Ministry of Forests and Soil Conservation

REDD-Forestry and Climate Change Cell

Development of a Measurement, Reporting and Verification (MRV) System for Emissions and Removals

Contract No.: FCPF/REDD/S/QCBS-7

MRV Full Cost Proposal

April 2014

AGRICONSULTING S.p.A.

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This publication is a property of REDD-Forestry and Climate Change Cell and is part of the MRV project funded by the World Bank

We would like to thank the whole REDD Cell Staff, in particular:
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Dr. Narendra Chand, Policy and Program Planning officer, REDD Cell
who provided insight and expertise that greatly assisted the project

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ACRONYMS AND ABBREVIATIONS

AFO	Assistant Forest Officer
ANSAB	Asia Network for Sustainable Agriculture and Bio resources
BAU	Business as Usual Baseline
BZCFUGs	Buffer Zone Community Forest User Groups
CBFM	Community Based Forest Management
CBFMUGs	Community Based Forest Management Users Groups
CCB	Country Capacity Building
CF	Community Forest
CFI	Continuous Forest Inventory
CFOP	Community Forest Operational Plan
CFUGs	Community Forest User Groups
CoFM	Collaborative Forest Management
COPs	Conference of Parties
CSO	Civil Society Organization
DBH	Diameter at Breast Height
DBMS	Database Management System
DDC	District Development Committee
DFO	District Forest Office/Officer
DFRS	Department of Forests Research and Survey
DOF	Department of Forests
ESMF	Environmental and Social Management Framework
ESS	Environmental and Social and Safeguards System (ESS)
FAO	Food and Agricultural Organization of the United Nations
FAO FP	FAO Forestry Paper
FCPF	Forest Carbon Partnership Facility
DSCO	District Soil Conservation Officer
FECOFUN:	Federation of Community Forest Users Nepal
FGD	Focus Group Discussion
FMU	Forest Management Unit
FRA	Forest Resources Assessment of Nepal Project
GHG	Greenhouse Gas Emissions
GIS	Geographic Information System
GLCN	FAO/UNEP Global Land Cover Network
GPG	International Panel on Climate Change: Good Practice Guidance
GPS	Geographic Positioning System
ICIMOD	International Center for Integrated Mountain Development
IPs	Indigenous Peoples
IPCC	Intergovernmental Panel on Climate Change
LCCS	Land Cover Classification System
LhFUGs	Leasehold Forest User Groups
M and MRV	Measurement and Monitoring, Reporting and Verification
MIS	Management Information System
MRV	Measuring, Reporting and Verifying

NAFIMS	National Forestry Information Management System
NFCAG	National Forest Carbon Action Group
NEFIN	Nepal Federation of Indigenous Nationalities
NGO	Non-Government Organization
NORAD	Norwegian Agency for Development Cooperation
PSP	Permanent Sample Plots
REDD	Reducing emissions from deforestation and forest degradation
REDD+	The REDD"+" is more than just avoided deforestation. It is tied to measurable and verifiable reduction of emissions from deforestation and forest degradation as well as sustainable management of forests, conservation of forest carbon stocks and enhancement of carbon stock
RL/REL	Reference Emission Level
R-PP	Readiness Preparation Proposal
SLMS	Satellite Land Monitoring System
UNFCC	United Nations Framework Convention on Climate Change
WISDOM	Wood fuel Integrated Supply and Demand Overview Mapping
WWF	World Wildlife Fund

1. INTRODUCTION

1.1 Background

Reducing Emissions from Deforestation and Forest Degradation (REDD) is evolving as a means to reduce forest sector carbon emissions through forest management and enhanced forest governance in forestry and related sectors.

REDD+ preparation activities in Nepal have progressed significantly, with support from the World Bank's FCPF, the country developed a Readiness Preparation Proposal (R-PP).

The Nepal R-PP has provided Nepal's roadmap for developing and implementing the REDD strategy, based on certain underlying principles agreed by representatives of all stakeholder groups in Nepal's forest sector. These include:

1. Aligning the National REDD Strategy with Nepal's overall development strategy, and with the new priorities being established by the upcoming Constitution.

2. Enhancing coordination between different sectors and government agencies responsible for these sectors to ensure sustainability and avoid conflicts between national and sectorial policies and programs.

3. Ensuring multi-stakeholder involvement in aspects of REDD that reflects the diversity of actors in Nepal's forestry sector from both government and civil society and including those stakeholders from other sectors such as agriculture, local development, energy and infrastructure

4. Utilising and building the capacity of existing multi-stakeholder institutions at national, sub-national levels for designing and delivering the REDD strategy and for sharing benefits from REDD

5. Linking Nepal's REDD Strategy with national priorities for addressing poverty and enhancing the livelihoods of people who are dependent on forest resources. This means that implementation of REDD has potential co-benefits for Nepal's poverty reduction strategy.

6. Using the REDD Strategy to capture and fully value the wide range of ecosystem benefits coming from forests including maintenance of biodiversity, soil and water conservation, sustainable development and economic growth as well as the value of timber and non-timber forest products.

7. Establishing a clear link between carbon ownership rights and land tenure and by clarifying issues of rights to forests as a priority during the preparation of REDD

8. Recognising the important role that forests play in adaptation to climate change as well as their role in climate change mitigation through REDD

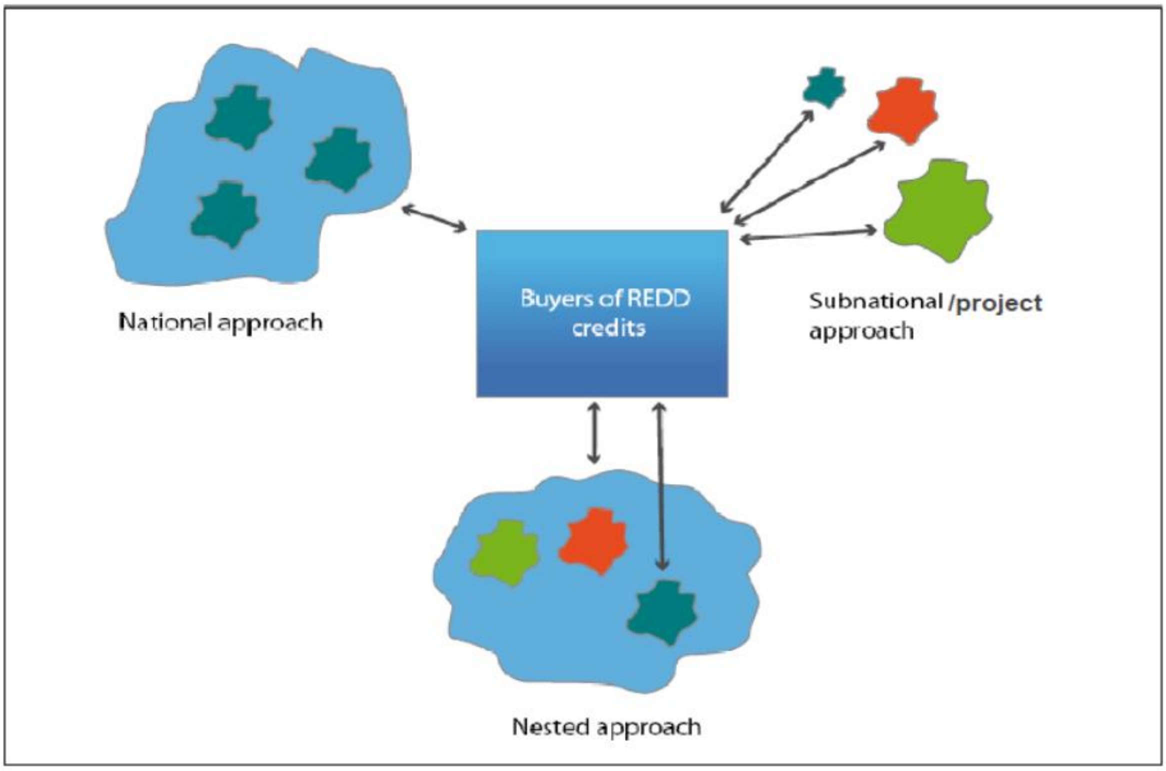
9. Building and expanding on Nepal's internationally recognized successful experiences with reducing deforestation and forest degradation and forest conservation and enhancement through participatory approaches to forest

management and benefit sharing and by encouraging further piloting and sharing from during the REDD preparation phase

10. Seeking and coordinating international funding support from Nepal's development partners to ensure consistency of approach and greater cost effectiveness of REDD

Nepal's national REDD+ strategy needs to build on the many community based forest management (CBFM) mechanisms being practiced since over three decades now. Over one third of Nepal's forests are under one or the other CBFM regime which clarifies the potential role of communities in Nepal's REDD+ implementation. CBFM and particularly the community forestry (CF) user groups have evolved as robust institutions with institutional arrangements and accumulated experiences of forest management planning and implementation. With realization of forest user groups' stake and potential role in REDD+, Nepal's R-PP has already justified the need of a hybrid (nested) approach which will enable the country to go for early participation in REDD+ at sub-national/local level while engaging in continuous improvement of its MRV institution and capacity for MRV system strengthening.

A nested approach is a flexible mechanism. It allows countries to start REDD+ efforts through sub-national activities and gradually move to a national approach, or for the coexistence of the two approaches in a system where REDD credits are generated by projects and governments, thus maximizing the potential of both approaches.



1.2 Description of the present assignment and scope of this document

Description of the present assignment

The World Bank's Forest Carbon Partnership Facility (FCPF) is assisting Nepal with support to develop and apply strategies to address the drivers of deforestation and forest degradation.

Some of the key technical elements of REDD+ readiness work, namely, designing a Monitoring, Reporting and Verification (MRV) System (the present assignment), developing a Strategic Economic and Social Assessment Tool for REDD+ safeguards and developing a Reference Scenario are already on-going.

In this context, with Nepal moving ahead in the readiness phase, it needs to establish the organizational capacity to efficiently and sustainably operate a national forest carbon MRV program.

A reliable, credible system of measuring, reporting and verifying (MRV) changes in forest carbon stocks is a cornerstone of any national REDD+ scheme and MRV is a crucial part of a performance based REDD+ mechanism.

An institutional architecture for MRV system ideally needs to ensure:

- *Effectiveness*: implying MRV system is driven by the development and implementation of Nepal's REDD+ policy and activities;
- *Efficiency*: ensuring transparent, consistent and cost-effective data collection and procedures. It requires clear terms of reference of actors involved and their sustained capacity to meet national and international REDD+ requirements and report forest carbon changes according to IPCC GPG;
- *Equity*: implying appropriate integration of local measurements with national monitoring, international requirements and independent reviews to ensure participation and transparency among all involved

Four fundamental requirements for a national institutional framework for MRV are:

- **Coordination:** a high-level national coordination and cooperation mechanism to link forest carbon MRV and national policy for REDD+, and specify and oversee roles, responsibilities and co-benefits, and other monitoring efforts;
- **Measurement and monitoring:** protocols and technical units for acquiring and analysing the data related to forest carbon at national and sub-national levels;
- **Reporting:** a unit responsible for collecting all relevant data in a central database, for national estimates and international reporting according to IPCC GPG, and uncertainty assessments and improvement plans; and
- **Verification:** an independent framework for verifying the long-term effectiveness of REDD+ actions at different levels and by different actors;

An institutional architecture for Nepal's MRV system is expected to need setting up the following institutions, with clearly defined roles and responsibilities, and with institutional arrangements for logical interaction among themselves:

- A national coordination and steering body or advisory board, including a national carbon registry;
- A central carbon monitoring, estimation, reporting and verification authority; and
- Forest carbon measurement and monitoring units;

In Nepal's case, assistance in the development of MRV systems will strive to ensure:

- Relevant government and non-government agencies/institutions, civil society organizations (CSOs) local communities and private sector having a stake in REDD+ at national, sub-national, district and/or local forest management unit (FMU) level are informed and consulted through their active participation in the process of setting up of the MRV system;
- The system developed becomes institutionally robust and fully operational meeting both national and international REDD+ MRV requirements;
- Ensures i) linking MRV (emissions and carbon impact) to policy (drivers of D and FD); ii) national estimation and reporting based on measurement at the sub-national and forest management unit scale driven by REDD+ related activities; iii) early participation and interim performance while the MRV system is established and gradually strengthened to achieve fully operational stage with enhanced capacity over time.

According to the country's R-PP , integrating the MRV system to include national, regional/district and management unit levels will enable accounting for REDD+ contributions at all levels thus allowing for equitable benefit sharing based on actual performance.

<u>In this context the present assignment was aimed at:</u>

- ✓ To assist the Nepal REDD Programme in the development of a comprehensive and detailed proposal for the continuous collection, analysis and verification of national data on forest-related carbon emissions and sequestration for implementation as part of REDD+ in Nepal.

Expected outputs were as follows:

- document the design and early implementation of an eventually coherent operational system of measuring and reporting changes in deforestation and/or forest degradation, and forest carbon conservation and carbon stock enhancement activities in Nepal;
- demonstrate the MRV system's capability to monitor the specific REDD+ activities as prioritised in Nepal's REDD+ strategy; the system must also enable the tracking of reversals of emissions reduction (i.e. non-permanence) and displacements of emissions (i.e. leakage);
- detail the MRV system's resolution, coverage and accuracy, and the carbon pools included; present an action plan to develop a fully operational system over time, including the required institutional arrangements and the existing vs. required capacities.
- present a 'Learning Plan for MRV' for capacity building that defines the remaining requirements for the implementation of the capacity building for MRV in terms of additional training activities, hardware and software.

The present proposal for the MRV system includes provisions for:

- the maintenance and periodic re-measurement of a system for established permanent sample plots representative of all major forest types in Nepal;
- the development of the forest inventory capabilities of the country's Community Forestry User Groups (CFUGs) and establishment of a system for the integration and consolidation of forest measurement and management information generated by CFUGs to fulfil their forest management obligations;
- national level forest carbon emission reporting / accounting based on acquisition and analysis of remote sensing data; and
- a full cost proposal for a system to strengthen forest data collection, analysis and support REDD transactions.

Overall outputs of the MRV Project

The MRV Project had duration of 9 months, from June 2013 to March 2014. During this period the following working papers have been produced:

Working Paper Number	Title	Brief description
1	MRV Geographic Information System Data catalog	Describes the spatial and statistical information collected and organized by the MRV Project.
2	Methodological approach of the MRV Project to REDD+ activities at local (CBFMUs) level	Methodological approach for MRV at sub-national and local level
3	Analysis of Institutional Structure for MRV System within Nepal's National REDD+, present Architecture	Analysis of Institutions related to MRV and REDD+ mechanisms.
4	MRV IT GIS Platform	Technical description of the prototype MRV IT GIS platform developed.
5	Case Study on Measurement and MRV Capacity Requirements of Communities, Local Forest Authorities and Other Stakeholders	Findings and recommendations from a case study on MRV implementation in two pilot local Communities.
6	WISDOM Nepal and contribution to MRV	Wood fuel Integrated Supply and Demand Overview Mapping for the whole Nepal. Includes fuel wood supply and demand balance, and its implications for forest degradation risk.
7	Remote Sensing for MRV: Activity Data Monitoring	Describes the proposed approach for monitoring activity data at National and Sub-National level, using Remote Sensing.
8	Nepal's MRV System Management Architecture: Structure, Functions, Human Resources and Capacities	Describes the proposed institutional architecture the future management of MRV.
9	IT platform user manual	Provides a user manual for operating the IT platform containing the prototype of the MRV System
10	MRV Full Costs Proposal	Summarizes the findings of the MRV proposal, including technical, institutional and financial requirements.
11	MRV Full Costs Proposal – Executive Summary	Provides an extreme synthesis of the full costs proposal

Scope of this document

Measurement and MRV forms one out of four key functions within the national REDD+ architecture (Vatn and Angelsen, 2009). Establishing and operationalizing a national MRV system needs to build on the link between the country's REDD+ policy and the forest carbon MRV (Herold and Skutsch, 2009).

In our view, the successful implementation of an MRV system requires significant actions on two sides:

a) Institutional development, and
b) Technical development.

In brief the two development components above should perform the following complementary tasks:

<u>Policy and the forest carbon MRV component will provide the basis for:</u>

a) Developing protocols and operationalizing technical units to gather/acquire and analyse the data related to forest carbon at national, sub-national and local levels (measurement and monitoring)
b) Establishing and operationalizing a unit responsible for collection of relevant data in central database for national estimates and international reporting as specified in IPCC GPG including uncertainty assessment and improvement plans (reporting);
c) Detailing out the measurement parameters for co-benefits, social and environmental safeguards and other monitoring parameters including roles and responsibilities at different levels of the system;
d) Establishing an independent framework for verifying the long-term effectiveness of REDD+ actions at multiple levels and by different actors (verification).

<u>Technical forest carbon MRV Unit should perform the following functions</u>

a) Measuring the changes in forest carbon stock at national level;
b) Evaluating the progress/performance of the country's national REDD+ strategy
c) Monitoring the periodic change in forest carbon stock and reporting; and
d) Monitoring the changes in forest carbon stock at a scale equivalent to where the payment is liable (e.g., payment at sub-national/project level and/or to a community engaged in REDD+ strategy implementation)

In addition both development functions (Institutional and Technical) need to be harmonized between national and sub-national level in an effective and innovative nested approach, peculiar to Nepal, given its tradition of long-term established community based forest management unit (CBFMU), which is a kind of unique development feature.

Following this framework, the present document is structured in logical Sections, in order to explain our understanding of the needed steps, as follows:

- <u>MRV at National Level</u>
    - Present situation
    - Institutional aspects
    - Technical aspects
    - Institutional and technical development needs

- MRV at Sub-National Level
    - Present situation
    - Institutional aspects
    - Technical aspects
    - Institutional and technical development needs

2. MRV AT NATIONAL LEVEL

2.1 General Approach

Regarding the capacity of the proposed Program entities to implement this approach for Nepal's REDD+ architecture, R-PP and MRV emphasizes on:

- ✓ Using existing institutional structures and arrangements to a possible extent ;
- ✓ Using multi-stakeholder bodies at sub-national, district and local forest management unit/community levels;
- ✓ Creation of a central clearinghouse/carbon registry to work as a depository of REDD related information, allow for enforcement of standards and engage in carbon transaction;
- ✓ Ensuring that information on measurement and reporting (MR) is readily available at all levels and to all actors including GOs, NGOs, CSOs, federations, research institutions and private sectors;
- ✓ Ensuring that local stakeholders and forest managers in all forest management regimes (e.g. CF, CoFM, government managed forests and PAs) participate and engage in field based monitoring as required and scheduled;
- ✓ Ensuring the data is generated through periodic monitoring of forests under REDD, through a tested and institutionalized internal verification system by the MRV implementing agency – the DFRS.

2.2 Present Institutional Structure for MRV System within Nepal's National REDD+ Architecture

MRV system as an institution forms one main pillar of National REDD+ architecture. An institutional assessment of actors and institutions that are engaged or are likely to engage directly and/or indirectly in gathering and verifying information on actual reductions in forest emissions, processing of information and reporting at multiple governance levels in Nepal's forestry sector was undertaken (Pls. see working paper 4).

Institutions need to be built on existing institutions and would need to include:

- ✓ A REDD+ policy steering authority at central level and institutions to manage technical, financial, administrative and supervisory aspects at sub-national and local levels
- ✓ An MRV system institution - that will gather and verify information on actual reductions in forest emissions and report to national and international counterparts;

- ✓ A REDD+ payment institution responsible to channel funds from international to sub-national and local level according to the volume, location and type of emission reductions;

Institutional Assessment is concerned with ways in which institutions are formed and function. It basically looks into i) distribution of rights and responsibilities among actors, ii) cost of coordination among them (transaction cost), and iii) ways in which the actors' interest, motivation and perspectives will be influenced by the institutional structure. An associated purpose of institutional assessment is to provide clarity as to whether the institutions put in place are legally appropriate and are widely supported within the democratic governance framework.

The national REDD+ architecture is interpreted as:

- ✓ An institutional structure defining the capacities and responsibilities of different actors including GOs, NGOs, CSOs and private sector involved in REDD+; and
- ✓ Rules that define the interaction among actors. Such rules clarify how the coordination between actors including communication, negotiation and control and management will take place.
- ✓ The operational format of these institutions will be reflected in the cost of coordination and the motivation cost of human resources within institutions.

Table 1: Multi-sector and Multi-level Actors in Nepal's REDD+ Architecture

Levels/ Sectors	Government Actors	Bi/Multi-level development Agencies	NGOs/CSOs
Central level	Ministries of: ・Forest and Soil Conservation, ・Agriculture and Cooperatives ・Science, Technology and Environment Energy, ・Land Reform ・Water Resources ・Physical Infrastructure &Transportation ・Local Development	・DFID ・UNDP, ・World Bank, ・FINNIDA	・International Centre for Integrated Mountain Development (ICIMOD) ・WWF Nepal ・FECOFUN, ANSAB, ・Forest Action ACOFUN, ・NEFIN, DANAR Nepal, NAFAN, ・Associations of TFPs and NTFPs traders, tourism and hydro-power promoters etc.
Regional level	・NRM related regional directorates ・Regional Forestry Directorate, Training Centre	・	・
District level	・DDC, NRM related district offices	・Forestry/NRM/CC adaptation projects,	・District chapters of national NGOs/CSOs
Local Level	・Forest and NRM related offices	・	・CFUGs, ・LhFUGs, ・Relevant CBOs

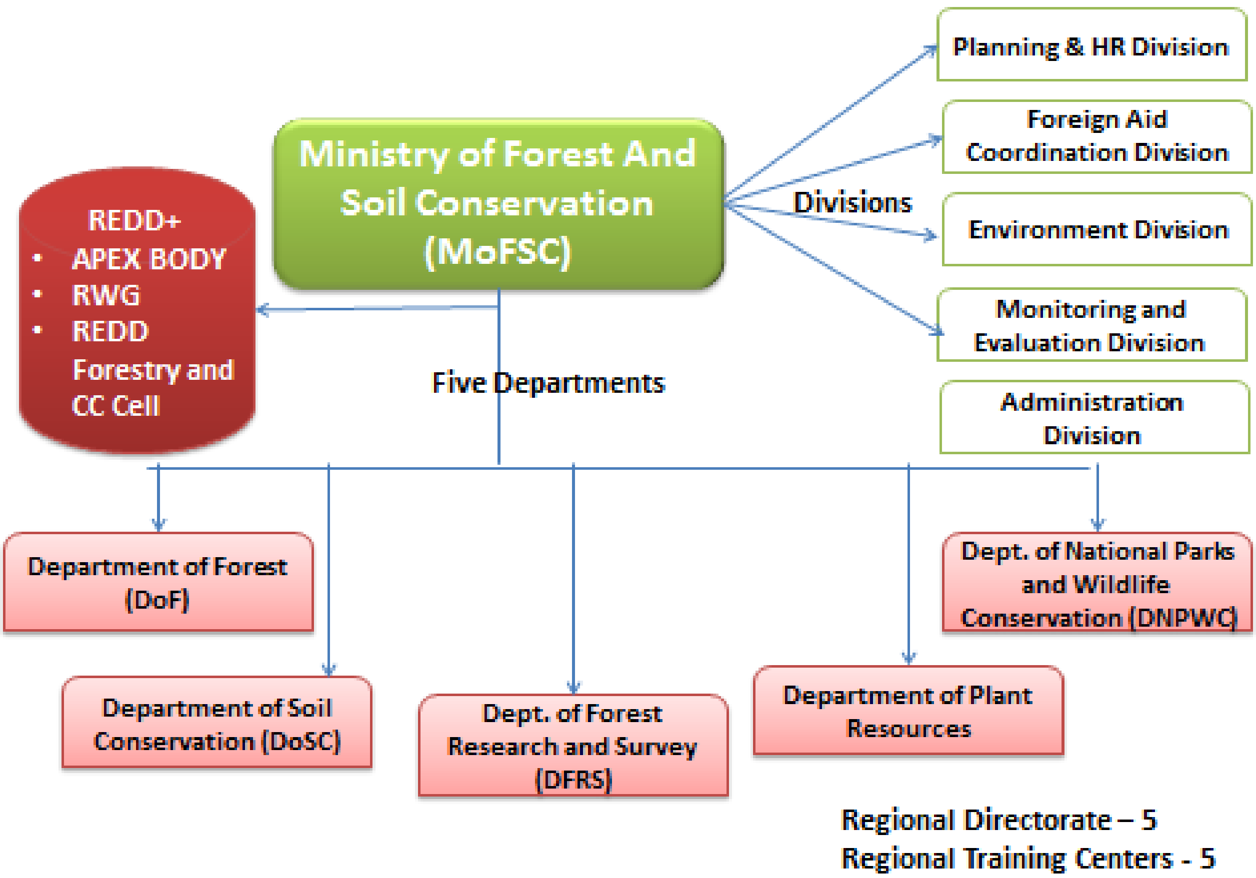
2.3 Actors of REDD+ in Nepal's Forestry Sector

2.3.1 MFSC and its Departments

MFSC is the highest forestry sector authority mandated for sustainable development of country's forests and watersheds including biodiversity and NTFPs conservation. It strives to promote participatory approaches and contribute in poverty reduction through promotion of forest based enterprises and employment generation.

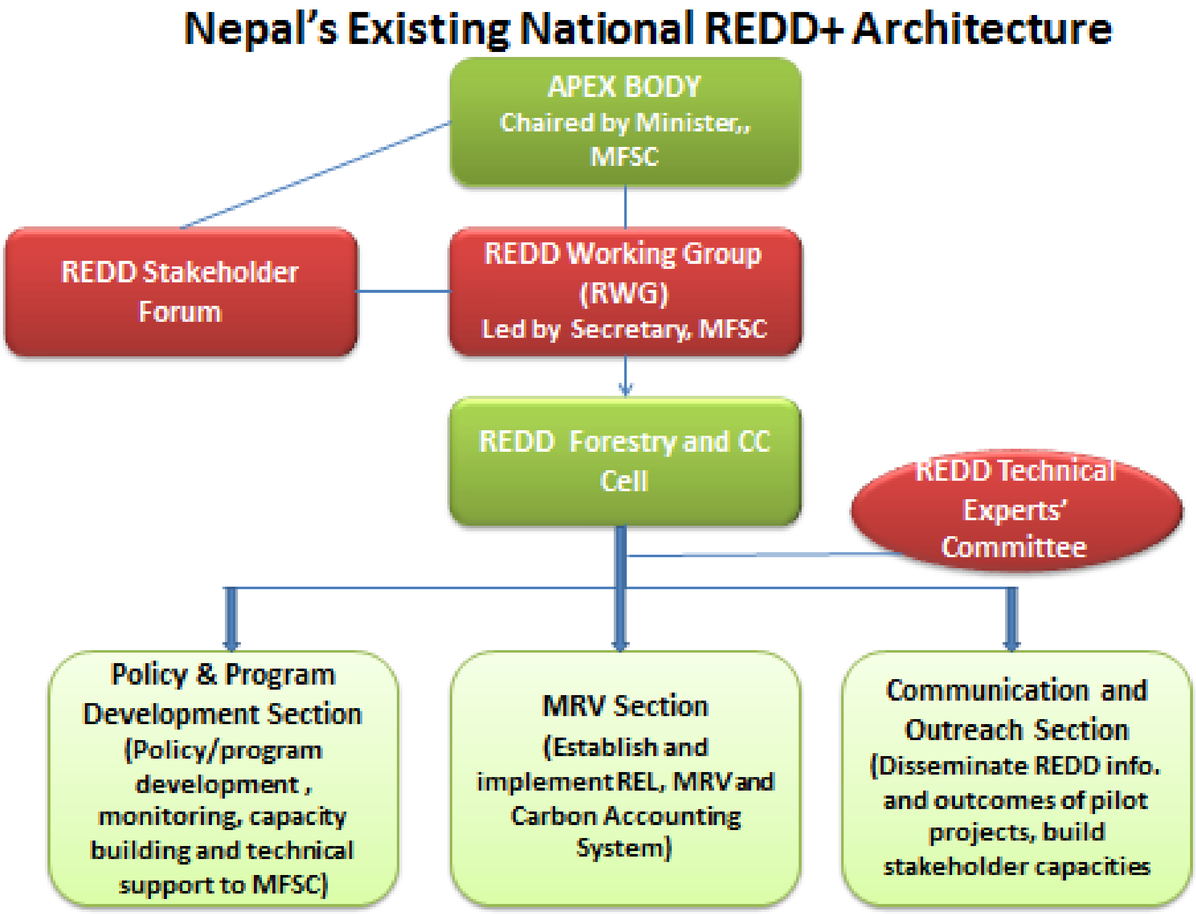
MFSC is the main actor in Nepal's REDD+ architecture with its four technical divisions (Planning and HR, Foreign Aid Coordination, Environment and M&E) and five departments [1) Forest (DoF), 2) Forest Research and Survey (DFRS), 3) National Parks and Wildlife Conservation (DNPWC), 4) Soil Conservation and 5) Plant Resources] charged with policy, strategic and operational level steering of forestry sector development.

Institutional Structure of Ministry of Forest and Soil Conservation of Nepal



In its pursuit to participating in global REDD+ mechanism and readiness preparation, in January 2009, Nepal's MFSC created a three-tiered institutional structure[1]. It comprises:

a) A 49-member multi-stakeholder and multi-sector high level policy steering, coordination institution named "Apex Body" chaired by the Forest Minister;
b) At operational level, a REDD Working Group (RWG) from within the national REDD+ stakeholder forum chaired by the Forest Secretary; and
c) A REDD Forestry and Climate Change Cell as a coordinating entity;



The Department of Forest Research and Survey (DFRS) of the Government of Nepal (GoN) has been identified as the national implementing agency for MRV system in Nepal's R-PP. As envisaged, the prime responsibilities of DFRS will be:

1) Periodic execution of forest assessments for deforestation and degradation monitoring,
2) Design, maintain and operate National Forest Information Management System (NAFIMS),
3) Coordinate the collection of sub-national level information, and
4) Disseminate NAFIMS and MRV deliverables through a web portal.

[1] This institutional structure is yet to get legally formalized. The REDD forestry and CC Cell does not exist in the GoN approved organogram of MFSC, and the staff therein are on deputation from MFSC departments.

DFRS will house the MRV institution of National REDD+ architecture and therefore, will need to build its institutional as well as technical capacities to manage, maintain and update the NAFIMS and MRV system in an effective, efficient and transparent manner.

2.3.2 Review of present objectives, functions, organizational structure and staffing of the DFRS

Mandate
As indicated in the operational manual 2004 of the DFRS, the **four main objectives** of DFRS are to i) develop new technologies based on studies and research on issues related to forestry sector, ii) undertake inventories of national forests and maintain updated record, iii) provide forestry related studies and research services and iv) coordinate with relevant agencies.

Accordingly, its **four major functions** are:

1. Updating and maintenance of forest inventory data for sustainable forest management;
2. Development and extension of appropriate technology for enhancement of the productivity of forests (both natural and plantation)
3. Development and extension of appropriate technologies for conservation, management and utilization of forest, wildlife and soil and watersheds
4. Communicating the results of studies and research in an effective manner to the target audience.

Organizational Framework
Led by a Director General (gazetted first class technical), DFRS has two divisions, i) Forest Research and ii) Forest Survey. Each division is led by one deputy director general (gazetted first class technical). The DFRS operational manual provides the objectives and key functions of all sections mentioned in the organizational structure. Terms of reference of all professionals from the director general down to the section heads of all sections in two divisions is elaborated in this manual.

Forest Survey Division is responsible for undertaking forest survey and inventory at national level once in 10 years. It is also responsible for forest inventory at district level for which it uses aerial photos, images obtained from remote sensing and field inventory approaches. It has six sections i.e.

1) Cartography;
2) Aerial photography;
3) Forest inventory;
4) Remote sensing;
5) Forest utilization and
6) Biometry.

The former four sections are each led by one senior forestry professional (gazetted second class) and assisted by one junior forestry professional (one gazetted third class). Each section has two or more rangers (senior forestry technicians) as appropriate. The last two sections are each led by one junior forestry professional (gazetted third class and one ranger. Subject specific expertise is mandatory for staff in all sections.

Forest Research Division was established for research on

i) enhancing forest productivity,
ii) managing natural and man-made forests,

iii) developing propagation technologies of multi-purpose and fast growing species and site species matching and their socio-economic impacts on forests.

It has six sections and five field units, one in each development region of Nepal. The six sections are:

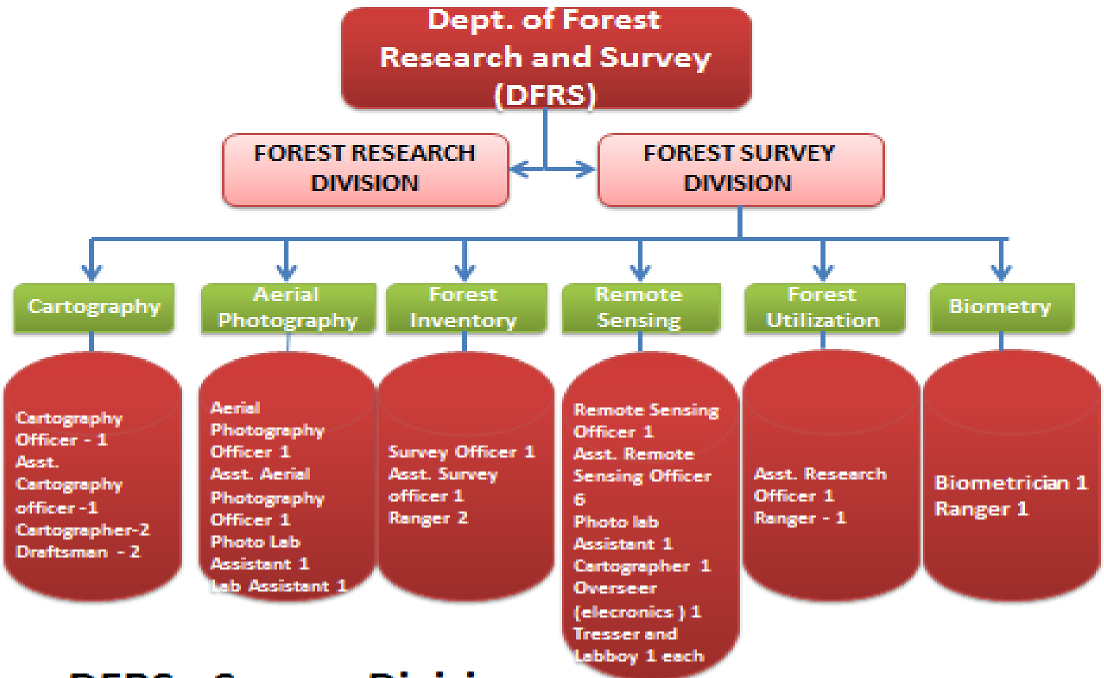
1. Plantation;
2. Natural forest;
3. Agro-forestry;
4. Tree Improvement;
5. Soil and
6. Socio-economic.

A senior forestry professional (gazetted 2nd class technical) leads each of these sections assisted by one junior professional (gazetted 3rd class technical). Plantation and natural forest section has 2 and 3 rangers respectively and remaining sections except for soil section has one ranger each. Soil section has two lab boys. Each of the field units are led by one ranger (senior forestry technician) with one forest guard.

Existing Human Resources

Excluding the drivers and orderlies (5+4), the department has a staffing of 70, comprising 31 professionals and 39 mid-level technicians. Given that Survey Division will have to play the key role in operationalizing and maintaining the NAFMIS and MRV this document focuses on the Survey Division only.

The Survey Division has 16 professionals and 15 technicians including rangers. The chart below provides the type and number of human resources in different sections of the Survey Division.



DFRS - Survey Division

2.4 *Proposed Framework of National REDD+ Institutional* **Architecture**

As presented in the introduction section above, it is required to build a national level institutional structure for REDD+ comprising all three elements of REDD+ architecture e.g. policy, coordination and steering entity, MRV system entity and carbon payment entity from central down to sub-national and district/local levels . The next step will be to work out their respective functions including flow of required information among these entities both horizontally and vertically. Human resources and their capacity needs at different layers of institution including the institutional strengthening will need to be analyzed. Finally a framework of the policy/legal arrangements will have to be designed and enacted for effective, efficient and transparent functioning of the designed REDD+ architecture.

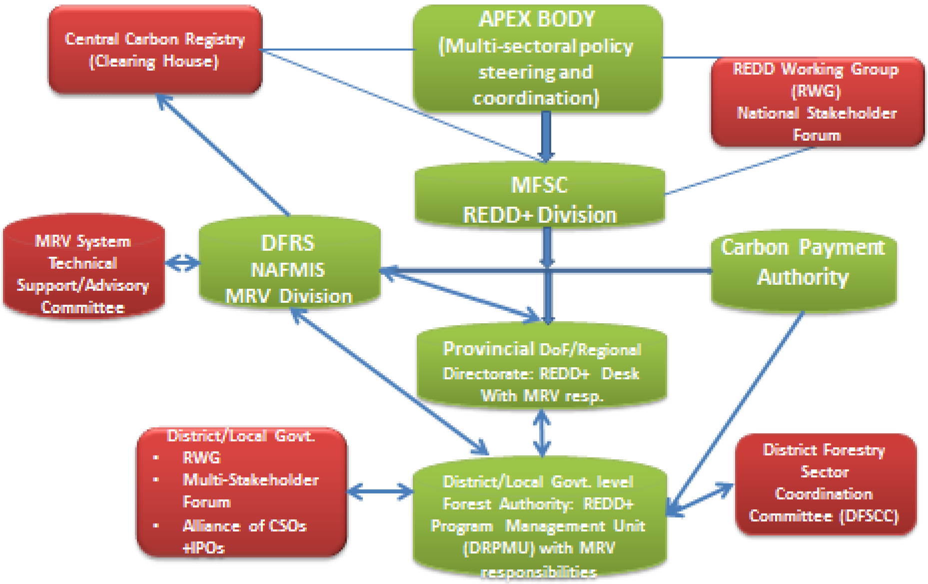
For Nepal's REDD+ architecture, R-PP emphasizes on:

- Using existing institutional structures and arrangements to a possible extent (page 47);
- Using multi-stakeholder bodies at subnational, district and local forest management unit/community levels (page 48 -49);
- Creation of a central clearinghouse/carbon registry to work as a depository of REDD related information, allow for enforcement of standards and engage in carbon transaction (page 50);
- Ensuring that information on measurement and reporting (MR) is readily available at all levels and to all actors (page 66) including GOs, NGOs, CSOs, federations, research institutions and private sectors;
- Ensuring that local stakeholders and forest managers in all forest management regimes (e.g. CF, CoFM, government managed forests and PAs) participate and engage in field based monitoring as required and scheduled,
- Ensuring the REDD relevant data is generated through periodic monitoring of forests, through a tested and institutionalized internal verification system by the MRV implementing agency –the DFRS

National REDD+ architecture has been conceptualized in the flow chart below in line with the R-PP provisions. It comprises the three key elements of REDD+ architecture and has some salient features e.g.

- The central carbon registry is proposed in parallel with the Apex body keeping in view that it need to be an independent body represented by multi-sector/multi-level stakeholder representatives with a separate secretariat.
- An MRV system technical support/advisory committee is proposed with an objective to fulfill its research, technology and capacity needs including institutional strengthening in future. An associated objective is to maintain transparency in functioning of M and MRV at national level, and ensure that the perspectives of relevant MRV stakeholders and forest managers are captured in course of management, maintenance and strengthening of the MRV system on a regular and continued basis.

Representation from relevant organizations should however, be bilaterally discussed and it should be ensured that the organizations are capable, interested and willing to contribute in the strengthening of MRV system as per the objectives of the proposed MRV advisory committee. So far as the role of different stakeholders in MRV Advisory committee is concerned, the entities e.g., i) Nepal's national information center, MoSTE, NAST, ICIMOD and WWF etc. are likely to contribute in research, technology transfer and strengthening of national MRV system; ii) Academia e.g. TU/Institute of Forestry (IoF) and Kathmandu University (KU) could contribute through research and human resources development, and advise on the technological strengthening of the MRV system; iii) CSOs e.g., FECOFUN, ACOFUN, ANSAB etc. having stake in carbon forestry could bring in the forest managers' perspectives in M and MRV system management and strengthening. This should be considered as a broad ToR for the MRV advisory committee which is likely to get further refined once a functional MRV system accumulates learning and experiences over years to come.



National REDD+ Architecture of Nepal

Proposed in line with R-PP

2.4.1 Refinements deemed necessary in objectives, functions and operational modalities of DFRS and Survey Division.

Objective of the DFRS (1.2):

- Refine the bullet 2 of the objective of DFRS (it says "Undertake inventory of forests at national level and maintain updated data") and add: Periodic inventory of forest resources (using both remote sensing/GIS data and field validation) and maintenance, management and updating of NAFMIS
- Add one bullet under the objective - Maintenance, management and operationalization of the MRV system including planned gradual strengthening of the system based on procurement of improved technology, software and capacity.

Terms of Reference (ToR) of DFRS (1.3):

- Bullet 1 of DFRS's ToR says "For the purpose of SFM, maintain an updated record of the national forest inventory". After SFM add "and REDD/REDD+ related MRV "
- Add one bullet "Maintain, manage and improve the MRV system and make it functional at central, sub-national and local government (DFO) level. This shall include enhancing the efficiency through procurement of technology and capacity of human resources.

FRA has developed Open Source Forest Information System (OSFIS). This system in its current stage manages the inventory data, spatial data sets and also has a standard platform for data dissemination. The OSFIS however may not be considered as a full Management Information System as the system is primarily designed for the ongoing inventory only. It needs to be upgraded to enable continuous monitoring of the permanent sample plots with advance UIs and modules and database structure.

Once the FRA project has phased out, a major task of the DFRS will be to take over the OSFIS developed by FRA Nepal, integrate the MRV structure and maintain, manage and upgrade it through procurement of most relevant technology and capacity in a planned manner.

Another major task of DFRS as foreseen in Nepal’s RPP will be to maintain and manage the central level MRV system, improve its efficiency and effectiveness through procurement of relevant technology and enhance of capacity of the human resources involved in a phased and planned manner.

It should also establish, maintain and make operational the sub-national and local government level MRV system over time linked to the central level MRV system. Improve the efficiency and effectiveness of the sub-national and local government level MRV system through procurement of most relevant technology and enhance of capacity of the human resources involved in managing them at those levels.

Establishment of a Forest Survey and NAFMIS & MRV system Management Division should be considered as deemed appropriate by the MoFSC. In this case, the organization and management (O and M) study of this division could be done based on the functions to be performed by this division and accordingly the specific sections and required human resources could be proposed. This will mean that the existing survey division will be restructured to effectively undertake forest survey using both - the remote sensing and GIS technologies and further validation through field surveys and inventories.

2.5 Key tasks for effective operationalization of MRV System. The Management Architecture

The MRV project’s Working Document No. 4 provides the MRV management architecture and IT platform for the central level. Building on the working paper 4, the structure and functions of central level MRV section under the NAFMIS and MRV division of DFRS is further synthesized in following section.

The structure, role and responsibilities of the proposed MRV Section are described hereunder.

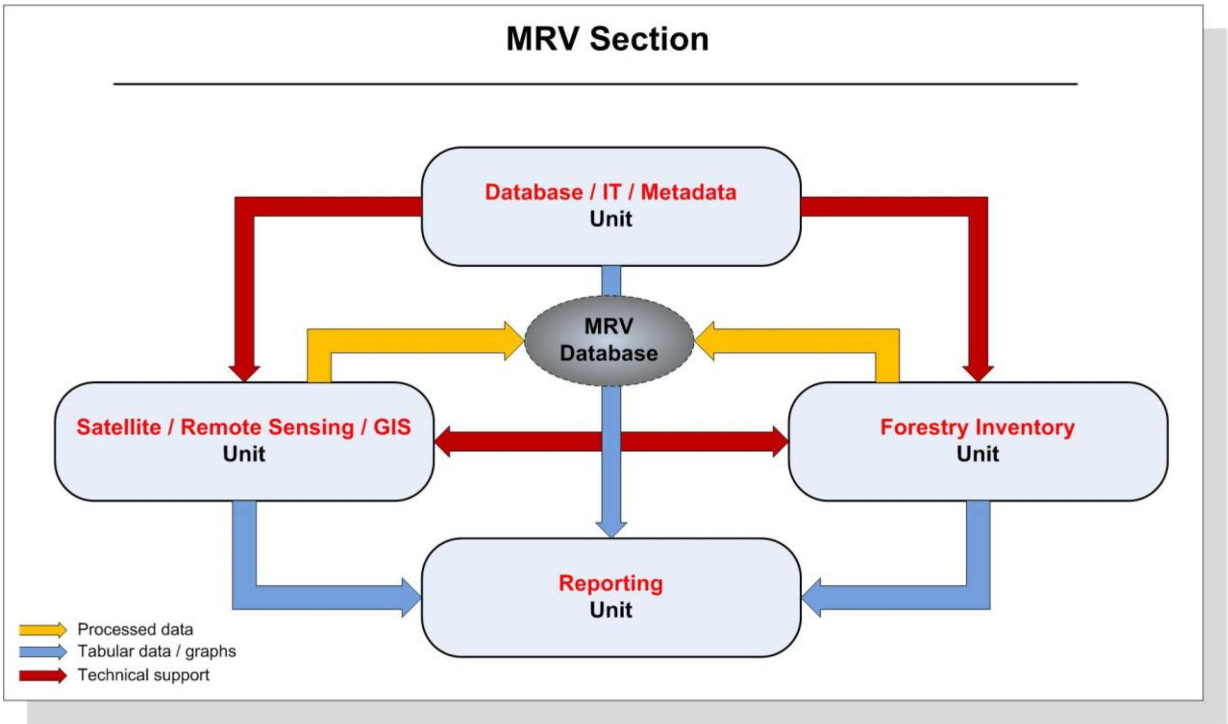
2.5.1 The Central level MRV Section

Under the Survey Division (which is most likely to have NAFMIS and MRV operationalization, maintenance and management responsibilities) of DFRS, a MRV section will be responsible for organizing all MRV related functions from national to sub-national and to district/local levels and managing the MRV professionals. This section will be coordinated by a MRV coordinator who will have dual reporting responsibility –

reporting to the divisional head in DFRS and also to the REDD division in the MoFSC. MRV section will manage and maintain the MRV system and also promote data dissemination about the project(s).

MRV section will require four independent but closely connected units, namely

1. Database/IT/ Unit
2. Remote Sensing/GIS Unit
3. Forestry Inventory Unit
4. Reporting Unit.



The MRV Section Management Architecture

2.5.2 The Database / IT / Unit (DBIT):

This is technically the core unit where 1 (one) System Administrator and 1 (one) DB Expert will work. Additionally, both professional should be on a part time basis (6 man \ months per year each) and their expertise should be shared with other units (e.g. FRA, NAFMIS).

The DB administrator will be responsible for managing and maintaining the MRV database structure (tables, relationships, keys) and assigning privileges and roles to different kind of users (public, editor, stakeholder, etc.), within the rules and protocols defined by the MRV Division.

The System Administrator manages and maintains the IT web platform interface, server system, OS, firewalls, web services, connections and software updates as well as the Web Content Management.

This DBIT unit provides support for graphs and tabular/aggregated data to Reporting Unit upon request.

2.5.3 The Remote Sensing / GIS Unit (RSGIS)

RSGIS Unit will be responsible for image processing and analysis to produce Land Use/Land Cover classification layers and perform GIS editing and analysis. It will ensure data integrity in MRV database. It will undertake change detection in different forestry classes and categories using multi-temporal satellite images, DEM and other ancillary data. Once LU/LC layers have been produced (and validated) they will be uploaded into the MRV database. The Unit is also responsible for REL and WISDOM data entry and spatial data integration in the MRV system and should be able to provide tabular data and graphs to Reporting Unit on request.
This unit will have 2 RS specialist, 2 RS technicians, 1 GIS specialist and 1 GIS technician and could also take advantage of technical support from the DBIT and FORINV Unit for specific tasks.

2.5.4 The Forestry Inventory Unit (FORINV)

FORINV will be responsible for undertaking forest inventories nationally and coordinating inventories at sub-national district/local governance unit level to estimate GHG emissions using very specific algorithms and models applied to local data collected at district/local governance unit level. Once GHG estimates have been produced (and validated) they will be loaded into the MRV database. It will require 2 Forestry Experts for the management of this unit.

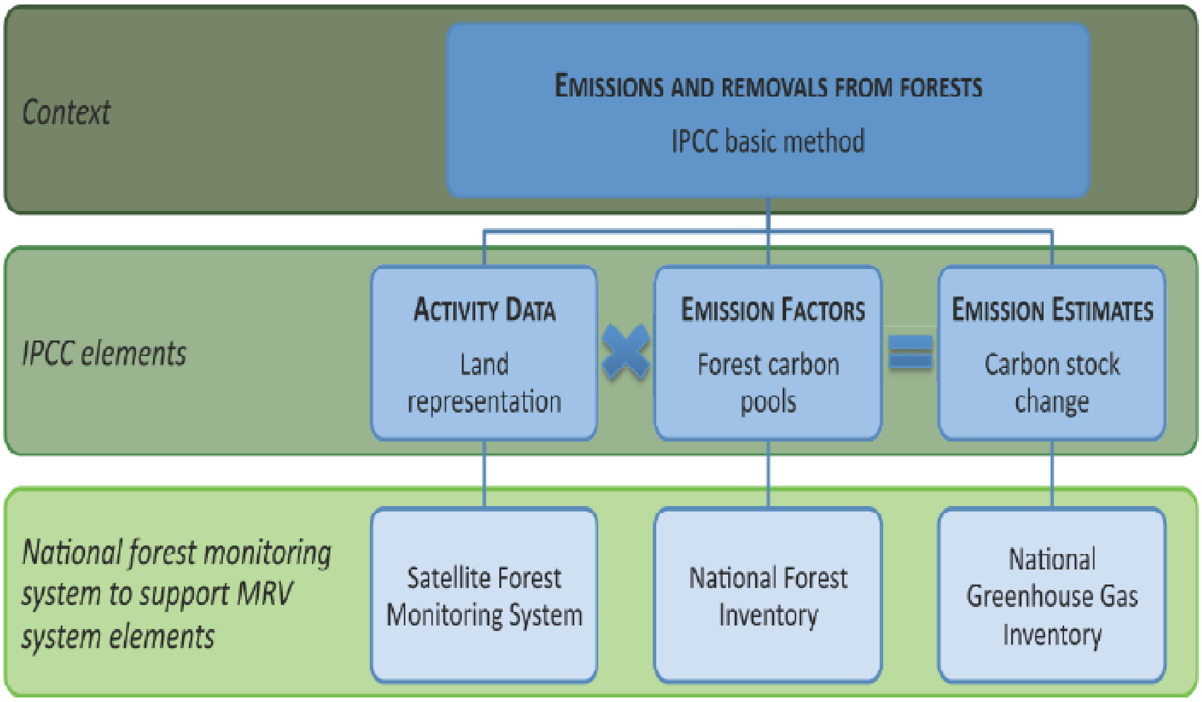
The Unit could also take advantage of technical support from the RSGIS and DBIT Unit for specific tasks. Graphs and tabular/aggregated data should be provided to Reporting Unit upon requests.

2.5.5 The Reporting Unit (REP)

This Unit provides periodic standard MRV reports (consistent with the reporting requirements outlined in the UNFCCC guidelines2) for dissemination of aggregated data and information, collecting the necessary info by the other three Units.
Reporting is a key element of MRV as it provides the means by which, the country's performance is assessed against its commitment or reference scenarios in future REDD+ mechanisms. Hence, it provides the basis for assigning incentives. Human resources needed to manage this Unit are 1 REDD-MRV expert.

2.6 Technical aspects for the National MRV

The Measurement component of the MRV system consists of data, procedures, protocols and tools to monitor human activities and their impact on forests, providing quantitative estimations of human-induced carbon stock changes. The three pillars of this component are reported in the figure below.



2.6.1 Estimation of Activity Data

A national monitoring system provides the foundation for reporting and to verify that all the forest-related or REDD+ activities at every level have a positive effect as regards human impact on forest carbon. To achieve this result the monitoring system (i.e. the MRV) must be capable to measure changes in forest area throughout all forests within a

[2] See the "MRV Manual", by FCMC (October 2013)

country's boundaries (the so-called wall-to-wall approach). Nationwide monitoring is needed to avoid displacement or leakage within a country where reduced deforestation could occur in one portion of the country but increase in another. Fundamental requirements of monitoring systems are that they measure changes throughout all forested area within the country, use consistent methodologies at repeated intervals (i.e. reporting time, which at the moment should be every two years) to obtain accurate results, and verify results with ground-based or very high resolution observations.

There is a general consensus that monitoring of forest cover change using satellite remote sensing is practical and feasible for determining baseline deforestation rates against which future rates of change can be based, provided that adequate validation and accuracy assessments are conducted and documented (Goetz et al. 2009; DeFries et al. 2007). The type of monitoring and baseline approach used is the subject of much discussion, with a range of modifications proposed to deal with equity issues among countries with different historical rates of deforestation. The final decision is left to each country according to its specific situation.

Key requirements for the national monitoring program in order to match REDD+ guidelines include coverage by satellite remote sensing imagery at a sufficient level of detail; access to such data at low-cost; and consensus protocols for satellite imagery analysis (Achard et al. 2010). Moreover, the possibility to ensure consistency of results across countries lies in verification that the methods are (as much as possible) reproducible, provide consistent results when applied at different times, and meet standards for assessment
The SLMS (and the MRV in general) should be built as much as possible on existing competences, data and information systems, to ensure sustainability on the long run and a cost-effective implementation. It should also be designed as a multi-purpose system so that its tools and data can be used for other scopes out of the REDD+ framework, maximizing the investments for its creation and maintenance.

The land cover classification has to be based on a proper number of classes that can vary according to the level (national or sub-national) and at a proper "reference" (or nominal) scale with the corresponding minimum mapping unit. Finally, the resulting forest cover change assessment must provide temporally and spatially explicit information, including conversion between classes (approach 3) with a level of uncertainty that is compatible with the REDD+ requirements.

Different steps are needed to implement a SLMS (UN-REDD Programme 2013):

- define the monitoring approach (i.e. type sensors, temporal and spatial frequency of forest data acquisition
- establish a clear and realistic roadmap for the development of the SLMS;
- build up the required technology and the capacities needed for its sustainable implementation;
- Implement SLMS with the objective of producing measurable results, which correspond to the operationalization of the MRV (based on the prototype created during the present project).

A national program to reduce net emissions from deforestation and degradation can benefit from an initial forest area map to represent the point from which each future forest area assessment will be made and actual negative changes will be monitored so as to report only gross deforestation going forward. This reference map is also called benchmark forest area map. At present this task is being implemented by the ongoing REL Project, however so far the final results of the REL Project are not yet available. The interpretation of the remote sensing imagery needs to identify only the areas (or pixels) that changed compared to the benchmark map. The benchmark map should then be updated at the start of each new reporting time. The forest area benchmark map can also show where forests exist and how these are stratified either for carbon dynamic, e.g. forest types and management types, or for other national needs, particularly for forest inventories.

Land cover and land cover (particularly forest) change in terms of type, intensity, shape, and pattern, have to be assessed in an historical perspective both to detect areas of activities and to identify the main human-induced drivers. Moreover, the analysis of trends is required to define a “business-as-usual” scenario that is the basis to assess the performance of a country and consequently to quantify the financial compensation in the REDD+ mechanism.

As a final remark, it is important to highlight that, according to the official guidelines and recognized in all the published papers on this topic, the remote sensing derived data must be always integrated with field measurements to provide accurate information, therefore a key element in a MRV system is the coordination between the SMLS and the NFI, and in general with the components of the MRV that works directly on the field.

2.6.1.1 Forest Cover and Forest Cover Change Monitoring

The forest cover and the forest cover change monitoring with remote sensing at both national and sub-national (local) level is the core element of the SMLS. It provides the estimation of the Activity data (for deforestation and, to some extent, forest conservation) that are then integrated with the Emission factors (estimated by the NFI) to produce the GHG inventory, which is the main scope of the MRV system. From a methodological point of view, this is achieved using satellite data that are interpreted for forest cover change; focusing on the interdependent interpretation of multitemporal imagery to detect and characterize changes.

2.6.1.2 Forest Degradation Monitoring

From a monitoring perspective degradation, like forest enhancement and sustainable management of forests, requires sequential stock change measurements, which is rather different from what is needed for monitoring deforestation (Herold and Skutsch 2010; Herold et al. 2011). Monitoring of degradation is limited by the technical capacity to sense and record the change in canopy cover because small changes will likely not be apparent unless they produce a systematic pattern in the imagery. Moreover, while deforestation is usually the result of a one-off decision by a particular actor to change land use, degradation is usually a gradual process, resulting from decisions of many actors over time as regards extraction of forest products that is more difficult to be detected, in particular using remote sensing techniques.

In fact, many activities cause degradation of carbon stocks in forests but not all of them can be monitored well with high certainty, and not all of them can and need to be monitored using remote sensing data (GOFC-GOLD 2012). Together with direct estimation of carbon stock, forest degradation is another hot topic in remote sensing research.

The main sources of degradation are:

- Area of forests undergoing selective logging (both legal and illegal). In this case, the best source of data to detect and quantify this kind of degradation are official statistics (for legal logging) and some proxy like forest fragmentation, roads, and log decks, that can be observed in remote sensing imagery, which can provide information on the extension of illegal logging at least where the logging activity is more intense. Remote sensing can be coupled with field data on selected areas that are previously identified as potential hot spots for logging.
- Degradation of carbon stocks by forest fires. This is difficult to monitor with existing satellite imagery and little to no data exist on the changes in carbon stocks. Depending on the severity and extent of fires, the impact on the carbon stocks could vary widely. A possible option for fire monitoring, at least for a general estimation of fire impact on Nepali forests is the use of MODIS-derived products (http://modis-fire.umd.edu/). ICIMOD already implemented a fire monitoring system for Nepal based on MODIS that can be integrated or replicated into the MRV system.
- Degradation by over exploitation for fuel wood or other local uses of wood. This situation is likely not to be detectable from satellite image interpretation unless the rate of degradation was intense causing larger changes in the canopy. This kind of degradation can be monitored using a more complex modelling approach. The WISDOM tool (see Working Paper on WISDOM methodology), integrated into the MRV system, is a key element for monitoring degradation.

In the MRV, the assessment of degradation is mainly performed at sub-national (local) level).

2.6.1.3 Estimation of Uncertainties

The reduction of uncertainties associated with the estimation of carbon stock changes is important because, according to the conservative approach, the uncertainties affect the performance of a country considered by the REDD+ mechanism and thus the possibility to claim financial compensation. Many sources of uncertainties exist in every step of the MRV process, but here we focus on the most important for Activity data: the accuracy related to the land cover and land cover change assessment.

Different components of the monitoring system can affect the quality of the outcomes. They include (GOFC-GOLD 2012):

- the quality and suitability of the satellite data (i.e. in terms of spatial, spectral, and temporal resolution),
- the radiometric and geometric pre-processing (i.e. correct geolocation),
- the cartographic and thematic standards (i.e. land category definitions and minimum mapping unit, MMU),
- the interpretation procedure (i.e. classification procedure),
- the post-processing of the map products (i.e. dealing with no data values, conversions, integration with different data formats, e.g. vector versus raster), and
- The availability of reference data (e.g. ground truth data) for evaluation and calibration of the system.

An independent accuracy assessment is therefore an essential component to link area estimates to a crediting system and reporting accuracy and verification of results are essential components of a monitoring system. According to the bibliography, interpretation accuracies of 80–95% are achievable for monitoring changes in forest cover with mid-resolution imagery when using only two classes: forest and non-forest.

Accuracy assessment for classifications of forest cover maps is most commonly generated from a comparison of the final classification result with data that are assumed to be true. Ground reference data or information derived from very fine spatial resolution imagery (that can be considered to be surrogate to ground reference data) are generally recommended as the most appropriate data to assess the accuracy of land-cover change estimation. In both cases, a statistically valid sampling procedure should be used to determine accuracy.

Another possible source of reference data for national level forest cover and forest cover change maps validation are the forest cover and forest cover change maps produced at sub-national (local) level, when available. An error matrix (also called confusion matrix) is generated in which classified points and reference points are compared for each class. Errors of commission (error of including an area in a category to which it does not truly belong, i.e. area overestimation) and omission (error of excluding an area from a category to which it does truly belongs, i.e. area underestimation) for the classification are displayed and an overall accuracy term may be calculated. Additional statistics can be used to describe classification accuracy (e.g., kappa coefficient, tau statistics) (Sanchez-Azofeifa et al. 2009). There is no fixed rule for the determination of the number of points to be validated, but a rule of thumb is that 30 to 50 points are needed for each class, where forest classes can be sampled at higher intensity. Validation is integral part of the Activity Data estimation.

2.6.1.4 MRV and REL

The accounting of emissions and removals from deforestation, forestation and changes in remaining forest areas requires assessing reference levels against which future emissions and removals can be compared. The reference level (or reference emission level, REL) represents expected business-as-usual carbon balance from forest related human activities at national or sub-national level and it is based on historical data and national circumstances (GOFC-GOLD 2012).

Although REL is not a component of the MRV system, which scope is to measure the real carbon stock changes, the REL and MRV estimates must be compatible because they are compared to assess the performance of a country in the framework of the REDD+ mechanism (a thus to quantify the financial compensation that can be claimed). The Forest Carbon Partnership Facility (FCPF) Carbon Fund Methodological Framework decision at 19^{th} Conference of Parties (-/CP.19) formally established that MRV and REL methodology must be consistent.

The easiest way to make REL and MRV estimation consistent is to use the same methodology, particularly for the estimation of forest cover changes. Therefore, the initial idea (discussed in all the meetings and workshops with REDD Cell) was to replicate the methodology (data source, classification and validation method, tools) adopted by the REL Project.

Unfortunately, the preliminary results presented in the draft of the REL Final Report (the official Final Report is not yet available at the date of the end of the MRV project), provide figures that seem to be inconsistent and with an accuracy that is not compatible with the requirements of the REDD+ mechanism, at least for the MRV. Moreover, no REL at local level has been defined. For these reasons, a different approach is proposed at both national and sub-national (local) level.

2.6.1.5 The Nested Approach

In the suggested MRV approach, national and sub-national level are integrated to balance the requirements of a standardized approach with the necessity to involve local communities and institutions. The goal of a nested MRV approach is to define protocols at local level that maximise the involvement of local people in forest monitoring, while also corresponding to the forest monitoring requirements made by the UN for the prospective REDD+ framework (Palmer Fry 2011). This contributes to establish a national forest carbon monitoring system able to provide data nationally but which is also flexible for more detailed, accurate measurement at the sub-national (particularly local) scale driven by REDD+ related activities that often focused on specific areas. Consequently, the proposed MRV is a stratified system that provides data with more precision and accuracy for the (sub-national and local) REDD+ implementation activities and less detailed, systematic monitoring in the rest of the country (Herold and Skutsch 2010).

There is growing evidence that local monitoring of carbon stocks is a task that can be carried out easily, reliably and at very low cost by the local stakeholders. Communities are well able to collect data, although they might require support from intermediary agencies for various tasks. This will give them legitimacy and a stronger claim to financial benefits from the carbon market or fund (Herold and Skutsch 2010). The same applies, to some extent, to the identification and validation of forest cover change at local level.

2.6.1.6 Proposed Methodology

According to our analysis, the best methodology at national level can be synthesised as a temporally and spatially explicit national land cover change assessment and as a conversion between classes through a wall-to-wall mapping approach based on Landsat images classified with a limited number of classes using a hybrid approach that combines automated image segmentation with visual interpretation with a minimum mapping unit of 5 hectares, to be repeated at every reporting time (e.g. 2 years) and a with a specific protocol for the accuracy assessment.

The analysis will be carried out by the Remote Sensing/GIS unit of the MRV section at central level. The methodology also include the definition of a baseline map (probably related to 2010), that should be coordinated with the forest map produced by the FRA project and the result of REL project. A more general harmonization process should be planned with REL data once the results will be officially available and adopted by the REDD cell.

Below, more details and discussions are provided about different aspects of the methodology: data source; classification method; classification system; validation of results. In some case, some alternative options are presented. The final standardized protocols must be defined during the operationalization of the MRV system according to a number of factors, including the available financial resources and more specific requests to participate to the REDD+ mechanism.

The first option among the available **data sources** for a national monitoring of forest cover and forest cover change is Landsat data (30 m resolution). Landsat has the advantage to be freely available for years 1990, 2000, 2005 and 2010, thus allowing a consistent data set that can be used also for the definition of historical trends. From 2013 on, Landsat 8 provides a complete coverage of the country every 2 weeks. Some pre-processing is needed to assemble a national mosaic, but no resources are needed for the data acquisition. The resolution permits to monitor forest cover changes with 1 to 5 ha Minimum Mapping Unit (MMU). Landsat is also the data source used by most national projects on forest monitoring. These data allow assessing changes of forest areas and producing a benchmark map of national forest area (to derive deforestation rates).

A possible alternative of medium resolution images is DEIMOS, a commercial satellite that provides data with a resolution comparable with Landsat (22 m), but with no historical time series available. It can be a low cost option if data have to be acquired already pre-processed and as a unique national mosaic (saving time and reducing the internal expertise needed to perform the national land cover change assessment).

A possible alternative (or integration) to Landsat are Rapid Eye images (5 m resolution). These have been used by FRA project and a complete coverage for 2010 exists for Nepal. The acquisition of a complete coverage of the whole country for a single date is around 130,000 dollars. This would have a number of advantages:

1. better resolution;
2. data are provided with all the pre-processing steps performed;
3. data can be used for sub-national (e.g. local) level.

On the other side, Rapid Eye also implies some disadvantages:

1. they are not free;
2. no long time series is available for historical analysis;
3. remote sensing data analyses become more difficult and more expensive with smaller Minimum Mapping Units (MMU), i.e. more detailed MMU’s increase mapping efforts and usually decrease change mapping accuracy and the largely increase the processing time.

The two data sets can be integrated, for example using Landsat data for the national assessment and Rapid Eye to validate the result and to closely monitor hotspot of deforestation or areas directly affected by REDD+ related management measures.

Aster images (15 m resolution, 3600 sq. km size of a single scene, 60 to 120 dollars for a single scene) can be used to monitor hotspots but are not recommended for a national monitoring system because it is very difficult to obtain a complete national coverage.

The **classification method** recommended for MRV Nepal is a hybrid approach combining automated digital segmentation with visual interpretation and validation of the resulting spatial objects. Image segmentation is the process of partitioning an image into groups of pixels that are spectrally similar and spatially adjacent. Boundaries of pixel groups delineate ground objects in much the same way a human analyst would do based on its shape, tone and texture. However, delineation is more accurate and objective since it is carried out at the pixel level based on quantitative values. Segments can be generated using a MMU of e.g. 1 hectare and then grouped during the visual interpretation phase to a MMU of 5 hectares. The visual interpretation can be driven by the contextual analysis of other ancillary data sets (e.g. human settlements, road network, hydrography, digital elevation models, land cover maps from other sources, automatic supervised or unsupervised classifications). Particularly, a supervised classification after segmentation can be used as preliminary classification, that can then be corrected and improved by the direct visual check of the analyst wherever needed. This approach is a good compromise between time, resources, expertise and quality of results. It is a simple, robust and cost effective method that is also suggested by GOFC-GOLD (2012). Moreover, it is perfectly compatible with the size of the country, which corresponds to the “equivalent” size of about 4 Landsat scenes (about 2 equivalent Landsat scenes correspond to cover forested lands), although more than 10 scenes are needed to have a real coverage of the country. Another advantage is that DFRS remote sensing experts have already been trained on this methodology in the framework of FRA project. The main limitation of the proposed classification method is that it is not completely replicable, but in general provides better estimates as compared with completely automated approach especially when applied on a pixel-base.

The land cover change detection can be performed applying multi-date image segmentation on image pairs instead of on single images separately. In fact, rather than compare independently produced maps from different dates to find change, it is almost always preferable to combine multiple dates of satellite imagery into a single analysis that identifies change directly. This subtle point is significant, as change is more reliably identified in the multi-date image data than through comparison of maps derived from individual dates of imagery. Some more difficulties might rise when the change assessment must be repeated at every reporting time (e.g. every two years). Some possible inconsistencies like the fuzzy boundary effect between land cover maps of different dates (change that are detected along the boundaries of land cover classes that are due to different delineation of the spatial units rather than to real land cover changes) can be managed in a post processing phase using GIS tools.

In general, a scene by scene analysis is preferred as it is more accurate than interpretation of scene mosaic and limits the problems that can derive from errors introduced in the pre-processing phase.
A possible alternative to the segmentation combined with visual interpretation is a classification completely based on visual interpretation. The main advantage is that this is a very simple method to be applied. The need for reproducible and verifiable results can be met through multiple interpreters and well-designed procedures.

The **classification system** is key element of the forest cover and forest cover change assessment. The number and typologies of class categories depends on many factors, including the availability of geographic data and analysis, ability to detect differences in land cover on remote sensed imagery, availability of carbon and profitability information of land uses, and the cost of each option (World Bank Institute 2013). The first level of the land classification is simply forest/non-forest. Then, according to the IPCC indications for GHG reporting, land must be subdivided in 6 main classes (Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Lands), further subdivided in managed and unmanaged. Forest or other classes can then be detailed in a set of subclasses that take into account the stratification needed for the Emission Factor definition. Particularly, the aim is to identify areas where occurred activities that are expected to generate GHG emissions/ removals. The proposed classification includes a further class: Other Wooded Land (e.g. shrubs, tree out of forest). Ancillary data set can drive the differentiation between managed and unmanaged forests. The use of ancillary data (e.g. ecological zones, morphology, climate, potential vegetation) can help to distinguish between broadleaved and coniferous forests. Remote sensing can also differentiate between closed and open forest. The use of more advanced indexes can also try to define the percentage of forest cover (see, for example, Rikimaru et al. 2002). Nevertheless, the reliability of this level of detail is to be verified.

In general, splitting land uses into sub-classes is needed when a class does not accurately represent a land use in terms of carbon stock or net returns, but a lower number of classes requires less data management and analysis. In addition, a false sense of precision may arise by creating numerous sub-classes from inadequate resolution of images, carbon or profit information. Finally, a greater level of detail may be used in areas that are of particular interest (local level in the nested approach). Due to the fragmented landscape in some areas of the country where small patched of forest are mixed with crop areas, aggregating (lumping) classes together may be needed because the minimum mapping unit (MMU) of imagery may not be small enough to differentiate classes; thus a mixed mapping unit might be required. In fact, while clearings for large-scale mechanized agriculture are easily detectable with coarse and medium resolution data, small agricultural clearings or clearings for settlements might require higher resolution data (<30 m) to accurately detect clearings of less than 0.5 hectares. Smaller clearings and more heterogeneous landscapes require data with finer spatial resolution (10 m), more complex computer algorithms capable of detecting less pronounced differences in spectral reflectance and greater involvement of an interpreter for visual analysis and verification (Achard et al. 2010). As this is not always possible, mixed classes are an option to solve the problem. Vegetation indexes can then be used, for example, to estimate forest coverage in forest/crop land mixed classes.

The recommended classification system for developing the legend is the Land Cover Classification System (LCCS; Di Gregorio 2005). The LCCS includes a thorough description of classification concepts and guidelines for matching land cover types to global standards. It has been adopted by many land cover-related projects in the world, including the FRA project in Nepal.

In the next table, there is an overview of the proposed classes.

<table>
<tr><td rowspan="6">Forest</td><td rowspan="2">Broadleaved</td><td>Open</td></tr>
<tr><td>Closed</td></tr>
<tr><td rowspan="2">Coniferous</td><td>Open</td></tr>
<tr><td>Closed</td></tr>
<tr><td rowspan="2">Mixed</td><td>Open</td></tr>
<tr><td>Closed</td></tr>
<tr><td rowspan="6">Non-forest</td><td>Cropland</td><td rowspan="6"></td></tr>
<tr><td>Grassland</td></tr>
<tr><td>Wetlands</td></tr>
<tr><td>Settlements</td></tr>
<tr><td>Other wooded land</td></tr>
<tr><td>Other land</td></tr>
<tr><td>Forest mixed with non-forest land</td><td colspan="2"></td></tr>
</table>

2.6.1.7 Validation of the Remote Sensing results

The **validation of the results** of the land cover and land cover change assessment is part of the classification process. Particularly, a stratified accuracy assessment must be done with a proper number of sample points (e.g. 50 control points per class, with a higher intensity for forest-related classes). The ground-truth information can be derived from different sources. Whenever possible, field data collected by the MRV forestry inventory unit, at national and local level, can be used. Local communities and local institutions are another possible source of field data. Field data collection can be organized for the purpose of the forest cover assessment. An alternative source of information is high resolution images. Particularly, in some area GeoEye data are available, while a complete coverage of Rapid Eye exists for Nepal. High resolution images from Google Earth and Bing Aerial can be a useful support when the date of the images is compatible with the analysis.

2.6.2 Estimation of Emission Factors (Forest Carbon Stock Changes over time)

2.6.2.1 The Continuous Forest Inventory approach

Traditionally, forest inventories in several countries have been done to obtain a reliable estimate of the forest area and growing stock of wood for overall yield regulation purpose. The information was used to prepare the management plans for utilization and development of the forest resource and also to formulate the forest policies. The forest inventory provides data of the growing stock of wood by diameter class, number of the trees as well as the composition of species. Repeated measurement of permanent sample plots also provides the changes in the forest growing stock/ biomass.
Field inventories are a key element in the Measurement component of MRV since they provide a unique source of forest volume and biomass that can be converted in Carbon stock as a direct input to national GHG inventories.

In Nepal, the tradition of forest inventories dates from the mid-sixties. Since then numerous field inventories were carried out at national and especially sub-national level.

<u>The FRA Nepal Project</u>

At present, a national forest inventory is being carried out by the FRA Nepal Project. So far FRA Nepal has completed the Terai mapping and field inventory and is planning to conclude the National Inventory by end of 2014.

The Forest Resource Assessment (FRA) Nepal Project (2010-2014) was designed to provide comprehensive, up-to-date, national-level forest resource information for use in national forest policy development and national-level forestry sector decision-making. In addition, the project is intended to support the collection of the national-level baseline information required for REDD.

By establishing the national network of forest sample plots, FRA Nepal has introduced the possibility of conducting continuous forest inventory, necessary for:

- calculating the annual increment;
- determining the annual allowable harvest;
- monitoring forest carbon flux;
- monitoring forest health;
- monitoring the impacts of climate change on forests; and
- monitoring the sustainability of broadly applied forest management practices.

The information generated by FRA Nepal is extremely valuable in the MRV context and will be used as a basis for establishing a Continuous Forest Inventory system at national level for Nepal.
The methodology of FRA Nepal is described in detail in the technical documentation of the Project. Just a few key elements relevant for the MRV proposal are reminded here.

<u>Forest inventory</u>
The inventory design adopted was largely based on the methods developed by Kleinn (1994). Sampling survey methodology was finalized through collaboration between international and regional FRA experts and the DFRS's counterparts. The design was created during the first year and tested in the field in three trial inventories and training

sessions. After each test, the method was revised to improve its functionality. The variables measured were selected based on the suggestions given by the national level data need assessment workshop of the FRA data partners in Nepal.

Sampling regions

In FRA Nepal inventory, the Country was divided into 21 sampling regions according to physiographic zones (5 regions: Terai, Siwaliks, Mid Mountains, High Mountains, High Himal) and Development Regions (5 regions). The main reason for dividing the country to different sampling regions was that in this way, it is possible to ensure that enough data are collected for each development region and for each physiographic zone. Another reason is that it is possible, if needed, to apply different sampling schemes in each sampling region.

The following strata have been defined.

1. Terai has been divided into Far-western, Mid-western, Western, Central and Eastern Development Regions (5 strata)
2. Siwaliks is divided into Far-western, Mid-western, Western, Central and Eastern Development Regions (5 strata)
3. Mid Mountains is divided into Far-western, Mid-western, Western, Central and Eastern Development Regions (5 strata)
4. High Mountains is divided into Far-western, Mid-western, Western, Central and Eastern Development Regions (5 strata)
5. High Himal is considered as one stratum (1 stratum)

The allocation of sample to each stratum was done proportionally to the forested area in each stratum, as follows:

Table 2: Allocation of number of clusters by Physiographic and Development Regions

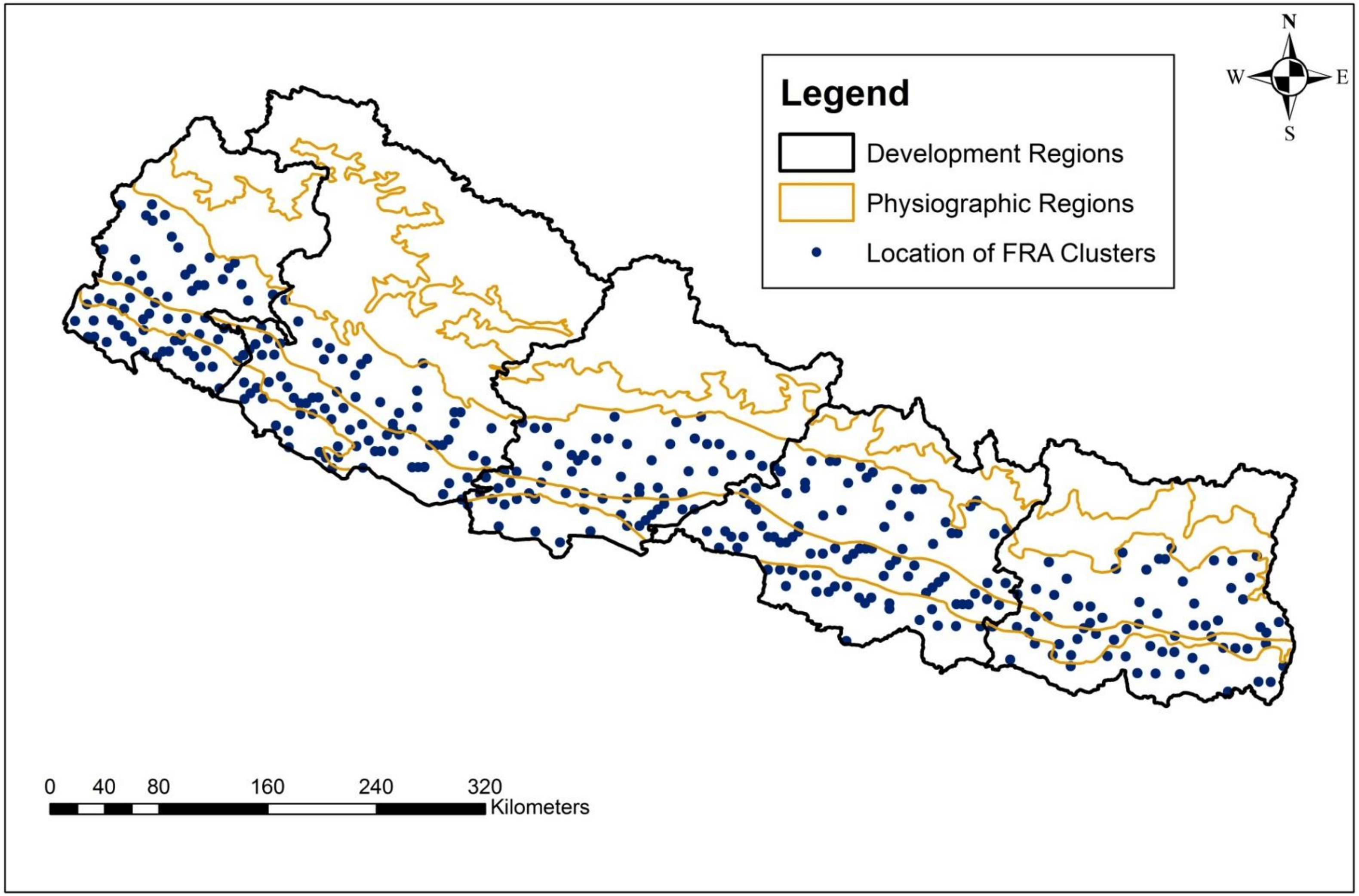
Physiographic Regions	**Development Regions**					
	FWDR	**MWDR**	**WDR**	**CDR**	**EDR**	**Total**
Terai	14	9	6	8	3	40
Siwaliks	13	26	15	34	17	105
Mid Mountains	29	32	34	26	33	154
High Mountains	17	54	17	18	28	134
High Himal	(2)	(5)	(5)	(2)	(3)	(17)
Total	**75**	**126**	**77**	**88**	**84**	**450**

(source FRA Nepal)

FRA Nepal is planning to measure 450 clusters in the field. Since each cluster is composed of 4 plots in the Terai and 6 plots in the rest of the country, the total number of plots to be established by FRA Nepal by end of 2014, is between 2’000 and 2’500, depending also on accessibility.

The following map illustrates the preliminary allocation of clusters as defined by FRA Nepal.[3]

Figure 1: Location of field sample cluster of FRA Nepal Inventory

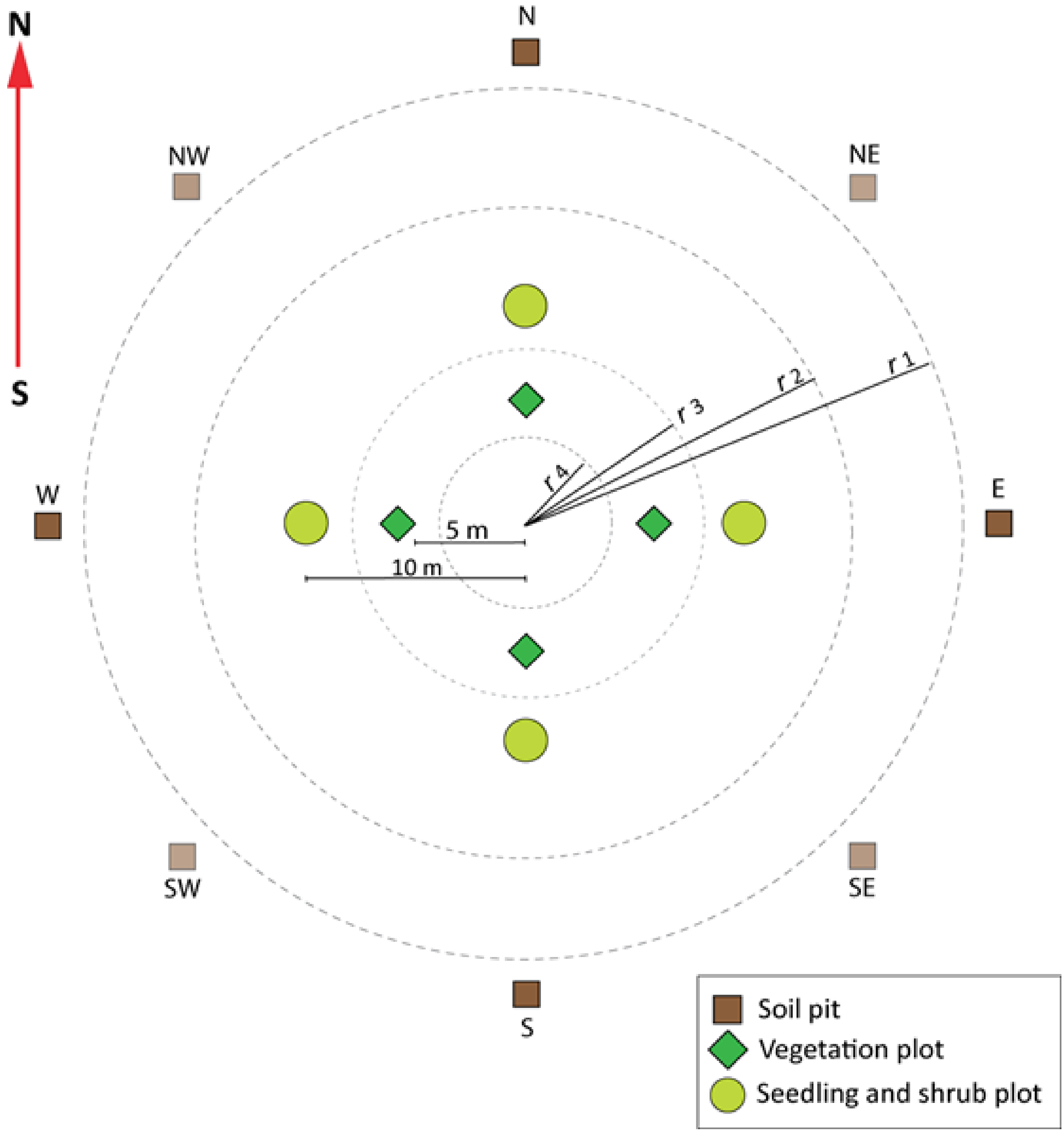


[3] As mentioned, the FRA Nepal Project is still on-going. The map above illustrates the most updated information received by the MRV Project from FRA Nepal Project. It is expected that the final FRA Nepal cluster allocation may differ.

<u>Sample plot design</u>

Each sample plot was designed as Concentric Circular Sample Plot (CCSP) having four concentric circles of different radius to measure the different sized trees. The trees that were measured in the circle of different radii were as follows:

- trees having 30 cm DBH or more were enumerated within a 20 m radius plot (area: 1256.6 m^2)
- trees having 20-29.9 cm DBH were enumerated within a 15 m radius plot (area: 706.9 m^2)
- trees having 10-19.9 cm DBH wee enumerated within a 8 m radius plot (area: 201.0 m^2)
- trees having 5-9.9 cm DBH were enumerated within a 4 m radius plot (area: 50.3m^2)



Within each Concentric Circular Sample Plot (CCSP), other sub-plots were established to assess the status of seedlings, saplings, shrubs and herbs other than trees. More particularly, seedlings, saplings and shrubs were measured in four circular sub-plots, each with a radius of 2 m, located at 10 m away from the centre of the plot in each of the four cardinal directions (N, E, S, and W). Species-wise stem counting and mean height estimation was done for the tree/shrub species having DBH less than 5 cm. Information about non-woody vascular plants were collected from four 1 m^2 square plots each located at 5 m away from the centre in the four cardinal directions. Dead and decaying wood were assessed in a circular plot with a radius of 10 m from the plot centre. Based on field observation, fifteen categories of natural and anthropogenic forest disturbances were assessed regarding their occurrence and intensity (high, medium, low) in each 20 m radius CCSP using the FRA Field Manual.

The MRV proposal for a Continuous Forest Inventory

The experience of FRA Nepal constitutes a major landmark for forest inventories in Nepal. FRA Nepal has developed a modern technique of forest inventory, using appropriate scientific methods and a statistically sound approach. So it is natural to implement a CFI based on the same approach and methods used by FRA Nepal.

In particular the same sample plot design should be implemented with 4 concentric plots for tree measurement and sub-plots to assess the status of seedlings, saplings, shrubs and herbs other than trees. Homogeneity in the field measurements is essential for assuring comparability of the results, which is an essential pre-requisite for MRV.

Sampling intensity

For the Continuous Forest Inventory design in the context of MRV it is proposed to revisit 1'000 FRA Nepal field plots over a cycle of 5 years i.e. to measure 200 plots in the field every year. The number of 1,000 PSP is somehow arbitrary. The main reasons for proposing 1,000 PSP was based on the following considerations:

The number of plots in a forest inventory is generally based on the following principles:

- The level of precision required, and
- The variance of the variables to be estimated.

In our case the minimum desired level of precision is ± 10% at 95% probability. However the overall variance of key variables (like for instance Total Aboveground Biomass), is not yet known, as it should be calculated by FRA Nepal inventory, which is not yet completed. In the absence of a complete variance estimate, some proxies were used, as follows:

1. The experience of FRA Nepal has shown that field work in Nepal is difficult, due to terrain conditions and poor accessibility. For this reason the number of 1'000 plots seems a good compromise between the required statistical precision and a realistic annual work load for the field crews.
2. Regarding the statistical precision of the results, the NFI of 1994 achieved a precision of ±6% for the Hilly Area (including Siwaliks, Mid-hills and Mid-Mountains) with 600 plots, which is compatible with the proposed sampling design.
3. Finally, the proposed sampling intensity can be compared with the present CFI on-going in India. The extent of forests of India is estimated at around 69 Million ha

(Forest Survey of India). The CFI of India is measuring a total of 8'000 PSP. So one plot is established per 8'625 ha of forests.

4. In the case of Nepal it is proposed to measure both forests and other wooded land (mainly shrubs). The reason being that in a perspective of Carbon stock monitoring the transition from forests to shrubs (or vice versa) must be fully accounted in the Carbon balance and related emissions. So field data for estimating Carbon stocks are necessary for other wooded land as well. Assuming an extent of forests + other wooded land of around 6 Million ha for Nepal, each of the 1,000 plots will represent 6'000 hectares of wooded land, which is more intense than the design used in India.

Implementation

As discussed earlier, the present proposal suggests the establishment of 1'000 PSP on a cycle of five years, with 200 different sample plot re-measured every year. The decision of which of the FRA plots will be re-measured in the MRV CFI design is difficult to formulate now. Only when the final results of FRA are available a sound judgment of which plots are more representative can be made. For the time being, using the same allocation criteria as FRA Nepal the 1,000 MRV PSP would be distributed as follows:

Physiographic region	Development Regions					
	FWDR	MWDR	WDR	CDR	EDR	Total
Terai	31	20	13	17	8	89
Siwaliks	29	58	33	75	38	233
Mid Mountains	64	71	76	58	73	342
High Mountains	38	120	38	40	62	298
High Himal	5	11	11	5	6	38
Total	**167**	**280**	**171**	**195**	**187**	**1000**

Additional criteria for the PSP selection could be to sample with greater intensity the areas that are more subject to deforestation, if reliable REL data are available. In this case a Probability Proportional to Size could be adopted. To help in the PSP selection process also the results of the WISDOM model, highlighting area likely to be subject to anthropological pressure for fuel wood demand could be used.

Expected Results

The CFI will produce:

Updated field measurements including

- Number of trees per hectare
- Species composition
- Diameter distribution
- Status of regeneration
- Stem volumes
- Stem biomass
- Total tree biomass
- Seedlings, saplings, shrubs and herbs biomass
- From the point of view of the MRV core business, i.e. carbon emissions, the following variables will be considered:
- Total above ground biomass, including tree and non-tree (shrubs and non-vascular plants);
- Dead and decaying wood

- Total belowground biomass.

Total aboveground biomass will be derived from stem volume using allometric equations and specific wood density. The FRA Nepal used the allometric equations for biomass developed by Sharma and Pukkala (1990). In the first instance the same methodology should be followed, however the current equations are outdated and cover only a limited number of species (21 spp.). For this reasons it is advisable to develop new allometric equations, more comprehensive.

Once total aboveground biomass is calculated, the corresponding belowground values, as well as carbon stocks will be derived using the default values as indicated by IPCC.

As discussed with the REDD Cell and the REL Project we propose to exclude Soil Carbon from the measurements. Soil Organic Carbon (SOC) will be excluded because:

- Its contribution to total carbon dynamics is marginal;
- Experiences carried out by other Projects in Nepal (e.g. FRA Nepal) showed that the correlation with land use dynamics is erratic;
- A sufficient precision is difficult to achieve;

In particular we quote the following working paper of FRA Nepal: "Soil Carbon in the Terai Forest - by Purna Lal Maharjan and Anish Joshi, May 2013",[4] stating
3.2. SOC and Canopy Closure (page 7)
On comparing the total SOC with field measured (observed) canopy density, a weak correlation of ρ=0.32 (Spearman's Rho) is found at 0.01 significance level. This indicates that the SOC is not correlated with canopy closure. Similarly very weak correlation is observed between the mean litter & debris carbon with the canopy closure (ρ=0.11).
3.3. SOC and Growing Stock (Page 8)
On comparing the mean SOC with growing stock volume, the correlation is found to be weak (ρ=0.396), hence entailing that these two parameters do not have relationship in the forests of the Terai.

- The cost for including such measurements is high and the cost/benefit balance is negative.
- Similarly the GHG to be included will be only CO2, given the absence of mangroves in Nepal and peat swamps.

After the completion and validation of the field work the results will be integrated in the MRV database where the number of observations will continuously grow over time, thus gradually improving the precision of the results.
Summarizing, the CFI will generate this type of Report at plot, stratum, physiographic region, development region and total for the whole country.

[4] This Interim Report was taken in consideration as draft FRA Nepal Final Report on Terai, however we are not aware whether these correlations have been confirmed in the final report.

Totals or per ha values

Year	Aboveground biomass (t Carbon)			Belowground biomass (t Carbon)	Total biomass (t Carbon)
	Tree	Non tree	Total		
Year t					
Year t+5					
Difference					

This information will form the basis for the estimation of emission factors, which will be coupled with activity data to produce a National GHG inventory.

Besides the data on Carbon emissions the CFI will also produce auxiliary information useful for forest management and forest and land use planning, such as: tree growth and yield, forest degradation or forest enhancement, status of regeneration, etc., which can be later integrated in the NAFMIS.

Field work

Some logistics considerations suggest that the field work could be coordinated by Development Regions. In this case the 200 PSP to be annually measured would be distributed by Development Regions as follows.

Number of plots to be measured annually	FWDR	MWDR	WDR	CDR	EDR	Total
	34	56	34	39	37	200
Mission (crew/month)	3	5	3	3	3	17

Some very useful information on cost and efficiency of FRA field work was found in the paper.
Monitoring Aboveground Forest Biomass: A Comparison of Cost and Accuracy between LiDAR-Assisted Multisource Programme (LAMP) and Field-based Forest Resource Assessment (FRA) in Nepal.
P.N. Kandel, K. Awasthi, S.M. Shrestha, M. Hawkes, T. Kauranne, B. Gautam, K. Gunia, E. Dinerstein. Presented at International Conference on Forest, People and Climate: Changing Paradigm 28-30 August 2013, Pokhara, Nepal.

Where, based on the FRA Nepal experience, it is stated that " On average, the field inventory crews spent 24 days on a mission, and measured 12 sample plots"

Using these calculations the number of man/month needed for one field crew to measure the required number of sample plots is annually of 17 man/crew. With the deployment of 2 crew per each Development Region (Total of ten field crews), the annual time to be spent in the field for each annual CFI campaign would be of around two months per year.

In our proposal we suggest that the field work should be carried out by 10 crews. A forest inventory field crew, taking into account the amount of information to be collected and the tasks of each individual, is composed by four technical members, namely:

- the crew leader

- one assistant to crew leader,
- one technical assistant with forestry expertise and
- one ecologist (taxonomist).

Thus in total 40 persons are needed for the CFI annual field work. If the field crews are not allowed to spend two months per year in the field (according to S.K Gautam of DFRS, Pers. Communication, present Government travel rules, none is allowed to spend more than 21 days). We are proposing 24 days/year per crew member in the field and if this cannot be reconciled, the number of field crews for the CFI should be increased accordingly, but the discrepancy is small.

Regarding field inventory, Nepal as compared to most developing countries, features an outstanding tradition of forest inventory expertise, matured over time including the following achievements:

1. Forest Resources Survey Office (FRSO) 1963/64
2. Land Resource Mapping Project (LRMP) 1978/79
3. Master Plan for the Forestry Sector (MPFS) 1986
4. National Forest Inventory (NFI) 1994
5. Forest Cover Change Analysis of the Terai Districts (DoF) 2005
6. Forest Resources Assessment of Nepal (2010 – ongoing)

The proposed CFI will be based on the experience matured by FRA Nepal, which has already put in place a technical structure to carry out all phases of field work and data processing. However, the FRA Nepal Project is still on-going and no conclusive results are available, allowing a full evaluation of the field work and data collection efficiency. In general the MRV CFI approach should be a direct FRA Nepal follow-up component that needs to be institutionalized, and the sooner the CFI begins, the less capacity will dissipate. Certainly there is a need for continuous technical assistance, new and more equipment and staff training.

As per capacity building and technical assistance needs, the following considerations can be made:

As discussed in the previous Section of the present document, the knowledge needed for the CFI implementation will have to be institutionalized through the proposed MRV Section to be created within DFRS. In particular, for the Forest Inventory Component, two professionals need to be employed on a full time basis, with the following responsibilities:

Forestry Inventory design, coordination of field work and data processing for estimating emission factors and GHG emissions both at national and sub-national level, and their required skills are as follows:

- ✓ Sampling design
- ✓ Forest inventory
- ✓ Forest mensuration
- ✓ Statistical analysis
- ✓ Reporting

Given the complexity of a CFI design, especially in an MRV context, it is expected that some substantial technical assistance is needed to the following fields:

- ✓ Optimization of sampling designs

- ✓ Biometry and statistical analysis
- ✓ Data processing and reporting

For this reasons a financial component is allocated to Technical Assistance in the cost section of this document.

2.6.2.2 Special study on new allometric equations

A very important component needed in a CFI and MRV context, is the biomass estimation. Since the minimum required for the proposed MRV design is to comply with the requirements of Tier 2, local allometric equations are needed for biomass estimates.

The FRA Nepal used the allometric equations for biomass developed by Sharma and Pukkala (1990). However the current equations are outdated and cover only a limited number of species (21 spp.). For this reasons it is advisable to develop new allometric equations, more comprehensive

Given the diversity of forest types existing in Nepal, it is nearly impossible to build reliable allometric equations for all species. For practical reasons, keeping in mind the difficulties of field work and the costs for destructive sampling, it is better to concentrate the sampling and the field work on the most important forest species in terms of their contribution to total volume and biomass, and also to their distribution according to ecological conditions and species composition. For instance it is known that in general coniferous have lower wood density than broadleaved and also there may be differences in the relationship between dbh and biomass depending on the branch development for a given species.

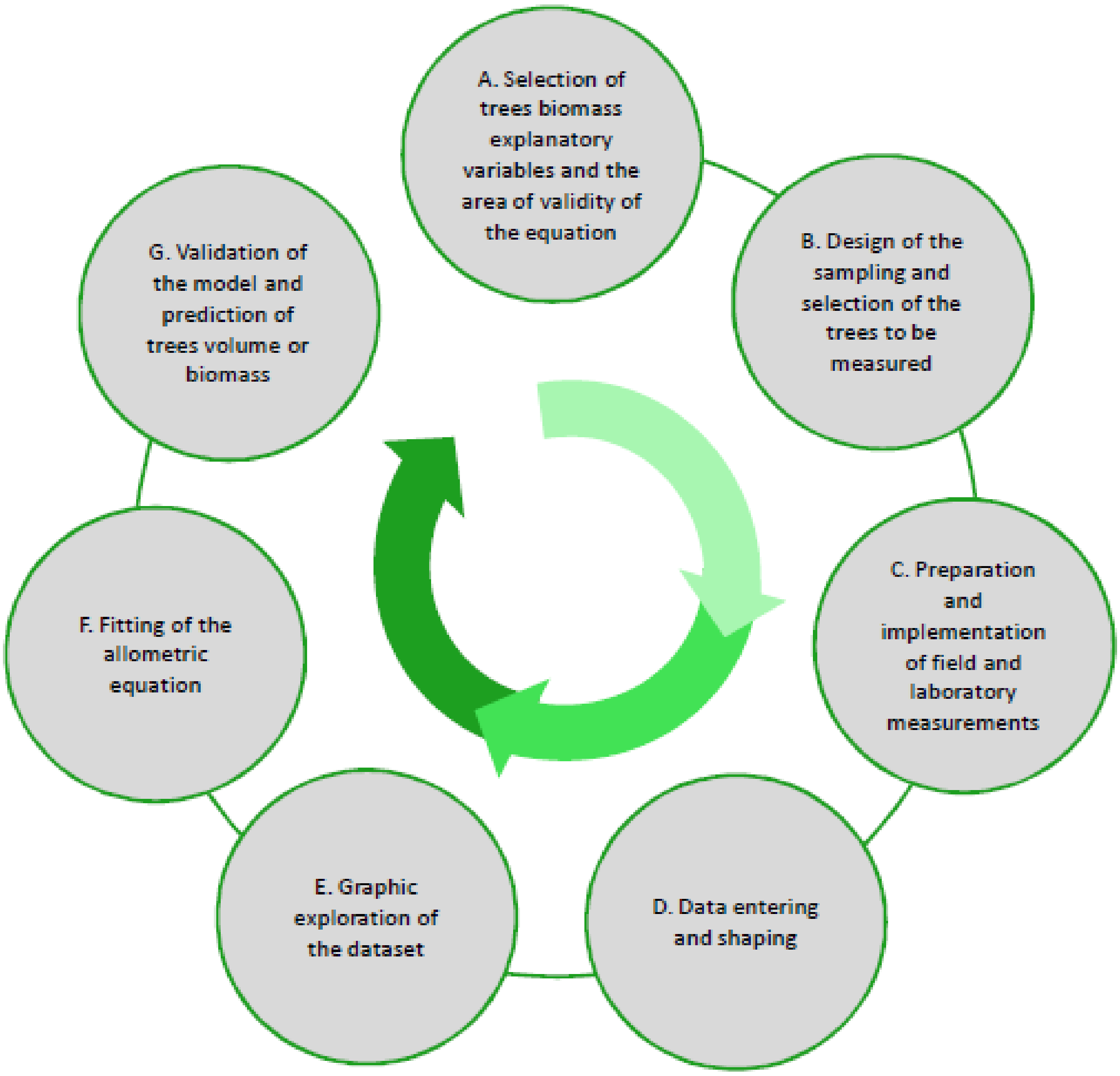
Before undertaking a field campaign for biomass estimation, a rigorous evaluation of the existing information is needed for optimizing the sampling design.

In general the following principles should be considered:

1. Allocate the number of trees to be sampled according to the relative species abundance as determined from the final results of FRA Nepal;
2. Ensure that the entire range of diameters for the selected species is represented in the sample;
3. Introduce ecological criteria to distribute the sample (rainfall, temperature, altitude, etc.) to cover to the extent possible the stand variability;
4. Construct individual biomass tables for the most important species, and average tables for all other species.

The amount of work that can be realistically carried out in the field will depend on financial and technical constraints. A good summary of the methodological steps required to provide accurate allometric equations is provided in the following graph.

Methodological Steps



(Source: *'Summary of the manual for building tree volume and biomass allometric equations – From field measurement to prediction'. CIRAD et FAO, 2012*)

2.6.3 GHG inventory and Reporting

The GHG inventory will be based upon the work done under activity data and emission factors. Once these two pillars are established the GHG inventory is quite straightforward:

Activity data (forest area reduction or increase, or forest degradation) are estimated at national or sub-national level. This gives an estimate of the area change calculated for each process over time;
Carbon stocks are derived from for inventory for each vegetation class, using the stratified approach described above.

Finally the two factors are combined to derive a GHG emission at national or sub-national level.

The proposed MRV procedure for preparing a GHG Inventory is described in the next paragraphs.
In order to illustrate the procedure with realistic data, some preliminary information existing for Nepal, was used, namely:

1. For activity data we used data elaborated in the study "*Evaluation of the forest change assessment of Terai by Walter Antonio Marzoli – MRV Team Leader*" Based on FRA Nepal and preliminary REL data.
2. For emission factors we used data provided in the preliminary Report for Terai provided by FRA Nepal.

It is stressed that the calculations presented here **are not meant to represent any official data.** This exercise is just intended for showing the calculation procedures needed for a GHG Inventory. Use of realistic data was chosen to better illustrate the calculation procedures to be implemented in Nepal, with the data available or likely to be available.

Finally, regarding data supporting this analysis, what is presented here is rather a REL estimation, using the period 1991-2010, although the procedures for a proper MRV GHG emission for say 2010-2015 or 2020 would be technically similar. The reason for presenting an ad-hoc REL as a worked out example is that at the time of drafting of this document (March 2014), the results of the REL Project are not available, and therefore they cannot be used for demonstration.

The quality of the GHG inventory depends not only on the robustness of the results from the measurements made and the credibility of estimates, but also on the manner and method in which the information is collected and presented. Reporting is a key element of MRV because it provides the means by which, in a future REDD+ mechanism, will be assessed the country's performance as compared to its commitments or reference scenario, and therefore will represent the basis for assigning incentives. Information must be well documented, transparent and consistent with the reporting requirements outlined in the UNFCCC guidelines.

Transparency: all the assumptions and the methodologies used in the inventory should be clearly explained and appropriately documented, so that anybody could verify its correctness. GHG estimates are reported at a level of disaggregation which allows verifying underlying calculation and most relevant background data are provided in the report. The possibility to aggregate data at different levels is also functional to the involvement of stakeholders that might potentially have interests that range for the local forest to national scale.

Here is an example on how assumptions and methodologies used in GHG inventory are documented.

Activity data:
For activity data the following data sets are used:
First reference year was 1991, for which land cover area was produced by DoF. The second reference year was 2010, and in this case the preliminary estimates of FRA Nepal were used.
The original activity data figures compiled are as follows:

Table 3: ***Areas in thousands of hectares***

Region	District	Land area	Forest area DOF 1991	Forest area FRA Nepal 2010
Central Region	Bara	106.8	32.6	30.7
	Dhanusa	84.8	0.3	0.4
	Mahottari	84.0	9.5	9.7
	Rautahat	94.1	20.2	18.2
	Parsa	83.5	25.5	24.9
	Sarlahi	102.7	13.3	12.4
Sub-total Central		555.9	101.4	96.3
	Jhapa	141.1	13.6	11.5
	Siraha	93.1	2.0	1.1
	Saptari	105.2	2.1	3.9
	Sunsari	107.6	15.5	15.9
	Morang	148.2	23.3	23.7
Sub-total Eastern		595.2	56.5	56.1
	Kanchanpur	137.7	58.0	57.6
	Kailali	180.7	79.0	69.1
Sub-total Far Western		318.4	137.0	126.7
	Banke	106.2	38.8	35.7
	Bardiya	129.2	50.4	41.1
Sub-total Mid-Western		235.4	89.2	76.8
	Rupandehi	106.5	7.6	6.8
	Nawalparasi	50.1	3.2	3.7
	Kapilbastu	142.9	43.2	35.4
Sub-total Western		299.5	54.0	45.9
Grand Total Terai		2004.4	438.1	401.8

Data are provided by Districts, however in our analysis we will use data for Terai aggregated at Development Region, since every unique combinations of Physiographic Zones and Development Regions represent one stratum, as discussed for the CFI design.

Aggregated Forest Area Change data are as follows:

Physiographic Region: Terai

Development Region	Annual Forest Area Change 1991-2000 Unit: hectares
Central Dev. Region	-270.0
Eastern Dev. Region	-21.1
Far-Western Dev. Region	-542.1
Mid-Western Dev. Region	-652.6
Western Dev. Region	-426.3
Total Terai	-1,912.1

Moreover, the FRA Nepal case study identified not only the total magnitude of forest area change but also the land cover class to class transition, as required, as follows:

Development Region	Land Use / Land cover transition type	Annual area change (hectares)	Type of process
Central Dev. Region			
	Forest to Other Wooded Land	- 16	Forest degradation (1)
	Forest to Agriculture	-159	Deforestation
	Forest to Grassland	-1	Deforestation
	Forest to Other Land	-94	Deforestation
Eastern Dev. Region			
	Forest to Other Wooded Land	- 45	Forest degradation (1)
	Forest to Agriculture	0	Deforestation
	Forest to Grassland	-1	Deforestation
	Forest to Other Land	0	Deforestation
	Agriculture to Forest	+25	Afforestation / Reforestation
	Other land to Forest	+6	Afforestation / Reforestation
Far-Western Dev. Region			
	Forest to Other Wooded Land	-70	Forest degradation (1)
	Forest to Agriculture	-347	Deforestation
	Forest to Grassland	-10	Deforestation
	Forest to Other Land	-115	Deforestation

Note: negative values refer to a decrease in forest area, while positive values refer to an increase.

(1) The term forest degradation is used here purposely in an improper manner. The original process is defined by the FRA document as ‘forest reduction’, implying the transition from forest to other wooded land with tree density not reaching the minimum threshold of 10%. So according to the FAO definition being used it should be a transition from forest to non-forest (Other wooded land), to be assessed as deforestation. However it was decided to record this land cover transition as forest degradation for including examples of various land use / land cover types changes in our reporting example. On the other hand the transition from forest to other

wooded land suggests that the land is not entirely converted to agriculture or other land, implying some elements of forest degradation process is in place.

Emission factors

For emission factors we used a combination of data from different sources mainly FRA Nepal data for Terai for tree biomass and dead wood, MRV WISDOM data for Agriculture and Cropland biomass, and IPCC default values for Belowground biomass.

Unit: Metric tons per hectare

Land Cover	Air Dry Biomass		Oven Dry Biomass		Total Above-Ground Biomass	Below-Ground Biomass	Total Biomass
	tree	dead wood	tree	dead wood		Below-ground	Total biomass
Forests	196.2	6.5	178.5	5.9	184.4	44.3	228.7
Other wooded land	30.0	0.0	27.3	0.0	27.3	5.5	32.8
Cropland	10.0	0.0	9.1	0.0	9.1	1.8	10.9
Grassland	4.0	0.0	3.6	0.0	3.6	0.7	4.4
Other Land	0.0	0.0	0.0	0.0	0.0	0.0	0.0

From biomass data conversion factors related to decrease (or increase) of biomass stock for the recorded land cover class transitions.

Parameters for change matrices. Biomass stock change per ha				Total per ha
LULC Transition	Trees	Dead Wood	Below-ground	
Forest to Other Wooded Land	-151.2	-5.9	-38.8	-195.9
Forest to Agriculture	-169.4	-5.9	-42.4	-217.7
Forest to Grassland	-174.9	-5.9	-43.5	-224.3
Forest to Other Land	-178.5	-5.9	-44.3	-228.7
Agriculture to Forest	100.0	0.0	20.0	120.0
Other Land to Forest	100.0	0.0	20.0	120.0

The following assumptions were made:

For the transitions from forests to any other land cover classes the dead wood biomass was supposed to go to zero. In some areas there was a transition from Agriculture or Other Land to Forest. This was interpreted as afforestation or reforestation, and a tentative value of 100 tons of biomass per hectare, assuming a yield of 5 tons per ha over a 20 years period.

GHG Reporting

Finally the activity data and the emission factors are combined to calculate the emission level. The estimated biomass stock changes in tons per ha of biomass were converted to Mg of Carbon Stock Change per ha using a conversion factor of 0.47. Carbon stocks were then converted into CO2 emissions multiplying Carbon stocks change by 44/12.

Following the format for Reporting GHG emissions suggested by IPCC, the following sample reports have been prepared.

R1. Reporting Unit: Terai – Central Development Region   Reporting period: 1991-2010

Table 1: Biomass Stock Changes									
Land Use Transition Classes	Annual area change (ha)	Biomass Stock Change per unit area (Metric tons per ha)				Total Biomass Stock Change (Metric tons)			
Deforestation		Above ground	Dead wood	Below ground	Total per ha	Above ground	Dead wood	Below ground	Total Biomass Change
1. Forest to agriculture	-159	-169	-6	-41	-216	-26,936	-935	-6,523	-34,394
2. Forest to grassland	-1	-175	-6	-42	-223	-166	-6	-40	-211
3. Forest to other land	-94	-179	-6	-43	-227	-16,787	-553	-4,029	-21,368
Total Deforestation	**-254**					**-43,889**	**-1,493**	**-10,591**	**-55,973**
Forest degradation									
1. Forest to other wooded land	-16	-151	-6	-37	-194	-2,425	-94	-599	-3,118
Total Forest degradation	**-16**	**-151**	**-6**	**-37**	**-194**	**-2,425**	**-94**	**-599**	**-3,118**
Grand Total Biomass Stock Change	**-270**					**-46,313**	**-1,587**	**-11,191**	**-59,091**

Table 2: Carbon Stock Changes										
Land Use Transition Classes	Annual area change (ha)	Carbon Stock Change per unit area (Mg Carbon per ha)				Total Carbon Stock Change (Mg Carbon)				CO2 Emissions
Deforestation		Above ground	Dead wood	Below ground	Total per ha	Above ground	Dead wood	Below ground	Total Carbon Stock Change	Total CO2 Emissions (Mg CO2)
1. Forest to agriculture	-159	-80	-3	-19	-102	-12,660	-439	-3,066	-16,165	59,272
2. Forest to grassland	-1	-82	-3	-20	-105	-78	-3	-19	-99	364
3. Forest to other land	-94	-84	-3	-20	-107	-7,890	-260	-1,894	-10,043	36,825
Total Deforestation	**-254**					**-20,628**	**-702**	**-4,978**	**-26,307**	**96,460**
Forest degradation										
1. Forest to Other Wooded Land	-16	-71	-3	-18	-91	-1,140	-44	-282	-1,466	5,374
Total Forest degradation	**-16**	**-71**	**-3**	**-18**	**-91**	**-1,140**	**-44**	**-282**	**-1,466**	**5,374**
Total C.S.Change	**-270**					**-21,767**	**-746**	**-5,260**	**-27,773**	**101,834**

R2. Reporting Unit: Terai – Eastern Development Region   Reporting period: 1991-2010

Table 1: Biomass Stock Changes

Land Use Transition Classes	Annual area change (ha)	Biomass Stock Change per unit area (Metric tons per ha)				Total Biomass Stock Change (Metric tons)			
Deforestation		Above ground	Dead wood	Below ground	Total per ha	Above ground	Dead wood	Below ground	Total Biomass Change
1. Forest to agriculture	0.0	-169.4	-5.9	-41.0	-216.3	0	0	0	0
2. Forest to grassland	-7.7	-174.9	-5.9	-42.1	-222.9	-1,350	-45	-325	-1,721
3. Forest to other land	0.0	-178.5	-5.9	-42.8	-227.2	0	0	0	0
Total Deforestation	**-7.7**					**-1,350**	**-45**	**-325**	**-1,721**
Forest degradation									
1. Forest to other wooded land	-44.8	-151.2	-5.9	-37.4	-194.5	-6,772	-263	-1,674	-8,710
Total Forest degradation	**-44.8**					**-6,772**	**-263**	**-1,674**	**-8,710**
Reforestation									
1. Agriculture to Forest	25.1	100.0	0.0	20.0	120.0	2,509	0	502	3,011
2 Other Land to Forest	6.4	100.0	0.0	20.0	120.0	636	0	127	764
Total Reforestation	**31.5**					**3,145**	**0**	**629**	**3,774**
Grand Total Biomass Stock Change	**-21.4**					**-4,977**	**-309**	**-1,370**	**-6,657**

R2. Reporting Unit: Terai – Eastern Development Region (continued) Reporting period: 1991-2010

Table 2: Carbon Stock Changes

Land Use Transition Classes	Annual area change (ha)	Carbon Stock Change per unit area (Mg Carbon per ha)				Total Carbon Stock Change (Mg Carbon)				CO2 Emissions
Deforestation		Above ground	Dead wood	Below ground	Total per ha	Above ground	Dead wood	Below ground	Total Carbon Stock Change	Total CO2 Emissions (Mg CO2)
1. Forest to agriculture	0.0	-79.6	-3	-19	-102	0	0	0	0	0
2. Forest to grassland	-7.7	-82.2	-3	-20	-105	-635	-21	-153	-809	2,966
3. Forest to other land	0.0	-83.9	-3	-20	-107	0	0	0	0	0
Total Deforestation	**-7.7**					**-635**	**-21**	**-153**	**-809**	**2,966**
Forest degradation										
1. Forest to Other Wooded Land	-44.8	-44.8	-151.2	-5.9	-37.4	-194.5	-6,772	-263	-1,674	-8,710
Total Forest degradation	**-44.8**	**-44.8**					**-6,772**	**-263**	**-1,674**	**-8,710**
Reforestation										
1. Agriculture to Forest	25.1	47.0	0	9	56	1,179	0	236	1,415	-5,189
2 Other Land to Forest	6.4	47.0	0	9	56	299	0	60	359	-1,316
Total Reforestation	**31.5**	**94.0**				**1,478**	**0**	**296**	**1,774**	**-6,504**
Grand Total Carbon Stock Change	**-21.4**					**-2,339**	**-145**	**-644**	**-3,129**	**11,471**

R3. Reporting Unit: Terai – Far Western Development Region Reporting period: 1991-2010

Table 1: Biomass Stock Changes

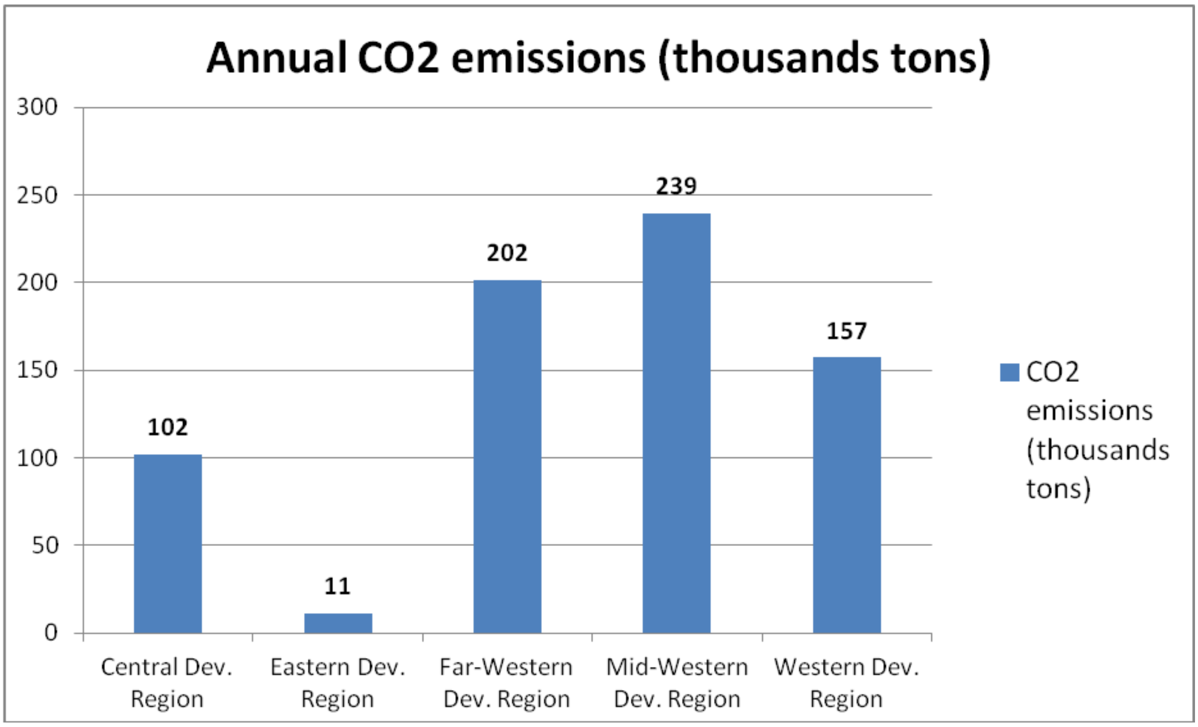
Land Use Transition Classes	Annual area change (ha)	Biomass Stock Change per unit area (Metric tons per ha)				Total Biomass Stock Change (Metric tons)			
Deforestation		Above ground	Dead wood	Below ground	Total per ha	Above ground	Dead wood	Below ground	Total Biomass Change
1. Forest to agriculture	-347	-169	-6	-41	-216	-58,767	-2,039	-14,230	-75,036
2. Forest to grassland	-10	-175	-6	-42	-223	-1,697	-57	-409	-2,163
3. Forest to other land	-115	-179	-6	-43	-227	-20,604	-678	-4,945	-26,228
Total Deforestation	**-472**					**-81,069**	**-2,775**	**-19,584**	**-103,427**
Forest degradation									
1. Forest to other wooded land	-70	-151	-6	-37	-194	-10,604	-412	-2,622	-13,638
Total Forest degradation	**-70**					**-10,604**	**-412**	**-2,622**	**-13,638**
Grand Total Biomass Stock Change	**-542**					**-91,673**	**-3,187**	**-22,206**	**-117,065**

Table 2: Carbon Stock Changes

Land Use Transition Classes	Annual area change (ha)	Carbon Stock Change per unit area (Mg Carbon per ha)				Total Carbon Stock Change (Mg Carbon)				CO2 Emissions
Deforestation		Above ground	Dead wood	Below ground	Total per ha	Above ground	Dead wood	Below ground	Total Carbon Stock Change	Total CO2 Emissions (Mg CO2)
1. Forest to agriculture	-347	-80	-3	-19	-102	-27,620	-958	-6,688	-35,267	129,312
2. Forest to grassland	-10	-82	-3	-20	-105	-798	-27	-192	-1,017	3,728
3. Forest to other land	-115	-84	-3	-20	-107	-9,684	-319	-2,324	-12,327	45,200
Total Deforestation	**-472**	**-80**	**-3**	**-19**	**-102**	**-27,620**	**-958**	**-6,688**	**-35,267**	**129,312**
Forest degradation										
1. Forest to Other Wooded Land	-70	-71	-3	-18	-91	-4,984	-194	-1,232	-6,410	23,502
Total Forest	**-70**					**-4,984**	**-194**	**-1,232**	**-6,410**	**23,502**

degradation										
Total C.S. Change	**-542**					**-43,086**	**-1,498**	**-10,437**	**-55,021**	**201,742**

To make it more informative, the Reporting should display the results in a graphic format as well.



For the future monitoring cycles the results should be reported as follows:

Reporting Unit	Reference period	Annual CO2 Emissions (Gg CO2) (1)	Reference period	Annual CO2 Emissions (Gg CO2) (2)	Difference (2) – (1)
Terai Central Dev. Region	1991-2010	102	2010-2015		
Terai Eastern Dev. Region	1991-2010	11	2010-2015		
Terai Far-Western Dev. Region	1991-2010	202	2010-2015		
Terai Mid-Western Dev. Region	1991-2010	239	2010-2015		
Terai Western Dev. Region	1991-2010	157	2010-2015		
Total Terai	1991-2010	711	2010-2015		

2.6.4 Verification

The dissemination of transparent estimates together with the data (both raw and processed), metadata, tools and documentation and the use of a transparent and replicable methodology respond to two major requirements of the MRV: the results must be available and suitable for an independent review when it will come to carbon claims, and they must be accessible by the stakeholders that must be able to monitor the whole process. The R-PP recommend that the information from the MRV system will be made available at all levels and to actors in different sectors to support decision making related to possible REDD strategy options.

The "Verification" function will be designed to stimulate the participation of all the stakeholders and to allow verification processes through a set of web-based tools for data and metadata sharing and visualization (e.g. Web GIS), and user-friendly graphical user interfaces. Every step of the process and the methods used will be documented and disseminated on the web, according to an access permission policy that will be based on different levels of users. This set of tools will support (internal) Quality Controls and (external) Quality Assurance. The use of data formats compliant with the international standard and the use of open source software would contribute to grant the accessibility of the information and the interoperability of the software platform.

It is suggested that the Verification function will be performed by an international independent authority. Given the present uncertainties of the complex MRV System at national and sub-national level, and on the potential Carbon Credits buyers. This option is left open for each carbon credit buyer to designate the authority for the Verification.

2.6.5 Monitoring

Here we consider that a National Forestry Management System can serve simultaneously two different functions: a "Monitoring" function and a "Measurement, Reporting and Verification (MRV)" function. The "Monitoring" function is primarily a domestic tool to allow countries to assess a broad range of forest information, including in the context of REDD+ activities. It focuses on the assessment of the impacts and outcomes of 1) demonstration activities carried out during the development and implementation of REDD+ and 2) national policies and measures for REDD+ in the operational phase of REDD+ (resulting projected anthropogenic emissions by sources and removals by sinks of GHG). In synthesis, "Monitoring" means tracking national policies and measuring their results.

The monitoring of REDD+ related policies and measures can be related to simple parameters and indicators such as: forest area, number of trees planted, forest ecosystem types, protected areas network creation or enlargement, certification systems implementation, legal context application, participation of the civil society and / or indigenous people. These indicators are not directly related to carbon, but it is clear that this information, when combined with data on trends on forest biomass, could indicate whether the implementation of measures on sustainable forest management is successful.

2.7 Learning plan for the MRV

At National level we propose that the MRV implementation will be carried out by the Central MRV Section to the created within DFRS as a new structure, with the following roles and responsibilities:

MRV section will require one Coordination unit and four independent but closely connected units, namely:

1. Database/IT/ Unit
2. Remote Sensing/GIS Unit
3. Forest Inventory Unit
4. Reporting Unit.

For each unit the MRV Project proposal has clearly identified the benchmarks professional skills that are defined as follows:

Coordination Unit

Expert: MRV Coordinator

Quantity: 1

Role:

- Submits data and reports to REDD Cell.
- Coordinates activity from DFO to central MRV Section.

Expertise / Skills

- Knowledge of MRV REDD+ Guidelines
- Ability to manage and coordinate experts

Job duration: Full time

Database/IT/ Unit

Expert: DB Expert
Quantity: 1
Role: DB administrator manages and maintains MRV database structure (tables, relationships, keys) and assign privileges and roles to different kind of users (public, editor, stakeholder, etc.), according to what REDD Cell defined.
Expertise / Skills

- PostgreSQL / PostGIS
- DBMS performance
- SQL
- Stored Procedures

Job duration: Part time (six man/months per year)

Expert: IT Platform Expert / System Administrator
Quantity: 1
Role: Manages and maintains the IT web platform interface, connections and software updates.
Expertise / Skills

- Linux System installation and upgrade management
- Linux based web server platform (Apache http, Tomcat)
- Object Oriented Programming
- Java
- CMS (liferay, alfresco, wordpress, plone, zoomla, etc.)
- Web applications (GeoServer, GeoNetwork, NFMS)
- Portlet
- Single Sign On
- Object Oriented Programming
- Junit
- Web content management

Job duration: Part time (six man/months per year)

Remote Sensing/GIS Unit

Expert: Remote Sensing specialist

Quantity: 2

Role:
Together with GIS expert they are responsible for land cover and land cover change assessment, spatial data integration in the MRV system at national and sub-national level
.
Expertise / Skills

- Remote Sensing software
- Image pre-processing
- Visual interpretation
- Supervised and unsupervised classification
- Image segmentation
- Accuracy assessment
- Knowledge of the Forestry Sector
- GIS
- Spatial modelling

Job duration: Full time

Expert: Remote Sensing technician

Quantity: 2

Role:
They give technical support to RS specialists in the image classification and land cover change assessment

<u>Expertise / Skills</u>

- Remote Sensing software
- Image pre-processing
- Visual interpretation
- Supervised and unsupervised classification
- Image segmentation
- Accuracy assessment
- Basic of GIS

<u>Job duration</u>: Full time

<u>Expert</u>: GIS specialist

<u>Quantity</u>: 1

<u>Role</u>:

- Together with RS experts he/she is responsible for data collection and harmonization, entry and spatial data integration in the MRV system.
- Manages GIS data in desktop environment doing geometric and attribute edits, spatial analysis, preparing legends and symbology, providing static maps for printing.
- Manages and maintains the Metadata Catalogue: updates of metadata in OGC standard format, manages and tunes the GeoNetwork platform to keep Metadata Catalogue updated and consistent.
- Uploads and updates spatial data in the MRV central database, connected to GeoServer and GeoNetwork platforms

<u>Expertise / Skills</u>

- GIS advanced level
- Vector editing
- Spatial analysis
- Attribute editing
- Create map layouts
- Open Geospatial Consortium metadata standards
- XML
- GeoNetwork and GeoNetwork platform

<u>Job duration</u>: Full time

<u>Expert</u>: GIS technician
<u>Quantity</u>: 1
<u>Role</u>: He/she will support the GIS analyst for the technical work related to spatial analysis and modelling, spatial data editing and map composition
<u>Expertise / Skills</u>

- GIS
- Vector editing
- Spatial analysis
- Attribute editing
- Create map layouts

<u>Job duration</u>: Full time

Forest Inventory Unit

Expert: Forestry Experts

Quantity: 2

Role:
Forest Inventory design, coordination of field work and data processing for estimating emission factors and GHG emissions both at national and sub-national level.

Expertise / Skills
- Sampling design
- Forest inventory
- Forest mensuration
- Statistical analysis
- Reporting

Job duration: Full time

Reporting Unit

Expert: MRV - REDD+ Expert

Quantity: 1

Role:
Provides periodic standard MRV reports (consistent with the reporting requirements outlined in the UNFCCC guidelines) for dissemination of aggregated data and information.

Expertise / Skills
- REDD /MRV Guidelines and methodology
- Biometry
- Statistics
- Quality Control

Job duration: Full time

According to this plan a total of 12 Experts are needed to efficiently run the proposed MRV System at National level, whose Terms of Reference and related skills are detailed above. It is now up to the DFRS to evaluate which of the expertise and skills are already available in-house, especially after the completion of FRA Nepal Project, which skills still need to be developed through on the job training by skilled experts (National or International, depending on the expertise required and available) and which skills are not likely to be available and should be better outsourced. In our vision, there are two high technical positions which are not likely to be available within DFRS, namely the DB Expert and the IT Expert. In this case the solution to outsource these two posts could be the most convenient, keeping in mind that these two Experts are needed on a part time basis and their salaries could be shared with other DB / IT activities within DFRS. In this respect the possible synergies with existing Project are elaborated in the next Section of this document.

The problem of training professional Experts and then retaining them once they have acquired skills that can be better remunerated by the private sector is common to all developing countries, and has no easy solution. Performance based incentives or outsourcing of services are two possible alternatives, however these are political decision to be taken by MFSC and are outside the scope of this consultancy.

However, since the decision whether to outsource the services or to rely on improved institutional capacities have implication on the costs, two scenarios are elaborated in the costs section, one based on outsourcing and one based on existing institutional resources.

In all cases, given the complexity related to the functional implementation of an MRV System, a technical assistance component is foreseen. Ideally the technical assistance should be stronger during the early implementation phase of the MRV, and should gradually decrease over time, when national capacity has been built.

Recommended IT Synergies with existing Projects

The FRA Nepal Project is undertaking development of Open Source Forest Information System (OSFIS). Currently, a prototype of this system has been developed and is under preliminary testing phase. The OSFIS will be implemented and institutionalized in the Department of Forest Research and Survey (DFRS). The DFRS will act as a custodian and an administrator of the system and data hosted in the system. Currently, FRA Nepal Project is hosting and administering the server system and OSFIS prototype. This responsibility will be transferred to the DFRS by the mid-of the year 2014 during the handover phase of the project. This will be supported by the mechanism of institutional capacity building and human resources development within DFRS, ensuring the sustainability and continuous operations of the OSFIS[5].

For the prototyping phase of MRV, Agriconsulting has provided an autonomous server where the MRV Information System is currently stored.

However a strong recommendation is made to further develop the synergy with FRA Nepal OSFIS, and to finally host both Information Systems (OSFIS and MRV) on the same server.

At present the FRA Nepal Project is negotiating with the Government Integrated Data Centre (GIDC) Singha Durbar. GIDC is established under the premise of National Information technology Centre (NITC) as an Internet Data Centre (IDC). The GIDC is providing centralized location for the storage, management, processing and exchange of data (currently government owned data).

This alternative will significantly reduce the maintenance costs all will also ensure the security of the systems and the databases long term sustainability upon their full institutionalization within the DFRS.

[5] Source: 'Hosting Open Source Forest Information System in Government Integrated Data Center (GIDC) - Technical Note' by Anish Joshi and Ashwin Dhakal – June 2013

2.8 Estimated costs for the MRV at National level

As outlined earlier given the complexity of implementing an MRV System at national level, different alternatives can be undertaken depending on financial, technical and institutional constraints. In our case to the extent possible for each activity a minimum and maximum cost have been calculated and described in this section.

The costs calculated for the MRV implementation at National level include:

1. Institutionalization of the MRV Section
2. Activity data (Remote Sensing and GIS)
3. Emission factors (the Continuous Forest Inventory)
4. Special study on biomass equations

The costs have been calculated for the initial MRV operational period of five years.

Estimated costs for the MRV implementation at national level

(Unit: US$)

Activity / Sub-activity	Year 1		Year 2		Year 3		Year 4		Year 5		Total	
	min	**max**	**min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**
Institutionalisation of the MRV Section											(1)	(2)
Coordination Unit	3,600	10,800	3,600	10,800	3,600	10,800	3,600	10,800	3,600	10,800	18,000	54,000
IT and DB Unit	3,000	9,000	3,000	9,000	3,000	9,000	3,000	9,000	3,000	9,000	15,000	45,000
Remote Sensing and GIS Unit	17,400	52,200	17,400	52,200	17,400	52,200	17,400	52,200	17,400	52,200	87,000	261,000
Forest Inventory Unit	6,000	18,000	6,000	18,000	6,000	18,000	6,000	18,000	6,000	18,000	30,000	90,000
Reporting Unit	3,000	9,000	3,000	9,000	3,000	9,000	3,000	9,000	3,000	9,000	15,000	45,000
Equipment and running costs	24,000	24,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	72,000	72,000
Sub-total Institutionalisation of the MRV Section	57,000	123,000	45,000	111,000	45,000	111,000	45,000	111,000	45,000	111,000	**237,000**	**567,000**
Activity data (Remote Sensing and GIS)											(3)	(4)
Image procurement	10,000	65,000	10,000	65,000	10,000	65,000	10,000	65,000	10,000	65,000	50,000	325,000
Field verification	10,000	50,000	10,000	50,000	10,000	50,000	10,000	50,000	10,000	50,000	50,000	250,000
Sub-total Activity data (Remote Sensing nag GIS)	20,000	115,000	20,000	115,000	20,000	115,000	20,000	115,000	20,000	115,000	**100,000**	**575,000**
Emission factors (the Continuous Forest Inventory)												
Field work	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	1,500,000	1,500,000
Equipment / vehicles (5)	500,000	500,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	700,000	700,000
Quality control of field work on 7% of field plots	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	105,000	105,000
Sub-total Emission factors (the Continuous Forest Inventory)	821,000	821,000	371,000	371,000	371,000	371,000	371,000	371,000	371,000	371,000	**2,305,000**	**2,305,000**
Technical Assistance	270,000	270,000	270,000	270,000	180,000	180,000	180,000	180,000	180,000	180,000	(6) **1,080,000**	**1,080,000**
Special study on biomass equations	0	250,000	0	250,000	0	0	0	0	0	0	(7) **0**	**500,000**
Grand total for MRV at National level	**1,168,000**	**1,579,000**	**706,000**	**1,117,000**	**706,000**	**1,117,000**	**706,000**	**1,117,000**	**706,000**	**1,117,000**	**3,722,000**	**5,027,000**

Notes:

(1) The minimum costs for institutionalisation of the MRV Section are based on GoN Salary schedules.

(2) The maximum costs for institutionalisation of the MRV Section are based on expected fees for performance based incentives or outsourcing of the services.
(3) The minimum costs for RS implementation are based on acquisition of LANDSAT imageries (30 meters resolution).
(4) The maximum costs for RS implementation are based on acquisition of Rapid Eye imageries (6.5 meters resolution).
(5) The costs for equipment and vehicles are expected to be undertaken in first year. For the following years only maintenance costs are foreseen.
(6) Technical assistance (TA) needs will depend on the capacity reached by national actors. At this stage TA needs are budgeted assuming 6 m/m for 3 international experts for on the job training in the field of DB/IT, RS and Forest Inventory for the first two years and 2 m/m for the successive years.
(7) The budget for the special study on biomass equations is based on a binary option i.e.0. minimum: no study, 1. Maximum: full study.

The financial plan for MRV implementation at national is expected to be between 3.7 and 5.0 Million US Dollars for a 5 year cycle and can be further summarized as follows:

(Unit: US$)

Activity	Year 1		Year 2		Year 3		Year 4		Year 5		Total	
Proposed budget	**min**	**max**	**min**	**max**	**Min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**
Institutionalisation of the MRV Section	57,000	123,000	45,000	111,000	45,000	111,000	45,000	111,000	45,000	111,000	**237,000**	**567,000**
Activity data (Remote Sensing and GIS)	20,000	115,000	20,000	115,000	20,000	115,000	20,000	115,000	20,000	115,000	**100,000**	**575,000**
Emission factors (The Continuous Forest Inventory)	821,000	821,000	371,000	371,000	371,000	371,000	371,000	371,000	371,000	371,000	**2,305,000**	**2,305,000**
Technical Assistance	270,000	270,000	270,000	270,000	180,000	180,000	180,000	180,000	180,000	180,000	**1,080,000**	**1,080,000**
Special study on biomass equations	0	250,000	0	250,000	0	0	0	0	0	0	**0**	**500,000**
Grand total for MRV at National level	1,168,600	1,579,800	706,000	1,117,000	616,000	777,000	616,000	777,000	616,000	777,000	**3,722,000**	**5,027,000**

2.8.1 Details of costs estimation

In order to fulfil the ToRs of a well-documented full cost proposal for the MRV the following section is devoted to an analysis of how each cost element was derived.

2.8.1.1 Institutionalisation of the MRV Section

According to our plan a total of 12 Experts are needed to efficiently run the proposed MRV System at National level,

Since the decision whether to outsource the services or to rely on improved institutional capacities have implication on the costs, two scenarios are elaborated in the costs section, one based on outsourcing and one based on existing institutional resources.

Quantity	Profile	Internal DFRS Personnel		Outsourcing or performance based incentives
		Qualification	Annual cost (US$)	Annual cost (US$)
1	MRV Coordinator	Gazetted First Class	3,600	10,800
1	IT System Administrator	Gazetted Second Class	1,500 (part time)	4,500 (part time)
1	DB Expert	Gazetted Second Class	1,500 (part time)	4,500 (part time)
2	Remote Sensing Specialists	Gazetted Second Class	6,000	18,000
2	Remote Sensing Technicians	Gazetted Third Class	5,600	16,800
1	GIS Specialist	Gazetted Second Class	3,000	9,000
1	GIS Technician	Gazetted Third Class	2,800	8,400
1	Forestry Expert	Gazetted Second Class	3,000	9,000
1	Forestry Expert	Gazetted Second Class	3,000	9,000
1	MRV - REDD+ Expert	Gazetted Second Class	3,000	9,000
Total			**33,000**	**99,000**

2.8.1.2 Activity data (Remote Sensing and GIS)

For the national Remote Sensing component two alternatives have been considered:

(1) The use Landsat imageries (30 meters resolution), basically free of costs

(2) The use of Rapid Eye (6.5 meters resolution).The current price for a complete coverage of Nepal is 135,000 US$. Equal to 65,000 US$ per year for a periodic assessment every two years.

Advantages and disadvantages of both methods have been extensively discussed in Working Paper N.7

2.8.1.3 Emission factors (The Continuous Forest Inventory)

The cost estimation for a CFI approach is certainly the most difficult. The following approach was adopted.

Some very useful information about forest inventory costs in Nepal was found in the paper quoted above.

Monitoring Aboveground Forest Biomass: A Comparison of Cost and Accuracy between LiDAR-Assisted Multisource Programme (LAMP) and Field-based Forest Resource Assessment (FRA) in Nepal.
P.N. Kandel, K. Awasthi, S.M. Shrestha, M. Hawkes, T. Kauranne, B. Gautam, K. Gunia, E. Dinerstein. Presented at International Conference on Forest, People and Climate: Changing Paradigm 28-30 August 2013, Pokhara, Nepal.

This paper presents the results of a study which compares the cost and accuracy of LAMP and multi-source FRA methods applied in TAL-Nepal for the estimation of AGB.

On the basis of total allocated budget, costs of field based FRA was USD 0.48/ha. This study reveals that administrative cost (USD 0.26/ha) of field based FRA is higher than the variable cost (USD 0.22/ha). The reason behind is that about 46% project cost goes to the salary of experts; international 39%, regional 7% and about 16% is under operating cost(GoN/GoF 2010).

A break-down of the total cost under each item and cost per hectare are presented in the following Table.

Cost items	Cost US$ / ha	Percent of total cost
Procurement of satellite Image	0.0079	3.60
Procurement of ancillary data & maps	0.0011	0.50
First phase sampling	0.0013	0.59
Method development and testing	0.001	0.46
Training cost	0.0034	1.55
Cost for second phase field inventory	0.15	68.27
Data entry, processing and analysis	0.055	25.03
Total cost	**0.2197**	**100.00**

In the case of proposed CFI approach only the actual implementation costs will be considered i.e. cost for field inventory and data entry, processing and analysis. The administrative costs will be considered under the MRV Section implementation. In fact the Forest Inventory unit of the MRV Section will provide technical supervision, coordination and quality control of field inventory data.

Analysing of variable cost of multisource FRA (Table above) shows that the field inventory forms the most expensive component. Average per plot cost was USD 531.5.

Data entry and processing consists of approximately 23% of the all cost. Expenditure under remaining items seems insignificant.

The actual costs were calculated including the following items

Details of cost items involved in field-based multisource FRA Expenditure items	Details under each items	Data sources
Second-phase field inventory (in-situ measurement)	Preparatory cost Hardship allowance for field crews and local staff paid by the project Expenses required for social survey Accommodation cost for field crew Cost of vehicles and fuel Salary of crew members Field gear	Mission-wise record from FRA Nepal Project Salary sheet
Quality control of second-phase field inventory	About 7% cost of second-phase sampling	Quality control team
Data entry, processing analysis		

Summarizing, the cost per each inventory plot was calculated as follows

Cost of field inventory work (US$ per plot)	Data entry, processing analysis (US$ per plot)	Total cost (US$ per plot)
532	191	723

The estimated costs presented here refer to the experience matured by FRA Nepal in the Terai Region. At present, no updated cost estimations for Hilly and Mountain Regions, as the field work of FRA Nepal is still on-going. However, moving from Terai which is mainly a flat region with good accessibility to hilly and mountain regions of the Country, it is expected that the per unit cost is likely to increase greatly due to steep slopes and poor road network, that may require use of alternative transportation means, e.g. helicopters in some cases. As mentioned earlier, since FRA Nepal has not yet completed the field work in the most difficult terrain conditions, and it was not possible to obtain updated cost estimates. Another question to be considered while estimating costs for consecutive inventory cycles is that these could significantly increase the future, due to prices of materials and labours. For this reason it was decided to adjust the costs also to account for the possibility of using improved materials or new emerging techniques (e.g. LIDAR).

Finally the estimated cost per plot was set at 1,500 US$.

In addition to the costs for field work, the needs for equipment, including vehicles will have to be considered. In our case he costs for equipment and vehicles is expected to

be undertaken in first year. For the following years only maintenance costs are foreseen.
The costs related to technical assistance needs are treated in a separate session. Assuming the cost for field work of 1,500 US$ per plot, the total costs for a CFI over a cycle of 5 years with 200 PSP measured in the field every year is as follows

Unit: US$

Activity	Cost for year 1	Cost for year 2	Cost for year 3	Cost for year 4	Cost for year 5	Total cost
Field work	300,000	300,000	300,000	300,000	300,000	1,500,000
Equipment / vehicles	500,000	50,000	50,000	50,000	50,000	700,000
Quality control of field work on 7% of field plots	21,000	21,000	21,000	21,000	21,000	105,000
Total	**821,000**	**371,000**	**371,000**	**371,000**	**371,000**	**2,305,000**

2.8.1.4 Technical Assistance

Technical assistance (TA) needs will depend on the capacity reached by national actors. At this stage TA needs are budgeted assuming 6 m/m for 3 international experts for on the job training in the field of DB/IT, RS and Forest Inventory for the first two years and 2 m/m for the successive years

2.8.1.5 Special study on biomass equations

For the special study on biomass equation a lump sum of 500,000 US$ has been estimated.

3. THE MRV AT SUB-NATIONAL LEVEL

3.1 Conceptual approach

3.1.1. The role of Community Based Forest Management Units (CBFMU)

Nepal's R-PP envisages local level implementation of specific REDD+ activities wherever CBFMU areas exist. REDD+ initiatives and regular/periodic carbon monitoring will be undertaken by respective CBFMU communities with capacity and technical support from local forest authorities.

The present full cost proposal is also aimed at proposing a methodology for assisting in the devolution of management functions and responsibilities (including forest inventory) of large areas of forest to Community Based Forest Management User Groups, and the technical capacity development needs and potentials of CBFUGs as they relate to both forest carbon and more conventional forest inventory and management issues.

Over the last twenty five years, successive government programs, with significant donor assistance, have turned forests over to local communities (in the form of Community Based Forest Management User Groups (CBFMUG) for protection and management. Individually small in area, in total the community forestry subsector consists of some 19,000 CBFMUG and now accounts for around 25 percent of the total estimated forest area (mostly in Hill districts). CBFMUG management seems to be proving sustainable and generally socially sound and equitable (although some significant and troubling instances of elite capture and internal governance problems have been reported). These internal governance challenges interplay with a large scope for improving the technical and commercial quality and profitability of CBFMUG forest management to form the basis for a second generation of community forestry development programming.

While not without limitations, rural communities have demonstrated a great propensity for internal cohesiveness, conflict resolution and stewardship that translate into effective, and sometimes highly effective, forest resource management. These aspects have been fully recognized during the field visits undertaken by the present project (see Working Paper N. 5 for more details).

In our vision, data collected will be transferred to sub-/national MRV system in a transparent manner, and the participating CBFMU communities will be compensated based on an appropriate crediting system established under the REDD+ strategy. An appropriate mechanism for ensuring environmental and social safeguards will be implemented side by side which will consider both environmental conservation, and distribution of carbon and non-carbon benefits ensuring forest dependent interest groups/communities impacted due to REDD+ are benefitted in an equitable manner.

The R-PP also plans to share the carbon monitoring role with local bodies e.g. village development committees (VDCs) in case of "government managed forests" and with buffer zone council and groups in case of forests in "protected areas". The R-PP aims at community based ground inventory for all carbon pools in the long run however emphasizes on above/below ground biomass at initial stages.

Implementation of MRV at CBFMU level

The development of an MRV system at CBFMU level is a challenging issue, both from the technical and the socio-economic point of view. The purpose of this paper is to describe the various steps needed for its implementation.

The proposed approach will rely on three major actors, namely

1. The MRV team established at national level;
2. District Forest Officers and rangers in the districts and FMU levels;
3. CFUGs and other local forest managers in case of different community based forest management modalities.

The role of NGOs and civil society should also be taken into adequate consideration.

Schematically, the implementation of MRV at CBFM unit's level includes the following steps:

MRV Phases	Step	Responsible body	Output / Product
Preparation	Step 1: Preparation phase	FUGs / REDD Cell / MRV Section	A formal agreement between FUGs and the REDD cell / MRV on the establishment of REDD+ activities in given communities.
Measurement of activity data	Step 2: Delineation of project boundaries	FUGs / DFOs / MRV Section Jurisdictional boundary	A digital map with the boundaries of the project area.
	Step 3: Land use and land cover mapping	MRV Section/FUGs/Local forest officers	The baseline LULC map, and the changes that occurred in the recent past, prior to the project initiation.
	Step 4: Stratification of the project area	MRV Section / FUGs / Local forest officers	Project area stratification map
Measurement of emission factors	Step 5: Preparation for the field work and capacity building of local communities.	Local forests authorities / service providers/ NGOs	Local communities are trained for field work.
	Step 6: Pilot inventory for variance estimation	MRV Section / FUGs / local forest officers	Field sampling design established
	Step 7: Field work	FUGs, local forest authorities	Field inventory executed
	Step 8: Quality assurance and quality control	Local forest authorities	Validated field data
	Step 9: Data processing and estimation of emission factors and GHG	MRV Section	Estimation of GHG emissions (REL)

MRV Phases	Step	Responsible body	Output / Product
	emission		
Reporting	Step 10: Analysis of trends	MRV Section	Trends in carbon emission balance established
	Step 11: Detection of leakage	MRV Section and local forest officers	Quantification of leakage
	Step 12: Estimation of net (deducting leakage) carbon emissions	MRV Section	Net carbon emission balance established
	Step 13: Collating and presenting the information on GHG emissions/removals.	MRV Section	A report in a REDD+ standard and documented format.
Verification	Step 14: Verification	Independent authority	Certified net carbon emissions
Payments of carbon credits	Step 15: Payments of carbon credits	MRV Section and designated REDD+ authorities	Carbon transactions in place
Follow-up	Step 16: Follow-up	MRV Section / REDD Cell	Sustainable REDD mechanisms are in place

The procedures presented above for CBFMUs approach are valid for any sub-national unit in general in terms of methodological approach, however there will be differences in the actors involved, depending on the management regime of the forests, as follows:

Forest management regime	Preparation phase	Measurement of activity data	Measurement of emission factors	GHG emission estimates and reporting	Verification, Carbon credits payment and follow-up
Community forests	CFUGs / REDD Cell / MRV Section	MRV Section Support: CFUGs / DFOs	CFUGs Support: Local Forest Officers / MRV Section	MRV Section	Independent authority and Designated REDD+ authorities
Collaborative forests	CFUGs / REDD Cell / MRV Section	MRV Section Support: CFUGs / DFOs	CFUGs Support: Local Forest Officers / MRV Section	MRV Section	Independent authority and Designated REDD+ authorities

Forest management regime	Preparation phase	Measurement of activity data	Measurement of emission factors	GHG emission estimates and reporting	Verification, Carbon credits payment and follow-up
Government managed forests	Local Forest Officers / VDC / REDD Cell / MRV Section	MRV Section Support: VDC / DFOs	Local Forest Officers /VDC Support: MRV Section	MRV Section	Independent authority and Designated REDD+ authorities
Protected forests	National Park Officers / Buffer Zone Council /REDD Cell / MRV Section	MRV Section Support: National Park Officers / Buffer Zone Council	National Park Officers / Buffer Zone Council Support: MRV Section	MRV Section	Independent authority and Designated REDD+ authorities

3.1.2 Capacity building at CBFMU (Institutional, technical)

The MRV approach at sub-national level can be a good opportunity to strengthen the capability of existing CBFMUG to develop sustainable forest management programs on the basis of forest surveys, mapping and analysis.

The component would finance CBFMUG training; provision to CBFMUG of basic survey equipment and tools.

Revision of existing guidelines for CBFMUG operational forest management planning and operations should constitute a natural follow-up to be implemented by a successive project.

Moreover, the CBFMUG approach presents the opportunity to couple the traditional and local knowledge on forest resources, and natural resources in general, with some modern techniques like advanced Remote Sensing, Database and GIS techniques to be applied to forest management in an innovative manner.

In the Section above we have outlined the necessary steps deemed necessary for implementation of MRV at CBFMU level.

The roles and functions of local CBFM practicing groups are emphasized in:

i) preparation phase (step 1);
ii) steps involved in activity data measurement phase (steps 2 – 4); and
iii) Two of six steps involved in emission factor measurement phase (steps 6 and 7) for implementation of field inventory.

More specifically, enabling the CBFM groups to participate meaningfully in REDD+ requires them to acquire:

- Knowledge and awareness about the possible benefits and disadvantages and/or risks associated with establishing REDD+ activities;
- Knowledge and skills involved in delineating forest boundaries;
- Basic understanding of the land use map of CBFM area and ability to interpret the map to some level;
- Ability to understand the basic and specific parameters on which the forest area is stratified and the sample plots are located;
- Knowledge and skills of doing forest inventory and recording the data;

Key role and functions of the DFO and its field staff revolves around the facilitation of whole process involved in all phases of Table. They need to do social/institutional mobilization in close coordination with existing local and district level relevant CSOs and NGOs and at the same time be technically capable to train the CBFM groups on point 2) to 5) above.

DFO staff will also need to record, maintain and manage the measurement related data and communicate with the MRV team at district and sub-/national level MRV teams.

3.1.3 Creating Awareness on REDD and Seeking Free, Prior, Informed Consent (FPIC) for participation in REDD+

In order to understand the need and significance of creating awareness on REDD+ among the participating communities and seeking their FPIC, the MRV project team undertook a case study in the pilot areas of ICIMOD/ANSAB/FECOFUN implemented REDD+ pilot project in Gorkha and Chitawan districts. The findings of the case study reveal that

- Most CFUG members perceive an additional benefits in terms of payment for carbon through REDD+
- IPs and Dalit groups within CFUG found REDD+ to be supportive with respect to strengthening their forest rights and enhancing their livelihoods;
- There has been significant rise in women's participation in forest protection;
- Those engaged in fuel wood and fodder harvesting take special care not to damage new saplings and sprouting shoots of plants;
- Incidences of fire hazard in adjoining forests rarely communicated timely and urgently between concerned CFUGs prior to REDD+ pilot project implementation have now become a regular practice;
- In Kayarkhola pilot area of Chitawan district a drastic decrease in shifting cultivation has been reported;
- Forest dependent households who in past had often found CF threatening to their forest based livelihoods found incentive to engage in forest protection due to alternative livelihoods provided under REDD+;

Key findings as regards REDD related knowledge and awareness creation are: i) it should ideally be undertaken by locally trusted and credible CSOs/NGOs; ii) Awareness should be created on all possible likely issues, challenges and risks associated with REDD+ in future, not only the possible monetary benefits; iii) General bodies of all participating CBFM groups should be well informed and should decide for participation;

An all agreed format for FPIC should be prepared for CBFM groups to submit for planned REDD project.

The case study findings suggest that in future REDD+ project areas in Nepal:

- Awareness creation and capacity building will have to be undertaken extensively prior to embarking on the project implementation. This should include all stakeholders at all levels of the project.
- Capacity building should follow all the steps mentioned in table 3. Communities should have opportunity to engage in agreed process of FPIC.
- Communities participating in REDD+ should understand i) the forest boundary delineation, ii) land use maps development process and interpretation, iii) basic criteria used for forest area stratification and identification of sample plots for periodic measurement. At least two pairs of men and women members of each CFUG should be able to undertake inventories and measurements as per the agreed standards and record the data in standard format.

3.2 Decentralized functions, including personnel, training needs and equipment

3.2.1 The Sub-National Level REDD Cell and MRV Section

Sub-national level institutional and technical arrangements for REDD and MRV is of utmost importance for Nepal given the remarkable diversity in its forest conditions in different physiographic and development regions. Differences in nature, rate and intensity of impact of a range of parameters responsible for deforestation and degradation of forests also demands sub-national level REDD and MRV arrangements and this has been justified by adopting a nested approach for the country.

As shown in the proposed institutional framework for the MRV system, under the policy and strategic guidance of the central level REDD division the sub-national MRV will remain integrated with the national MRV system. The sub-national REDD MRV institution will provide policy and operational guidance for the implementation of MRV at CBFMU level and to REDD FMUs other than CBFMUs (e.g., government managed, collaborative, protected and leasehold forests). It will also oversee and guide the capacity building of various stakeholders and beneficiaries of REDD+ engaged in such projects. Its major technical functions will be i) coordination and implementation of forest inventory and field verification of GIS based forest maps produced from central MRV; ii) data processing and reporting to central MRV; iii) technical/capacity and other defined support at local project (FMU) level;

The sub-national level REDD MRV institution (could be called cell, section or unit) located in the sub-national or regional forestry directorate office) will coordinate with and guide the district/local government level forestry institutions and also supervise and monitor their REDD and MRV related activities. It will be managed by a sub-national level REDD and MRV coordinator (a forestry expert) assisted by an IT/monitoring expert skilled at operationalizing the MRV related data base. Institutional and human resources capacity strengthening responsibilities at sub- national level will be taken care of by the relevant Regional Training Centre and this will be coordinated by the already existing Regional Forestry Director/Directorate. The forest inventory unit of the central MRV will provide technical assistance to the Regional Training Centres to plan and organise the capacity building activities for all districts in sub-national level.

Human Resources requirements for sub-national level REDD and MRV Unit while no/few REDD+ projects exist in Nepal and sub-national level MRV responsibilities could be taken care of from the regional forestry directorate's office, could be limited to maximum 3, - 1 sub-national REDD and MRV coordinator, 1 IT/MRV database expert and 1capacity building expert.

3.2.2 The District/Local Governance Unit Level REDD and MRV Section

The role of existing DFOs is foreseen to be the depository of REDD related knowledge , official entry point of all sorts of information/data generated in course of REDD+ implementation and as facilitating agency for effective REDD+ implementation at local CBFM and other FMU level. These roles have been well recognized by all stakeholders from national down to local level as revealed from the case study undertaken by the MRV project team (refer to case study working paper)

Despite the fact that participatory approach to forest carbon measurement and monitoring is advocated by all stakeholders, the verification and validation of such data will have to be done by DFO prior to their entry into the national MRV database[6]. DFOs have presence down to the range post level and each range posts are responsible to provide forest protection and management services in tentatively 4 to 10 VDCs. Forest technicians located in range posts work closely with local communities promote CBFM as and where applicable.

At the DFO level therefore, a REDD and MRV section will need to be established with computer and internet based database management arrangements. Forest carbon measurement data from all CBFM units and other FMUs participating in REDD+ will have to be validated by the DFO, refined and entered in the database maintained there. For this purpose it will need a computer operator skilled at data entry, its maintenance and management in DFO.

An adequate number of DFO field staff should be trained to work as a facilitator capable of providing technical assistance to local forest managers of CBFM and other FMUs as and when required. They might also need to create awareness and train the local forest managers involved in participatory forest carbon measurement activities.

Human resources required at DFO level will be at least two forestry technicians with additional knowledge and skills of IT and database maintenance/management. For facilitation and capacity building of local forest managers, at least 4 rangers and 8 forest guards should be trained on REDD and MRV related social and technical aspects.

[6] DFRS exists at the central level and does not have field presence in districts. It therefore, needs to coordinate with DoF and DFO for forest inventory and forest carbon measurement and recording at sub-national and district level.

3.2.3 Functional Relationships along the Three Tiers of MRV System Governance Mechanism

The national/central level MRV Section is overall responsible for all MRV related functions under the policy/strategic guidance of the REDD Division and technical guidance from the Survey Division of the DFRS. It will need to ensure that the sub-national level MRV system is well integrated with the national level. The central level MRV provides all technical/technological support, procures the human resources and builds capacities and infrastructure required for effective management and operationalization of the sub-national MRV. It also steers and supervises the Sub-national level MRV functions.

In addition to performing the MRV functions the sub-national MRV institution also provides the technical oversight, guidance and capacity support to the DFOs for effective and timely forest inventory, participatory forest carbon measurement, data entry and maintenance of database in DFO.

3.3 Technical approach for MRV at Sub-National level

3.3.1 Remote sensing and mapping at Sub-National Level

In Section 2.6.1.5 we have discussed the importance of a nested approach to monitor carbon stock, where a national level is integrated with more detailed local studies in areas of special interest. The general framework of the MRV nested approach is reported in the Working Paper 2. Sub-national studies can be defined at different levels, for example regional or local. The MRV nested approach is focused on the local level because a locally-based approach that also involves the community in planning, data collection, analysis, and decision making, can potentially generate local support and ownership for the monitoring programme, enhancing its longevity (Palmer Fry 2011). Moreover, in a large portion of Nepal forest there is a direct involvement of local actors in the active management of forest. Thus, this is a consolidated approach and local community can directly benefit from a policies oriented to the reduction of carbon emissions. This is a resource that can be used to increment the reliability of the MRV carbon stock estimations. Other sub-national levels can be defined in the future with some adaptation that can be sensitive to the size of the study area and to the desired level of accuracy of the results.

A land cover change assessment at local level necessarily need a higher spatial resolution of satellite images than that used at national level, a more detailed classification system and more accurate information from the field both for the calibration and for the validation of the classification. This implies higher cost that can be partially reduced by the direct role of local institution and local communities.
The main requirements for a forest cover monitoring system at local level in Nepal are the following:

- It must be financially sustainable (cost-effective), where the cost must be a minimal part of the potential compensation from the REDD+ mechanism; for this reason local studies must have a size above at least 10,000 hectares.

- It must be technically feasible, particularly taking into account the technical resources of the MRV Remote Sensing/GIS unit that will have to take care both of the national and local level
- The level of detail must be higher than the national level, e.g. a reference (nominal) scale of 1:25,000 should be used (corresponding roughly at a minimum mapping unit of 1 hectare).
- It must be consistent when used over time, but as the same time must be flexible in order to use different data source: higher resolution data are costly and it can happen that different sensors will be available at the different point in time. As no very high resolution images are available for the 20th century, historical trend at local level must be based on an integrated analysis of medium (e.g. Landsat) and high resolution images.
- The result must be consistent with the national level: whenever the land cover and land cover change assessment at local level are different from the results produced at national level, the national level should be corrected using the information from the local level (although some difference can be accepted taking into account the different reference scale)
- The methodology must be efficient when performed on a large number of limited and sparse areas (e.g. if many images have to acquired, pre-processing must be simple and fast).
- The approach must include a direct and active involvement of local actors (CFO, CBFM-UG).
- The classification system must include a further level of detail compared to the classes used at national level.

3.3.1.1 Proposed Remote Sensing methodology at Sub-National level

According to the requirement analysis discussed in the previous section, to the official guidelines and to the results of the test done on a pilot area , the best methodology at local level can be synthesises as a temporally and spatially explicit land cover change assessment of the study area and conversion between classes based on high resolution images (e.g. Aster at 15 m resolution, Rapid Eye at 5 m resolution) classified using an automated image segmentation approach with a preliminary expert-based interpretation (supervised classification or visual interpretation) followed by a collection of feedbacks from the local actors and then finalized with a further visual interpretation to integrate the information based on the local knowledge. The minimum mapping unit should be at least 1 hectare. The assessment should be repeated at every reporting time (e.g. every 2 years). The image interpretation will be carried out by the Remote Sensing/GIS unit of the MRV section at central level in coordination with local communities and local institutions that will provide key information to improve the interpretation and field data for the final accuracy assessment. Monitoring at ground level is also essential in addressing the other REDD+ components such as sustainable forest management, forest conservation, biodiversity, and safeguards.

This approach grants a full and effective engagement of indigenous peoples and local communities to the assessment of forest cover change, and the contribution of their knowledge to monitoring and reporting activities (Larrazabal et al. 2012), creating a direct connection with the forestry management plans

Below, more details and discussions are provided about different aspects of the methodology: data source; classification method; classification system; validation of results. In some cases, some alternative options are presented. The final standardized protocols must be defined during the operationalization of the MRV system according to a number of factors, including the available financial resources and more specific requests to participate to the REDD+ mechanism.

The satellite **data source** must be at a spatial resolution of at least 15 meters (or finer), but at the same time must be compatible with the financial resources of the project considering that, unless local studies will be in contiguous areas, an image per study has to be acquired. The cheapest option is Aster, which optical bands have 15 meters of spatial resolution, plus a number of other bands at 30 and 60 meters of resolution. A single scene of about 3,600 square kilometers costs 60 dollars (120 dollars with ortho-rectification). It might be difficult to create mosaics of Aster image if the study area falls into different scenes. An alternative option is RapidEye with 5 meters of spatial resolution. A complete coverage of Nepal in 2010 is already available through the FRA project. This resolution allows a detailed discrimination of forested areas and can also be used to support and validate the land cover assessment at national level. RapidEye costs about 1.3 dollars per square kilometer, but they must be purchased in tiles larger than 500 square kilometers. It is possible to buy the full coverage of Nepal for about 130,000 dollars. This can be good options if many local areas must be analyzed, also considering that the same images can be used at national level (see Chapter 3). If no financial resources are available, Landsat images can be used, applying more detailed interpretation techniques and extensive data from the field. This option is not recommended because the results would be in any case similar to those of the national level. A partial improvement can be obtained with the fusion of the panchromatic band (15 meters) with optical and near-infrared bands. For the future, an interesting perspective for monitoring the local level is offered by the unmanned aerial vehicle.

For the **classification method,** automatic and semi-automatic methods (e.g. segmentation + supervised classification) can be used as basis for the assessment and supervision of the analyst which can also take full advantage of field data and local knowledge, stimulating the involvement of local actors. In this case it is important to give a major to the operators in the interpretation/classification in order to take into proper consideration the feedback from the local communities (a rigid automatic classification would limit the role of local actors only to carry out the field surveys for data validation). The final classification should be performed by the analyst integrating all the available information in a holistic perspective. The minimum mapping unit should at least of 1 hectare (or smaller). A finer “detection unit level” at approximately 0.5 hectare can be used (according to the resolution of the selected data source) in the segmentation process and labelling step before aggregation to 1 hectare objects for the interpretation phase. Detection of changes from the benchmark objects at very reporting time, rather than a new interpretation to be compared to the original, is recommended to detect only real and relevant changes.

Moreover, even if analyst-based approaches are more subjective and have limited repeatability (although they can still be verified), over small areas are usually simpler, faster, and more practical. They are very flexible and can be adapted to availability of expertise and data from different remote sensors. Moreover, analyst-based approaches can better help to keep consistency between local and national level, and can improve the classification of classes with similar spectral response and classes with fragmented spatial patterns.

The **classification system** starts from the classification at national level, adding a further hierarchical level where floristic composition attribute is added to forest classes (e.g. Sal, Tropical Mixed Hardwood, Birch, etc.) through the information provided by the local forestry experts that integrates the information directly derived from remote sensing.

The **validation of the results** can be carried out by local communities with the support of local forestry institutions through field survey and the local knowledge of the area, according to a sampling schema defined by the central MRV Remote Sensing/GIS Unit.

3.3.1.2 Integration with the National Level

It is important that the land cover change assessment at local and national level over the same areas is consistent. The local level will provide more detailed information, it is thus acceptable that, for example, small patches of forest are detected in the local level but non at national level (due to the different MMU). The difference must be limited to these specific cases: wherever the two levels disagree, generally the national level should be corrected using the information coming from the local level.

The spatial consistency can then be achieved using the local level to calibrate/validate the national level, while, whenever the national level is available before the local level analysis is performed, the local assessment can start from the result of the national level. The semantic consistency is given by the use of a hierarchical legend, so that classes at local level will be a more detailed specification of the classes at national level. The coordination between the two levels can be tuned once the system is operational.

3.3.2 Forest inventory

Some details on the forest inventory work to be carried out at sub-national level including CBFMU and other management regimes have been highlighted in section 3.1 above 'Implementation of MRV at CBFMU level'. Summarizing the following steps are required:

i. Preparation for the field work and capacity building of local communities
ii. Pilot inventory for variance estimation
iii. Field work
iv. Quality assurance and quality control

The methodologies to be applied at sub-national level must be consistent with the proposed CFI at national level in terms of Carbon Stock to be measured, in order to ensure a coherent implementation of the nested approach. Similarly to CFI at National level, the Sub-National forest inventories must provide estimates of:

- Number of trees per hectare
- Species composition
- Diameter distribution
- Status of regeneration
- Stem volumes
- Stem biomass
- Total tree biomass
- Seedlings, saplings, shrubs and herbs biomass

- Total above ground biomass, including tree and non-tree (shrubs and non-vascular plants);
- Dead and decaying wood
- Total belowground biomass.
- Total biomass
- Total Carbon Stock

The main difficulty in defining the protocols for forest inventory at sub-national level is that, while for the National level the size of the population to be sampled is well defined (i.e. total forests and other wooded land of Nepal), for the sub-national level the area of interest will be necessarily variable, depending on the number and size of the Forest Management Units (FMU) that will participate in the REDD+ mechanism.

Different FMU can be envisaged depending and the land tenure and management regime, like:

- Community forests
- Collaborative forests
- Government managed forests
- Protected forests

Each FMU should be regarded as a different stratum from the statistical point of view, and sampled independently.

Within each FMU further stratification will be carried out according to the vegetation types defined by the Remote Sensing component.

The Sub-National approach on forest inventory should be based on the FMU concept. A FMU should be defined as a significant territorial unit from the forest management point of view, representing:

- Relatively homogeneous Land Units and Land Systems;
- Land tenure and forest management current status and perspectives;
- Social aspects (including ethnicity, poverty, and other social indicators);
- Environmental risks, including deforestation, forest degradation, soil erosion and risk of biodiversity loss, for instance.

Following this approach, the SNU will not only represent a viable unit for implementing Carbon Emissions reductions, but also a FMU in the sense of the traditional practice of forest management, and thus having close linkages to NAFMIS.

For instance the approach followed by the ANSAB Project, defined by watershed or sub-watershed land units seems promising.

<u>Size of the SNU Projects</u>
Specific attention must be paid on the size of the Sub-National Unit to be considered because the implementation of REDD+ and MRV mechanisms bears some fixed costs which are independent from the area to be considered.

Such fixed costs include, among others:

- Purchase and interpretation of satellite imageries (the smaller the area the higher the costs, in general)

- Purchase of field inventory equipment and training of local personnel
- Administration and REDD+ transaction costs

Such costs need to be supported by a sufficient Carbon Credits compensation expressed in CO2 tons of avoided emissions at current market price. At this stage no consolidated data on the likely present emissions and possible avoided CO2 emissions per hectare of forest is available for Nepal, so the estimation of the minimum viable area for a given REDD+ Project is only tentative, and is based on the existing case studies.

The Sub-National MRV approaches consulted are:

- The ANSAB / ICIMOD / FECOFUN study carried out in three pilot watersheds, covering around 10,000 hectares of forests, and
- The Terai Arc Landscape Project, carried out by WWF and covering around 1 Million hectares of forests

It is evident that the difference in area is huge between the two Projects, and that the approaches followed so far in Nepal are very variable.

Based on the analysis of these case studies, tentatively we estimate that the minimum area of forest for implementing a REDD+ Project at Sub-National level should be not less than 10,000 hectares of forests, based on logistics and economic considerations. However this minimum unit can be revised when data on current CO2 emission are available from FRA Nepal and REL Projects.

As mentioned earlier, the Sub-National MRV approach will not be limited to a specific management regime. However, special emphasis should be given to CBFMU, in view of their territorial importance and of the social and environmental benefits that can be associated to REDD+ mechanisms at CBFMU.

Now, the area of CBFMU in Nepal varies from less than 1 ha to a few thousands hectares. It is then evident that no single CBFMU is eligible for REDD+ and MRV alone.

The average size of Community Forest area was 100 ha in the ANSAB / ICIMOD / FECOFUN study and 150 ha in the Terai Arc Landscape Project. Single CBFMU should be bundled in of FMU of sufficient magnitude.

For example to form a FMU of about 10,000 ha of forests, on average around 100 CBFMU should join. The mechanism of joint forest management among several communities has been successfully implemented in three watershed pilot projects and it is strongly recommended.

<u>Sampling design at Sub-National level</u>
Given the heterogeneity of the FMU at sub-National or local level no uniform and standard sampling design can be recommended. Sampling design can be optimized depending on local conditions like forest types, accessibility, management regime, size, etc.

However some basic principles must be respected for any sampling design chosen:

1. The area must be stratified into
   a) Forest Management Unit type, first, and subsequently into
   b) Major land cover types as defined from Remote Sensing

2. Each stratum will be sampled independently using a significant number of plots per stratum
3. The sampling intensity will be determined for each inventory, using existing variance estimations, if available, or implementing a pilot inventory for variance estimation
4. The number of samples in each stratum will be determined in order to achieve a given level of statistical error (at least a confidence limit of ± 10% at 95% probability should be reached);
5. Both systematic or random sampling can be applied, providing they follow a well-documented and solid statistical procedure
6. The biomass and carbon stock to be measured and reported must be identical in all Sub-National inventories

For Sub-National inventories, given the limited size of the area and the likely much better accessibility, no clustering of plots is necessary, thus independent sample plots can be laid out using a random or systematic design.

Frequency of measurements
It is advisable to repeat field inventory every two years, to increase the consistency and reliability of the emission factors. The repeated field inventories will also provide a better understanding of the degradation processes, which may not be fully captured by Remote Sensing. Frequent monitoring may also be useful to maintain the momentum created with involvement of local communities.

3.3.3 Detection of leakage

Leakage is an important factor to be considered in the MRV. The concept of leakage is related to the idea that local communities involved in REDD activities could preserve the forest area designated under REDD mechanisms, but at the same time they could as well revert to deforestation and forest degradation in adjacent forest areas, outside REDD defined areas. In this case, the statistics derived from REDD committed areas may not reflect the true picture of carbon emission.
For the determining the possible leakage, the following monitoring measures are proposed:

- Extend the forest change monitoring, and ground samples to neighbouring areas using an appropriate buffer (e.g. 5 km.) or better carrying out a contextual land cover analysis, in order to determine which forest areas, within reachable distance, could be a potential source of leaking, and perform RS monitoring and ground samples in order to assess deforestation and forest degradation over time, in such potential leakage areas
- Potential leakage analysis will also be carried out at administrative unit level (e.g. District), in order to determine if Districts, where community based REDD actions are in place, show significant deviations from average deforestation and forest degradation average patterns., which might be an indication of leakage.

3.3.4 Validation, Data processing and Reporting

As discussed earlier the field work for Sub-National forest inventories will be carried out by Forest Community members. Prior to the field work community members will receive appropriate training and equipment for forest measurement. On average 4 members of each Community (two females and two males) should be trained in forest measurement.

In support, DFOs and Rangers will be responsible for:

1. Training of Community members
2. Supply of technical equipment
3. Technical supervision of the field work
4. Validation of the field measurements (at least 10% of the sampling plots should be revisited for quality control)
5. Data processing and
6. Reporting

For data processing and reporting, the MRV Team has implemented a prototype of data entry procedure and reporting, which includes internet based user's friendly computer applications for:

1. Standard Forms for data entry, and
2. Standard Reporting functions including volume, biomass and carbon stock calculations.

This functionality has been integrated in the MRV web portal as a prototype. This application, when finalized, will be run in DFOs Offices and will permit:

1. Immediate calculations of the inventory results at local level;
2. Automatic upload of newly collected inventory data into the central MRV database.

3.4 Estimated costs for MRV implementation at Sub-National level

As stated earlier, a global full cost proposal for the MRV at Sub-National level cannot be completely formulated because the likely area of application is not known *a priori* and in a way will be determined by the success of the REDD+ initiatives at local level.

What can be done at this stage is to try to determine the MRV total costs at SNU on a per area unit base.

Assuming that 10,000 hectares of forests is the minimum unit area for REDD+ viable implementation, the estimated costs will be assessed using 10,000 hectares as baseline for calculations.

According to the proposed institutional architecture, the responsibility of the SNU component of the MRV will be shared among the following actors, in order of importance:

Actors	Main tasks
CBFMU Members	• Verification and validation of satellite based map • Support to stratification of forest types based on local knowledge • Execution of field work
DFO's	• Creating Awareness on REDD and Seeking

Actors	Main tasks
	Free, Prior, Informed Consent (FPIC) for participation in REDD+ • Training of Community members • Supply of technical equipment • Technical supervision of the field work • Validation of the field measurements (at least 10% of the sampling plots should be revisited for quality control) • Data processing and • Reporting
Central MRV Section	• Land use and land cover mapping • Stratification of the project area • Data processing and estimation of emission factors and GHG emission • Analysis of trends • Detection of leakage • Collating and presenting the information on GHG emissions/removals

Assuming a minimum area unit of 10,000 ha of forests, a tentative assessment the costs related to field inventory at Sub-National level, is summarized as follows:

Actor	Item	Year 1	Year 2	Year 3	Year 4	Year 5	Total
CBFMUg	Field work allowances	1,000	1,000	1,000	1,000	1,000	5,000
	Equipment (1)	1,000	-	-	-	-	1,000
Sub-total CBFMUg		2,000	1,000	1,000	1,000	1,000	6,000
District Forest Office	Field work allowances	800	800	800	800	800	4,000
	Equipment (2)	5,000	-	-	-	-	5,000
Sub-total District Forest Office		5,800	800	800	800	800	9,000
Grand Total		7,800	1,800	1,800	1,800	1,800	15,000

The calculations above are based on the following assumptions:

- On average 100 plots are established every 10,000 ha, i.e. one plot per 100 ha;
- Each plot will be measured in one day, meaning that 100 field inventory crew days are needed;
- If, for instance , 4 (four) field crews are deployed then 25 days per year are required for the field inventory work;
- The support of DFO includes awareness raising, local capacity building and quality control of the field measurements.

Regarding the estimated needs for equipment, the following recommendations can be made:

(1) Minimum equipment requirements at CBFMUg
- Diameter tape: for measuring tree diameter
- Meter tape: for measuring distance
- Compass: for measuring bearing
- Clinometer: for measuring tree height and slope
- Plot centre marker: for marking plots
- Number tag: for marking trees
- Spring Scales: for weighing destructive samples
- Cloth bags: for collecting understorey samples
- Hand saws/Sickles: for cutting destructive samples
- Forms and stationeries: for recording data
- Map with coordinates: for locating sample plots
- Densiometer: to determine forest canopy class

(2) In addition to the equipment above, the District Forest Offices should be endowed with the following equipment:
1 or 2 GPS for plot location and boundaries delineation;
1 or 2 Vertex + Transponder for tree height and distance measurements;
1 PC with internet connection and 1 printer for data entry and printing of reports.

Finally an attempt is made here to provide a broad estimate of the MRV costs at National level. Since the total area to be covered is not known a priori, two scenarios have been elaborated, as a minimum and maximum approach, as follows:

a) Minimum scenario: the area under REDD+ at sub-national level is equal to the area to be covered by the on-going R-PIN proposal for the Terai Arc Landscape, covering approximately 1,000,000 ha of forests.
b) Maximum scenario: all CBFMUG of Nepal are involved. In this case the area involved is estimated at approximately 3,000,000 ha.

For each scenario the corresponding costs are estimated as follows:

MRV implementation at sub-national level	Year 1		Year 2		Year 3		Year 4		Year 5		Total	
Scenarios	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Estimated costs	780,000	2,340,000	180,000	540,000	180,000	540,000	180,000	540,000	180,000	540,000	**1,500,000**	**4,500,000**

4. Overall synthesis of MRV costs

The following table presents a synthesis of the estimated costs for an MRV implementation in Nepal according to the proposed nested approach, comprising national and sub-national level, according to a minimum and maximum scenarios. The financial plan for total MRV implementation is expected to be between 5.2 and 9.5 Million US Dollars for a 5 year cycle.

Unit US$

Estimated MRV implementation costs	Year 1		Year 2		Year 3		Year 4		Year 5		Total	
Scenarios	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
MRV at National level	1,168,000	1,579,000	706,000	1,117,000	616,000	770,000	616,000	770,000	616,000	770,000	**3,772,000**	**5,027,000**
MRV at Sub-national level	780,000	2,340,000	180,000	540,000	180,000	540,000	180,000	540,000	180,000	540,000	**1,500,000**	**4,500,000**
Grand Total	1,948,000	3,919,000	886,000	1,657,000	796,000	1,317,000	796,000	1,317,000	796,000	1,317,000	**5,222,000**	**9,527,000**