and 19,000 ha conifer). The latter were established mainly since 2005.

In Uganda 64 % of the forest is on private land, 18 % is managed by the Uganda Wildlife Authority (National Parks), 17 % by the National Forestry Authority (Central Forest Reserves) and District Forest Service (Local Forest Reserves) and less than 1% under dual joint management.

Forest in protected areas (National parks and Forest Reserves) was deforested at a rate of 0.7 % annually between 1990 and 2005, while forest on private land disappeared at a rate of 2.3 % annually in the same period. The overall deforestation rate was 1.8 %. Accordingly, the total forest area declined from 4.9 million ha to 3.6 million ha during this period or nearly 90,000 ha per year. The forest plantation area across this period hardly changed, but Uganda lost 19 % of its precious tropical high forest and 29 % of its woodlands.

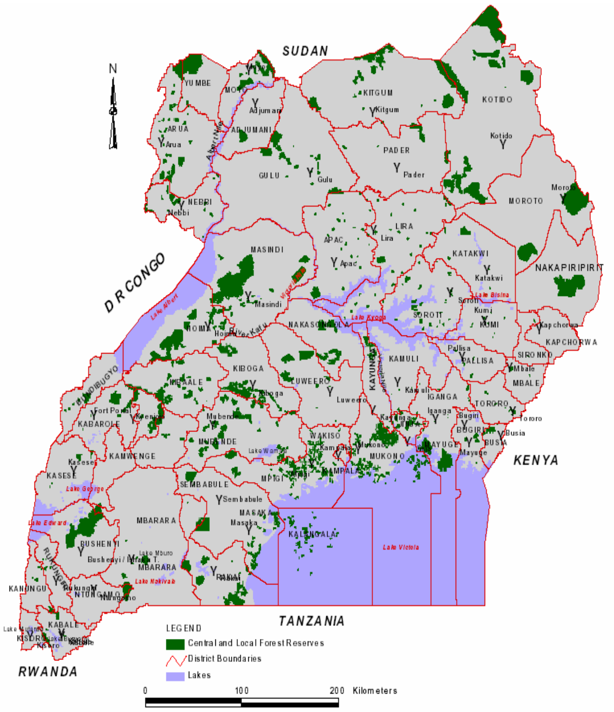

Figure 1: Map of Uganda with central and local forest reserves.

Agricultural expansion and charcoal production are the main drivers of deforestation in Uganda (NFA, 2009, NEMA, 2008). Small-scale farmland increased from 8.4 million ha to nearly 8.9 million ha between 1990 and 2005, large-scale farmland from 68,000 ha to 107,000 ha and bush-land from 1.4 million to almost 3 million hectare during the same period.

Despite the fact that Uganda has one of the highest deforestation rates in Africa, forest degradation can be considered to be the biggest source of forest related GHG emissions (see also component 2a). According to NFA (2009) the biomass density in 43 districts declined from 28.6 t/ha in 1990 to 24.6 t/ha in 2005.

In component 3 we will i) present the results of the institutional capacity analysis and ii) review the available data and its quality to build a reference scenario. Furthermore, iii) information gaps will be highlighted that should be addressed in the framework of analytical studies. Subsequently, we will iv) assess the feasibility of the different options to establish a reference scenario, i.e. historic extrapolation of deforestation and forest degradation trends or adjusted historic extrapolation considering changes in the drivers of deforestation or broader economic and demographic development. Finally, v) we will outline the work flow for developing a national reference scenario and subnational reference scenarios for deforestation and forest degradation hotspots and provide an estimate of the cost implications.

Key principles and definitions

To our best knowledge there is no "best practice" to design REDD+ reference scenarios or forest monitoring systems. We also neither believe that it makes sense to define respective practices in detail because the technical and organizational options are plenty. REDD+ is operating in a very dynamic and evolving international regulatory environment and new research and technologies are advancing rapidly that may question the previous *single best* option identified. Therefore, we will outline the structure of the reference scenario design referring to the IPCC (2006) Good Practice Guidance. Furthermore, it is important to avoid pitfalls and errors, and that is best done by consulting with experts in forest inventory, carbon accounting and those who have local expertise and can give practical advises. In the Annex 1: Some "not-to-do's" or a "guide to avoid bad practice" when designing and implementing a forest monitoring system some "to do´s" and "not to do´s" are listed. The list is not aiming to be comprehensive and it needs to be further elaborated.

Key principle criteria to which the design of the reference scenario and the forest monitoring system should conform to are:

- The system design and its implementation has to maintain overall credibility;
- Objectives should be clearly spelled out and considered;
- Adequate precision is required (adequate means: defined as a part of the overall REDD+ objectives and evolving international standards);
- Sound methodology based on scientific principles and following statistical sampling criteria;
- Transparency in all steps from planning to reporting; essential part of this is comprehensive and transparent reporting and documentation, both in expert language and "translated" for decision makers and other relevant users.

A number of key terms need to be clearly and explicitly defined, such as activity data, emission factors, representativeness of collected data, precision requirements for the major attributes and products expected such as maps (most appealing but least precise), statistics etc. Last but not least, *each variable* that is been observed needs to be defined in terms of subject matter and measurement procedure. In the Annex 2: Definitions of key termskey terms are defined.

Annex 3: Flow of activities when planning and implementing a forest monitoring systemprovides procedures for measurement of variables relevant for remote sensing analysis and field inventories.

In order to be able to determine the historical emissions from deforestation and forest degradation a forest definition is required, which has several implications:

- area eligible for REDD+ activities (e.g. areas under agroforestry with a comparatively low crown cover might be excluded or included)
- technical requirements to assess deforestation (the lower the crown cover threshold the more limited is the use of remote sensing data)

At the moment Uganda has two forest definitions. The UNFCCC CDM forest definition:

- 30 % tree crown cover (i.e. percent of a fixed area covered by the tree crowns using a vertical projection based on a terrestrial inventory, remote sensing or aerial photo interpretation),
- 1 ha minimum forest area,
- 5 m minimum tree height or able to reach this threshold.

And the FAO definition, which was used for the National Biomass Study:

- 10 % tree crown cover,
- 0.5 ha minimum forest area,
- 5 m minimum tree height or able to reach this threshold.

Unless defined differently by UNFCCC, Uganda will use the FAO forest definition for REDD+ in order to be consistent with the National Biomass Study.

Capacity analysis

Institutional capacity

During consultation meetings the institutional capacity for REDD+ inventory and monitoring of different governmental and non-governmental organizations at national level was evaluated (see Annex 4). The National Forestry Authority is considered to be the most suitable institution to develop the Reference Scenario and to design and maintain the REDD+ monitoring system at the national level. Nevertheless, it requires substantial investments to upgrade existing capacity. Furthermore, opportunities to partner with other institutions or options to outsource individual tasks should be considered. With regards to sub-national REDD+ activities a number of organisations have relevant analytical and field capacity already (e.g. WCS or UWA). For the development of REDD+ reference scenarios a national framework should be established with the option to integrate higher resolution data or additional variables to be monitored at the sub-national level. Below a summary of the existing capacities is presented, while a detailed SWOT analysis can be found in Annex 4: SWOT analysis.

Governmental institutions:

- National Forestry Authority: Knowledge and experience in mapping of land cover and land use based on medium resolution remote sensing data and biomass estimation and mapping based on destructive sampling, classic forest inventories and remote sensing. Inventory design and statistical analysis capacity needs to be improved.
- Forest Sector Support Department: Nominal oversight of the entire forest estate but little capacity to fulfil its guiding and law enforcement role.
- Uganda Wildlife Authority: Very little primary data on forest cover and biomass is collected. The organisation works closely with communities and monitors wildlife and has prior experience with monitoring afforestation and reforestation carbon projects in Mt Elgon and Kibale National Park. Therefore, it could potentially play an important role in the sub-national REDD+ monitoring or of additional benefits of REDD+, such as biodiversity, and in actively including communities into the monitoring processes.
- National Environment Management Authority: It is the lead agency for coordination, monitoring, regulation and supervision of the environmental management in Uganda. Information crucial to REDD+ implementation and monitoring is collected by NEMA through the Environmental Information Network.
- Uganda Bureau of Statistics: Relevant information provided by the agency is often collected by other agencies that are working in the specific sector. UBOS verifies and joins different data sets. Aggregated data is freely available.

Non-governmental institutions:

- Wildlife Conservation Society: Biodiversity surveys and land cover assessments have been conducted in western and northern Uganda, based on remote sensing data analysis and field inventories. Carbon stocks, biodiversity and socioeconomic information is currently collected for western Uganda in the framework of a REDD+ feasibility study for forest corridors.
- World Resources Institute: Considering their extensive research on socio-economic development in Uganda and their relation to natural resource development, the institution is well positioned to support the development of reference scenarios.

Research and analytical capacity

There is a strong interest in REDD+ related topics among research institutions in Uganda, but limited capacity and few pilot projects that can be used to add research components. Makerere University (e.g. Institute of Environment and Natural Resources; Economic Policy Research Centre, Faculty of Forestry and Nature Conservation) and the National Forest Resources Research Institute (see Annex 4: SWOT analysis) have conducted some relevant studies and/or provided input for the National Biomass Study. A REDD+ dedicated training programme, organized by the different institutes mentioned above and with student attachments in international organisations working on REDD+, would help to build capacity.

Existing regional research networks like the African Forest Research Network or Agricultural Research in Eastern and Central Africa (ASERECA) are important partners to share experiences with other FCPF partner countries in Africa.

Capacity gaps

Major gaps regarding know how and technology are related in particular to the statistical design and analysis of forest inventories, considering IPCC and UNFCCC guidelines and evolving international REDD+ rules.

The capacity of government agencies as well as of research institutions can be strengthened by supporting close cooperation with international organisations such as Wildlife Conservation Society and World Resources Insitute. Training and guidance by external experts will be needed to close the existing knowledge gaps and ensure the establishment of a sound reference scenario (see also Annex 11: Training on training).

In addition to that the Government of Uganda will have to increase core funding of government agencies in the forest sector. The FCPF readiness programme can only support REDD+ implementation.

Data availability and gaps

To determine data availability and gaps a survey of studies and projects concerned with land cover, land use and biomass of the aforementioned institutions was conducted. The results are outlined below.

Activity Data

The main activity data set in Uganda on land use changes is the National Biomass Study (NFA, 2009). It is based on i) the interpretation of two sets of satellite images (SPOT XS from 1990-1993 and Landsat TM from 2004-2005) using the FAO Land Cover Classification System (LCCS) and ii) a national grid based biomass field inventory with 2 to 4 data points per forested sampling point from the period between 1990-2005. From this study historic deforestation and forest degradation activity data and emissions can be extracted. Considering that a minimum of three data points in time are recommended (GOFC-GOLD Sourcebook, 2009) for some sample points additional remote sensing analysis is required and the NFA is currently preparing to analyse Landsat data for 2010.

Unfortunately, the accuracy level of the remote sensing and the biomass field inventory is unclear and needs to be analysed. The reporting must be aligned with IPCC guidelines. Depending on the accuracy level historic information may not be suitable for developing REDD+ scenarios and/or the inventory design needs to be modified.

In addition to national data a number of sub-national data sets exist that needs to be assessed in terms of its quality and integrated into a national database (see above and Annex 4).

Instead of using low resolution remote sensing images for national wall-to-wall analysis and mapping, sample based remote sensing analysis based on high resolution images (e.g. Rapid Eye) around the field plots should be tested. This in general proves to provide statistically more robust data at lower costs. At sub-national REDD+ hot spot project areas wall-to-wall remote sensing analysis is recommended. An overview of the available technologies is provided in Annex 9.

Emission data

In the framework of the National Biomass Study phase I 3,000 trees from 123 species were sampled destructively and for 4,500 trees green and dry weight were measured and single tree biomass functions were developed. Almost 4,000 permanent sampling plots were established in Uganda to estimate woody biomass for different forest types. 10 % of these sample plots have been revisited several times to gain information on biomass dynamics, reflecting degradation and growth. However, the quality of the emission data is uncertain and needs to be assessed before it can be used to develop the reference scenario.

Emission factors

From the available emission data emission factors or carbon content can be derived for each land use class. For below and above ground carbon pools and land use changes IPCC Tier 2 and 3 emission factors will be used. In the framework of the National Biomass Study data is available only for the living above ground carbon pool (see Annex 2). The quality of the data is unknown.

For the estimation of the carbon density per land use class the two components of the National Biomass study (activity data and emission factors) need to be merged in order to assign a carbon content to each land use class and to understand the emissions related to land use change.

Historical emissions

The calculation of the historic emission level will be done following the IPCC Good Practise Guidelines (2003) and the IPCC Guidelines for National GHG Inventories, Volume 4 AFOLU (2006), using suitable and available Tier 2 and 3 data.

The historic emissions resulting from deforestation and forest degradation will be integrated into the next National GHG inventory. The publication data of the next National GHG inventory is unknown.

Developing the Reference Scenario

Approaches to develop a Reference Scenario

The reference scenario can be set using two different methodological approaches. The reference scenario can be based purely on the historical emissions extrapolating them into the future. The second approach is also based on historical emissions but adjusted to take into account changes in the REDD+ deforestation/degradation drivers related to socio-economic changes. Respective adjustments based on modelling land use change with varying parameters will result in several possible future scenarios. The most likely of these scenarios will be set as the Reference Scenario against which all future emissions will be accounted and most likely has to be defended at the international level. Figure 2**Error! Reference source not found.** provides an overview of the two possible approaches. While the first approach is transparent because no adjustment anticipating future developments are conducted it is very likely that historic emissions will not reflect the future Business As Usual scenario very well. This approach will most likely overestimate future emissions, which would result in more emission reductions. Adjusting the Reference Scenario using simple adjustment factors or models requires a very good understanding between socio-economic development and deforestation and forest degradation. For Uganda in-depth studies on related repercussions are currently lacking, which highlights the need for some targeted analytical work to be able to define adjustment factors.

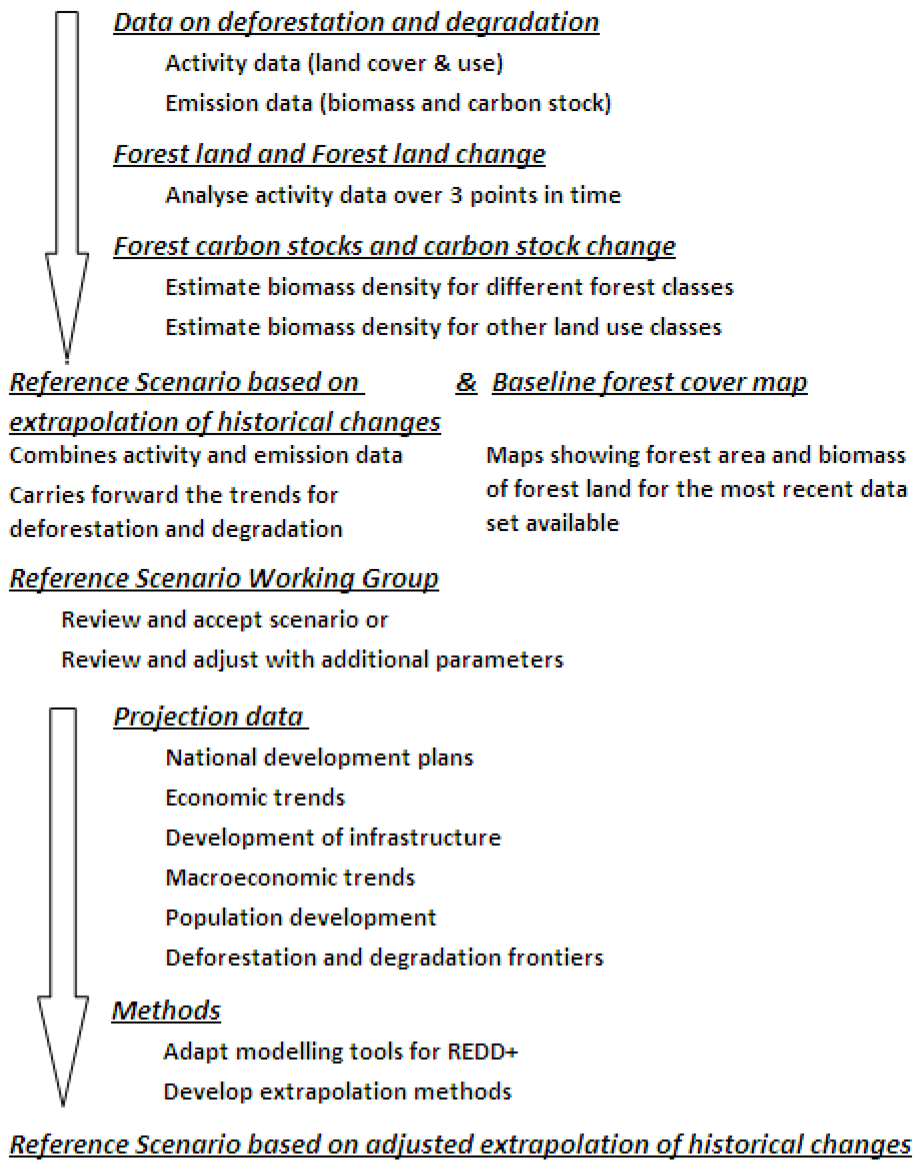

Figure 2: Approach and work flow for setting a Reference Scenario

Uganda's REDD+ working group recommended to develop a reference scenario based on adjusted historical extrapolation, considering simple adjustment factors and models. This is expected to reflect best future emissions under a Business As Usual scenario.

Setting up a "Reference Scenario" working group

The working group will engage with national and international experts to define in a transparent process a realistic REDD+ reference scenario.

The "Reference Scenario " working group will involve individuals from relevant Ministries and government agencies, such as the Ministry of Finance Planning and Economic Development, Ministry of Water and Environment, Ministry of Agriculture Animal Industry and Fisheries, Uganda Bureau of Statistics, research institutes and NGO's. Additionally representatives of private forest owners will be engaged. The individuals from the different organisations should have a good background in socio-economics and/or forestry. The actual composition of this group will be determined by the planning agency for REDD+ and the current REDD+ working group.

Data requirements for reference scenarios based on adjusted historical extrapolation

For the development of adjusted historical extrapolation of emissions robust socio-economic data e.g. rural/urban population growth, infrastructure development including energy infrastructure investments, rural employment and business development etc. are required. However, as highlighted above the relation between economic development and deforestation is quite complex and often not linear (e.g. Marcaux, 2000).

Developing sub-national reference scenarios

Sub-national REDD+ activities can either apply the national reference scenario or develop a more situation specific sub-national reference scenario. While the former approach will ensure consistency it will most likely underestimate deforestation and forest degradation in the without project scenario. Sub-national reference scenarios require transparent development protocols and a standardised approach to reconcile and harmonize the sub-national reference scenario with the national reference scenario (De Gryze et al, 2010).

Sub-national REDD+ activities will be located in REDD+ hot spot areas that have medium-high carbon stocks, high deforestation and forest degradation threats and medium-high biodiversity or other co-benefits. However, REDD+ activities may not be feasible in all REDD+ hot spot areas in Uganda, considering that e.g. areas in Western Uganda with oil fields will have very high opportunity costs.

Budget for Developing a Reference Scenario

Activity	Sub-activity	Time schedule and estimated costs in US$					Funding source	
		2011	**2012**	**2013**	**2014**	**Total**	FCPF	other
Design and coordination		100,000	50,000	50,000	50,000	**250,000**	250,000	
Capacity building		20,000	20,000			**40,000**	40,000	
Evaluate and modify the NBS	Accuracy assessment of NBS	20,000				**20,000**	20,000	
	Methodology modification to match REDD+ requirements	25,000	25,000			**50,000**	50,000	
Remote sensing data (gather and process activity data)	Acquisition of equipment (hardware & software)		100,000					
	Acquisition of remote sensing data		600,000[1]			**600,000**	-	UNEP via NEMA[2]
	Data processing, analysis & interpretation			100,000	100,000	**200,000**	100,000	NFA
	Accuracy assessment				10,000	**10,000**	5,000	NFA
Field inventory (gather and evaluate emission data)		50,000	50,000	50,000	50,000	**200,000**	100,000	NFA
Historical emissions	Combination of activity and emission data				50,000	**50,000**	25,000	NFA
Reference Scenario including peer review	National Reference Scenario		40,000			**40,000**	40,000	
	Selection of hot spots and develop 1-2 sub-national reference scenarios			40,000		**40,000**	40,000	
Total		**215,000**	**285,000**	**540,000**	**560,000**	**1,500,000**	670,000	830,000

[1] Cost are calculated assuming the use of free of charge Landsat data and high resolution imagery for REDD+ hotspots (12,000 km^2) at app. 50 US$/$km^2$

[2] An agreement between National Environment Management Authority and UNEP permits Uganda to source remote sensing data of various providers. Costs will be covered by UNEP. The specifics of the agreement were not disclosed.

COMPONENT 4: DESIGNING A MONITORING SYSTEM

Scope of MRV in Uganda

The design of a forest monitoring system requires thorough planning to be successful. Overall credibility of the methodology and the results is the major guiding principle for designing such a system. A monitoring system varies considerably as a function of the i) specific set of major objectives, ii) local biophysical and institutional conditions, iii) size of the inventory area and iv) data sources and v) overall resources available. Forest monitoring systems need to be methodologically sound – and economically feasible.

In conclusion an integrated national – sub-national monitoring system as outlined in Component 3 is considered the best option for REDD+. The system should provide costly but highly accurate emission data for deforestation and forest degradation hot spots and less costly but reliable data on national level, permitting Uganda to claim credible emission reduction credits at comparatively low cost.

Procedure of Planning

The general monitoring system design principles to be applied are illustrated in Figure 3. Each task will be addressed in more detail below, reflecting the Ugandan context. In addition a work plan outlining the flow of activities for planning and implementing a forest monitoring system is outlined and the proposed responsible agency for each activity is highlighted in the

Annex 3: Flow of activities when planning and implementing a forest monitoring system.

Setting the foundations.

Justification – funds – objectives – defining mandates.

Inventory planning.

Definition of technical objectives, development of inventory design, inventory protocol.

Data collection.

***Remote sensing:* From decision on imagery to final map products.**

***Field data:* Organisation, training, implementation, supervision.**

Data management and analysis.

Data base development, data entry, data analysis, database maintenance.

Reporting.

Figure 3: General procedure of designing the forest monitoring system

Setting the foundations

The justification for Uganda to implement a REDD+ monitoring system is the strong commitment to protect forests and its multiple functions by attracting international positive incentive mechanisms for REDD+ under the Forest Carbon Partnership Facility and other evolving mechanisms.

The design of the monitoring system has to consider severe capacity and budget constraints. Therefore, a simple but robust monitoring system is considered to be most suitable for Uganda. Hence Uganda is targeting to provide:

- Tier 2 data on national level and
- Tier 3 data for hot spots

for the monitoring of emissions or emission reductions from forests.

Defining mandates

The National Forestry Authority (NFA) will coordinate REDD+ monitoring at the national level and the definition of standards for sub-national activities and data management, considering evolving REDD+ standards on the voluntary carbon market and within the UNFCCC process. As part of the overall coordination NFA will engage other organizations that have complimentary mandates (e.g. National Environment Management Authority, Forest Sector Support Department) or capacities (including NGO's) in the overall REDD+ monitoring framework. This will ensure ownership of REDD+ implementation beyond the forest sector, including broader societal choices concerning land use.

Designing a forest monitoring system requires an explicit information request, which was defined in component 2, to justify the need for the monitoring system. The REDD+ working group decided that the REDD+ monitoring system at the national level will be integrated into the National Biomass Study. The National Biomass Study serves a number of different information needs and land based agencies, such as the Ministry of Agriculture Animal Industry & Fisheries, Ministry of Energy & Minerals, Ministry of Water & Environment including the National Forestry Authority, the National Environment Management Authority and Uganda Wildlife Authority. In addition REDD+ can enhance inter-sectoral/agency communication and collaboration, which is already relatively successfully established in Uganda with the National Biomass Study, which is considered as a common information platform.

The mandate of the National Forestry Authority will include:

- coordination of all monitoring, reporting and verification efforts of the different stakeholders involved, including work-plan development and enforcement,
- adaptation of the National Biomass Study design to REDD+ requirements and
- provision of standards and ensuring data compatibility for sub-national REDD+ monitoring, including a well integrated data management system.

Planning a monitoring system

The National Biomass Study methodology may have to be adapted to reflect evolving REDD+ methodology guidelines provided by the IPCC and UNFCCC and probably the voluntary carbon market. This concerns in particular the land classification design (currently FAO LCCS classes are used), sampling and plot design and the estimation design to avoid biased estimates and meet expected accuracy standards. A detailed analysis of the National Biomass Study, in particular assessing the accuracy of the data, is planned under Component 3.

The objective of the monitoring system will be the monitoring of biomass where it is threatened by deforestation and forest degradation at an appropriate accuracy level as specified in Component 3. Another objective of the monitoring system is to capture changes to other forest related benefits as outlined below under "Monitoring of Co-benefits".

Field inventory manuals, including form sheets, need to be revised and adjusted, data entry software might be purchased if portable data loggers are used.

It is also recommendable to assess in more detail the design and the quality of the existing National Biomass Study data base and the options to add additional data from national and sub-national REDD+ monitoring. Ideally a respective test data set is used to simulate the suitability of the database to analyse REDD+ relevant data sets.

The objectives to be achieved with the forest monitoring system will determine the number and type of variables to be collected as well as the frequency of data collection. More attributes to be measured mean higher cost so there must be a convincing justification to integrate additional variables or target objects (target objects for REDD+ may be "trees in forest" and "other vegetation in forest" while other users may want additional information such as "non-timber forest products" or wildlife habitat characteristics etc.). It is suggested to monitor forest change at two year intervals.

Based on the information request related to monitoring "deforestation", "forest degradation", "forest structure", "biodiversity" and "sustainability of forest management" –

a list of variables (that serve as indicators) need to be defined, so that they become operational for a forest monitoring system.

In order to be able to anticipate the data requirements of all stakeholders as completely as possible they need to be consulted prior to the continuation of the inventory. During the consultation process relevant groups were consulted (see Annex 4: SWOT analysis) however; more consultations will have to be conducted by the National Forestry Authority in particular with stakeholders outside the forest circle like conservationists, agronomists and tourism developers. Additionally a "methodology" working group combining experts from different government agencies and relevant NGO's will be formed to determine which information should be collected in the inventory and how information can be shared and aggregated.

In Annex 5: Available data sources and Annex 6 existing data sets, documents, maps and contacts have been compiled. Additional available data sets should be incooperated assuming the quality is recorded and proves to be acceptable. In general data or maps without information on the quality have to be treated cautiously.

Design of sub-national monitoring systems

The final design of the sub-national monitoring system (e.g. nested approach) will depend on evolving REDD+ accounting requirements within the UNFCCC and on the voluntary carbon market. Uganda will encourage respective international investments and will provide clear guidance for project developers.

The following variables are tentatively suggested for prioritisation of deforestation and degradation hotspots:

- carbon stock,
- area,
- variables indicating deforestation and/or forest degradation threats (dynamic of forest frontiers, population density, road and energy infrastructure etc),
- biodiversity value and
- governance.

The national guidelines for sub-national REDD+ monitoring will basically refer to existing REDD+ standards and methodologies. In addition, requirements for data management and data sharing will be provided, as well as standards that will enable to integrate sub-national monitoring data into the national monitoring system.

Data collection

Remote sensing

Sample based field observations provide punctual data on a series of forest mensuration attributes and remote sensing allows a large area synoptic assessment and analysis of a limited set of area attributes (as visible from above). Together, these two data sources make up the major part of a forest monitoring system and they need to be designed such that they complement each other. Also remote sensing based maps together with the field sample data are a valuable data base for manifold research activities! The data should be proactively made available to research institutions. Best would be to contract out specific research questions so that these institutions (that usually suffer from a tremendous lack of resources) have the possibility to do serious research, and to link them to research institutions from developed countries, to foster international collaboration.

For REDD+ monitoring, estimation of emission factors (carbon densities) is mainly collected from field observation, while remote sensing technology is used to estimate activity data (area per land-use class).

Remote sensing analysis results in thematic maps providing variables of interest for the entire area of interest; usually forest/non-forest, forest types, tree density, biomass density, carbon density are mapped. It may also be used to identify deforestation and forest degradation hot spots.

A remote sensing component in a forest monitoring project requires expertise in image procurement, image processing and analysis, image interpretation (see Annex 10**: Technical steps for processing and analyzing remote sensing data**). When the objective is to go beyond interpretation and mapping and to link field observations with remotely sensed information, expertise in modelling plays an important role. Active sensor remote sensing techniques like lidar and radar require additional specific expertise as the data format and information extraction is very different from the common optical passive imagery (e.g. aerial photographs). In Uganda in-depth modelling and active sensor interpretation expertise is currently not available.

The technical interpretation of the results needs to be done in close collaboration with the project management team, which should be responsible to meet pre-defined quality benchmarks, and the expert for the field data collection.

Data management and reporting

A REDD+ monitoring system requires an archiving system and, as mentioned above, should enable and encourage research organisations to use the existing information. Uganda will apply all respective guidelines provided be IPCC, 2006 Volumes 1 and 4.

The monitoring system should be located at the National Forestry Authority (NFA). The National Environmental Management Authority (NEMA), which is in charge to approve the environmental and social impact assessment of all REDD+ activities should receive access to the original data set and analysed and aggregated information, i.e. reports and maps, for additional archiving. NEMA which is managing the Environmental Information Network should also facilitate data sharing among Government agencies and provide researcher conditional access to the data. This arrangement will also strengthen cross-departmental exchange and transparency.

The Forest Sector Support Department in cooperation with the newly established, but not yet functional District Forestry Service at the local government level, will contribute to collect data on law enforcement and other drivers of deforestation and forest degradation. Respective data collection and management protocols and incentive mechanisms will be developed. Locally based NGO's and community organisations are expected to join respective efforts.

The archiving system will contain all the procedures and methods used, the reference scenario, monitoring data and their analysis as well as estimations of accuracy and uncertainty. The responsible department will need to work closely with other agencies to ensure that all data is up to date at any given time.

The monitoring system will be designed in a way that permits the annual accounting for deforestation, forest degradation and afforestation and the estimation of the resulting emissions or emission reductions in comparison with the reference scenario. Cost recovery mechanisms for maintaining the monitoring system will be established. Public access to the monitoring system needs to be assured. Capacity building on information management and technology is required (see also Annex 8: Good Reporting). Reports on emissions or emission reductions related to forestry will be integrated in the next national GHG inventory of Uganda.

Quality control (QC) and quality assurance (QA) is an integral part of reporting. It includes error assessments (see Annex 7: Sources of errors and error analysis), reviews of methods used for data collection and analysis and control of completeness and consistency. QC and QA will be done by the reporting agency together with external experts e.g. in form of regular peer reviews and should also involve activities such as re-measurement by independent field teams and cross checks with other data sources e.g. the IPCC default values and the Emission Factor Database (EFDB IPCC).

Community involvement in forest monitoring

Community forestry in Uganda is lacking a supportive governance environment and accordingly community based monitoring capacity is still relatively weak.

Experiences from other countries e.g. Nepal show that communities with support from dedicated local NGO's can manage high quality REDD+ monitoring systems (Skutsch 2010). In Uganda various national, international and local NGO's as well as the Uganda Wildlife Authority work closely with communities, but have limited experience in REDD+ monitoring. Therefore, it is envisaged to establish community monitoring systems in the framework of small community based pilot REDD+ projects to increase capacity and confidence in respective governance and monitoring systems. Related monitoring systems will be over time fully integrated into the national REDD+ monitoring system.

Monitoring of co-benefits

Monitoring of co-benefits of REDD+ implementation will be an integral part of the monitoring system, among others to meet the monitoring requirements of the UN Convention on Biological Diversity. Furthermore, important forest and non-forest products, including ecosystem services will be monitored either in the framework of the national monitoring system, sub-national monitoring or dedicated research projects. Of course this requires additional funding which needs to be secured.

Budget for designing a monitoring system

Activity	**Sub-activity**	**Time schedule and estimated costs in US$**					Funding source	
		2011	**2012**	**2013**	**2014**	**Total**	FCPF	other
Coordination		50,000	50,000	100,000	100,000	**300,000**	300,000	
Objectives and standards of the monitoring system		20,000				**20,000**	20,000	
Capacity building	Monitoring at district level	50,000				**50,000**	50,000	
	Training on evaluation of high resolution remote sensing data	25,000	25,000			**50,000**	50,000	
	Pilot projects for community monitoring		20,000	20,000	20,000	**60,000**	60,000	
	Training on data management	10,000	10,000			**20,000**	20,000	
Development of moni-toring plan	Develop set of indicators and measurement methodologies for monitoring of ecological and social co-benefits	50,000	50,000			**100,000**	100,000	
	Selection of methodology and tools		30,000			**30,000**	30,000	
	Development of procedures and work plans		20,000	20,000		**40,000**	20,000	NFA (as part of NBS)
Development of report-ing system	Design of data management system		40,000	20,000		**60,000**	60,000	
	Integration of REDD+ projects			20,000	20,000	**40,000**	40,000	
System review					25,000	**25,000**	25,000	
MRV implementation	Equipment		30,000			**30,000**	30,000	
	Acquiring remote sensing data				600,000[3]	**600,000**		UNEP through NEMA[4]

[3] Cost are calculated assuming the use of free of charge Landsat data and high resolution imagery for REDD+ hotspots (12,000 km²) at app. 50 US$/km².

Activity	**Sub-activity**	**Time schedule and estimated costs in US$**					Funding source	
		2011	**2012**	**2013**	**2014**	**Total**	FCPF	other
	Acquiring field inventory data				105,000	**105,000**		NFA as part of NBS
	Data processing and analysis			100,000	100,000	**200,000**	100,000	NFA as part of NBS
	QC and QA			50,000	25,000	**75,000**	75,000	
	Verification				50,000	**50,000**	50,000	
Total		**205,000**	**275,000**	**1,080,000**	**1,055,000**	**1,855,000**	1,030,000	825,500

[4] An agreement between National Environment Management Authority and UNEP permits Uganda to source remote sensing data of various providers. Costs will be covered by UNEP. The specifics of the agreement were not disclosed.

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ANNEXES

Annex 1: Some “not-to-do’s” or a “guide to avoid bad practice” when designing and implementing a forest monitoring system

The inventory techniques toolbox is so versatile that there are always various methodological possibilities of inventory designs that allow accomplishing the goals. The author is therefore convinced that the definition of one single “good practice guide” is not helpful as it would suggest that other good options would not be appropriate.

To the author it deems much more straightforward to list a number of bad practices that should be avoided in order to reduce the risk that an inventory study ends in a disaster.

Not-to-do’s:

1. Never start collecting field sampling data before the “estimation design” is solved and elaborated.
2. Never invent and implement a sampling design or a plot design just because it is so easy and cost-efficient to implement in the field. If there is no sound estimation design developed - all data collection is meaningless.
3. Don´t look at a forest monitoring exercise as a pure technical study (be it statistical sampling or modelling or remote sensing based image processing). The technical side is but one element, but there is the “political” and “decision making” side as well. The context of providing information to decision makers is at least as important as the data provision part.
4. Don´t use available data sources without having checked the methodological soundness and appropriateness of the data (also in terms of up-to-dateness).
5. Don´t add variables or other design elements to a monitoring system (and increase cost) without having a clear idea what that data is being used for. There are various examples of forest inventories where eventually many of the “would-be-interesting-to-measure” variables were never processed nor analysed.
6. Some organizational and institutional points in inventory planning can well be solved by common sense considerations. This is not possible when it comes to the planning of a sampling study. There, the rules of statistics overrule common sense.
7. Don´t look at a remote sensing mapping study as an independent product. In order to be compatible with other project components (field observations) the definition of categories in the field and in RS imagery need to be identical or at least “compatible”. It is one of the difficult methodological issues that field based definitions of land use classes are often much more detailed (but explicitly formulated) than definitions in RS studies (which are frequently not explicitly formulated in detail).
8. Don’t rely on the eventual availability of large-area complete RS imagery – even if you have all funds necessary. Clouds or technical problems may lead to the situation that the coverage is incomplete. Think about a plan B.

9. Don´t report results without providing a clear definition of terms.
10. Don´t report any estimates without stating the error of estimation. Otherwise, it is impossible to judge the quality of the estimation. For any sampling related error given it must be clear whether that is the simple standard error or the confidence interval (in the latter case, including the error probability)
11. Don´t use terms from sampling statistics without knowing their definition, because that may cause endless confusion. Typical terms are "bias", "sampling error", "precision", "accuracy", "representative", "independent", and others alike.

Annex 2: Definitions of key terms

Forest:

The CDM Designated National Authority in Uganda, i.e. the Ministry of Water and Environment has defined forest land as areas with at least 30 % tree crown cover, covering continuously at least one hectare and where trees have a height of at least five meter or have the capacity to reach that height in the future.

Forests in Uganda are commonly divided into (NFA, 2009):

- Tropical High Forest well stocked and low stocked
  Tropical High Forest is closed, multi-storied and very species rich forest dominated by trees that can be found in patches of varying extend along the Albertine Rift Valley, on Mt. Elgon and along Lake Victoria. In 2005 it covered an area just over 740,000 hectares, of those 200,000 hectares were degraded.
- Woodland
  Woodlands covered more than 2,800,000 hectare in 2005, in particular in northern, central and west Uganda. Trees and shrubs are predominant. The average height of the trees must exceed four meter. Woodlands can be further subdivided into wet and dry types. The wet type occurs along wetlands (riverine forest) and the dry type is found on upland areas.
- Broad leaved plantations and coniferous plantations
  Plantations are planted with mainly conifers and eucalyptus, the area exceeded 33,000 hectare in 2005.
- Bushland is not considered forest land, although it is often created by overuse of woodland or Tropical High Forest. It covered an area of just under three million hectares in 2005 and is expanding. The vegetation is dominated by bush, scrub and thickets growing together that do not exceed an average height of four meters.

REDD+ eligible activities:

The IPCC GPG (2006) defines three categories of land use and land use change relevant for REDD+.

- Forest land remaining forest land: includes forest degradation and carbon stock enhancement
- Land converted to forest land: includes afforestation and in some cases reforestation (i.e. under CDM reforestation is only eligible when the land was already non-forested since the 31.12.1989)
- Forest land converted to other land: includes deforestation

  - Forest degradation is in the context of REDD+ a direct, human induced, long term loss (persisting for x years or more) or at least y % of forest carbon stocks since time T and not qualifying as deforestation (IPCC, 2003a).
  - Deforestation is the direct, human induced conversion of forested land to non-forested land (IPCC, 2006) and therefore means that at least one of the thresholds of the forest definition is not met anymore.

- Afforestation is the direct human-induced conversion of land that has not been forested for at least 50 years to forest land through planting, seeding and/or human induced promotion of natural seed sources (IPCC, 2006).
- Reforestation is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or human induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. […] limited to reforestation occurring on those lands that did not contain forest on 31. December 1989. (IPCC, 2006)
- Carbon stock enhancement of forest or non-forest land can be human-induced (e.g. afforestation, enrichment planting) or without human intervention (natural recovery) and will lead to increased carbon stock.

Two types of data will be needed to estimate historic and future emissions or emission reductions.

Activity data:

The term activity data refers to all data sets that permit the evaluation of changes of land cover and land use over time. The analysis of data from different times provides spatially explicit trajectories for deforestation, reforestation and in limited form for forest degradation and carbon stock enhancement or in other words the areal extend of an emission or removal category at a given time. It is usually based on images of the surface taken from satellites or other carriers.

Emission data:

Emission data refers to all the information necessary for the estimation of the carbon content of a certain land use class or the changes in carbon stock after land use change has taken place. Data is commonly gathered on the ground but can also be estimated with high resolution remote sensing data combined with field inventories.

Emission factors:

The emission factor is the average amount of CO_2 equivalents bound by a certain land cover form and biomass content. When changing the land use to another one an according amount of CO_2 equivalents are released or sequestered.

IPCC principles:

Accuracy refers to the agreement of the measurement and the true value. It is influenced by the sum of errors, meaning the variation above or below a mean value. The IPCC gives clear guidelines how to improve accuracy. Uganda's reference scenario will be developed applying the most recent IPCC good practice guidelines.

Comparability of emission reductions with other nations will be assured by using IPCC methods and UNFCCC reporting guidelines.

Completeness*:* The IPCC guidelines (2006) state that it is good practise to address all forest carbon gains and losses. The GHG inventory for Forest Land should include all land under Forest Land and all land use categories converted to Forest Land. Therefore emission sources and sinks for the entire country will be considered across Uganda.

Data going back to 1990 (availability provided) will be analyzed, to set a valid reference scenario.

Consistency means that Uganda's inventories for different years will be internally consistent, regarding the used data and methodologies. This applies also to future estimations of GHG emissions as outlined under Component 4 MRV.

Efficiency: According to the IPCC (2003b) it is good practise to make the most efficient use of available resources by identifying those categories that have the greatest contribution to overall inventory uncertainty. By identifying these key categories in the national inventory, inventory agencies can prioritise their efforts and improve their overall estimates. Generally the uncertainty of the final estimate of emissions is chiefly determined by the higher uncertainty in carbon stock estimates. This means that the chosen tier must be the same for both carbon stock and activity data. Generally the cost to acquire emission data sufficient for tier three is higher than the cost associated to similarly accurate activity data (Böttcher et al., 2009). Therefore information, both on land use change and carbon stock should be gathered primarily for hot spots in land cover and land use change.

Transparency and **accountability** will be achieved by providing access to all data used for Uganda's reference scenario and for future calculation of emission reductions for open and independent review. Assumptions and methodologies for the reference scenario estimation will be clearly documented and explained to relevant assessors and stakeholders.

To address failures in achieving high levels of accuracy and completeness the principle of **conservativeness** will be employed. For Uganda's REDD+ context conservativeness means that reduction in emissions or increases in carbon stock shall not be overestimated, e.g. by identifying key categories (IPCC, 2003b).

The **uncertainty** level of the emissions and emission reductions will be estimated based on the guidelines provided by IPCC (2000 and 2003). This will be based either on expert judgement or in case of statistical sampling will be calculated with statistical methods. IPCC (2003) suggests the use of a 95% confidence interval.

Representativeness: The data sets analysed for the reference scenario and data collected for monitoring must represent the Ugandan context. To that end three data sets will be analysed for estimation of the historic emissions and sampling will be done according to the latest guidance by the IPCC or UNFCCC (e.g. IPCC 2003b).

Precision level: The required level of precision for REDD+ is as of today not specified by the IPCC or the UNFCCC. Uganda will incorporate respective guidance as soon as it is available.

Carbon stock estimation:

According to the IPCC (2006) there are two methods to estimate the carbon content of biomass. One is the **Gain-Loss method**, which is based on growth and carbon transfers from one pool to other pools and mainly used for Tier 1 estimations. The second one is the **Stock Difference method** where calculations are based on two measurements in time. Uganda will use the second method with a tier 3 to 2 level.

IPCC Tiers reflect the uncertainty determined by the data used for the calculation of carbon stock and carbon stock changes. While no explicit definitions are available for the different tiers the IPCC (2006 Volume 4, chapter 4) provides guidelines what data should be used for what tier for the respective carbon pools.

Tier 1: High uncertainty; IPCC equations and IPCC default values or aggregate data can be used.

Tier 2: Medium Uncertainty; IPCC equations can be combined with country-specific data with temporal and spatial resolution and disaggregated activity data.

Tier 3: Low Uncertainty; Use of models or equations for specific situations and high-resolution activity data which is disaggregated at sub-national level.

Carbon pools:

The following Carbon pools need to be considered when estimating GHG emissions or emission reductions from land cover or land use change:

- Above Ground Biomass
- Below Ground Biomass
- Dead wood and litter
- Soil carbon (organic and an-organic)
- Non-CO2 gases

Literature Annex 2:

NFMA FAO: National Forest Monitoring and Assessment online at: http://www.fao.org/forestry/nfma/en/ (24.06.2010)

Annex 3: Flow of activities when planning and implementing a forest monitoring system

I. Defining the objectives of the monitoring system

Including

1. Define the area of interest.
2. Define the "target object".
3. Define the information needs and targeted precision levels.
4. Define target land cover categories as to be used as pre- or post-stratification criteria.
5. Translate the information needs into measurable variables (indicators).
6. Decide which forest definition is to be used (CDM, FAO or national or an own one; it is important to have that definition and to have it operational; it is lesser about right or wrong; it is about "clearly defined for a monitoring system" and "not clearly defined …"!!)

II. Defining the institutional and organizational setting

Including

7. Formulate the mandate / generating the legal basis for such system.
8. Secure financial resources.
9. Assign the implementation responsibility to a suitable institution / unit (here: *NFA*). Identify required institutional measures (founding new unit, capacity building, contracting national and international consultants, linking into international cooperation …).
10. Name a responsible co-ordinator and establish a planning group; this should embrace identifying national experts in
    - forest inventory, including sampling statistics
    - remote sensing, including statistical modelling
    - GIS
    - data management
    - project planning and policy processes.

    Although some expertise is available at NFA additional staff or training might be necessary.

    In some cases, such national experts are difficult to find. Then, international organizations (like the NFMA Programme of FAO) or international consultants may be contacted and asked for advice.
11. Start establishing partnerships
    - with public and non-governmental institutions related to forest management,
    - with potentially interested institutions from other sectors and
    - with research institutions.
12. Make the study and its national relevance publicly known in newspapers, broadcast and other suitable media. When land owners have heard about the study, they will likely more easily collaborate and grant access to their lands for measurements.

13. Define measures of quality control and corresponding responsibilities for all working steps.

III. Prepare the design planning for the monitoring system,

including

14. Search existing maps and documents (inventory reports, technical papers on models such as volume or biomass functions, remote sensing based forest mapping studies…) – *much of this is already combined in the National Biomass Study but can be further improved by e.g. incorporating data from other institutions like WCS* – and evaluate their quality.
15. Make a gross calculation and allocation of resources to field work and remote sensing.
16. Decide whether to use paper form sheets or portable data loggers.
    Data loggers are more modern; they require programming for tailor made templates, and training for data entry and troubleshooting; they facilitate data management and allow comprehensive plausibility checks right in the field, thus improving data quality. Spare devices need to be provided for each team (expensive!) in order not to hinder work flow.
    Paper sheets are traditional, they require data entry in a separate step and data entry is more error prone. Water proof paper allows data entry under very difficult conditions.

IV. Define the scope of remote sensing (RS) integration,

including

17. Define for what purposes remote sensing shall be employed; which are the objectives / products that base on / require remote sensing imagery.
18. The three basic methodological options are:
    - wall-to-wall mapping: which classes? This requires mainly RS expertise; however, an immediate link (conceptually and methodologically) to the other data sources must be established,
    - sample based RS analysis: which plot size around field plots; only around field plots or on a denser grid - good experiences from an NFMA inventory in Costa Rica exist (Kleinn et al 2005),
    - a combination of the prior two: field samples are used to establish a relationship between remotely-sensed and field-observed variables and apply the resulting model to the entire image. Then, the entire image serves as “carrier data” in a so-called regionalization approach.
19. Define target accuracy (including the definition of the accuracy measure used!) and targeted minimum mapping unit.
20. Identify which image products (type, sensors) are ideally to be used to achieve the defined goals; and which image products are readily available from other projects; in terms of technical suitability (mainly spatial and spectral resolution) and in terms of up-to-dateness.
21. Procure imagery (and don´t believe that all imagery can easily be procured if the money is available; frequently it takes a lot of time and in some cases clouds prevent large-area complete coverage by optical sensors).

22. Search and contract RS experts. It is always helpful to have RS experts who are open for general methodological questions and are not only and strictly at home in the "world of digital image processing".
23. Procure software and specific training, if required.
To be independent of expensive commercial software, it is recommended to train and educate experts in open source image processing software, as for example GRASS. This is in any case recommendable, independently of a particular monitoring project planning.

V. Define the sampling design

including

24. Assess and refine the sampling design of the National Biomass Study, including the elements "stratification" and "systematic sampling"; however lesser usual techniques like multi-phase sampling may be indicated, in particular double sampling for stratification.
25. Calculate the possible field sample size (available resources for field work divided by estimated cost per sample location) – and decide whether that is adequate (if not: more funds need to be secured). This decision is best made by graphing the expected cost over achieved precision.
26. Select / define the sample locations. Usually a grid of points is laid over the entire area sampling frame (the region of interest). *For the National Biomass Study a national grid of 5 x 10km was chosen.*
27. Identify which sampling points fall into forest.

VI. Define plot design

including

28. Defining plot type(s): usually large area forest monitoring systems use complex plot designs in order to accommodate the possibility to produce estimates for many different variables. Plot design components include nested fixed area plots, relascope sampling, line intercept sampling, adaptive plots and possibly others.

29. Define plot size (area of fixed area plot, basal area factor of relascope sample).

For the National Biomass Study permanent sample plots of 2500 m² in clusters of 2 to 4 around grid points were established. It needs to be assessed how this sample design affects accuracy and if it can be improved.

30. Define Variables to be recorded on each plot design component, including measurement procedure and format of data recording. This must strictly follow the information needs and the indicators derived from them.

During the National Biomass Study data on species, DBH (when > 3cm), total height, height of bole and crown width was collected.

31. Where applicable: set a range of possible values that can be used for plausibility checks when doing the measurements.

32. Defining the modes for slope correction (when plots are in sloped terrain) and border correction (when there is a slop-over of plots over a boundary between the pre-defined land use categories).

VII. Define the information system

including

33. Identify the institution where the information system is to be located. (here: *given the previous experience the NFA is the most likely candidate, which was seconded by the REDD+ working group*)
34. Assign clear responsibilities (data base manager).
35. Define the structure of the data base along the variables to be observed.
36. Purchase software and contract IT expert
37. Define the work flow (and responsibilities) of data from entering them in the field to entering them to the information system. There are many options from wireless connection between mobile data loggers and the data base to manual data recording on paper sheets and entering the data manually into the data base.
    Because they are "closer" to the place of data generation, it is recommendable to ask the field teams themselves to enter the data into the data base. That may reduce transfer errors.

VIII. Detail planning of field work

including

38. Write a comprehensive field manual. Most parts can easily be copied from prior inventories i.e. the National Biomass Study. Emphasis must be made that all variables are defined. Measurement procedures are to be defined as well.
39. Topographic maps with sample point locations and lists with their grid coordinates and other relevant information need to be prepared.
40. Depending on distances, road network, the number of field teams and the time available, sample points are assigned to the field teams.
41. Prepare, for each field team, a complete set of materials, including maps and form sheets.
42. Organize training for field teams. That training should serve (1) to train specifically the mensuration techniques required in the field work, (2) general overview of the project, (3) sensibilization towards the role of each individual staff member for data quality and quality of the final product. If field teams use their own measurement devices, calibration of these devices must be done during training. If the monitoring system is considered a longer-term exercise, training should be conceptualized as a long-term capacity building measure.
43. If necessary, provide training in first aid in case of accidents (or insect or snake bites).
44. Define a schedule and deadlines for field teams.

45. Establish a communication structure (radio).
46. Define a regular communication and reporting back structure so that field teams maintain permanent contact with the co-ordinator in the project headquarters. Any problems need to be reported immediately.
47. Organize meetings of all field teams to exchange experiences after some weeks of field work.
48. Define data flow: who records the data, who keeps the form sheets (or data loggers), who submits the data to the data base group, who is responsible for questions about data should such questions occur.

IX. Data management and analysis

including

49. Establish an information system (IS) to accommodate all data on the long run. This point is a broad one, and embraces
    - identification of the physical location and organizational embedding (e.g. with UBOS, NaFoRRI, NEMA or the NFA since they are the planning agency) of the IS
    - assign longer term responsibilities.
50. Define all steps of standard data analysis and clear them before starting the costly field work. That means that all estimators are known and explicitly formulated and the format of the reporting output tables is defined.
    The former refers to the standard analyses; it does not preclude that there are usually many more analyses that are found to be meaningful when diving into an "exploratory data analysis".
51. Contract an expert with sound background in sampling statistics and good command of statistical software. It is possible to do a lot of analyses in MSExcel® - however there are limits. To be independent of expensive commercial software, it is recommended to train and educate experts in open source statistical software, as for example R+. This in any case recommendable, independently of this particular monitoring project planning.
52. Design the data base (software, structure, variables to be entered) such that it can possibly also be used for future inventories and for an expansion of the scope of the monitoring study.
53. Establish a procedure of comprehensive quality control of data management.
54. Produce point estimations (means, totals) per variable of interest per region of interest (or broken down to other variables).
55. Produce interval estimates for all point estimates (usually standard error of estimation or confidence interval).
56. Identify research questions that may result from exploratory data analyses and that possibly can be worked on with the data collected.
57. Check all results for plausibility, also by someone who has not participated in the analyses.

X. Reporting

including

58. Define the reporting products. In any case, this must comprise (1) the results´ report and (2) the methods´ description. Policy briefs, scientific articles and general media reports for dissemination may also be produced.
59. Establish a thorough proof reading process by experts in all related fields.

Annex 4: SWOT analysis

Objective: NFA as the leading institution for setting historic emission levels from land use and land use change and for implementing MRV for REDD+.

Institutional SWOT for National Forestry Authority	
STRENGTHS: • The NFA has considerable experience with mapping of land use and biomass based on optical remote sensing data and field inventories. • The NFA holds the data for the national forest inventory, which provides information on land use, land use change (deforestation), biomass and biomass change (degradation and carbon stock enhancement) across different land use categories. • The National Biomass Study is an ongoing project, where REDD+ monitoring could be integrated.	**WEAKNESSES:** • At the moment NFA staff is not familiar with IPCC and UNFCC guidelines for GHG inventories (apart from CDM), especially in terms of determining accuracy and uncertainty. • NFA staff has no working experience for processing and analysing high resolution remote sensing data such as Lidar and SAR. • No established link to national GHG inventory → reporting system not in place • The equipment (hardware and software) used is partly not up to the necessary standard. • There is not enough technical staff to be able to cope with additional REDD+ monitoring.
OPPORTUNITIES: • Existing linkages to other organisations such as WRI (mapping biomass), Woods Hole Research Centre (capacity building in radar technology), FAO (AFRICOVER project), FACE foundation (on Kibale and Mt. Elgon projects) are in place. • Existing but not operational information sharing systems (EIN, Geo-Information Management Working Group) could be improved.	**THREATS:** • The existing topographic base map (needed for GIS) stems from the 1960 and is therefore in many areas outdated. • Well educated experts can find better paid jobs in the private sector easily. Therefore, there is the risk that NFA trained staff will look for employment elsewhere. • Due to recent events the NFA is not perceived as trustworthy, resulting in constraint donor funding. Also this has caused a very bureaucratic control system, which makes fast action nearly impossible.

Objective: NEMA as a partner for setting historic emission levels from land use and

Institutional SWOT for National Environment Management Authority	
STRENGTHS:	**WEAKNESSES:**
• NEMA's mandate is to coordinate, **monitor**, regulate and supervise the environmental management of Uganda. • NEMA is the secretariat for and coordinates the	• NEMA staff is working at full capacity, meaning that additional tasks, such as aggregating data for reporting will require more staff.

land use change and monitoring and reporting of C-stocks and REDD+ related activities.

work of the Environmental Information Network (EIN) in Uganda. The EIN is amongst others composed of the major leading agencies in the environmental sector: e.g. Survey and mapping department, NFA, UBOS and Agriculture Planning Department. • NEMA has projects that can contribute to REDD+: o Payment for ecosystem services (Albertine Rift valley, wildlife corridor between Bugoma and Budongo CFR's): This project will on a scientific basis estimate how effective PES schemes on private and community land are in Uganda. o Restoration of lake shores, river banks and catchment areas with native species. o Further relevant projects have been proposed but are not approved yet.	
OPPORTUNITIES:	**THREATS:**
• By working closely with all the agencies in the environmental sector NEMA aggregates a lot of data already. It is therefore in a good position to actively participate in reporting of REDD+ implementation. • NEMA was originally funded solely by the Worldbank. WB funding is now gradually being replaced by government funds, securing stable funding of operating costs (government) and projects (WB and other donors). • Apart from other governmental agencies NEMA cooperates with NGO's and Makerere University for research and project evaluation and implementation.	• Much of NEMA's the information collection/projects implementation is actually done by the lead agencies for the respective sectors (e.g. forestry – NFA) leading to a dependency on their work and capabilities on NEMA's side.

Institutional SWOT for Forest Sector Support Department	
STRENGTHS:	**WEAKNESSES:**
• FSSD represents the central government in the forest sector, having the nominal oversight over the entire forest estate which is managed by UWA, NFA and DFS (Local Governments). FSSD is therefore in a good position to play a	• In contrary to its mandate the FSSD is at the moment not involved (apart from the FIEFOC pilot programme) in the collection of statistics or in the reporting of such. No clear reporting structure exists.

Objective: FSSD participating in the reporting of REDD+, being the agency where reports from different forest estates are joined.

crucial role in reporting and verification. • The FSSD already has a monitoring program of activities in the forest sector. o To monitor activities on private forest land and in EPR's a pilot program has started recently (FIEFOC). Activities such as capacity building, tree planting and reporting are monitored against a set of performance indicators in selected sub-counties of 50 districts. o Activities of the NFA are monitored via a performance contract.	• Despite having many mandates the FSSD has a very low budget and subsequently few full time technical staff. The possibility to successfully take on the additional task of coordinating and overseeing REDD+ reporting is under the given circumstances low.
OPPORTUNITIES: • Forest governance is increasingly becoming a focus of the public attention. The awareness that institutions like the FSSD must be strengthened is rising as well. Ideally this will result in better funding of the FSSD and the improvement of reporting structure in the forest sector.	**THREATS:** • According to the WB survey at the Forest Governance workshop (Kampala 2010) the FSSD is not perceived as "being trustworthy and **competent**". (Questionnaire respondents were comprised from GO's, NGO's and the private sector related to Uganda's forest sector)

Institutional SWOT for Uganda Wildlife Authority

STRENGTHS:	**WEAKNESSES:**
• Large proportions of Uganda's forests are situated in areas managed by UWA. • UWA has experience with Carbon funded projects (AR in Kibale and Mt. Elgon together with the FACE foundation) for the voluntary	• Work is restricted to national parks and wildlife reserves. • UWA's work is primarily management of protection areas. Research, especially regarding biomass and land cover is not a priority.

Objective: UWA as a partner for setting of historic emission levels from land use and land use change and monitoring and reporting of REDD+ implementation and additional REDD+ benefits.

market. • UWA works with communities inside and outside protected areas. Activity monitoring (poaching, illegal logging) through communities is already being implemented via a remuneration system by UWA. • REDD+ implementation should provide additional benefits, such as increased biodiversity and socio-economic benefits. UWA already monitors wildlife and contributes to the income of communities around protected areas.	Very little primary data is collected by UWA. • Only 30% of UWA's budget is covered by the government. The remaining 70% of the funds come from income such as NP fees and third party funding. This means that a lot of UWA's capacity is locked in fundraising and income creation. • The Community Conservation Department is small and has foremost an overseeing function with the actual groundwork done by local NGO's. The involvement of communities in monitoring is therefore better implemented by these NGO's.
OPPORTUNITIES: • Close cooperation with government (NEMA), non-governmental organisations (e.g. WWF, WCS) and Universities (e.g. Makerere) who do most of the research in protected areas.	**THREATS:** • Important data is acquired from other organisations (e.g. maps from WCS), meaning that availability and cost can vary.

Objective: UBOS as a partner in setting historic emission levels from land use and land use change.

Institutional SWOT for Uganda Bureau of Statistics	
STRENGTHS: • UBOS' mandate is to coordinate, monitor and supervise the National Statistical System. To that end it collects and combines information surveyed by lead agencies of each sector. • UBOS monitors surveys done by other agencies, which ensures the quality of the information and enables them to comment on the survey design. • Some drivers of deforestation and forest degradation are directly reflected through statistics, e.g. the fuel wood and charcoal consumption per household. • UBOS can provide necessary links to the original provider of information. • The GIS department of UBOS produces maps that visualise statistics and can combine different information highlighting interdependencies.	**WEAKNESSES:** • At the moment detailed information on sources of agricultural and forest products is not available. • UBOS provides data in aggregated format only while in some cases the underlying original data can be important. In such cases the original data provider has to be contacted.
OPPORTUNITIES: • The environmental statistics department works in close cooperation with the WRI on indicators for valuation of the environment. • UBOS can access different funding sources but is largely funded by the government.	**THREATS:**

Objective: NaFoRRI as a partner for setting historic emission levels from land use and land use change and monitoring of C-stocks.

Institutional SWOT for National Forest Resources Research Institute	
STRENGTHS: • NaFoRRI's mandate commits it to freely share data. • NaFoRRI recently started projects on growth and biomass yield of plantation and agroforestry species. • In 2008 a research programme on biomass and biomass growth of woodlands in Nakasangola and Apach started. Permanent sample plots were established.	**WEAKNESSES:** • Despite the mandate to share data, no easy access to NaFoRRI's work, e.g. via the website or over publication lists exists. • NaFoRRI covers four main research areas: Agroforestry, Forest management, Forest products and Genetic resources; none of which is directly related to the estimation or monitoring of biomass and C-stocks • After the forest sector reform the direct involvement in the national forest inventory ceased and all data was handed over to the NFA, meaning that NaFoRRI is in possession only of very old data and very recent one (see strengths). • The relatively short project cycles of 5 years make continuous biomass monitoring programmes less feasible.
OPPORTUNITIES: • Research at NaFoRRI is demand driven. With REDD+ being implemented at national scale and concerning many of the relevant stakeholders of NaFoRRI biomass monitoring and C-stock research will likely be integrated in NaFoRRI's research programme in the future. • NaFoRRI has comparatively stable funding (some fluctuation exists) through the government, with the possibility to access additional funds for particular research projects. • NaFoRRI is actively involved with the Forest Working Group (combining NGO's, CBO's and research institutions) national and international NGO's as well as Makerere University. A MoU with the NFA is in place.	**THREATS:** • Stakeholders comprise the private sector, NFA, universities, local governments (presented by the District Forest Service) and the general public resulting in a multitude of demands and the possible subsequent splitting of the budget into many small projects without greater cohesion. • Priority research projects are confirmed or set new every year during a committee meeting of the stakeholders, making long term planning (beyond the 5 year project cycle) difficult.

Objective: WCS as a partner for the setting of historic emission levels from land use

Institutional SWOT for Wildlife Conservation Society	
STRENGTHS:	**WEAKNESSES:**

and land use change and monitoring and reporting of REDD+ implementation.

• WCS works with private landowners and at community level through its extension network of local NGO's in northern and western Uganda.	• WCS has no or little presence in central, eastern and southern Uganda.
• WCS' projects have landscape level approach ensuring control of leakage effects.	• Some projects of WCS have pilot character. It cannot be said with security that they will be maintained and implemented over long time and on larger scale once the pilot project is finished. However for most of its projects WCS is committed long term with a strong focus in implementation.
• WCS conducted an assessment for woodland change in northern Uganda between 1986 and 2002. • A REDD+ feasibility study is currently conducted for the Murchison-Semliki landscape: o Land cover (based on satellite images, aerial photographs and field visits) and biomass assessments since 1985 for Murchison-Semliki region (ongoing) with mostly high accuracy (>80%), o Concluded pilot surveys of carbon stock, socio-economic and biodiversity parameters in Kasato Forest Reserve. o Similar surveys are still taking place within the region. • WCS has a capacity building programme for UWA staff. • WCS is together with UWA and Ugandan conservation NGO's working towards setting up a trust fund for payment of environmental services. • WCS is actively involved in the Trans-Boundary secretariat for protected areas. (DRC-Uganda-Rwanda and Uganda-Sudan)	
OPPORTUNITIES: • WCS works in close cooperation with government institutions (e.g. NEMA, US forest service, Trans-boundary Core Secretariat), non-governmental organisations (e.g. Woods Hole Research Centre, Ecotrust) and Universities (e.g. ITFC [Mbarara], MUIENR [Makerere], Gulu University) • The WILD project works towards improved governance and management of natural resources. While not being focused exclusively on REDD+ it can contribute significantly to REDD+ implementation.	**THREATS:** • WCS is donor dependent. • The organisation has no explicit mandate to participate in REDD+.

Institutional SWOT for World Resources Institute

Objective: WRI as a partner for setting Uganda's Reference scenario and for Monitoring and Reporting of REDD+ implementation.

STRENGTHS:	**WEAKNESSES:**

• WRI has extensive experience of mapping of ecosystems and ecosystem services across the world and has mapped wetlands and wetland uses across Uganda. • An extensive analytical expert network is available for specialized tasks in particular remote sensing and data analysis and mapping. • WRI has specialists for capacity building in data handling/storage and evaluation. • WRI has several programmes of relevance for REDD+ in Uganda, e.g. Mainstreaming Ecosystem Services Initiative (MESI), Forest Landscape Initiative and Poverty and Ecosystem Services in East Africa.	• WRI is based in Washington and has got no permanent staff working in Uganda.
OPPORTUNITIES: • During its previous work good relationships to Ugandan ministries/departments and institutions (NEMA, Makerere EPRC, NFA) have been established.	**THREATS:** • WRI has no explicit mandate to participate in REDD+ for Uganda. • Their work is based on available data, no primary data is collected • WRI's programmes are donor dependent.

Annex 5: Available data sources

Source	Owner	Details
National Biomass Study (NBS) I	NFA	Biomass of different forest types, bush land and agricultural land based on destructive sampling
National Biomass Study 2003 (II)	NFA	National forest inventory, based on SPOT XS satellite images 1990-1993, permanent sample plots and NBS I
National Biomass Study 2009 (III)	NFA	National forest inventory, based on Landsat 2005/6 images, permanent sample plots and NBS I and II
Natural Forest inventories	NFA	Exploratory inventories of several Central Forest Reserves
Vegetation and Forest Cover Change Map Semliki/Murchison landscape	WCS	Based on ASTER images 2005, 2006, aerial photographs (2006-2010)and NBS
Enso Mosaic maps of WILD project areas in northern Uganda	WCS	Based on Landsat images 1986, 2000 and aerial photographs 2007
Remote sensing data	NEMA	Medium and high resolution satellite images from different sources will be available upon request through NEMA

Annex 6: Contacts to support the development of Reference Scenarios and the design of a monitoring system in Uganda

Organisation	Person	Email	Details
National Forestry Authority (NFA)	National Forest Authority 10/20 Spring Road, Bugolobi P.O. Box 70863 Kampala Telephone: +256 (0)312 264 035/6 or +256 (0)414 230 365/6		
	John Diisi	johnd@nfa.org.ug	Head of GIS department
	Israel Kikangi	israelk@nfa.org.ug	Head of Plantation department
	David Elungat	davide@nfa.org.ug	Head of Biomass department
Wildlife Conservation Society (WCS)	Kansanga, Kampala		
	Juraj Ujhazy	jujhazy@wcs.org	Programme Manager WILD program
	Simon Akweteireho	sakweteireho@wcs.org	Programme Manager
	Andy Plumptre	aplumptre@wcs.org	Director Albertine Rift
World Resources Institute (WRI)	10 G Street, NE Washington, DC 20002 USA		
	Norbert Henninger	norbert@wri.org	People and Ecosystem Program
National Forest Resources Research Institute (NaFoRRI)	Forestry Resource Research Institute P.O.BOX 1752 Kampala, Uganda Telephone: +256 (0)414 255164		
	Dr. Epila Otara	Epilaotara @gmail.com	Research Entomology About to retire
	Dennis Mujuni	Dbmujuni @yahoo.com	Forest Resource Management
	Katumba Balikitenda	Bmkatumba @yahoo.com	Research Agroforestry

Uganda Wildlife Authority (UWA)	Uganda Wildlife Authority Plot 7 Kira Road, Kamwokya PO Box 3530 Kampala, Uganda Telephone: +256 (0)414 355000, +256 (0)312 355000		
	Imelda Bacudo	dada.bacudo @gmail.com	Consultant
	Aggrey Rwetsiba	aggrey.rwetsiba @ugandawildlife.org	Monitoring
Uganda Bureau of Statistics (UBOS)	Statistics House Plot 9 Colville Street P.O. box 7186 Kampala, Uganda Telephone: +256 (0)414 706000		
	Sam Kaisiromwe	sam.kaisiromwe @ubos.org	Leader of technical working group environmental statistics
National Environment Management Authority (NEMA)	National Environment Management Authority Nema House, Plot 17/19/21 Jinja Road, P.O.Box 22255 Kampala,Uganda Telephone: 256 (0)414 251064/5/8		
	Francis Ogwal	fogwal @nemaug.org	Natural Resource Management Specialist
	Goreti Kitutu	gkitutu @nemaug.org	
Forest Sector Support Department (FSSD)	Forest Sector Support Directorate Environment Affairs Ministry of Water and Environment P.O. Box 20026 Kampala, Uganda		
	Rachel Musoke	rachelmusoke @yahoo.com	Comissioner
	Charles Byaruhanga	charles_k_byaruhanga@ yahoo.com	Monitoring and evaluation officer

Annex 7: Sources of errors and error analysis

A forest inventory is usually a complex project where often many people are involved in different steps during the process. Errors cannot be completely avoided but should be reduced to the minimum possible. It is certainly wrong "to simply believe" in the results of a sample based study, one needs to know how to make a proper interpretation of the results and their associated sources of error and uncertainty.

There are various types of errors that occur in forest inventories; they can be categorized into two classes: systematic errors and random errors.

- Systematic errors are committed when the error is systematically distributed over the population such as measurement errors due to ill calibrated devices. Systematic errors have always either the same absolute, relative size or at least the same direction.
- Random errors vary in size and usually follow a statistical distribution (the normal distribution, if we deal with a metric variable). Measurement errors that are not due to ill calibrated devices, wrong usage or misunderstandings of definitions belong to the class of random errors and occur with any measurement, be it metric variables such as height, categorical variables such as stem quality classes and plot establishment such as plot size, slope correction and border trees, or nominal variables such as tree species (where the latter is frequently not referred to as measurement error but as not-identification).
  Of course, the standard error due to sampling is also a type of random error.
  Model errors are another class of random errors in forest inventory which are introduced through the usage of statistical models such as volume functions or height curves. The values determined from these models deviate randomly from the true values – at least if the model applies; if the model is ill-applied in a given situation, the model error may well be a systematic error.

What we usually specify in an inventory report is the standard error, i.e. the error due to sampling. All other errors are not specified and frequently not even mentioned. It is difficult to determine the size of the measurement errors for single variables: it can only be done by repeated measurements of the same objects and evaluation the variability of those results. Also, the true size of the model errors can only be determined by close examination of the models as applied to the actual data sets.

In all steps of a forest inventory there is the chance of errors to be committed:

- find plot location and establish the plot;
- identify the tree to be measured (some trees can be overlooked, or some measured twice);
- measure, observe and classify the variables of interest;
- record the measurement (writing errors or unclear writing or wrong digitization);
- transport and transfer to the central "data base".

Some of the errors can immediately be identified by so-called plausibility checks – others remain undetected.

There are not many studies that deal with an analysis of errors in forest inventories. Usually, we take the measured data as truth; or at least as the best available data.

Annex 8: Good Reporting

There are many formats and structures of forest inventory reports. In general, the report should contain all information required to meet the forest monitoring objectives. Arrangement and wording of the report should be understandable to those who need the information provided and who will use the results. There should be a section for experts with all technical details that are necessary to understand if someone is interested in, for example, the sampling and plot design, while sections should also be easily accessible to the non-expert.

The structure of a typical forest monitoring report may be as followed:

- Introduction including justification, legal basis (if applicable), potential, users etc.;
- data sources, sampling design, plot design and estimation design;
- organization and implementation,
- organization of data management and data analysis;
- results including totals and broken down to smaller reporting units (strata) for all relevant variables of interest;
- technical discussion of results and inventory; description of problems encountered; possible comparison with earlier studies.

The report should be the basis that allows the decision maker to convert the analyzed and condensed inventory data into relevant information.

A report should have (and this is no different from reports for other projects) an executive summary which states briefly the objectives, planning, implementation and a summary of results. It is important to always give precision statement (interval estimation). The report should have a clear description of the methods used, and specify the reasons for choosing this method and not another. All practical or other problems should be discussed as no forest inventory went perfect and as planned. Field manual and form sheets should be included into the reporting documents and maps can be provided whenever possible. Acknowledgement is also a very important aspect.

Other information such as time consumption for different planning and implementation steps can be included (or even budget). Overall organization of the exercise, training measures and composition of field crews can be described.

Of course there is no specific way of writing a report and the principles stated above are some suggestions for a clear and transparent report. These suggestions are exercised depending on the need of the users. But incompleteness of the reports should be avoided as best as one could. This includes:

- Background and objectives not clearly spelled out;
- models, definitions and measurements procedures not or not sufficiently specified;
- no precision statements;

- implementation problems not addressed, which are important to know in order to properly interpret the results and which are interesting to know for future inventory planning;
- no information on time consumption, which is relevant mainly for future inventory planning.

Annex 9: Remote sensing applications for monitoring deforestation and forest degradation

Technology	Data provided
SPOT or Landsat (optical)	Medium resolution remote sensing data, wall to wall
LIDAR (laser)	High resolution remote sensing data for selected areas
SAR (radar)	High resolution remote sensing data for selected areas
Quickbird, Ikonos, Rapid Eye etc. (optical)	High resolution remote sensing data for selected areas
Aerial photography	High resolution remote sensing data for selected areas

Annex 10: Technical steps for processing and analyzing remote sensing data

The steps in remote sensing integration into a forest monitoring system are presented below. There is no strict order and considerable overlap with a number of activities implemented in parallel:

- Appoint remote sensing advisor with in-depth knowledge in forest monitoring who is responsible for the coordination of tasks and that the results meet evolving international REDD+ monitoring requirements.
- Define the detail technical objectives of the remote sensing integration: what is the expected product; is it necessary to adapt the FAO Land Cover Classification System from the National Biomass Study?
  Some points are to be observed in particular:
  - Standard land cover maps are straightforward and can be produced in a common production process.
  - Integration of more advanced technology such as high resolution radar (like TerraSAR X) or Lidar offer additional options in particular to cope with cloud cover (radar) and for modelling of forest attributes (Lidar) – but there are no standard procedures yet. That means that integration of such technology requires substantial investments in foreign experts to build the analytical capacity and conduct the research to develop the most suitable procedures.
  - The possibility to combine full cover by low spatial resolution imagery (e.g. MODIS, free, short revisit times) with sample based images of moderate spatial (e.g. Landsat 7: free but with the current SLC-off quality issues unresolved) and/or high spatial resolution imagery (such as RapidEye, QuickBird, Ikonos2, GeoEye1 or WorldView) should be considered. Image procurement is also an issue. But more important is that a clear processing and estimation approach must be designed before acquiring imagery. The high resolution imagery may be used as "groundtruth" element complementing the sample based field observations. For any estimates of carbon, area etc. statistical estimation procedures need to be specifically developed. There are no standard procedures available and this is a very demanding technical and scientific challenge.
- Define the schedule for image analysis and map generation; calculate time and staff required. Contract dedicated staff.
- Define a project monitoring system for the remote sensing component in order to supervise adherence to time schedule and adherence to objectives. It is not a good idea to wait until the end of the project to assess the quality of the work.
- Assign tasks to the participating technical and scientific staff. It is recommended to integrate national universities and/or research institutes at an early stage because a national forest inventory remote sensing project provides opportunities for students and young researchers to acquire valuable experience and to build knowledge in the framework of MSc and PhD theses.
- Identify and purchase the required hard- and software, identify suitable lab space. Install the lab. Provide comprehensive training for technical staff.
- Define the scope of remote sensing, considering that remote sensing is one data source for the monitoring project. Guiding questions to be asked include: Is remote sensing imagery to be used for mere land cover mapping purposes or to produce regionalized maps for target variables like biomass or carbon? Is a complete

coverage required or are samples sufficient (e.g. strips or patches)? Is it about mapping or about identification of hotspots?

- Define the imagery to be used. The range of commercial imagery is wide in terms of spatial and spectral resolution, of cost, and of availability. The following points need to be observed:
    - The major management factor is the processing capacity (in terms of experienced staff and equipment).
    - Technical factors are the required spatial resolution which is determined by the desired map spatial quality (definition of minimum mapping unit) and the required spectral resolution (that co-determines the options of vegetation classification).
    - The imagery must be available *in the defined time frame for the defined area in the expected quality*.
    - Cloud cover is an issue, in particular in Uganda: the complete map for the entire area will need to be composed (mosaicked) by many images (tiles) that comply with the cloudiness-expectations. Satellite systems with a high repeat rate of image taking (like RapidEye, daily) have a better potential than others (like Landsat, for example: 16 days). However, cost and availability do heavily interact with this criterion! A complete cloud free coverage of an area is often not feasible for a specific date, but only for a period of one or several years. Areas with permanent cloud cover require special treatment, in particular when forest areas are expected underneath: alternative imagery or application of imputation techniques can be used. Radar imagery (penetrating clouds) is another option, but introduces an additional dimension of complexity.
- Procure additional digital data, including digital elevation model (DEM) and digital maps of infrastructure. The DEM is essential for geometric corrections and spectral normalization, in particular in hilly and mountain areas. The usual DEM used in developing countries is the 90m resolved SRTM data (Shuttle radar topographic mission) available free for the entire globe from 56° S to 60° N.
- Define the approach to gather ground truth information. As far as possible, field observations from the field forest sampling campaign are used. However, ground truthing for image analysis requires a minimum number of field observations per tile which does usually not match the field sampling intensity. Additional campaigns need to be planned to provide the corresponding data. Besides field observations, other sources will be used like recent aerial photographs and high spatial resolution satellite images.
- In view of costly equipment and highly qualified staff that is only temporary needed for monitoring REDD+ it should be further assessed if remote sensing processing and field inventory tasks might be outsourced to Uganda based technical service provider(s), with only a core team of experts based in the NFA. However, a cost benefit analysis should guide this decision, also considering the value of in-house expertise. Considerable REDD+ related data collection and analysis is regularly done by a number of NGO's. The National Forest Authority may wish to consider cooperating with these organisations to achieve the tasks as efficient and effective as possible.

Annex 11: Training of inventory field teams

Training prepares the field teams in a consistent manner. It is good to train all field teams together directly prior to the inventory and to end the training with the serious tallying of a real field plot.

Further training should be given in the course of the inventory; either by convening the field teams and discussing questions and issues or by occasionally accompanying the field teams and observe their field measurement practices. The latter is a mixture of training and checking the team's performance.

Other means of checking the quality of the team's work is that supervising teams measure some plots again. This check cruising is usually done on about 10-15% of all plots. This is a very costly undertaking, but we must take into consideration that the data is the most important product of an inventory. All depends on the data. And that should also be known to the field teams. On the other hand, being out in the forests for weeks and months and doing field observations every day is a physically extremely demanding task. It is important to keep in mind that the field crews do also have it in their hands what the overall quality of the inventory results is. They are, so to say, the key persons in the inventory – but frequently also the least paid; in particular when helpers are employed that do, for example, the *dbh* measurements.

There are many technological options to do checks of the field teams. One may, for example, program GPS devices such that the route of the field team is recorded. Then, the inventory coordination team may later on check whether the field team was really at the sample point or not. For remote sample points, there is hardly any other chance to check.

One should try to keep the field teams motivated by making clear how important the role is that they play in the whole inventory process, by equipping them with state-of-the art technology where appropriate, by organizing in regular intervals meetings of all field teams and by visiting them frequently in the field.

Contacts should always be maintained between field crews and between coordination teams and field teams. In the ideal case, the field teams should be the ones who enter their own data into the forest inventory data base.

However, not always do field teams perform according to the expectations of the inventory coordination. It is important to have the contracts with the field teams or the field team members such that it can be cancelled if the expected quality is not delivered. Unpleasant, but sometimes necessary.

Field teams are organized like usual working teams: a clear assignment of responsibilities fosters smooth work flows. Usually, a clear hierarchy helps as well: there is the field crew leader, frequently a forest engineer with academic background, assisted by a technician and helpers. The team leader takes all decisions and is responsible for the data quality. He or she records the data and coordinates and supervises the work of the others. The technician is responsible for the "more demanding" measurements that require a more intensive training such as height measurements and the usage of electronic measurement devices. Depending on the type of inventory done, the helpers are either contracted for few days or for a longer time. Their level of training and skills determines which tasks they may responsibly take on.