Training modules *for*

greenhouse gas inventory teams in the Agriculture Forestry and Other Land Use (AFOLU) sector

Coalition for Rainforest Nations

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

THÜNEN

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Training modules for greenhouse gas inventory teams in the Agriculture, Forestry and Other Land Use (AFOLU) sector

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The Coalition for Rainforest Nations (CfRN) conceived of and designed CD-REDD in response to calls from developing and developed countries to initiate and develop GHG inventory practices in rainforest nations. The Coalition leads the project with the assistance of partners, the Thünen-Institute (TI) and the Deutsche Gesellschaftfür Internationale Zusammenarbeit (GIZ) GmbH.

The project's first phase began in early 2008 and successfully transitioned to a second phase in 2009. Through the generous support of BMUB and the cooperation of GIZ, the Coalition oversees project activities in seven countries in West Africa and Latin America and TI. The TI is responsible for project activities in five countries in Southern and East Africa. The CfRN leads common activities for all project countries on a global level.

The CD-REDD project partners
Rome, Italy, June 2014
www.cdredd.org

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1. Introduction

1.1 Target audience

The National Greenhouse Gas Inventory (NGHGI) training targets inventory compilers, individually or as part of an inventory team, dealing with NGHGI, National Communications (NC) and Biennial Update Reports (BUR) for non-Annex I countries. Among them, we especially focus on beginners dealing with NGHGI tasks, in particular working in the Agriculture, Forestry and Other Land Use (AFOLU) sector. Basic REDD+ (Reducing Emissions from Deforestation and forest Degradation) knowledge is helpful, including knowledge about physical correlations or natural sciences and basic political knowledge about international climate change negotiations (UNFCCC).

1.2 Scope

The training provides basic understanding of the AFOLU NGHGI as part of National GHG Inventory System and ultimately as a part of measurement, reporting and verification (MRV) and REDD+:

- To build NGHGI capacity in developing countries in the AFOLU sector with focus on forest-related GHG fluxes.
- To train on the Intergovernmental Panel on Climate Change (IPCC) methods as well as on establishing sustainable workflows and incorporating components recommended for a National GHG Inventory System.

This training is intended to help train experts in their efforts to develop systems of conducting GHG inventories. It contains technical guidance on the process for building up NGHGI. Several modules are illustrated with practical examples based on experiences from the CD-REDD project. Additionally they incorporate results from academic research.

The modules contain references to various parts of the 2003 Good Practice Guidance–Land Use, Land-Use Change and Forestry (GPG–LULUCF) and the 2006 IPCC Guidelines. In some cases, if methodologies have been significantly changed, the revised 1996 IPCC Guidelines are mentioned. The training materials for NGHGI developed by the consultative group of experts (CGE) are used in this training and highly recommended as a summary of information from the Revised 1996 IPCC Guidelines, the Good Practice Guidance 2000 and 2003 GPG–LULUCF.
Building a robust, sustainable, multi-purpose NGHGI relies heavily on internationally available guidance with, inter alia, of the growing set of guidelines provided by the IPCC and the UNFCCC portal on general reporting. This training does not preclude the participant from studying these documents closely, seeking further advice and/or a more detailed description of the matter.

1.3 Structure of the NGHGI training

The training follows a step-by-step approach that guides the user logically through the modules. The different modules are:

1. Introduction
2. The NGHGI
3. The benefits and requirements of a NGHGI
4. Technical elements that compose a NGHGI
5. Capacity building in NGHGI

The training was developed by NGHGI experts from the Coalition for Rainforest Nations (CfRN) and the Thünen Institute (TI).
The developers of this training are happy to receive feedback. In this way, it can be continuously improved and adjusted to the needs of the audience.

2 The NGHGI

This chapter defines what a NGHGI is within the context of REDD+ and NAMAs and how important it is for policy-makers. It also gives an inside to a couple of remarkable decisions made during climate change negotiations.

2.1 Definition

A NGHGI is an assessment of anthropogenic GHG emissions by source and removals by sink and is developed for a variety of purposes, such as international reporting requirements (UNFCCC Resource Guide) and national policy development including Nationally Appropriate Mitigation Actions (NAMA) and policy measures. In this context the NGHGI is an assessment of anthropogenic emissions/removals of the most relevant GHG within a certain region (e.g. regional, national or sub-national) by the main economic sectors and period of time, usually a year or another period as defined by the relevant country. Figure 1 shows a graphical projection of principal results of a NGHGI.

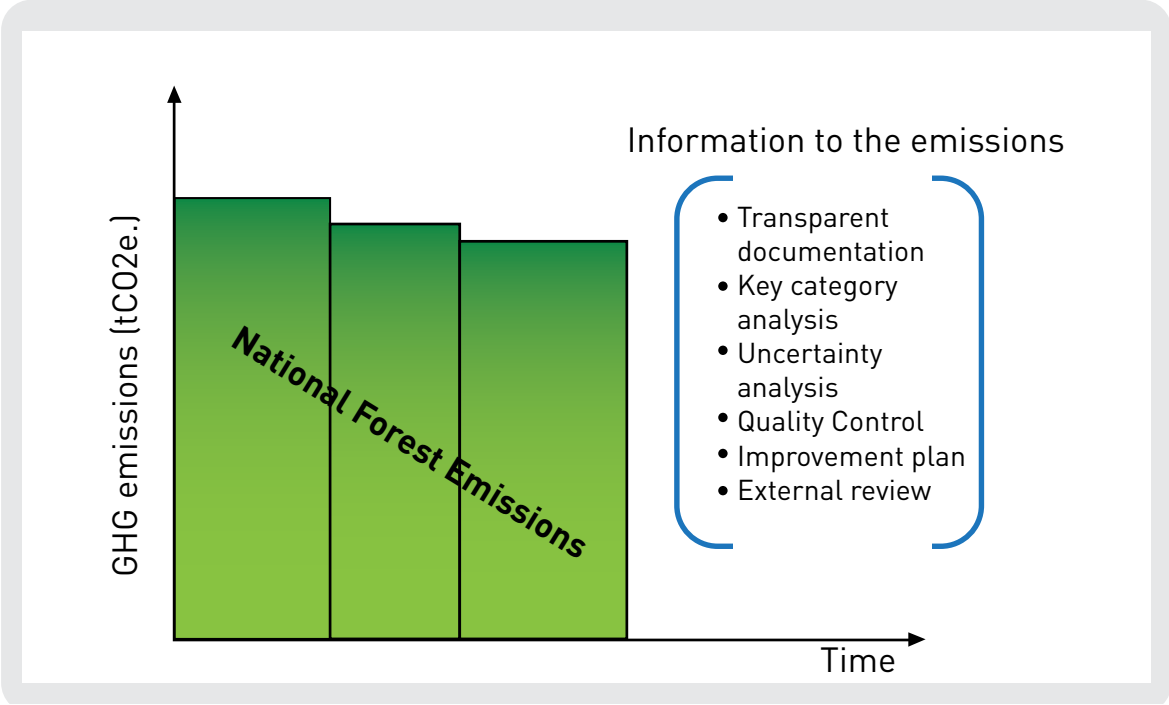

Figure 1 Components of a NGHGI: this is an example of a projection of emissions in the forestry sector, reported in CO2 equivalents. (Figure made by CD-REDD)

The NGHGI should contain credible and accurate information based on sound national and international scientific data sources and methodology. The inventory should be embedded in a National System (NS) with clear national institutional arrangements (IA). It should be handled by a team of technicians from official ministerial institutions with easy access to resource institutions and a good understanding of technical knowledge on how to build up and sustain the inventory.

2.2 The importance of a NGHGI

The importance of a NGHGI is illustrated in the five-part reasoning illustrated in Figure 2.

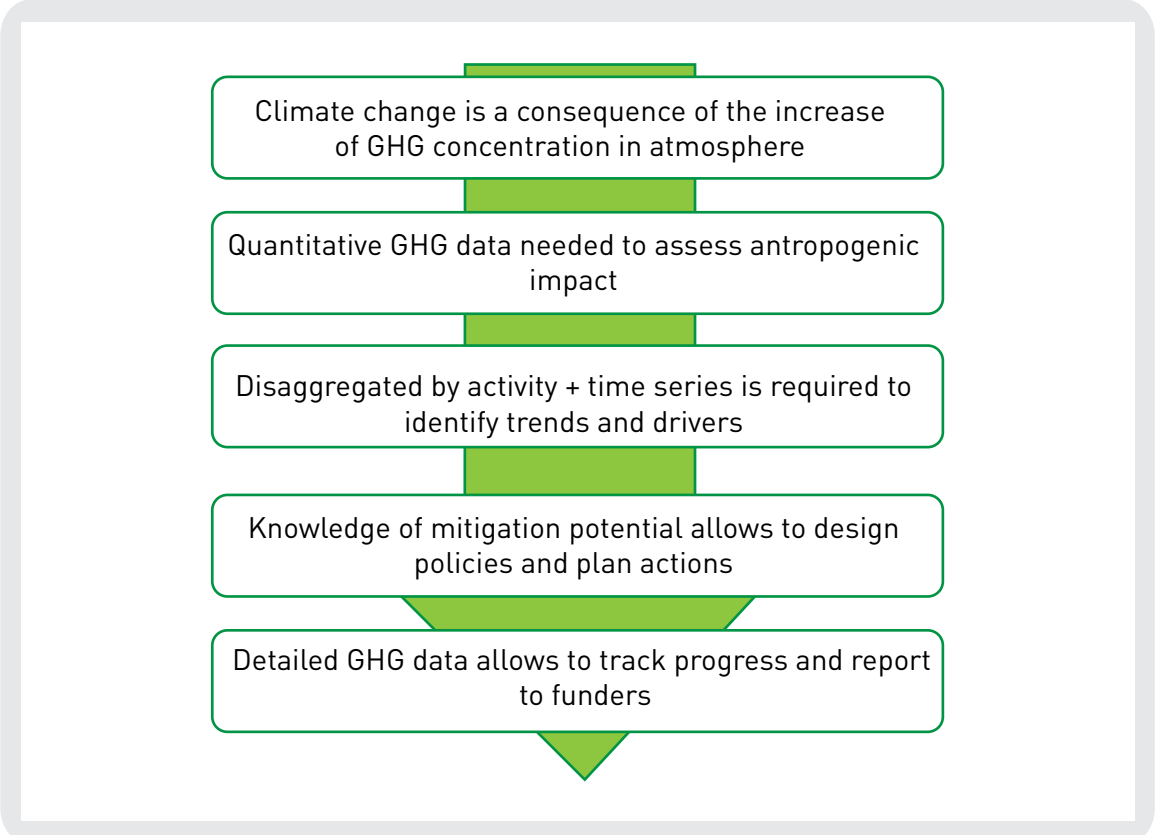

Figure 2. The importance of a GHG Inventory (Figure made by CD-REDD)

One of the most important steps to collectively address the long term challenge of climate change was achieved on 11 December 2010 when Parties during the Conference of the Parties (COP) 16 manage to develop the Cancun Agreement. These are a set of significant decisions by the international com-

munity that comprehensively agreed to take concrete action, over a period of time, to speed up the global response to climate change.

Decision 1, COP16 provides the basis for the largest collective effort the world has ever seen to reduce emissions, in a mutually accountable way, with national plans formalized at international level under the banner of the UNFCCC. They include the most comprehensive package ever agreed upon by governments to help developing nations deal with climate change. This encompasses financial, technological and capacity-building support to help them meet urgent needs to adapt to climate change and to speed up their plans to adopt sustainable paths to low emission economies that can also resist the negative impacts of climate change.

Parties agreed to reduce GHG emissions to avoid an increase in global average temperature of above 2°C (paragraph 4, Decision 1, COP 16). It was also agreed that a low carbon development strategy is a foundation to sustainable development (paragraph 6, Decision 1, COP 16).

Paragraph 10, Decision 1, COP 16 also "realizes that addressing climate change requires a paradigm shift towards building a low-carbon society that offers substantial opportunities and ensures continued high growth and sustainable development" among other things.

Chapter III, Decision 1, COP 16:"Enhanced action on mitigation" in Section B introduces the actions that developing countries should take to address climate change – through National Appropiate Mitigation Action (NAMA).

Section C deals with forests under "Policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+) in developing countries."

These two sections set the track that developing countries should follow to address climate change. The REDD+ mitigation potential by 2020 is estimated at between 1.3 to 4.2 GtCO2eq.

Paragraph 60 of the Decision states clearly that developing countries should "enhance reporting in national communications, including inventories". In the same paragraph (under point c) developing countries have agreed that they "consistent with their capabilities and the level of support provided for reporting, should also submit biennial update reports containing updates of NGHGI, including a national inventory report and information on mitigation actions, needs and support received, with exception of SIDS and LDC countries"

Developing countries have shown a strong interest in slowing, halting and reversing forest cover losses and carbon losses. Paragraph 70, Decision 1, COP16 mentions five areas of REDD+. In the same line under paragraph 71a it says countries must devise a National Strategy or Action Plan and in 71b that developing countries must determine a national forest emission level and paragraph 73 states that activities should be implemented in phases as illustrated in Figure 3[1]:

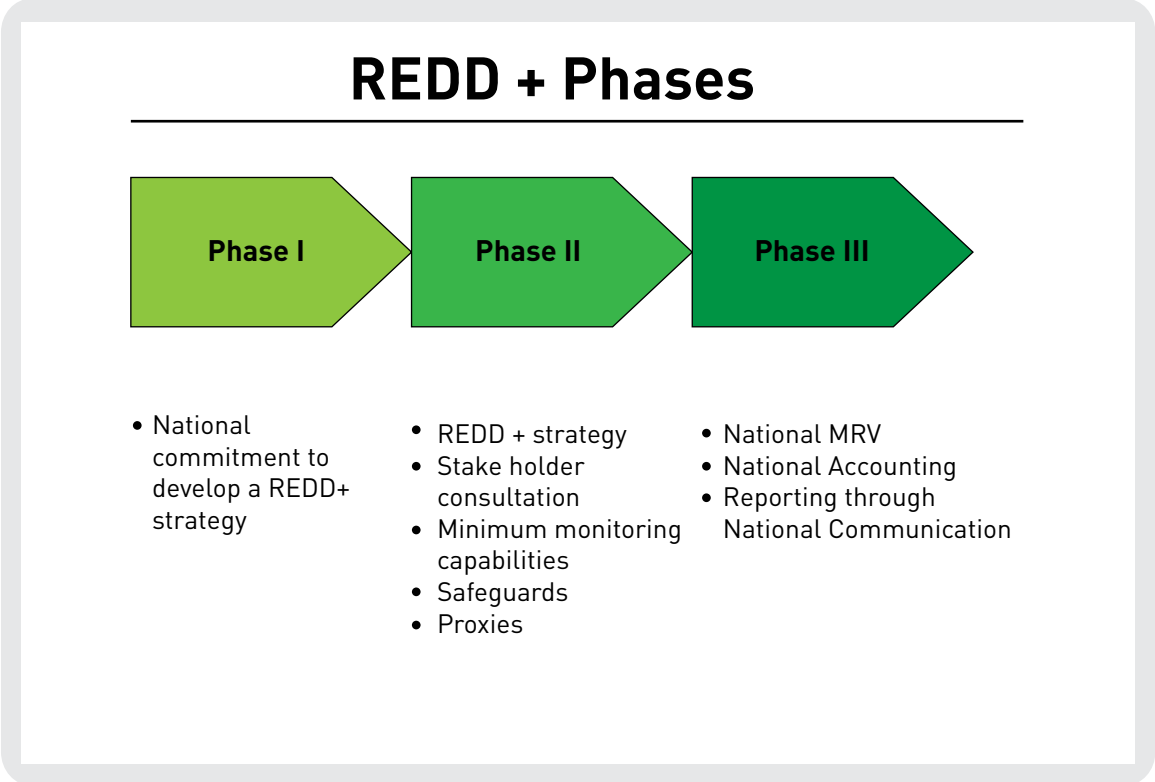

Figure 3. REDD+ Phases (Figure made by CD-REDD)

1 The phased approach for REDD+ was conceived and designed by the Coalition for Rainforest Nations (CfRN) in early 2008. CfRN delivered to the UNFCCC a formal submission of views on the three phases in July 2008 and it was introduced by Ambassador Kevin Conrad at the third meeting of the Ad hoc Working Group on Long-term Cooperative Action in Accra, Ghana in August 2008. The Coalition further defined the phases in a second submission in January 2009.

In order to implement the various phases, the below activities are necessary:

- Phase 1 Activities
  Development of national strategies or action plans, policies and measures, and capacity building.
- Phase 2 Activities
  Implementation of national policies, measures and national strategies or plans that could further TRIGGER capacity building, technology development and transfer and results based demonstration activities.
- Phase 3 Activities
  Implementation of results-based actions that are fully measured, reported and verified.

Under these agreements, developing countries must generate national forest monitoring systems for robust and transparent reporting of activities that will be presented under the BUR to be conducted through an international consultation and analysis (ICA) as stated in paragraphs 63 and 64 of the Decision.

Finally, paragraph 66 "Agrees on a work program for the development of modalities and guidelines for: facilitation of support to nationally appropriate mitigation actions through a registry; measurement, reporting and verification of supported actions and corresponding support; biennial reports as part of national communications from Parties not included in Annex I to the convention; domestic verification of mitigation actions undertaken with domestic resources; and international consultations and analysis."

A capacity development project should respond to the UNFCCC negotiations agreement as explained above. It is extremely important that developing countries start to adapt their own Climate Change Development Plan (CDP) to a Low Carbon Strategy and one of the first and most important steps is to understand their NGHGI. REDD+ is a priority in many developing countries, which means that the NGHGI part related to AFOLU is essential in creating domestic capacity to develop NGHGI in a more consistent way.

2.3 The NGHGI under the convention

The ultimate objective of the UNFCCC is the "... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."
To achieve this ultimate objective, the NGHGI assists the national organization in:

- Quantifying emission levels, identifying the main sources and asses the impact on health and environment through appropriate models.
- Ensuring compliance with national emission limits and reduction commitments undertaken under various international contexts.
- Developing strategies and identifying abatement priorities through cost–effect analysis and integrated models.
- Verifying the effects of policies and measures undertaken to reduce emissions at different levels (sectoral, regional, national and international).
- Verifying the interaction between sectoral policies, economic accounts and environmental impacts.
- Providing comparable and publicly available information through appropriate indicators.

Stakeholders in countries need to have free access to the appropriate data on GHG fluxes for various reasons:

- **Scientists:** To develop models and assess the impact of human activities on GHG concentration in the atmosphere.
- **Business, public and others:** To develop a better understanding of the sinks, sources and trends of the country's emissions and removals.
- **Policy-makers:** To evaluate the impact of policies and measures on the national GHG budget with the aim of developing low-carbon strategies and policies for emission reductions.

2.4 Commitments by Parties to the convention

Commitments by Parties to mitigate climate change are specified in Article 4 of the convention (see figure 4). The article also includes references to commitments related to the Land-Use Change and Forestry (LUCF) sector.

Article 4, paragraph 1(a)

Develop, periodically update, publish and make available to the COP, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all GHG not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the COP.

Article 4, paragraph 1(d)

Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all GHG not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems.

Figure 4. Commitments related to the Land-Use Change and Forestry (LUCF) sector

A different level of commitment for developed and developing countries (UNFCCC Annex I and non-Annex I Parties, respectively) has emerged from Art. 4 of the Convention. Within the AFOLU sector, mitigation consists of actions taken to reduce GHG emissions and enhance carbon sinks and reservoirs, compared to a business-as-usual scenario/reference level. Parties need to report these actions periodically to the UNFCCC, as specified in a series of decisions agreed upon at the annual Conference of Parties (COP).
Specifically Non-Annex I parties need to report:

- National Communications (NC), containing information on national circumstances, national GHG emissions/removals, steps taken or envisaged to implement the Convention, and any other information considered relevant to the achievement of the objective of the Convention including, if feasible, material relevant to calculations of global emissions and emission trends;

- Biennial Update Reports (BURs), containing updated information on national circumstances and institutional arrangements for reporting on a continuous basis, national GHG emissions/removals information, including a national inventory report, and information on mitigation actions, effects, needs, and support received.

National communications may be submitted (decision 10/CP.2) by non-Annex I Parties every 4 years following decisions for each submission taken by the Conference of the Parties (COP). They are prepared and reported periodically by non-Annex I Parties based on agreed reporting guidelines (decision 17/CP.8)[2] based on methodologies developed by the IPCC and adopted by the COP. Submissions by non-Annex I can be found here: http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

Biennial Update Reports are to be submitted (2/CP.17) by non-Annex I Parties every 2 years, and are prepared on the basis of agreed reporting guidelines (decision 2/CP.17)[3] based on methodologies developed by the IPCC and adopted by the COP. Least developed country Parties and small island developing States may submit biennial update reports at their discretion. The first biennial report (BUR1) is due by December 2014 and it is expected to contain information on current levels and trends of GHG emissions and removals within their territories.

The Biennial Update Reports will be subject[4] to a technical assessment[5] as part of the International Consultation and Analysis process, which is aimed at increasing the transparency of mitigation actions and their effects.

2 Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention (decision 17/CP.18) at http://unfccc.int/resource/docs/cop8/07a02.pdf

3 UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention (Decision 2/CP.17) can be found at http://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf

4 Decision 2/CP.17 (Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention) at http://unfccc.int/resource/docs/2011/cop17/eng/09a01.pdf#page=4

5 Decision ~/CP.19 (Composition, modalities and procedures of the team of technical experts under international consultation and analysis) at http://unfccc.int/files/meetings/warsaw_nov_2013/decisions/application/pdf/cop19_tte_ica.pdf

Read more:

- UNFCCC Resource Guide for preparing the national communications of non-annex I, NGHGI
- Full text of the convention
- The convention, article 4
- Le cadre du REDD et IGES, Workshop in DRC, Kinshasa, May 2013, presentation by Eduardo Reyes

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UNFCCC (2011), Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010, 9th plenary meeting, 15 March 2011. [online: http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2]

UNFCCC (2014), full text of the convention, article 4: commitments, United Nations Framework Convention on Climate Change, 2014 [online: http://unfccc.int/essential_background/convention/background/items/1362.php]

3 The benefits and requirements of a NGHGI

The quality and credibility of NGHGI rely on the integrity of the methodologies used, the completeness of reporting, and the procedures for compilation of data. To promote the provision of credible and consistent GHG information, the COP has developed standardized requirements for reporting on NGHGI. Today, these requirements help Annex I countries developing their National Inventory Report (NIR). Also non-Annex I countries can benefit from the set of guidelines to build NGHGI.

A major part of the provided guidelines and guidance are the so-called TCCCA (transparency, consistency, comparability, completeness and accuracy) principles promoted by the UNFCCC. You can find an introduction to them at the end of this chapter. In order for an inventory to meet the TCCCA principles, it is important to have a reliable National Inventory System (NIS) established.

3.1 Benefits of developing a NGHGI

A NGHGI should be seen not as one product but more as a continuous process checking and assessing itself constantly. To start this process a certain amount of effort has to be made, in order to establish the necessary legal and institutional arrangements, develop capacity and allocate or create a reliable source of funding for this process.

After the establishment of a system, the NIS, the investment starts to pay off by enabling the country to meet the requirements outlined above. Furthermore the NGHGI helps the country in meeting its international reporting requirements by:

- Assessing global progress towards limiting the increase in global temperature and combating climate change.
- Meeting national UNFCCC obligations and participating in future GHG agreements and programs.

It also creates a sustainable NIS with the result that the NGHGI is:

- Useful information for environmental assessment and environmental management.
- Useful data for economic development and planning.
- An ongoing assessment and feedback process regarding implanted policies and measures.
- Applied to all acting institutions in the country – in the government and the non-governmental sector.

3.2 The National Inventory System (NIS)

The IPCC Guidelines and relevant UNFCCC provisions require that Parties to the convention have a national system in place for estimating anthropogenic GHG emissions and removals and for reporting and archiving the results.
In the NIS several components work together to create a NGHGI. The robustness of an NIS is very much dependent on the agreements between the stakeholders involved.

Specific characteristics of organizations forming part of an NIS:

- An implementing organization must be identified for each of the functions.
- For each NIS function an appropriate IA within the organization and/or among organizations, shall be set up in order to ensure efficient performance of the function itself.
- In order for the organization to perform the assigned function, it must have sufficient capacity in terms of:
  - Financial and human resources and technical expertise
  - Legal authority

3.3 Institutional arrangements

IA consist of a set of formal arrangements (such as regulations, directives, laws, decrees or memoranda of understanding) aimed at providing the necessary financial and human resources, as well as the legal authority or mandate to ensure that NIS functions will be entirely and efficiently performed.

A well-functioning IA identifies where possible and/or sets up appropriate organizations to which it assigns the various NIS functions. An appropriate organization is one which has at its disposal the necessary financial resources, facilities, skilled personnel and legal authority to deal with the assigned function. Each organization is accountable for performing its function.

Ideally, a single national and official (by law) organization, called the lead institution, serves as the core engine of the NIS (see Figure 5). It is responsible for the delivery of the NGHGI with the following principal activities:

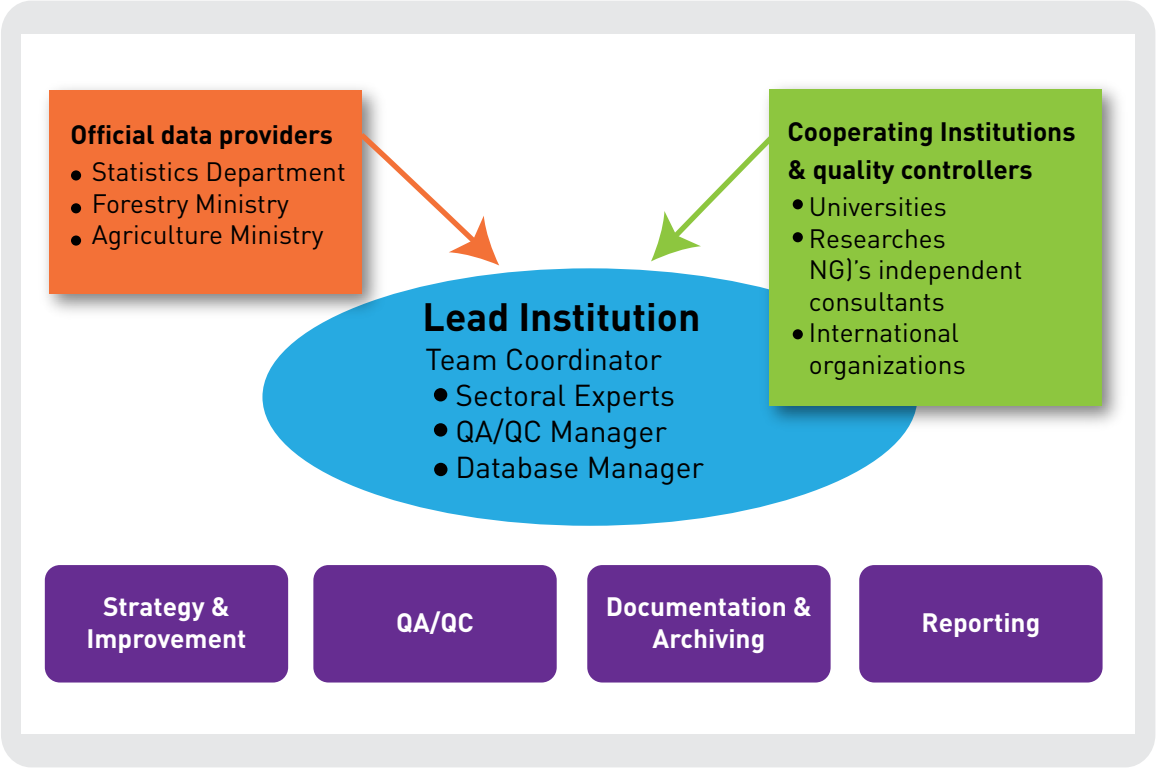

Figure 5. Necessary Institutional Arrangements for GHG Inventories (Figure made by CD-REDD)

- Empowering organizations to collect data by clearly assigning mandates and responsibilities and instructing key data providers.
- Inter-organizational communications and quality assurance/quality control (QA/QC) with legal mechanisms, memoranda of understanding (MoU), formal arrangements and contracts. MoU are frequently use because of their flexibility - they are not time-consuming and can be easily amended and edited.
- Secure sufficient funding for data collection.

In many cases, the statistical division has centralized data, which is important as countries should manage activity data (AD) in one collection center. The choice of organizational structure for the NIS is strongly influenced by existing frameworks. It is good practice to integrate existing frameworks as much as possible to optimize the use of available resources and minimize redundancy and overlap.

By applying this guidance to establish IA it is important to be aware of:

- Conflict of responsibility: Two organizations are assigned the same level of power of intervention on one of the functions.
- Vacuum of responsibility: A function is not assigned to any organization.
- Loops: One organization is assigned a role with authority over another team that in turn has authority over the first organization creating a "loop" of responsibility and hierarchical problems.

There are mechanisms to enhance institutional cooperation. These include: legally binding agreements to engage organizations; building up working groups; coordinating teams; advisory boards and steering committees.

Example: In some countries, there is a missing link between the REDD+ coordinator and NGHGI unit. A possible reason for that is if the NGHGI unit has not been officially recognized in the countries. As such the country's national REDD+ program objectives may risk inconsistency with what the NGHGI unit is setting up. Good coordination is beneficial to both units.

Learn more:

- Country Experiences with National Systems for GHG inventories, Kimberly Todd, UNDP/UNREDD, New York
- Key elements of a National GHG Inventory System, Webinar UNDP/US-EPA

3.4 Functionalities within the NIS

The functionalities of an NIS are based on coordination between organizations. The NIS includes all institutional, legal and procedural arrangements made within a country for monitoring and reporting purposes, in particular for:

- Production of estimates for the NGHGI.
- Reporting and archiving inventory information aimed at ensuring the transparency, consistency, comparability, completeness and accuracy of the NGHGI.

In doing the above, the NIS collects data from the monitoring instruments (inputs) and expands on it in the NGHGI (outputs).

According to the Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol (Decision 19, CMP.1)[6] the functions of the NIS are to establish and maintain the institutional, legal and procedural arrangements that:

- Ensure sufficient capacity for timely performance of the functions.
- Plan, prepare and manage for national annual inventories and supplementary information (Figure 6).

More specific functions of an NIS are:

6 This is a decision addressed to non-annex I countries, but has a valuable approach towards the national system also for non-annex I countries.

- Inventory planning: designate a single national entity; define and allocate specific responsibilities; develop an inventory QA/QC plan; establish processes for official consideration and approval of the inventory; plan ways to improve the inventory.
- Inventory preparation: collect data, process information and prepare emission estimates in accordance with the IPCC Guidelines; identify key categories; prepare an uncertainty analysis (UA); implement QA/QC procedures; compile information for reporting in accordance with Article 7, paragraph 1, of the Kyoto Protocol.
- Inventory management: archive inventory documentation; provide review teams with information and clarifications.
- Review QA/QC: data;the methodologies; verification by implied emission factors (EF) – GHG emission divided by the EF should give reasonable area/activity data; external review.
- Report emissions to the COP through the Secretariat of the UNFCCC as required in the Reporting Guidelines of the UNFCCC.
- Archive calculations and NIR. Document and keep both electronic and hard copies.

The functions of an NIS could be part of a biennial cycle of actions to prepare the inventory for the next biennial update reporting event. Learn more about the separate components of the biennial production cycle in module 4 Technical elements that compose an inventory.

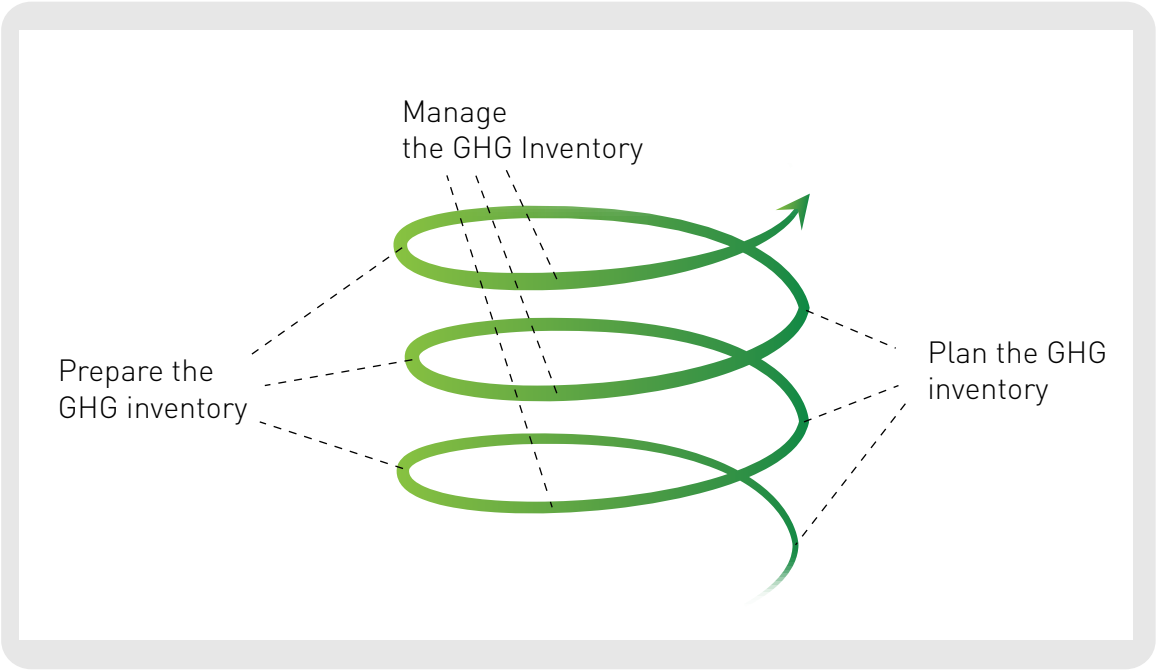

Figure 6. Continuous improvement across the GHG inventory cycle (Figure made by CD-REDD)

Learn more:

- Managing the GHG Inventory Process
  National Communications support unit handbook, UNDP
- Institutional arrangements for the national inventory system
  Sandro Federici, Coalition for Rainforest Nations.

Do it yourself:

Institutional Arrangements template US-EPA

3.5 TCCCA principles

The choice of methodology and the way of documenting estimates depends greatly on the national circumstances, capacities and ambition. Estimates submitted under the UNFCCC, should comply with criteria that are interna-

tionally agreed upon. The TCCCA principles are a set of qualitative indicators for assessing estimates. In general the principles state that estimates should be transparent, consistent, comparable, complete and accurate. During the CD-REDD project two further criteria were added to this list: the institutional setup and the approach to strategic inventory management.

- **Transparency** means that the data sources, assumptions and methodologies used for each estimate should be clearly explained, in order to facilitate the replication and assessment. A non-transparent estimate is equivalent to a non-estimate.
- **Consistency** means that an estimate is internally consistent for all reported years in all its elements. An estimate is consistent if the same methodologies have been used for all consecutive years and if consistent data sets are used. Under certain circumstances, an estimate using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner, in accordance with the IPCC Guidelines. To ensure consistency the IPCC provides methods to calculate overlap, surrogate data, interpolation and extrapolation.
- **Comparability** means that estimates of emissions and removals reported by Parties in inventories should be comparable among Parties. For this purpose, Parties should use methodologies and formats agreed by the COP for estimating and reporting inventories. The allocation of different source/sink categories should follow the split of the IPCC Guidelines, at the level of its summary and sectoral tables.
- **Completeness** means that an estimate has full spatial and time coverage e.g. a complete country area in an inventory year. But completeness also means the full coverage of all emissions by sources and removals by sink.
- **Accuracy** means that emission and removal estimates are neither systematically over-or under-estimated with respect to true emissions or removals and that uncertainties are reduced as far as practicable. To promote accuracy, appropriate methodologies should be used in accordance with the IPCC Guidelines.

- **The institutional setup** needs to be built to allow for continuity of activities and capacities, and continuous improvement of NGHGI.
- **Strategic inventory management** should provide for continuous improvement with each iteration of the inventory cycle and connect work to other uses of GHG data beyond NC.

Learn more:

- Presentation review of inventories, because quality matters
  Zoltan Somogyi, CD-REDD
- Presentation national arrangements
  Consultative Group of Experts (CGE), UNFCCC

Do it yourself:

Check the quality and improvements of your NGHGI with the CD-REDD self-assessment questionnaire.

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UNFCCC, 2005, Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol, Decision 19/CMP.1, p.14.

4 Technical elements that compose an inventory

There are several steps to compiling a NGHGI. These steps include planning, data collection, estimation of emissions and removals, verification, uncertainty assessment and reporting. A range of manuals and tools exist to guide an inventory team through the inventory process. It is important that the responsibilities for each of the steps are clearly defined among the inventory team. Figure 7 shows the interrelation of the principle steps in a NGHGI cycle.

Steps of the NGHGI process identified by CD-REDD (slightly different, but based on the steps suggested by the IPCC visualized in Figure 7):

- Define your methodology
- Collect your data
- Carry out key category analysis (KCA) and UA
- Carry out QA and QC
- Document and archive
- Make an improvement plan
- Undergo an external review

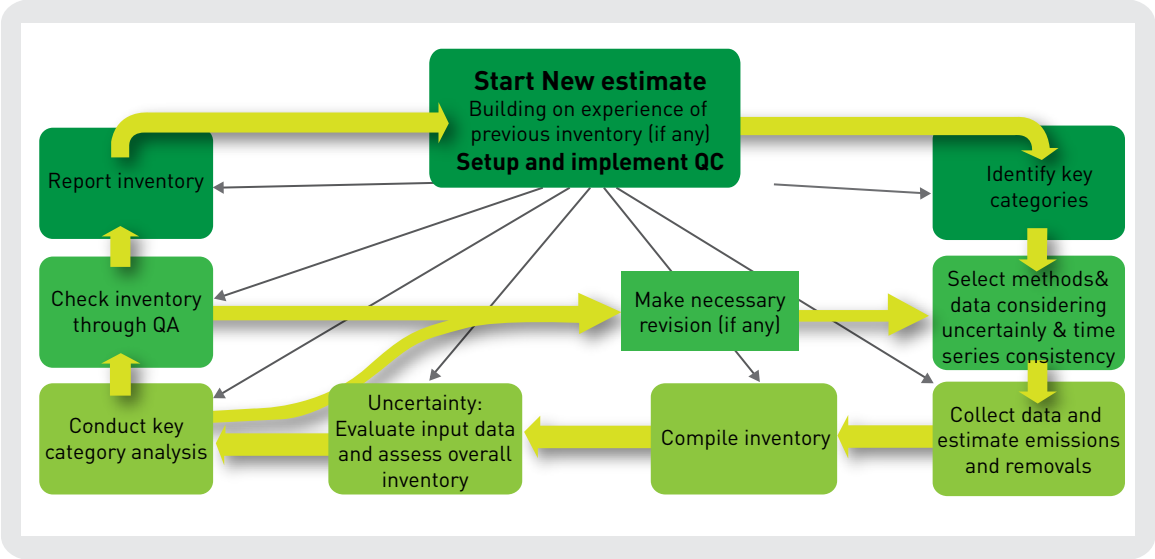

Figure 7. The NGHGI cycle by IPCC[7]

7 Source: Primer of the guidelines

4.1 Available guidance on estimating and reporting

The 2006 IPCC Guidelines provide default methods (Tier 1) for each source/sink category. An IPCC default method is based on assumptions and inferences considered quite robust and able to produce GHG estimates in any region of the world, with an acceptable level of uncertainties aimed at producing accurate assessment of trends.

An IPCC method does not set a **standard**, it is built on **good practices**. It provides an option as robust as possible.

- **A standard** is a rigid threshold that excludes everything that does not match it.
- **A good practice** is an instruction that can be followed to achieve the target (preparing national GHG estimates) by anybody under different national circumstances.

The IPCC Guidelines are to be followed by every nation for building up NGHGI. Except for the 1996GL, different levels of methodological complexity called Tiers are suggested by the GL (see also Tables 3 and 4). Tier 1 involves the most basic methodology. A Tier 1 NGHGI which involves the application of the most simple methodology using default data (i.e., averages suggested by IPCC for countries with lack of data) should always be seen as a starting point for further expansion on the country's strategy on improving its estimates.

The IPCC Guidelines not only give a complementary introduction to the topic of NGHGI, but also a reference to sources of Tier 1 AD and provide a comprehensive list of available default EF's/CSCF's (cross-sectoral correction factors) which are frequently updated in the EF database on the IPCC homepage. This database reflects the latest peer-reviewed set of EF for the various inferences used.

Each sector is divided into different categories and sub-categories of emissions and removals. The LULUCF (until 2013) and/AFOLU (beginning 2014) sector comprises all the emissions from Agriculture (including livestock, fertilizer and cropland management), Forestry (including carbon-stock changes from

growth, harvest and disturbances) and Other Land Use. Countries following the IPCC Guidelines will create estimates on the level of sub-categories and aggregate total emissions and removals for each category and gas. The Revised 1996 IPCC Guidelines and 2006 IPCC Guidelines differ in reporting categories, especially for the aforementioned sectors of Land-Use Change and Forestry (LUCF) and Agriculture.
This section gives the reader an overview of the default reporting categories according to the Revised 1996 IPCC Guidelines, the 2003 GPG–LULUCF, and the 2006 IPCC Guidelines and gives references to sources for more detailed information.

4.1.1 Default reporting categories under the 1996 IPCC Guidelines

Non-Annex I countries are required to report GHG using the Revised 1996 IPCC Guidelines. Vol.1, Ch.1 Understanding the common reporting framework, (although they are encouraged to use the 2006 GL). The reporting instructions of the guidelines also include the tables in a template format including a description of variables to be used and the related equation. Supplemented by the meta-information, this is meant for direct use by the inventory compiler. It is important to note that the 1996 GL used a simplified framework to capture land use changes.
Below are the reporting source categories for sector 4 (agriculture) and sector 5 (LUCF) of the Revised 1996 IPCC Guidelines in Tables 1 and 2 respectively.

Read more:

Revised 1996 IPCC Guidelines

Reporting the National Inventory, Revised 1996 IPCC Guidelines, Vol.1, Ch.2

Table 1. Reporting categories for sector 4 (agriculture) according to the revised 1996 IPCC Guidelines (Table made by CD-REDD)

Module	Reporting Category	Notes
4A	Enteric fermentation	CH_4 from domesticated animals Animal species are subcategories Tier 2: enhanced characterization required for different types of cattle
4B	Manure management	CH_4 and N_2O emissions from piled manure Data organized by animal species and Manure Management Systems (MMS)
4C	Rice cultivation	CH_4 emissions from flooded fields through anaerobic decomposition of organic materials Need to define the rice ecosystem, water management and organic amendments
4D	Agricultural soils	N_2O emissions that are direct (fertilizers), indirect (volatilization, run-off and leaching) and from animal production
4E	Prescribed savannah burning	N_2O and CH_4 and some precursors (CO and NOx) from biomass burned on grasslands
4F	Field-burning of crop residues	N_2O and CH_4 and some precursors (CO and NO_x) from burning crop residues
	Abandonment of cropland, pasture, plantation forests or other managed lands	

Table 2. Reporting categories for sector 5 (LULC) according to the revised 1996 Guidelines (Figure made by CD-REDD)

Module	Reporting Category	Notes
5A	Changes in forest and other woody biomass stocks	The most important effects of anthropogenic interactions with existing forests and other land with woody biomass content are considered within a single broad category This includes management such as wood harvest, fuel wood, disturbances, production and use of wood commodities, establishment and operation of forest plantations as well as planting of trees in urban, village and other non-forest locations (CGE Land-Use Change and Forestry sector). This reporting category deals with the emissions and removals of carbon (as carbon dioxide) resulting from changes in forest and other woody biomass stocks affected by anthropogenic intervention. • Need for estimating the total carbon content in annual growth of logged and planted forests • Estimate wood harvested, fuel wood collection, and account for carbon taken out of the forest because of disturbances
5B	Forest and grassland conversion	The conversion of forests and grasslands to pasture, cropland or other managed land can substantially change carbon stores in vegetation and soil (CGE Land-Use Change and Forestry sector). Tropical forest clearing is usually accomplished by cutting understory and felling trees followed by burning biomass on-site or as fuel wood. By this process some of the biomass is burned while some remains on the ground where it decays slowly (usually over a period of ten years in the tropics). Of the burned material, a small fraction (5–10 per cent) is converted to charcoal which resists decay for 100 years or more, and the remainder is released instantaneously into the atmosphere as CO_2.
5C	Abandonment of cropland, pasture, plantation forests or other managed lands	This reporting category deals with net CO2 removals in biomass accumulation resulting from the abandonment of managed lands which regrow into their prior natural grassland or forest condition. (Abandoned lands that further degrade are excluded from this category as they do not contribute to removal and usually have a small contribution to the emissions). • Calculate the annual uptake of carbon through regrowth

Module	Reporting Category	Notes
5D	CO_2 emissions and removals from soils	The methodology includes estimates of net CO2 emissions and removals from three processes: 1. Changes in carbon stored in soil and litter of mineral soils as a result of changes in land-use practices 2. CO_2 emissions from organic soils converted to agriculture or plantation forestry 3. CO_2 emissions from liming of agricultural soils For the Revised 1996 IPCC Guidelines, CO2 emissions or uptake associated with naturally occurring carbonate minerals in soils are not included.
5E	Others	

4.1.2 New approaches for LULUCF under the GPG–LULUCF

Taking into account land-use changes, the GPG–LULUCF is based on a land-use category approach. The concept of different land-representation approaches (Figure 8) is introduced in the 2003 IPCC Guidelines as well. Table 3 shows the reporting categories under the GPG–LULUCF related to the categories of the Revised 1996 IPCC Guidelines. The approach to be used (see approach 1 vs. approach 2/3) by a country depends on the availability of data and their formats.

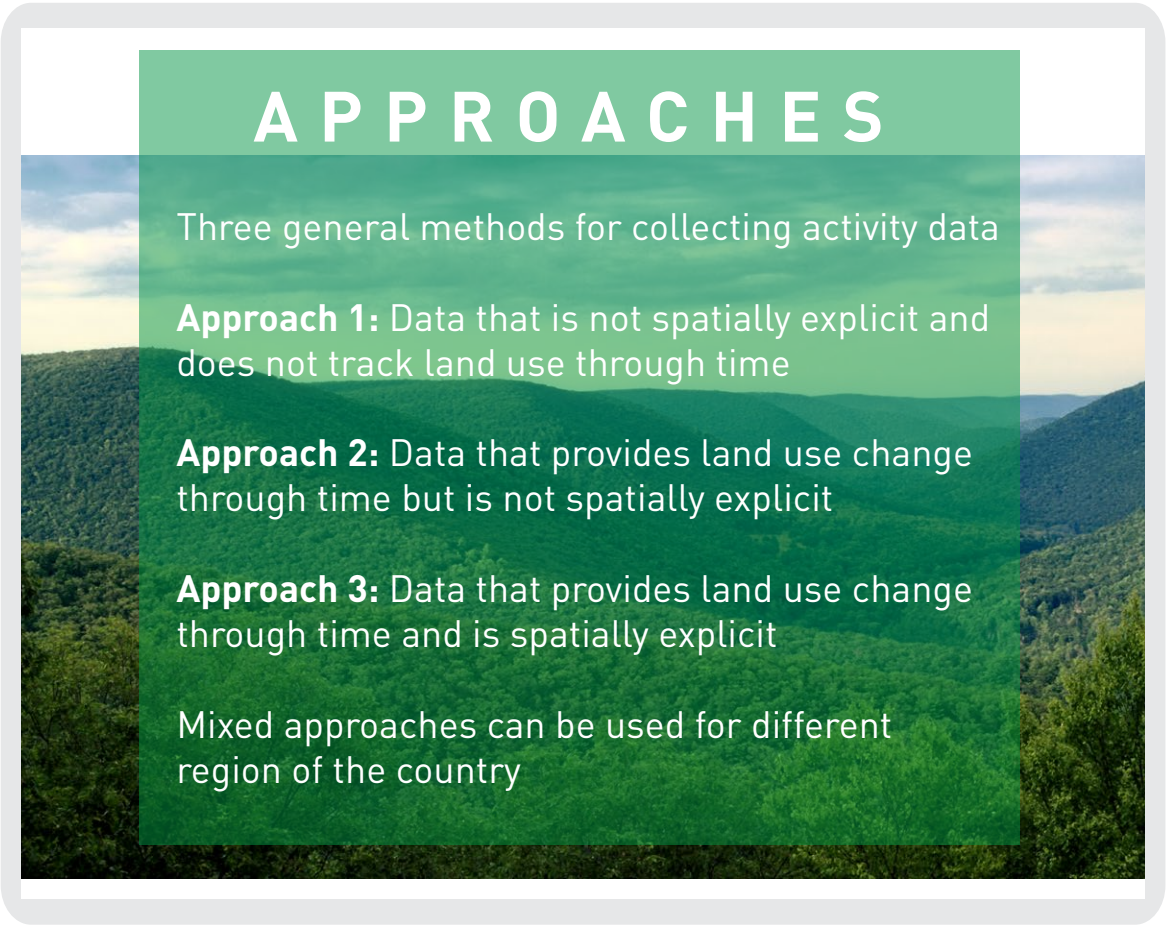

Figure 8. What are approaches? (Source: Ogle, S.M., 2011)

The GPG–LULUCF adopted two major advantages over the Revised 1996 IPCC Guidelines (GPG–LULUCF and CGE Land-Use Change and Forestry sector):

1. Introduction of three hierarchical tiers of methods that range from default data and simple equations to use of country-specific data and models to accommodate national circumstances. Table 3 and Table 4 are examples of data sources for the three different tier levels.

2. Land-use category based approach for organizing the methodologies.

Table 3. Example of sources of Activity Data for different tier level[8] (Source: UNFCCC, 2012 (5))

Activity data	Tier 1	Tier 2	Tier 3
Area of plantation/ forest	» National sources such as the Ministry of Environment / Forests / natural Resources » International data sources such as FAQ and TBFRA	» National sources such as the Ministry of Environment / Forests / Natural Resources	» National remote sending/ satellite assessment source
Harvest categories (e.g. sawn wood, industrial wood and fuelwood)	» National census	» National sources	» National sources according to forest/ plantation categories
Commercial harvest (e.g. industrial roundwood)	» FAO Yearbook of Forest Products*	» National sources » FAO Yearbook of Forest Products	» Country-specific data according to forest/ plantation categories » National production/ consumption data
Traditional fuelwood use	» FAO Yearbook of Forest Products*	» National data sources » FAO Yearbook of Forest Products	» Country-specific data » National production/ consumption data
Other wood use	Same as for commercial harvest/fuelwood use		

* Website: www.fao.org;

Table 4. Example of sources of Emission Factors/Removal Factors for different tier levels (Source: UNFCCC, 2012 (5))

EF/RF	Tier 1	Tier 2	Tier 3
Annual biomass growth rate	» Default values from IPCC 1996GL and GPL2003 » EFDB	» Default data; 1996GL, GPG2003 » Country-specification data » EFDB	» National Forest Inventory (NFI) or Monitoring System (NFMS) » Allometric equation
Carbon fraction of dry matter	» Default data of 0.5	» Default data of 0.5	» Species-specific data from laboratory estimations
Biomass expansion ration (BER)	» Default values of 1.8	» Dafult data of 1.8 » National data for key forest types	» Species-specific data from measurements

8 By the Consultative Group of Experts

Major differences between the Revised 1996 IPCC Guidelines and GPG–LULUCF categories include:

- No one-to-one link between the Revised 1996 IPCC Guidelines categories (5A to 5E) and the GPG–LULUCF land-use categories (i.e. forest land, cropland).
- Additional land-use categories, carbon pools and non-CO_2 gases are included in the GPG–LULUCF.
- For each land-use category of the GPG–LULUCF different categories from the Revised 1996 IPCC Guidelines are to be estimated. For example, category "forest land remaining forest land" of the GPG–LULUCF corresponds to category 5A of the Revised 1996 IPCC Guidelines, whereas under "land converted to forest land" the relevant categories under Revised 1996 IPCC Guidelines are 5A, 5C and 5D (see Table 5 and Table 6 for a comprehensive overview).

Despite the fact that the GPG–LULUCF and the Revised 1996 IPCC Guidelines reporting categories are linked, differences between the estimates could occur as a result of:

- Additional categories
- Additional pools
- Use of improved default values
- Estimation of biomass increment and losses in each land-use category and sub-category
- Link of biomass and soil carbon for each category

Table 5. Land categories and subcategories for 2003 GPG–LULUCF compared with 1996 IPCC Guidelines (Table made by CD-REDD)

Main land-use categories	Subsection in 2003 GPG–LU-LUCF	Sub-categories (based on transformation)	Reporting Category under 1996 IPCC Guidelines
Forest land	3.2.1	Forest land remaining forest land	5A
	3.2.2	Land converted to forest land	5A, 5C, 5D
Cropland	3.3.1	Cropland remaining cropland	5A, 5D
	3.3.2	Land converted to cropland	5B, 5D
Grassland	3.4.1	Grassland remaining grassland	5A, 5D
	3.4.2	Land converted to grassland	5B, 5C, 5D
Wetlands	3.5.1	Wetlands remaining wetlands	5A, 5E
	3.5.2	Land converted to wetlands	5B, 5E
Settlements	3.6.1	Settlements remaining settlements	5A
	3.6.2	Land converted to settlements	5B, 5E
Other land	3.7.1	Other land remaining other land	5A
	3.7.2	Land converted to other land	5B, 5E

Table 6. Differences in the approach and methods adopted in GPG2003 and IPCC 1996 Guidelines (Source: UNFCCC 2012 (5))

GPG2003	IPCC 1996GL
i) Land category based approach covering forest land, cropland, grassland, wetlands, settlements and others	i) Approach based on four categories, 5A to 5D (refer to section 5.1). All land categories not included, such as cof-fee, tea, coconut, etc. Lack of clarity on agroforestry
ii) These land categories are further subdivided into: • Land remaining in the same use category • Other land converted to this land category	ii) Forest and grassland categories de-fined in 5A and 5B differently

iii) Methods given for all carbon pools: above ground biomass (AGB);-below ground biomass (BGB);dead organic matter (DOM); soil carbon and all non-CO_2 gases	iii) Methods provided mainly for AGB and soil carbon Assumes as a default that changes in carbon stocks in DOM pools are not significant and can be assumed to be zero, i.e. inputs balance losses Similarly BGB increment or changes are generally assumed to be zero
iv) Key source/sink category analysis provided for selecting significant: • Land categories • Sub-land categories • C-pools • CO_2 and non-CO_2 gases	iv) Key source/sink category analysis not provided
v) Three-tier structure presented for choice of methods, AD and EF	v) Three-tier structure approach presented, but its application to choice of methods, AD and EF not provided
vi) Biomass and soil carbon pools linked, particularly in Tiers 2 and 3	vi) Changes in stock of biomass and soil carbon in a given vegetation or forest type not linked

4.1.3 Default reporting categories under 2006 IPCC Guidelines

The approaches introduced in the 2003 GPG–LULUCF lay the foundation to the new reporting categories for the AFOLU sector in the 2006 IPCC Guidelines. For an overview of the categories see Table 7. The latest set of IPCC Guidelines also introduced a few changes for estimating the methane and dinitrous oxide emissions from the agricultural sector.

Table 7. Reporting categories for sector 3 (AFOLU) according to the 2006 IPCC Guidelines (Source : 2006 IPCC Guidelines)

Subsection	Reporting category	Which emissions and removals are covered?
3A1	Enteric fermentation	GHG from enteric fermentation consist of methane gas production in digestive systems of ruminants and to a lesser extent of non-ruminants.
3A2	Manure management	GHG emissions from manure management consist of methane and nitrous oxide gases from aerobic and anaerobic manure decomposition processes. Indirect emissions from manure management are accounted for in 3C6.
3B1	Forest land	This category includes: • Forest remaining forestland • Land converted to forestland (from non-forest land i.e. cropland, grassland etc.)
3B2	Cropland	This category includes: • Cropland remaining cropland • Land converted to cropland
3B3	Grassland	This category includes: • Grassland remaining grassland • Land converted to grassland
3B4	Wetlands	This category includes: • Wetlands remaining wetlands • Land converted to wetlands
3B5	Settlements	This category includes: • Settlements remaining settlements • Land converted to settlements
3B6	Other land	This category includes: • Other land remaining other land • Land converted to other land
3C1	Biomass burning	This includes biomass burning on all types of lands under the form of controlled burning and wildfires (only wildfires that result in land-use changes should be accounted for).
3C2	Liming	Liming includes the use of limestone or dolomite on all kind of land.
3C3	Urea fertilization	Urea accounts for CO2 emissions and should be summed for all type of lands.

3C4	Direct N_2O emissions from managed soils	This category includes: • Inorganic and organic N fertilizer application for all type of land • Urine and dung N deposited on pasture, range and paddock by grazing animals • N in crop residues.
3C5	Indirect N_2O emissions from managed soils	Similar to the Revised 1996 IPCC Guidelines this category includes atmospheric deposition and N leaching/run-off.
3C6	Indirect N_2O emissions from manure management	
3C7	Rice cultivation	Similar to the Revised 1996 IPCC Guidelines, except that N_2O emissions are reported under direct N_2O emissions from N fertilizer.
3C8	Other	To be specified.
3D1	Harvested wood products (HWP)	Includes the annual carbon from HWP contributions to CO_2 removals and emissions, which can include: • Annual domestic harvest • Annual export of wood, paper, fuel wood, pulp, round wood and chips • Annual imports of wood, paper, fuel wood, pulp, round wood and chips.
3D2	Other	To be specified.

Read more:

The full table for reporting can be found in the 2006 IPCC Guidelines General Guidance and Reporting, Vol.1, Ch.8, Annex 2: Reporting Tables

Learn more:

- The 2006 IPCC Guidelines and their evolution from the Revised 1996 Guidelines, TFI Presentation at the UNFCCC AWG–KP Workshop on methodological choices, 2008
- The IPCC Guidelines 1996 and 2006, Johannes Broetz, joint meeting, Quito, 2013

Throughout the next sub-sections the 2006 IPCC Guidelines will be consistently referred to.

4.2 Methodology

An inventory team needs to make methodological choices. One important choice to make is the level of detail included. This choice is dependent on the availability of data and on the capacity of the NGHGI system.

In general, every method is based on the combined information on the extent to which human activities take place (captured by the so called AD) with coefficients that quantify the emissions or removals per unit activity (so called EF) which are also called the annual GHG flux (Figure 9). The EF depends on the type of GHG and other circumstances.

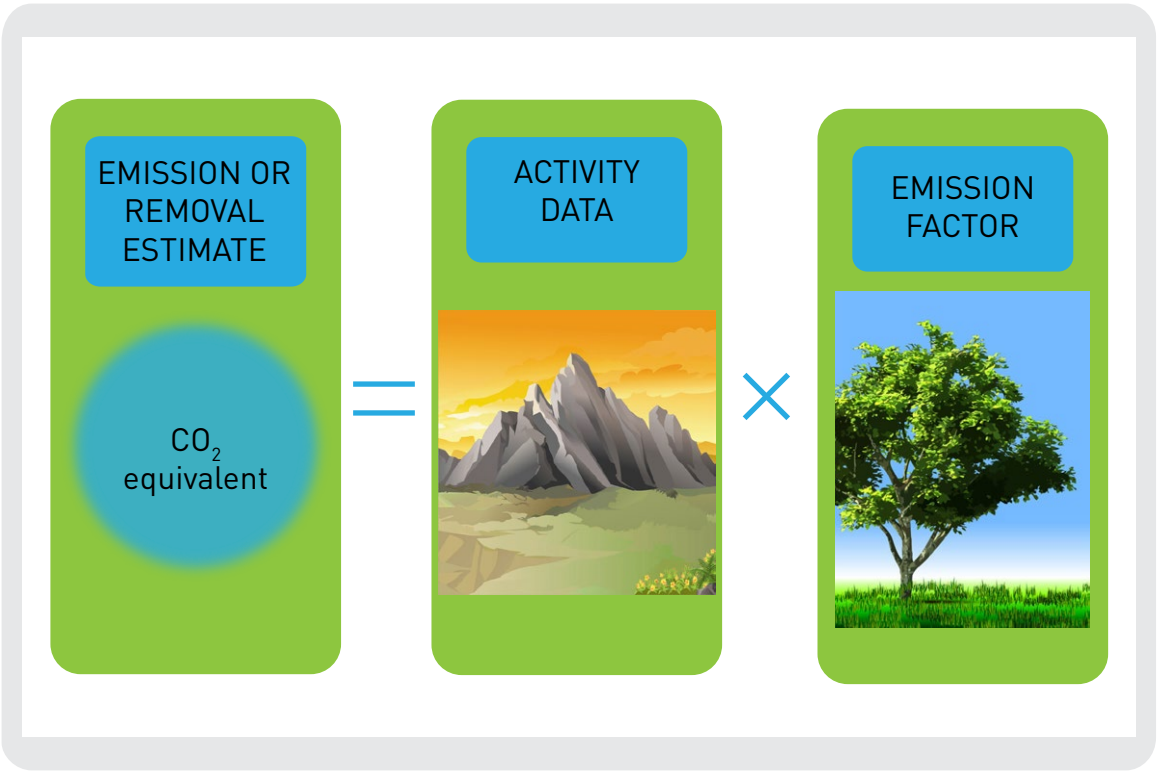

Figure 9. Basic equation to calculate the annual GHG flux (Figure made by CD-REDD)

Emissions are calculated for each source/sink category. Land-related CO2 emissions and removals are calculated from carbon stock changes. The

methodology of estimating such changes are different for different elements of the forest ecosystems that store carbon. These elements are called pools. The 2006 IPCC Guidelines identifies the following pools: above-ground biomass, below-ground biomass, litter, deadwood soil and harvested wood products.

The choice of methodology and the way of documenting the resulting estimates depends greatly on the national circumstances; the availability of capacity; their country-specific data and the level of ambition put into the project of establishing a NGHGI by the acting agencies.
Nevertheless, an estimate can only be accepted when it has the basic value of being transparent, consistent, comparable, complete and accurate according to the reporting principles.

As a rule of thumb, the best method provides GHG estimates:

- With the highest accuracy.
- With resource requirements compatible with the country's financial capacity and technical capability.

Typically, methodologies in the forestry and agricultural sectors contain exceptions to the basic rule of calculating the annual GHG flux. Several processes in the forestry and agricultural sectors are more complex due to parameters dependent on space and time such as carbon stock factors, root to shoot ratios, removal factors etc.

The IPCC Guidelines refer to generic methodologies and category-specific methodologies in the forestry and agricultural sector. An example of a fundamental generic methodological decision is whether the inventory team decides to use Gain-Loss Method or Stock-Difference Method (Figure 10). This decision is often dependent on the choice and use of software package, which is in turn dependent on the availability of consistent data over time.

The Gain-Loss Method is used commonly at Tier 1 level, which uses biomass growth rates that allow for any country to calculate the annual increase in carbon for each land-use type if an estimation of the area under this land use could be made. Tier 2 and 3 have higher levels of accuracy with less uncertain-

ty by use of country-specific data. This often goes hand- in-hand with high level approaches in which more disaggregated AD in time and space is used and therefore with more frequent use of the Stock-Difference Method.

GAIN-LOSS AND STOCK-DIFFERENCE METHOD BY THE 2006 IPCC GUIDLINES

ANNUAL CARBON STOCK CHANGE IN A GIVEN POOL AS A FUNCTION OF GAINS AND LOSSES (GAIN-LOSS METHOD)

$$\triangle C = \triangle C_G - \triangle C_L$$

Where:

C = annual carbon stock change in th epool, tonnes cyr^{-1}

$\triangle C_G$ = annual gain of carvon, tonnes Cyr^{-1}

ANNUAL CARBON STOCK CHANGE IN A GIVEN POOL AS AN AVERAGE DIFFERENCE BETWEEN ESTIMATES AT TWO POINTS IN TIME (STOCK DIFERENCE METHOD)

$$\triangle C = \frac{(C_{t2} - C_{t1})}{(t_1 - t_2)}$$

Where:

$\triangle C$ = annual carbon stock change in the pool, tonnes Cyr^{-1}

Ct1 = carbon stock in the pool at time t1, tonnes C

Ct2 = carbon stock in the pool at time t2, tonnes C

Figure 10. Gain-Loss and Stock-Difference method (Source: 2006 IPCC Guidelines)[9]

Several non-Annex I countries are preparing their inventory by using the most simple land identification approach, i.e. approach 1 (Table 8). In order to move to approach 2 countries need more detailed information on land-use changes on an annual and 20-year basis. As a result, the country can develop a complete land-use conversion matrix (Table 9).

9 Volume 4, chapter 2 generic, equation 2.4 and equation 2.5

Table 8. An example for the 6 land use categories under approach I[10] (Source: 2006 IPCC Guidelines)

THE SIX LAND USE CATEGORIES UNDER APPROACH I		
TIME 1	TIME 2	NET LAND-USE CONVERSION BETWEEN TIME1 AND TIME2
F = 18	F = 19	Forest Land = +1
G = 84	G = 82	Grassland = -2
C = 31	C = 29	Cropland = -2
W = 0	W = 0	Wetlands = 0
S = 5	S = 8	Settlements = +3
O = 2	S = 8	Other Land = 0
Sum = 140	Sum = 140	Sum = 0
Note: F=Forest Land, G=Grassland, C=Cropland, W=Wetlands, S=Settlements, O=Other Land, Numres represent area units (Mha in this example)		

Table 9. An example for the 36 land use categories under approach II visualized with a land use change matrix[11] (Source: 2006 IPCC Guidelines)

THE 36 LAND USE CATEGORIES UNDER APPROACH II VISUALIZED WITH A LAND USE CHANGE MATRIX								
NET LAND-USE CONVERSION MATRIX								
Final	**Initial**	**F**	**G**	**C**	**W**	**S**	**O**	**Final Sum**
F		15	3	1				**19**
G		2	80					**82**
W				0				**0**
S		1	1	1		5		**8**
O							2	**2**
Initial Sum		**18**	**84**	**31**	**0**	**5**	**2**	**140**
Note: F=Forest Land, G=Grassland, C=Cropland, W=Wetlands, S=Settlements, O=Other Land, Numres represent area units (Mha in this example)								

A variety of category-specific decisions need to be made too. Methods can be found in the category-specific chapters of the 2006 IPCC Guidelines (Vol.4, Ch.4–9). E.g. to determine the wood density in a certain sub-stratum of forest

10 Volume 3, chapter 3 land representation, table 3.2"; (numbers are the size of units of land (e.g. million ha) in the various categories)
11 Volume 4, chapter 3, land representation table 3.6"

land it could be decided to calculate a weighted density in function of tree species from default or one could decide to assume the stratum has only one species and use that default density factor. This example illustrates how methods are dependent on the availability of data. Transparent documentation is always important to justify the choice of method. (Glossary of forest land terminology in methods: 2006 IPCC Guidelines Annex 4A.1)

Example:

Methods for estimating forest biomass and changes:
2006 IPCC Guidelines, Vol.4, Ch.4, Box 4.2

Step-by-step procedure to establish your first NGHGI inventory:

1. Develop your system of institutions and persons that have to participate in inventory preparation (RE-NUMBER THE REMAINING ITEMS)
2. Divide all land into managed and unmanaged land.
3. Disaggregate the land into climate/soil/category/sub-category strata = **national land classification system.** (Figure 11)
4. Couple **specific management systems** to e.g. grazing for grassland your strata.
5. Assign **emissions factors** and **stock change factors** to your systems.
6. Conduct a basic **KCA** (key category analysis), **UA** (uncertainty analysis) and **QA/QC analysis.** Go back to steps 1–4 if necessary to revise and improve the estimates.
7. In conjunction with all steps above build your **improvement plan**.
8. Deliver your reporting tables, write **NIR** as input for your BUR, NC.

In all of these steps, it is important to be transparent and to keep a documentation folder in an archiving system.

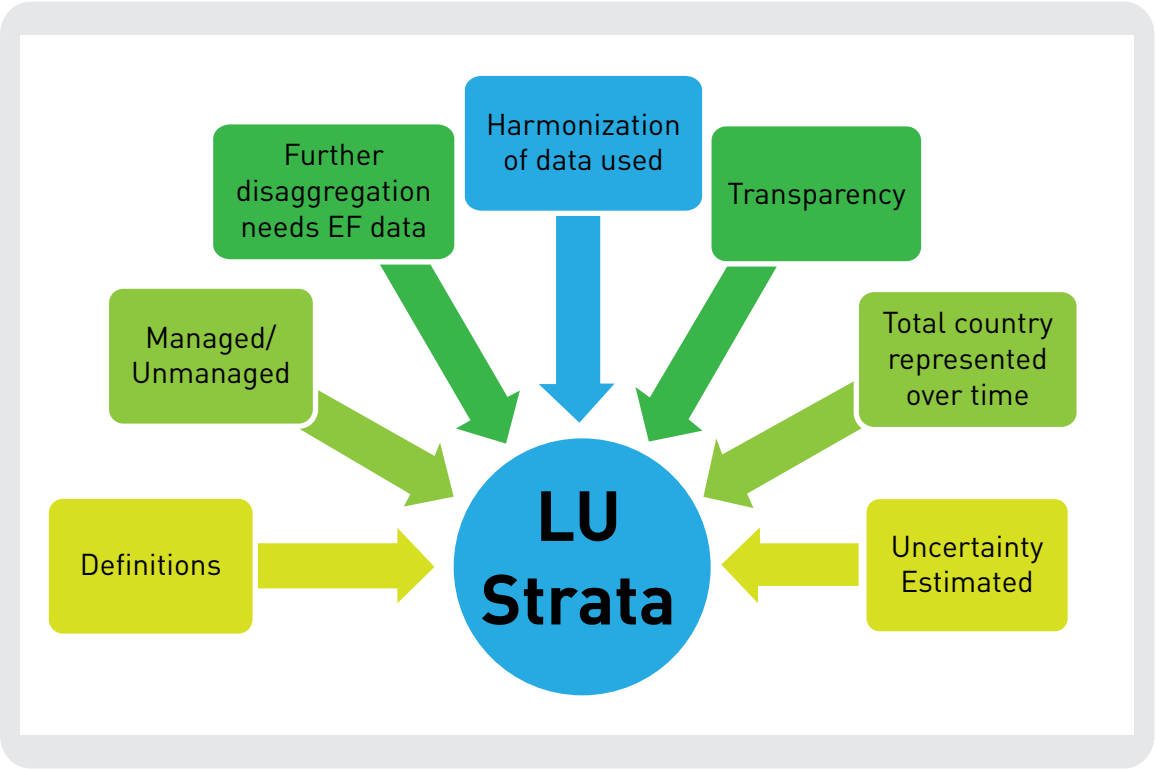

Figure 11. Important parameters to produce land-use strata (Figure made by CD-REDD)

Recommended reading in the IPCC:

- Approaches, Vol.4,Ch.3, 3.3.1
- Tiers in AFOLU, Vol.4, Ch.1, Box 1.1
- Steps in preparing inventory estimates, Vol.4, Ch.1.3.4
- Forest land, grassland, cropland, wetlands, settlements and other land, Vol.4, Ch.4–9. The IPCC provides a useful summary of calculation step for Tier 1 to the end of each reporting category chapter, it also provide valuable information for data sources for AD and EF.

Learn more:

- General methods for estimating stock changes in carbon pools, Sandro Federici, CfRN
- Methods for estimating non-CO2, lime and urea emissions, Marina Vitullo, ISPRA

4.3 Data collection

Data collection carried out for an inventory consists of collecting existing data, generating new data and adapting data for inventory use. There are a variety of data sources with different reliabilities upon which the uncertainty of the input data is dependent. Not all data are of the same importance. In different sectors tier levels can differ from Tier 1 to 3. Tier 1 data are generally default data with high uncertainty, meanwhile Tier 2 data are country-specific estimates with generally a higher specificity or lower uncertainty. Tier 3 data are country-specific and frequently monitored over space and time. A country will invest in generating new data to obtain higher tier levels. It is good practice to use resources for generating data in sectors with key emissions.

The minimum datasets required for AFOLU databases (Figure 12):

- LULC: climate, soil and (sub-) categories
- Land-management classes and systems: crop/tree type and age (special rice-management practices), agroforestry, management practices by category
- Livestock: population and manure management
- Fertilizer and lime
- Sewage sludge systems

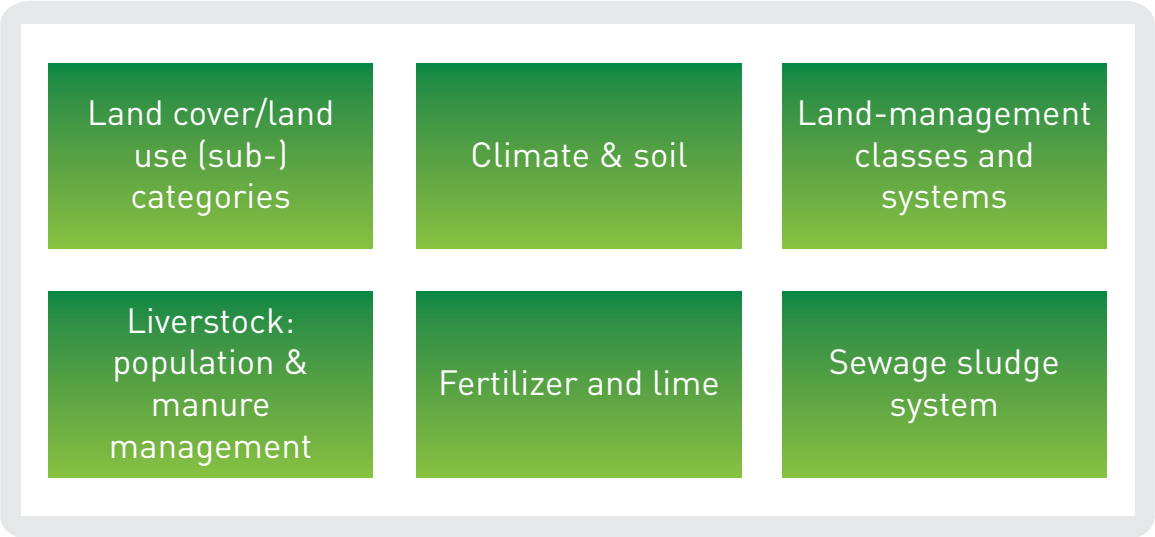

Figure 12. Data sets required (Figure made by CD-REDD)

FAO has launched the FAOSTAT emission database in support of Member Countries to compile NGHGI for the AFOLU sector. This database provides country level estimates of GHG emissions based on FAOSTAT AD (collected through FAOSTAT questionnaires) and using Tier 1 computations, following the 2006 IPCC Guidelines. Technical details of specific AD used and relevant computational steps employed are given (metadata) in order to guide national compilers. Countries can access the database and find information regarding AD, EF and GHG by emission source category here – http://faostat.fao.org.

Recommended reading in the 2006 IPCC Guidelines:

Gathering existing data, generating new data and adapting data for inventory use, vol. 1, ch. 1, ch. 2.2.1-3

Learn more:

- Data collection and analysis, Daniela Romano, ISPRA
- Addressing data gaps,Consultative Group of Experts (CGE), UNFCCC
- FAOSTAT, Rocio D. Condor, Mitigation of Climate Change in Agriculture Monitoring and Assessment of Greenhouse Gas Emissions (FAO's MICCA/MAGHG)

4.3.1 Activity data

The development of a national land-use classification system based on the land-use categories of the guidelines (2006 IPCC Guidelines, Vol.4, Ch.3.2, Table 3.1) is a fundamental first step in data collection. Other fundamental AD consist of management practices and animal populations.

The Global Land Cover Network (GLCN) is an initiative by FAO that aims to standardize the global land cover database. The network provides free global land cover maps with an international legend based on a common agreed land cover classification system (LCCS). These maps cover forest and non-forest areas and are highly recommended as a basis for stratification of the country. Free maps can be downloaded from the The Global Land Cover Network (GLCN).

Recommended reading in the 2006 IPCC Guidelines:

- Activity Data, Vol.1, Ch.2.2.5
- Land Representation, Vol.4, Ch.3, Annex 3A: Development of land-use databases

When it comes to area-based estimations of GHG emissions and removals more than an activity-based assessment, a consistent, reliable, easy-to-handle, affordable and up-to-date data source for area-change estimations is needed. Remote sensing (e.g. the results of processing information collected by remote sensing technologies in a GIS) gives unique opportunities in providing this kind of information.

Remote sensing is an umbrella term for any technology that has the ability to acquire information about an object without making physical contact with it (see Wikipedia -> Remote Sensing). In the case of data collection for a NGHGI, remote sensing technologies come in useful when acquiring information about land cover types and subtypes, especially in isolated or areas further afield.
Typical examples of remote sense data collection activities are raster images obtained by satellite or airborne sensors. These sensors basically collect the backscatter of sunlight radiation from objects such as trees, crops or bare soil in different spectral ranges. The composition of the different spectral ranges gives information about the object under surveillance. (Figure 13 and Figure 14)

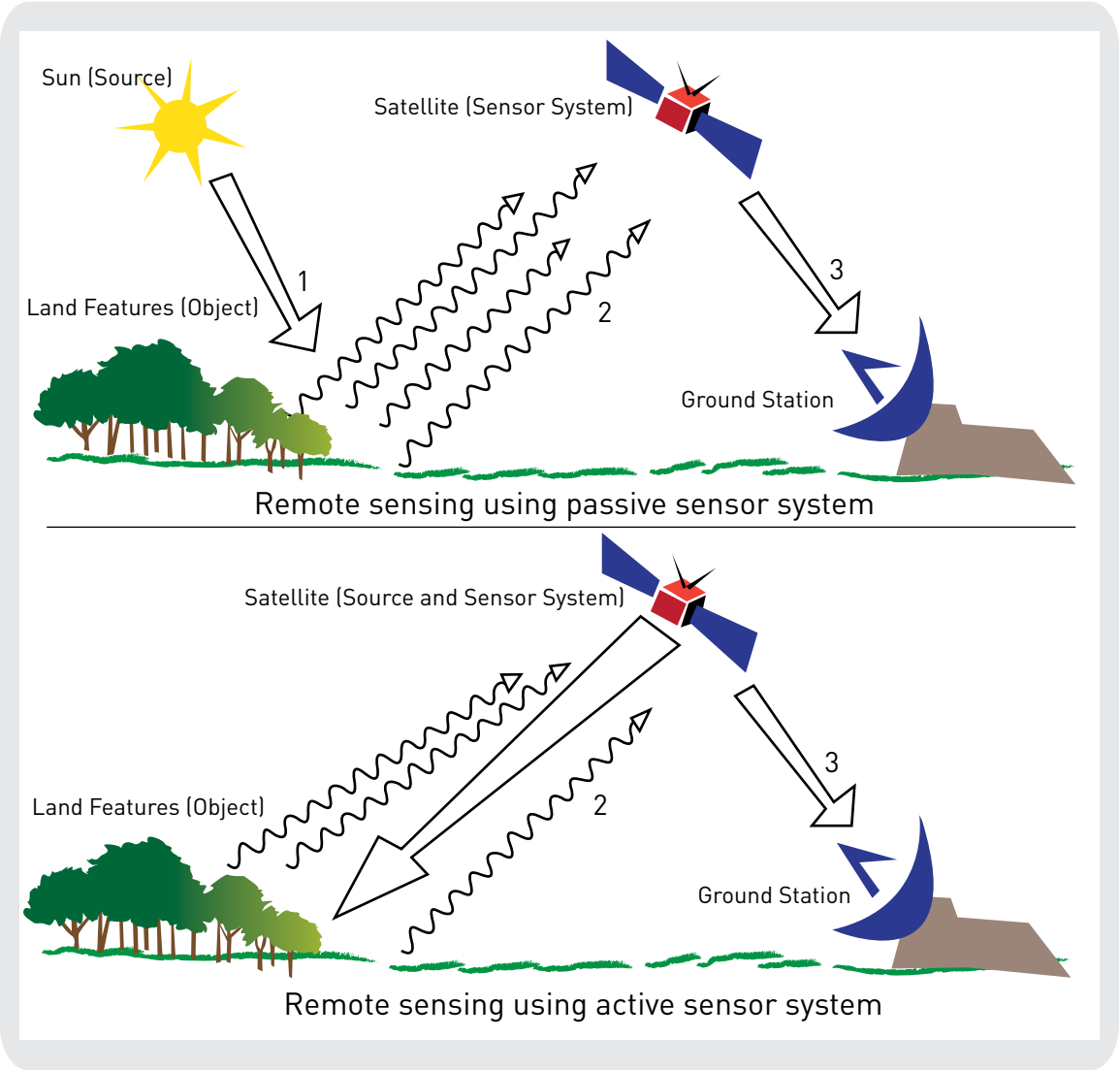

Figure 13. Remote Sensing Illustration[12]

12 Source: http://en.wikipedia.org/wikiFile:Remote_Sensing_Illustration.jpg

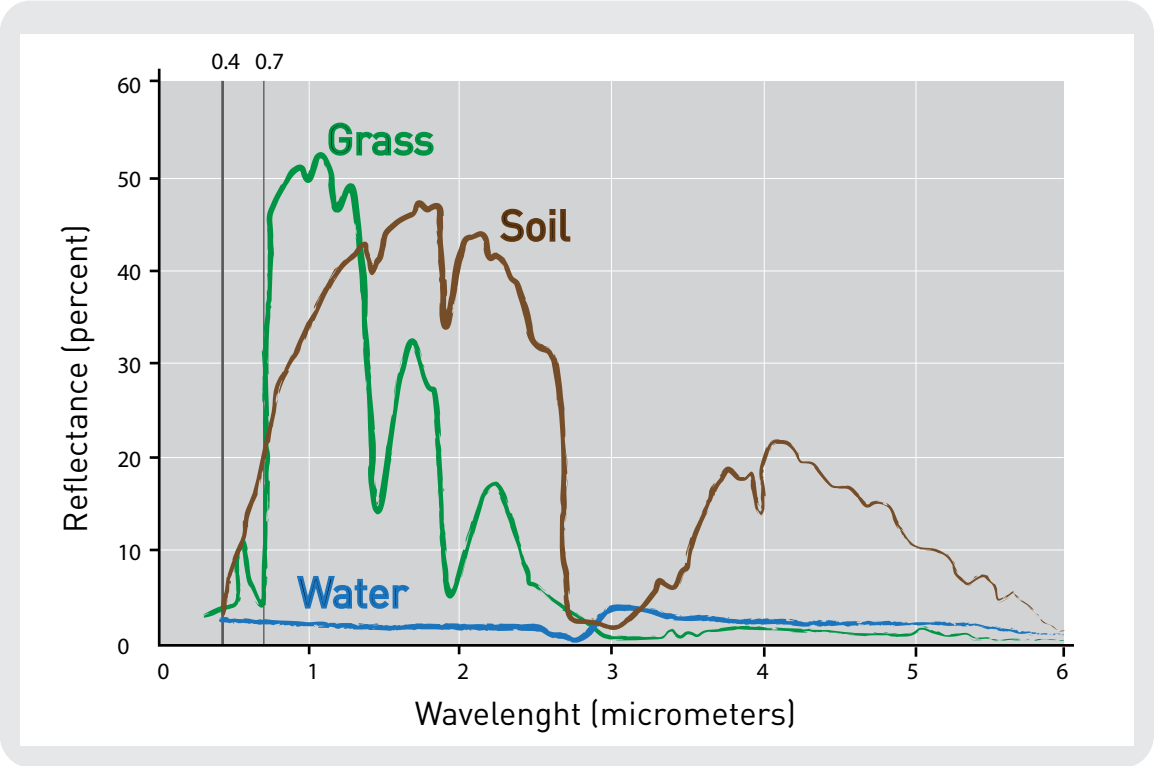

Figure 14. Wavelength composition of ground objects[13]

In the processing stage the composition of pixels in the image supports a classification of those pixels in clusters with certain thresholds. These thresholds, in the best case scenario, define forests, croplands, bare soil, grasslands, areas with settlements etc. The result of the classification can then be analyzed to create area estimations of the clusters in a certain threshold. (Figure 15)

13 Source: https://www.e-education.psu.edu/natureofgeoinfo/c8_p5.html

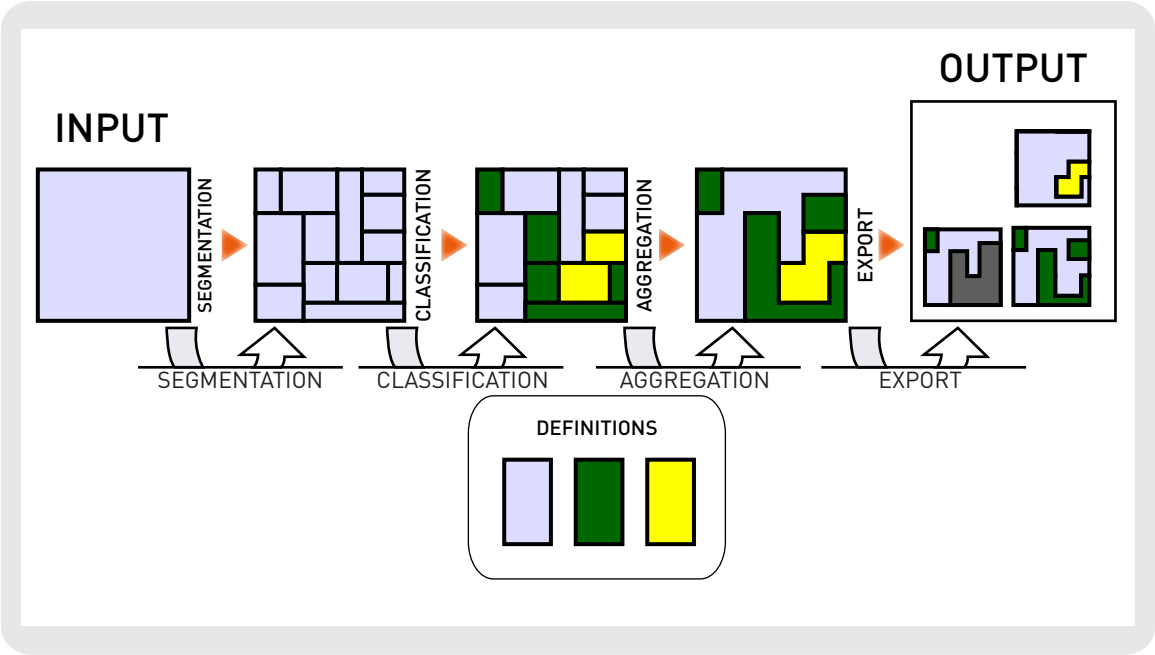

Figure 15. Classification based on pixel values and definitions[14]

By analyzing images from two different points in time and applying the same classification methods, a change of composition of pixels can be detected. Furthermore, by knowing how much carbon is associated with a certain land cover type (associated with the composition of pixels) carbon flow from the atmosphere to the land class and vice versa can be estimated over time. This latter point is why accurate land cover/land-use mapping is one of the most important inputs into the preparation of a NGHGI – especially in the AFOLU (former agriculture and land-use change) sectors.

Problems with this analysis or uncertainties in the results could stem from a variety of sources. Starting with incomplete remote sensing data sets such as time consistency, different spatial resolutions for parts of the country, cloud cover, different sensors used acquiring the data etc. Also, imprecise definitions of thresholds while classifying due to technical issues (the spectral composition of each class) or unclear definitions of land (how is a low-crown-cover forest [<10 percent] different from a grassland with high percentage of woody biomass and thus a high crown cover percentage?) are note worthy. Additionally, general issues like the actual shape and size of the country or area of interest could have an influence on the accuracy of the results.

14 Source: TUGRAZ.at

Since a reliable remote sensing data set of a country was identified as a key issue in land management, strategic planning and development strategies, a couple of initiatives supporting these kinds of activities in non-Annex I countries have emerged. Some bilateral arrangements are available, but also the UN-REDD program for example supports data collection in the field of remote-sensing contexts in their national programs.

All other information on land management available in the country could be used to further stratify land in the country to obtain more accurate estimations of GHG emissions. This goes especially for climate-zone maps (temperature, precipitation and height above sea level), areas of different soils (with different soil carbon stocks), and any other layer of information that informs the compiler about circumstances on the ground (test sites for improved agriculture management, natural reserves, zones of high priority for agricultural development etc.).

Even if there is no ongoing mapping attempt in the country or only two time points are available, but the compiler strives for creation of a whole time series, there are statistical methods for interpolation and extrapolation of the data available. This of course reduces accuracy by a certain amount.
Figure 16 illustrates the compilation of an approach 2-3 classification of the land by superposition of remote sensed data and as a result the LUC Matrix for two inventory time points.

		2010						
	LU/LC change table	CL	FL	GL	DL	SL	Wl	Grand Total
2000	CL	24,20%	3,19%	2,590%	0,11%	0,22%	0,15%	30,47%
	FL	8,20%	21,99%	2,90%	0,05%	0,03%	0,52%	33,70%
	DL	7,74%	2,88%	1,860%	0,03%	0,02%	0,23%	12,76%
	QL	0,02%	0,02%	0,03%	0,04%	0,00%	0,03%	0,18%
	SL	0,03%	0,00%	0,009%	0,00%	0,34%	0,00%	0,38%
	WL	0,98%	0,72%	0,26%	0,01%	0,02%	20,56%	22,51%
	Grand Total	**41,17%**	**28,87%**	**7,63%**	**0,26%**	**0,64%**	**21,50%**	**100,00%**

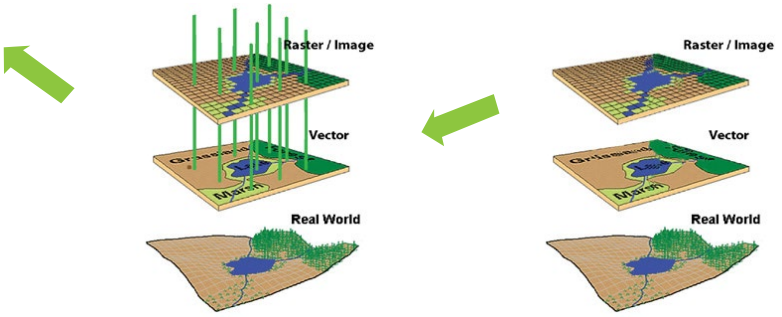

Figure 16. Illustration of the derivation of an approach 1 land classification and LUC matrix for two inventory time points (Figure made by CD-REDD)

Recommended reading in the 2006 IPCC Guidelines:

- Links to international databases of land cover maps, Vol.4, Ch.3, Annex 3A.1
- Advice for developing land-use databases, Vol.4, Ch.3, Annex 3A.2

Learn more:

- Spatially explicit land use mapping,
  Johannes Broetz, Coalition for Rainforest Nations
- Harmonized World Soil Database

4.3.2 Emission factors

The choice of the carbon stock, emission and removal factor is inter-related with the national classification scheme. It is important to document not only the classification system and EF, but also how they correspond to each other.

Recommended reading in the 2006 IPCC Guidelines:

- Emission factors and direct measurement of emissions, Vol.1,Ch.2.2.4
- Matching land areas with factors for estimating GHG emissions and removals, Vol.l 4, Ch. 3.4

Frequently the major inventory and monitoring resources used for LULUCF emission inventory in individual countries are the national inventory programs (Karsten D., 2012). The calculation of carbon stock and carbon stock changes depends on growing stock volumes and biomass expansion factors. The latter are the central variables estimated by the NFI. The NFI is a source of country-specific EF, but it is still important that national definitions are internationally comparable. Therefore transparency and harmonization of forest inventory estimates are key challenges of worldwide GHG reporting. Common reference definitions and country-specific bridges are means to harmonizing the EF and making NGHGI reporting on forests more comparable. (Cienciala, E et al, 2012.)

Recommended reading in the 2006 IPCC Guidelines:

Guidance to sampling for National Forestry Inventories, Vol.4, Ch.3, Annex 3A.3

Read more:

- Harmonizing greenhouse gas reporting from European forests: Case examples and implications for European Union level reporting, Karsten D. et al., Forest Science, 58 (3), p.248–256, 2012
- Preparing emission reporting from forests: use of National Forest Inventories in European countries, Cienciala, E. et al. Silva Fennica 42(1): 73–88, 2008

Learn more:

IPCC Emission Factor Database, Nadia Srivastava, IPCC

4.3.3 Data organization

A robust methodology to organize data is important to initiate a consistent, complete and transparent database. The database should clearly show gaps and assumptions made during the data collection so that it can serve as a foundation to be further developed with higher accuracy. At the start of the inventory process the organization and documentation is far more important than the quality of the gathered data itself. With the condition that the inventory process is embedded in a reliable NIS, the inventory will be improved with each subsequent iteration.

Several software packages and worksheets can be used to facilitate the data organization. In particular, the forestry sector requires complex data management for which several interfaces and tools have been developed to help organize the data. Specifically the ALU (agriculture and land use) software has been developed for data organization of AD and EF for NGHGI in the LULUCF sector. The ALU workbooks have been developed to organize data and are at the same time a quality-control tool for data entry. With the software itself it is possible to calculate emissions in an UNFCCC reporting format. The emissions are calculated automatically by the software in accordance with methodologies of the 1996 IPCC Guidelines and the 2003 GPG–LULUCF. The software can be downloaded free from the website (ALU). It has a user-friendly interface and is accompanied by a user manual.

Recommended reading in the 2006 IPCC Guidelines:

IPCC worksheets 2006 IPCC Guidelines annex, Vol.4 AFOLU

Learn more:

- ALU manual and workbooks, Stephen Ogle, Colorado State University

- Introduction to the IPCC software, IPCC
- Flowchart CD-REDD Data management compatible with ALU tool, Johannes Broetz, Coalition for Rainforest nations

Do it yourself:

- Download the ALU software here and follow the ALU manual (French, English)
- Download the IPCC software here

4.4 Documentation and archiving

An archiving system is an inexpensive yet critical step in the sustainability of the NIS because it serves as a starting point for future inventory teams.
The objective of an archiving system is to establish and document pathways (including all institutions that participated in the preparation of the inventory) through which all relevant information used for the development of the NGHGI of one inventory year can be accessed. This should support the estimates and enable the reproduction of the emission, removal and uncertainty estimates, and facilitate detailed review.

Documentation and archiving are often considered unimportant. In reality, they are the most fundamental activities a NIS should carry out in order to improve the inventory every inventory cycle on an institutional level.

Recommended reading in the 2006 IPCC Guidelines:

Documentation, archiving and reporting, Vol.1, Ch.6.11

Learn more:

- Documentation and category by category description, Marina Vitullo, ISPRA
- Inventory archiving system, Riitta Pipatti, Statistics Finland

Do it yourself:

- Archiving template CD-REDD
- Documentation template CD-REDD
- Archiving template US-EP
- Documentation template US-EPA

4.5 Uncertain analysis

Non-Annex I Parties are encouraged to provide information on inventory uncertainties, which may range from a simple qualitative assessment to a complex quantitative assessment. If uncertainties are to be assessed, the rules of procedure should state the minimum approach to be used and provide recommendations for more rigorous uncertainty analysis (UA) should source(s) team leaders decide sufficient resources are available. The UA plan should also include instructions for documenting and reporting the results of uncertainty assessment – UNDP 2005.

Uncertainty analysis is well described in the 2006 IPCC Guidelines. Some sources of uncertainty are more easily quantifiable than others. All potential sources of uncertainty are displayed in the 2006 IPCC Guidelines, Vol.1, Ch.3, Table 3.1. There are quantifiable and non-quantifiable uncertainties that need to be considered. The pragmatic approach to producing quantitative uncertainty estimates is to use the best available estimates, which are often a combination of measured data, published information, model outputs, and expert judgment. Expert judgment is important as a last source of data collection.

Recommended reading in the 2006 IPCC Guidelines:

- Uncertainties, Vol. 1, Ch.3
- Volumes 2 to 5 provide default uncertainty estimates for use with the methods described in this chapter.

Learn more:

Uncertainty assessment, Consultative Group of Experts (CGE), UNFCCC

Do it yourself:

- Uncertainty template CD-REDD

4.6 Key category analysis (KCA)

The concept of key categories was created by the IPCC as a way to help countries prioritize resources for improving NGHGI. Key categories have the greatest contribution to the overall level of national emissions. When an entire time series of emission estimates is prepared, key categories can also be identified as those categories that have the largest influence on the trend of emissions over time. In addition, when uncertainty estimates are incorporated into emission estimates, additional key categories are identified.

The results of the KCA provide a country with a list of their most important inventory categories. This list is a starting point from which a country can begin the process of improving their NGHGI. To improve the NGHGI, it may be necessary to consider applying more accurate or higher-tier methodologies, collecting more detailed AD, or developing country-specific EF. Limited resources need to be dedicated to improving the most important datasets. It is through an optimally functioning NIS that funds can be effectively spent. The inventory category list resulting from this analysis can provide a quantitative framework for the NGHGI team to develop an inventory improvement plan.

The KCA also provides more complete and transparent information for the NC (1996 and 2006 IPCC in U.S. EPA template for KCA).

Recommended reading in the 2006 IPCC Guidelines:

Methodological choice and identification of key categories, Vol.1, Ch.4

Learn more:

- Key Category Analysis, Daniela Romano, ISPRA
- Key Category Analysis, Consultative Group of Experts (CGE), UNFCCC

Do it yourself:

- KCA template CD-REDD
- KCA template US-EPA

4.7 Quality assurance (QA) and quality control (QC)

QC is carried out through a system of routine technical activities implemented by the inventory development team to measure and control the quality of the inventory as it is prepared. QA/QC is a key activity of the NIS (Figure 2).

QA is carried out through a planned system of review procedures conducted by personnel not involved in the inventory development process.

Cost-effective country-level bilateral arrangements can provide QA in cooperative programs, enabling data sharing to augment data quality and availability. Cross-country support enables the country to learn from other countries' experiences while lowering expenditure on external audits. It is also possible to develop regional cooperation programs between several countries with similar bio geographical backgrounds. An example is given at the end of this section.

The set-up of a QA/QC system includes the following steps (US EPA):

- Set up a country-specific QA/QC plan.
- Assign a QA/QC coordinator.
- Communication of the QA/QC plan to the entire inventory team (by regular meetings and reminder emails of QA/QC responsibilities carried out by the QA/QC coordinator).

- Define the QC procedures for source and sink categories and assign responsibility to team members.
- Define the QA procedures and assign external experts for the tasks.
- Develop a QA/QC improvement plan.

Recommended reading in the 2006 IPCC Guidelines:

QC procedures, Vol.1, Ch.6, Table 6.1

Example: Romania participated in bilateral projects with Austria and the Netherlands to exchange data collection and processing knowledge and to improve transparency in some other areas including key categorization, archiving, data documentation and recalculations of previous inventories.

Extracts of QA activities from the NIR of Romania (April 2011):

"Until now, NEPA (National Environmental Protection Act) was the beneficiary of technical support provided by the Austrian Environment Agency. One of the most important activities performed within this framework was the review of different sectors of the NGHGI. Austrian experts made specific recommendations including:

- Improvement of transparency at sectoral level taking into account the trend and recalculations description.
- Improvement of transparency at sectoral level by providing a cumulative table on the status of emissions/removals estimation for every sub-sector.
- Improvement of knowledge of practical ways of performing and documenting the QA/QC activities.
- Improvement of the NGHGI archiving structure.

Learn more:

- QC, QA and verification: Ensure high inventory quality, Zoltan Somogyi, CD-REDD
- Quality assurance/quality control: Examples from Germany, Karsten Dunger, Thünen Institute
- Quality assurance/quality control procedures, Consultative Group of Experts (CGE), UNFCCC
- National Environmental Protection Agency (EPA) of Romania, National Inventory Report 2010, Ministry of Environment and Forests, Bucharest

Do it yourself:

- QA/QC template US-EPA

4.8 Improvement plan

The improvement plan is highly country specific. Generally, the plan contains information on overall improvements regarding the NGHGI process and category-specific improvements. A NGHGI database always accompanies an improvement plan when it is submitted to the UNFCCC.

The process of inventory compilation should be thought of as continuous inventory cycle with each iteration an opportunity for improvement of the inventory. This process must be guided by an inventory improvement plan, i.e. a structured and prioritized list of activities to further develop procedures for estimating emissions and removals. The development of the inventory improvement plan should itself be informed by a KCA as well as by a UA of emission estimates to prioritize options for improvements. The process for inventory improvement (Figure 17) illustrates the importance of continuous improvement through an iteration process between EFs and ADs from the inventory database and the emission profile results.

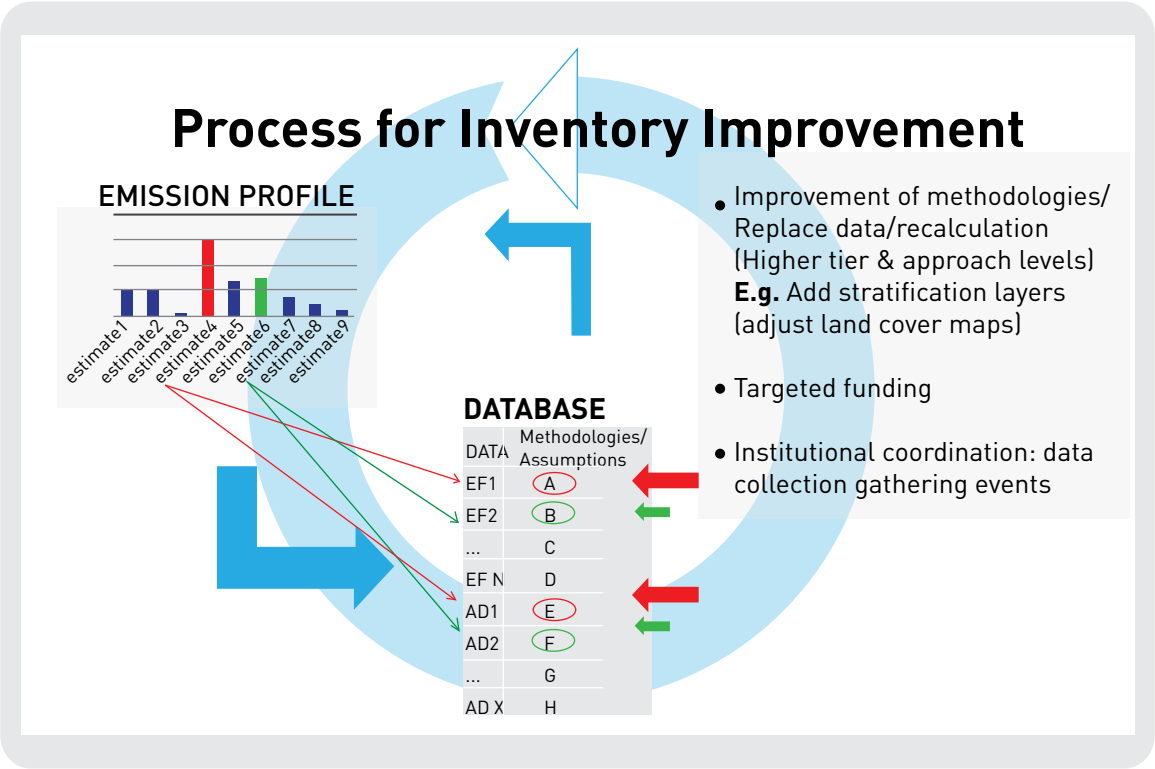

Figure 17. The interaction between the inventory database and the emissions profile as a method for continuous and efficient improvement (Figure made by CD-REDD)

Learn more:

- Advancing on capacity development for national GHG Inventory Systems, Till Neeff, CD-REDD
- Preparing a National Inventory Improvement Plan (NIIP), John Venezia, US EPA

Learn more:

- Guidelines for review under Article 8 of the Kyoto Protocol, Annex to Decision 22, CMP.1
- Inventory review reports of the UNFCCC

Do it yourself:

- Improvement plan template CD-REDD
- Improvement Plan Templates US-EPA

4.9 National Inventory Report

The aim of an NIR is to provide the information needed by any reader of the report (i.e. the UNFCCC, a reviewer, an inventory compiler who wants to repeat the inventory at a later time, or any interested member of the national community) to understand how the inventory was compiled.

Countries are expected to prepare this report, in a manner consistent with the effective provisions under the UNFCCC, which are exemplified by reports of other countries including the Annex I countries, with the necessary information and references but in a concise manner.

In order to facilitate the preparation of the report, a structure and content is suggested by CD-REDD in an easy-to-use format (see do it yourself section). Countries should follow the structure in order to ensure appropriate, consistent and sufficient documentation of all relevant information. All information is to be inserted under each subheading; all text in italics should then be removed. The information can include text, figures and/or tables in a concise, but complete way. Detailed information on specific issues (e.g. information on archiving system, details of input data) should be included in the annex (see more instructions there). Countries can, and are encouraged to, use information already collected as much as possible, but should provide at least a short written text for all relevant items.

Please note that the inventory report should include all information on estimates, methodology and all other relevant information, but not more. The report should include references to relevant country reports, scientific reports, scientific papers etc. which have provided information (e.g. EF) to the process. This information together with all details of the methodology, detailed datasets

etc. that are not included in this report but are directly or indirectly referred to, should be part of the so-called documentation, which is a collection of all information that was used to develop the inventory but not included in the actual inventory report itself. All information used for the inventory, including the one contained in the documentation, must be archived.

List of gases to be reported for Forestry and Agriculture:

There are six GHG (according to the Kyoto Protocol, annex A) that need to be reported in a NGHGI:

- Carbon dioxide (CO_2): uptake through plant photosynthesis, release via respiration, decomposition and combustion of organic matter.
- Nitrous oxide (N_2O): primarily emitted from ecosystems as a by-product of nitrification and denitrification.
- Methane (CH_4): emitted through methanogenesis under anaerobic conditions in soils and manure storage, through enteric fermentation and during incomplete combustion while burning organic matter.
- Perfluorocarbons (PFC).
- Hydrofluorocarbons (H-FKW/HFC).
- Sulfur hexafluoride (SF_6).

Regarding the reporting of GHG in the AFOLU sector, the first three listed GHG are relevant. The other gases mentioned do not occur in the AFOLU sector. Additionally, precursors to CO_2 and NO_2, such as carbon monoxide (CO) and mono-nitrogen oxides (NOx) respectively, are included in reporting.

Example:

NGHGI report, South Africa

Learn more:

- GHG Inventory Report, Katja Oehmichen, Thünen Institute
- Reporting Principles and Introduction of the Use of 2006 Guidelines, Mihaela Secrieru, CD-REDD
- Review of National Greenhouse Gas inventories, Marina Vitullo, ISPRA

Do it yourself:

Outline GHGI report CD-REDD

4.10 Review process

A review process is the standard QA procedure for documentation submitted to international organizations. Through the review process a Party may receive external input aimed at improving the quality of reported information. Furthermore, such independent assessment of information shows the international audience a clear knowledge of the status of anthropogenic GHG emissions and removals along with activities related to mitigation and adaptation to climate change. The most important review processes are mentioned underneath for reports submitted under the convention (accordingly the review of information submitted under the Kyoto Protocol is not discussed here).

Profile of an in-depth review for national communications (Annex I countries):

- Who: An international team of experts coordinated by the UNFCCC secretariat.
- What: Desk-based study and in-country visit.
- Outcome: An in-depth review report containing updates for NC.

The International Consultation and Analysis (ICA) of the Bianniel Update Report (BUR) for non-Annex countries has not yet been fully implemented. The discussion about the review process started with the Cancun Agreements (1/

COP16). Further decisions (COP17–19) have made the review requirements more concrete[15]. The most recent information specifying the profile of the team of technical experts (TTE) and the role of the secretariat and CGE is given in two decisions adopted at COP19.

Profile of an ICA review of the BUR (Decision 2, COP 17**, annex IV,** Decision 20, annex, COP 19 **and for REDD+ see also** Decision 14, annex, COP 19**):**

- Who: The TTE shall be composed of experts nominated by the UNFCCC roster of experts that have successfully accomplished the CGE training programme for BURs.
- What: Technical analysis of the BUR (part of NC or stand-alone update report) including information on REDD+ activities included in the Annex to the BUR and the SBI (Subsidiary Body for Implementation) will organize several "exchange of view" workshops after review.
- Outcome: A summary report and outcome of facilitative sharing of views.

Read more:

- Reporting and Review for Annex I Parties
- National Communications Non-Annex I

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15 Decision 2, COP17, annex IV, paragraph 1, Modalities and guidelines for international consultation and analysis (ICA).

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National Environmental Protection Agency (EPA) of Romania, National Inventory Report 2010, Ministry of Environment and Forests, Bucharest.

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Pipatti, R., 2011, Inventory archiving System, PowerPoint presentation, Statistics, Finland.

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5 Capacity building in NGHGI

5.1 Challenges

Several success factors for continuous improvement in national forest monitoring can be deduced from the experience of developing countries. This provides good practices and recommendations by offering insights into success stories, country-specific bottlenecks and improvement plans.

Besides country experiences, lessons in building sustainable NGHGI can be learned from the literature available. By a study (Tulyasuwan et al.) the needs of non-Annex countries during their inventory development were identified. According to the experiences studied and state of the art obtained from a questionnaire analysis the most common challenges are:

- Insufficient Institutional Arragements
- Inadequate financing
- Limited technical capacity
- Lack of available data

The questionnaire analysis has been the basis for further development of several capacity building programs for assisting in the building up of NGHGI systems in the CD-REDD project countries. The questionnaire has demonstrated the usefulness of building a strategy for capacity building in countries facing difficulties in GHG inventory data compilation.

Many suggestions for fulfilling the needs in building up NGHGI come from current practices in NGHGI management of Annex countries. To produce a national inventory on a regular basis the Parties need to establish different functions for planning, preparing and managing the inventory (see also 3.2 The National Inventory System). Currently, several non-Annex countries are developing GHG emissions for NC, but they have not invested in a permanent MRV system that would help to generate more sustainable (consistent, transparent) NGHGI over longer periods.

The previously mentioned challenges can be identified by studying the causes behind the data gaps and problems related to data collection:

- Insufficient IA

It is good practice to have staff on a permanent basis to retain technical expertise and experience. Often NGHGI are dependent on external structures created ad hoc by temporary consultancies hired through UNDP–GEF (United Nations Development Programme–Global Environment Facility) funding programs.

- Inadequate financing

The financial resources are very much related to the institutional issue. Several non-Annex countries still rely fully or partly on international funding support. There is a lack of national attention to finance projects encouraging the establishment of NGHGI. It is good practice for non-Annex countries to obtain long-term funding via national budgets.

- Limited technical capacity

Technical capacity refers to the development and use of software plus a QA and QC system. The knowledge of which software to use and how to carry out QA and QC is often limited.

- A lack of available data

Data availability remains a problem, especially in the following categories:

Forest carbon stocks: Insufficient capacity for data gathering is the main cause. Lack of historical data and data inconsistency are two other related causes.

Forest fire: Lack of historical data and accessibility because of private sector data.

Land representation: Data inavailability and inconsistency because of a lack of coordination between institutions and skilled human resources.

Learn more:

- Issues and challenges for the national system for greenhouse gas inventory in the context of REDD+, greenhouse gas measurement and management, Tulyasuwan et al., 2012
- Improving GHG inventories by regional information exchange: a report from Asia, Carbon balance and management, Umemiya, C. 2006
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5.2 The CD-REDD project

NGHGI systems need to produce high-quality emission estimates for the international community but also input for national mitigation and development planning. This is essential for countries to participate in results-based mitigation funding and REDD+. However, the quality of NGHGI systems remains limited in many developing countries because of the high technical complexity of the systems' specifications and in some countries the necessary capacities are only developing.

The CD-REDD project aims at improving this situation by providing capacity building for the inventory teams of 12 countries in West Africa, East Africa, Southern Africa and Latin America. CD-REDD coaches the inventory teams in how to develop transparent, accurate, consistent, comparable and complete NGHGI systems that are strategically managed and embedded in a solid institutional setup.

The project approach developing capacities for NGHGI in the forestry and agriculture sectors is focused on assisting the countries on a development path towards high-quality NGHGI systems that will deliver GHG information that is transparent, accurate, consistent, comparable and complete, in line with

the UNFCCC and IPCC reporting guidelines and structured for a range of uses in the countries and internationally. To help the countries advance on their capacity development trajectory, the project approach to building capacities includes several elements (Figure 18) that aim to use available data and resources while gradually building capacities on several fronts.

The project focuses on the inventory teams in the countries. The identification of the right people for such a team is crucial. They are technically skilled representatives from the lead institutions on climate change, forestry, agriculture and NGHGI. Much of our work involves coaching the inventory teams and providing them with an environment where they can learn by doing, how to compile the NGHGI and run the NIS. Therefore a mixture of complementary measures (in-country visits, remote support, and online training) to provide this support.

Two key determinants set the environment for capacity building: the appropriate level of ambition and the set of tools to be used for the NGHGI. The pace of work is set by the inventory teams and there are different levels of ambition among the countries according to their capacities and data availability. Despite the different levels of targeted inventory quality, in most countries a standardized set of tools was used, which was originally developed within the US-EPA's NGHGI Capacity Building Program. This includes the ALU NGHGI software for GHG data calculations and a set of national system templates that address important aspects of the NGHGI system. This enables teams to build a draft NGHGI, which functions as a point of departure for further elaboration on the country's process to improve the NGHGI system. This leads to a process of continuous stepwise improvement of the data and methodologies used within each iteration of the process – including made after conclusion of the project.

The project works with governments to improve the NGHGI systems using already available data and staff resources from national or international structures. The project does not support collection of primary data, neither does it provide countries with resources for staff or primary data collection. It is different in that regard from other initiatives that work on similar issues such as the UN-REDD program's MRV support or the US-EPA's work on NGHGI systems in developing countries. That is why a close coordination with institutions in the developing countries was sought.

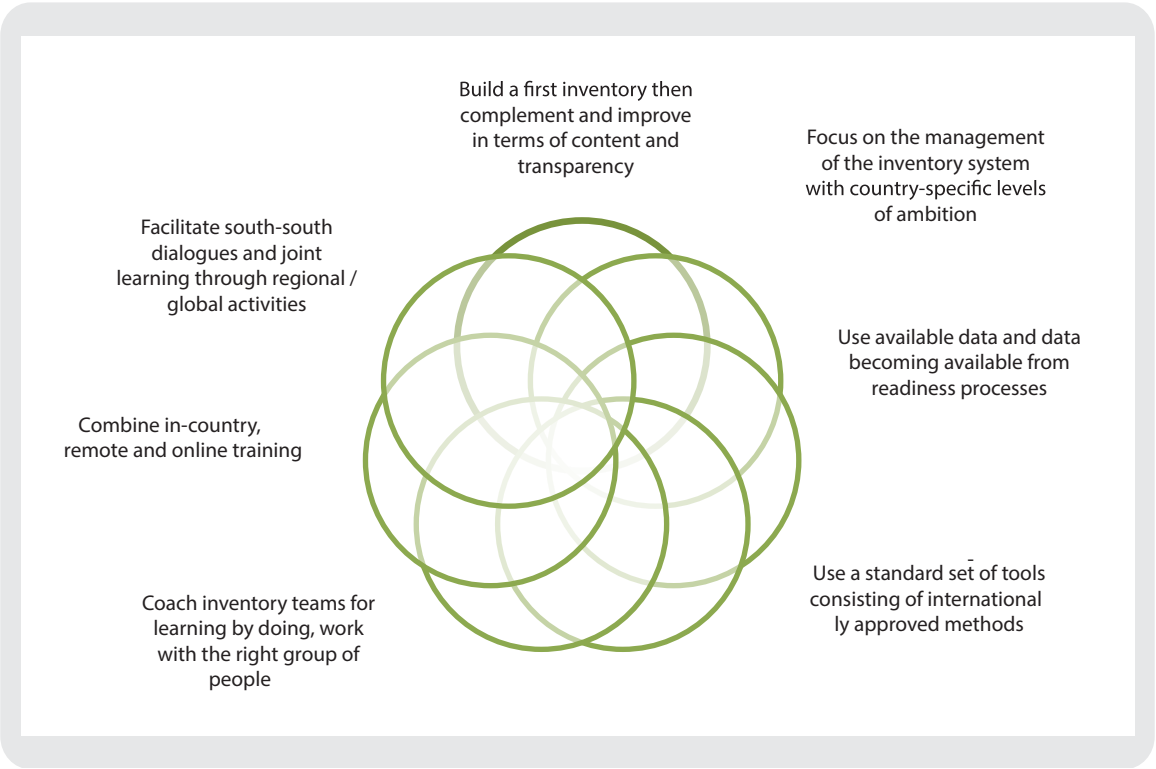


Figure 18. The elements of the approach to coaching inventory teams and building capacity for NGHGI systems (Figure made by CD-REDD)

Read more about the project:

- Advancing on capacity development for national ghg inventory systems

Read more:

- Sharing information about capacity building at the capacity building portal of the UNFCCC: http://unfccc.int/cooperation_and_support/capacity_building/items/7204.php
- The EU has established a data platform for member states to share experiences with other members states about forest inventories (Joint Research Center – European Forest Data Centre EFDAC: http://ef-dac-catalog.jrc.ec.europa.eu)

- Durban Forum, Talking about capacity building from the perspective of the trainer/development organization, First meeting Bonn 2012
- Background on EPA Capacity Building and Projects, Kick-off Workshop for Sustainable National Greenhouse Gas Management Systems in Eastern and Southern Africa, Tom Witch, 2011
- Questionnaire analysis, Training Workshop on the National System for GHG Inventories, Natacha Tulyasuwan,FAO HQ, Rome, 2011

Glossary of acronyms

AD	Activity data
AFOLU	Agriculture, Forestry, Other Land Use
AGB	Above ground biomass
ALU	Agriculture and land use
BGB	Below ground biomass
BUR	Biennial Update Reports
CDP	Climate Change Development Plan
CD-REDD	Capacity Development-Reducing Emissions from Defor estation and forest Degradation
CfRN	Coalition for Rainforest Nations
CGE	Consultative group of experts
CMP	Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol
COP	Conference of the Parties
CSCF	Cross-sectoral correction factor
DOM	Dead organic matter
EF	Emission factors
FAOSTAT	Food and Agriculture Organization Statistical Database
GHG	Greenhouse gas
GIS	Geographic information system
GLCN	Global Land Cover Network
GPG-LULUCF	Good Practice Guidance – Land Use, Land-Use Change and Forestry
HWP	Harvested Wood Products
IA	Institutional arrangements
ICA	International consultation and analysis
IPCC	Intergovernmental Panel on Climate Change
KCA	Key category analysis
LCCS	Land cover classification system
LECB	Low emission capacity building
LUCF	Land-Use Change and Forestry
LULC	Land use and land cover

LULUCF	Land Use, Land-Use Change and Forestry
MAGHG	Monitoring and Assessment of Greenhouse Gas
MICCA	Mitigation of Climate Change in Agriculture
MoE	Ministry of Environment
MoU	Memoranda of Understanding
MRV	Measurement, reporting and verification
NAMA	Nationally Appropriate Mitigation Actions
NC	National Communications
NEPA	National Environmental Protection Act
NFI	National forest inventory
NGHGI	National greenhouse gas inventory
NIR	National Inventory Report
NIS	National GHG Inventory System
QA/QC	Quality assurance/quality control
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SBI	Subsidiary body for implementation
TCCCA	Transparency, consistency, comparability, completeness and accuracy
TI	Thünen Institute
TTE	Team of technical experts
UA	Uncertainty analysis
UNDP-GEF	United Nations Development Programme-Global Environment Facility
UNFCCC	United Nations Framework Convention on Climate Change
US-EPA	United States-Environmental Protection Agency

The CD-REDD project provides capacity for the inventory teams of 12 countries in West Africa, East Africa, Southern Africa and Latin America. The CD-REDD staff of experts provides guidance and coaching to domestic inventory teams in the development of transparent, accurate, consistent, comparable and complete GHG inventory systems that are strategically managed and embedded in a solid institutional setup. GHG Inventory training is one product amongst many services that the CD-REDD provides to the countries.

The national GHG inventory teams need to produce not only high-quality emission estimates for the international community but also to provide input for national mitigation and development planning. The GHG inventory is essential for countries to participate in results-based mitigation funding and REDD+. However, the quality of GHG inventories remains limited in many developing countries. With this training, GHG inventory teams deepen their knowledge on GHG inventories and broaden their research field in climate change and mitigation.

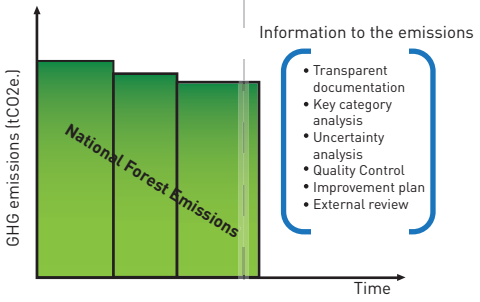
The Greenhouse Gas inventory memory game

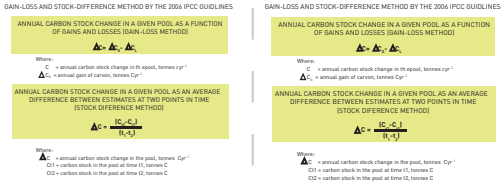
With the GHG inventory memory game you can test your knowledge!
Test your knowledge together with your GHG Inventory team. Every figure of the memory appears also in the training modules.

How do I play the GHG Inventory memory?

Cut all the figures following the instructions. Dispose all the cards over the table with the blanco side up-side. Start the game by turning two cards. Each player plays in turn. The goal is to collect as many pairs of cards possible.

The person who has most of the pairs wins the game. Every matching pair represents a figure or table from the training that the player should be able to explain to the other participants; the other participants can ask questions to make the game more challenging!





REDD + Phases

Phase I

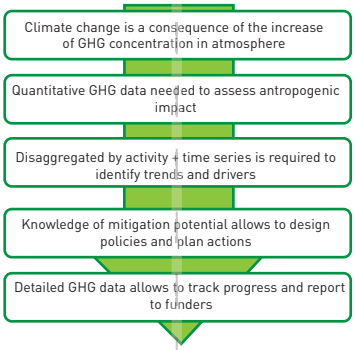
- National commitment to develop a REDD+ strategy

Phase II

- REDD + strategy
- Stake holder consultation
- Minimum monitoring capabilities
- Safeguards
- Proxies

Phase III

- National MRV
- National Accounting
- Reporting through National Communication



Article 4, paragraph 1(a)

Develop, periodically update, publish and make available to the COP, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all GHG not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the COP.

Article 4, paragraph 1(d)

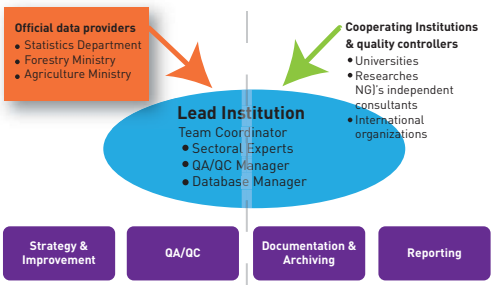
Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all GHG not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems.

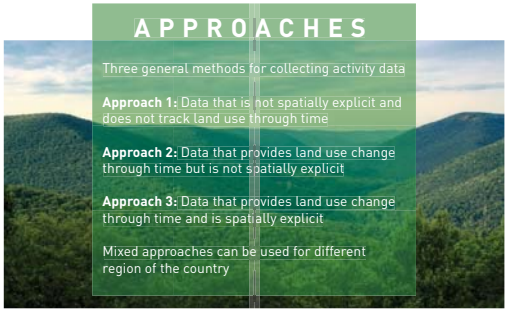
THE 36 LAND USE CATEGORIES UNDER APPROACH II VISUALIZED WITH A LAND USE CHANGE MATRIX

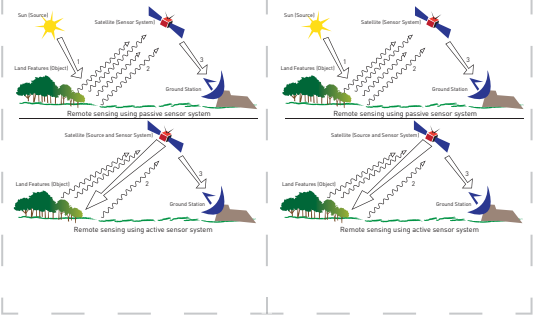
NET LAND-USE CONVERSION MATRIX

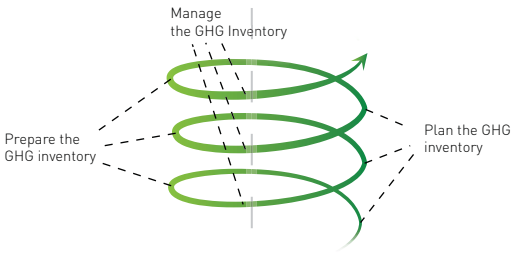
Final	Initial	F	G	C	W	S	O	Final Sum
F		15	3	1				19
G		2	80					82
W				0				0
S		1	1	1		5		8
O							2	2
Initial Sum		18	84	31	0	5	2	140

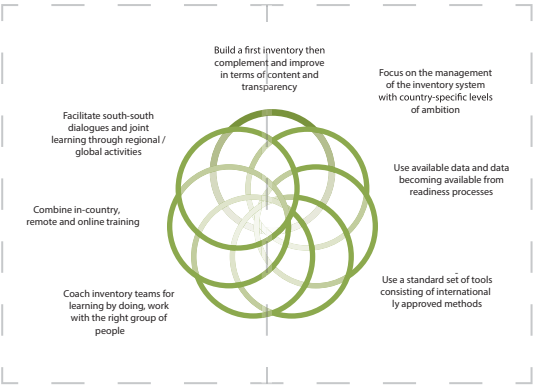
Note: F=Forest Land, G=Grassland, C=Cropland, W=Wetlands, S=Settlements, O=Other Land, Numres represent area units (Mha in this example)

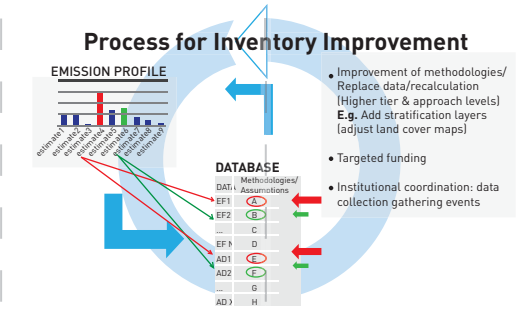


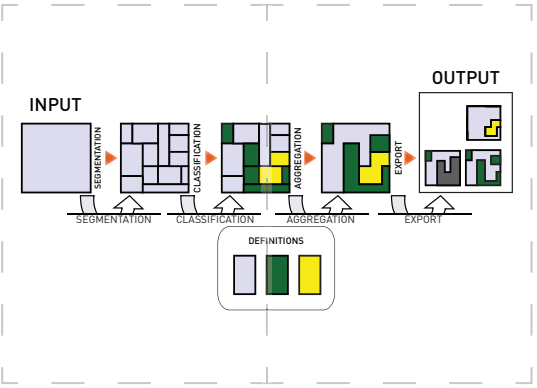


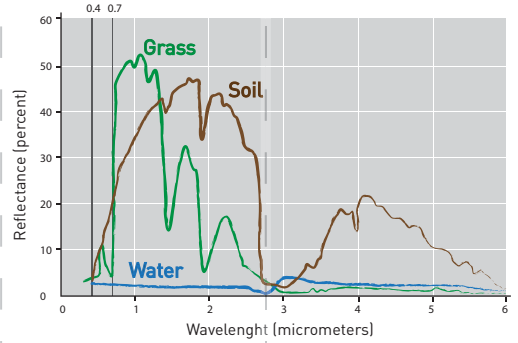

Sun (Source)
Satellite (Sensor System)
Land Features (Object)
Ground Station
Remote sensing using passive sensor system
Satellite (Source and Sensor System)
Remote sensing using active sensor system

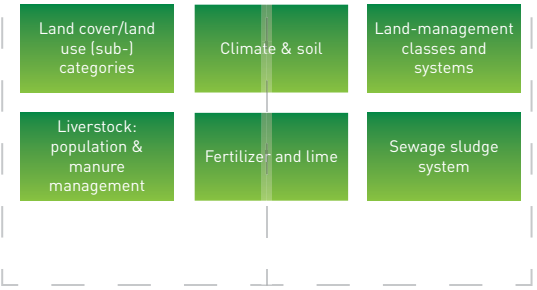

Manage
the GHG Inventory
Prepare the
GHG inventory
Plan the GHG
inventory

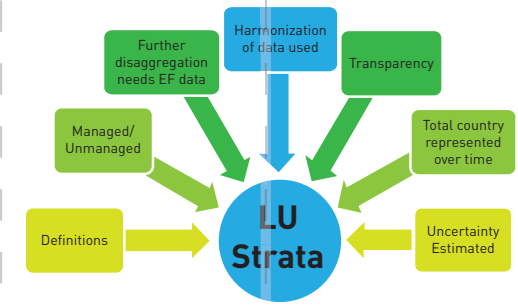

Build a first inventory then complement and improve in terms of content and transparency
Focus on the management of the inventory system with country-specific levels of ambition
Facilitate south-south dialogues and joint learning through regional / global activities
Use available data and data becoming available from readiness processes
Combine in-country, remote and online training
Use a standard set of tools consisting of international ly approved methods
Coach inventory teams for learning by doing, work with the right group of people

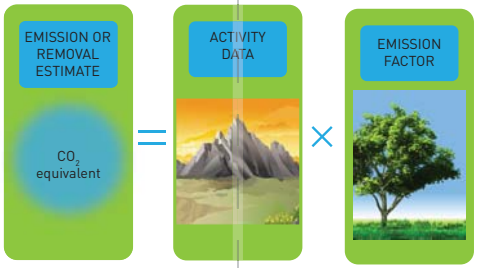

Process for Inventory Improvement
EMISSION PROFILE
DATABASE
Methodologies/ Assumptions
EF1
EF2
AD1
AD2
• Improvement of methodologies/ Replace data/recalculation (Higher tier & approach levels) E.g. Add stratification layers (adjust land cover maps)
• Targeted funding
• Institutional coordination: data collection gathering events

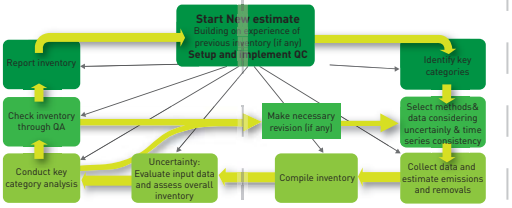

INPUT
OUTPUT
SEGMENTATION
CLASSIFICATION
AGGREGATION
EXPORT
DEFINITIONS

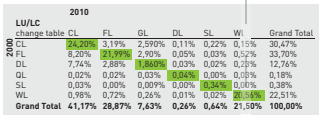

0.4 0.7
Grass
Soil
Water
Reflectance (percent)
Wavelenght (micrometers)


Land cover/land use (sub-) categories
Climate & soil
Land-management classes and systems
Liverstock: population & manure management
Fertilizer and lime
Sewage sludge system

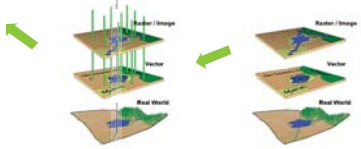

Further disaggregation needs EF data
Harmonization of data used
Transparency
Managed/ Unmanaged
Total country represented over time
Definitions
LU Strata
Uncertainty Estimated







2000 LU/LC change table	2010 CL	FL	GL	DL	SL	WL	Grand Total
CL	24,20%	3,19%	2,590%	0,11%	0,22%	0,15%	30,47%
FL	8,20%	21,99%	2,90%	0,05%	0,03%	0,52%	33,70%
DL	7,74%	2,88%	1,860%	0,03%	0,02%	0,23%	12,76%
GL	0,02%	0,02%	0,03%	0,04%	0,00%	0,05%	0,18%
SL	0,03%	0,00%	0,009%	0,00%	0,34%	0,00%	0,38%
WL	0,98%	0,72%	0,26%	0,01%	0,02%	21,51%	22,51%
Grand Total	**41,17%**	**28,87%**	**7,63%**	**0,26%**	**0,64%**	**21,50%**	**100,00%**



THE SIX LAND USE CATEGORIES UNDER APPROACH I		
TIME 1	TIME 2	NET LAND-USE CONVERSION BETWEEN TIME1 AND TIME2
F = 18	F = 19	Forest Land = +1
G = 84	G = 82	Grassland = -2
C = 31	C = 29	Cropland = -2
W = 0	W = 0	Wetlands = 0
S = 5	S = 8	Settlements = +3
O = 2	S = 8	Other Land = 0
Sum = 140	Sum = 140	Sum = 0
Note: F=Forest Land, G=Grassland, C=Cropland, W=Wetlands, S=Settlements, O=Other Land, Numres represent area units (Mha in this example)		