Working Paper

Training Workshop on “GHG Inventory Preparation for Forestry”

Cambodia, 2012

REDD+ CAMBODIA

Disclaimer

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Training Workshop on "GHG Inventory Preparation for Forestry"

MRV Team, Cambodia
CAMBODIA UN-REDD PROGRAMME
Angkor Paradise Hotel, Siem Reap Province, Cambodia
5-8 November 2012

The UN-REDD Programme, implemented by FAO, UNDP and UNEP, has two components: (i) assisting developing countries prepare and implement national REDD strategies and mechanisms; (ii) supporting the development of normative solutions and standardized approaches based on sound science for a REDD instrument linked with the UNFCCC. The programme helps empower countries to manage their REDD processes and will facilitate access to financial and technical assistance tailored to the specific needs of the countries.

The application of UNDP, UNEP and FAO rights-based and participatory approaches will also help ensure the rights of indigenous and forest-dwelling people are protected and the active involvement of local communities and relevant stakeholders and institutions in the design and implementation of REDD plans.

The programme is implemented through the UN Joint Programmes modalities, enabling rapid initiation of programme implementation and channeling of funds for REDD efforts, building on the in-country presence of UN agencies as a crucial support structure for countries. The UN-REDD Programme encourage coordinated and collaborative UN support to countries, thus maximizing efficiencies and effectiveness of the organizations' collective input, consistent with the "One UN" approach advocated by UN members.

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I. Executive Summary

The first training workshop on "Greenhouse Gas (GHG) Inventory Preparation for Forestry" was successfully organized by REDED+ Secretariat of the Cambodia UN-REDD National Programme. The workshop was held at Angkor Paradise Hotel, Siem Reap, from 5-8 November 2012. It brought together 46 participants representing relevant government ministries including Ministry of Agriculture, Forestry and Fisheries (MAFF); Ministry of Environment (MoE); and Ministry of Land Management, Urban Planning and Construction (MLMUPC); the Food and Agriculture Organization of the United Nations (FAO); universities; research institutions; non-governmental organizations (NGOs); and local and international experts. The workshop was co-chaired by His Excellency Chea Sam Ang, National Project Director of Cambodia UN-REDD National Programme, Deputy Director General of Forestry Administration and Dr. Mathieu Henry, Lead Technical Officer from FAO headquarters, Rome, Italia.

The workshop aimed to provide an overview on methods and guidance to be applied for preparing a National Forest Inventory (NFI) and a Greenhouse Gas (GHG) inventory with transparent, accurate, complete and consistent estimates, to be comparable among countries, and to provide information on data collection and analysis, and choices among methods for preparing GHG estimates.

The training workshop provided numerous technical presentations on principles, guidelines and protocols for reporting GHG emissions for REDD+; updated information on remote sensing/forest cover maps, NFI and other components of the UN-REDD Programme; and a short practice with United Nations Framework Convention on Climate Change (UNFCCC) software for default reporting. Workshop planners had also recorded suggestions and recommendations from group discussions for future improvement of MRV practice under the Cambodia UN-REDD National programme. The workshop helped achieve capacity building on forest inventory and GHG inventory among potential stakeholders and sectors. A network for REDD+ within the context of MRV related activities has been constructed and should expand widely in the near future with greater participation in REDD+ activities anticipated.

II. DAY ONE: Tuesday 5-November 2012

Session 1: Conference Opening

At the opening session, the welcoming remarks were delivered by Dr. Matieu Henry, FAO representative and His Excellency Chea Sam Ang, National Programme Director for Cambodia UN- REDD.

On behalf of FAO, Dr. Matieu Henry expressed his gratitude and privilege to be a co-chair this training workshop and honorary delivered a remark to participants. He stressed that the workshop is part of the national REDD+ process and under the UN-REDD programme support, in collaboration with our partners. He informed that the global forest resources diminish at an alarming rate. The rapid decrease of forest cover has serious consequences on the global environment and lifestyle. Indeed, deforestation and forest degradation contribute to about 17% of CO2 emissions, the main greenhouse gas responsible for climate change. There are many alternatives to contribute to the emission reductions and the UN-REDD programme tends to support the national process to decrease the emissions from the forestry sector. He confirmed that implementation of the activities in Cambodia under the UN-REDD Programme started less than a year ago and the team in charge of the implementation of the technical activities to support the national forest monitoring system is almost fully operational. As a first step, two parallel processes have been initiated. One process focuses on assessing the national capacities in order to identify the needs and to evaluate the most adapted options. The second process focuses on building capacities. Training exercises focus on the three main pillars of the national forest monitoring system, namely: (1) the GHG inventory, (2) the National forest Inventory, (3) the satellite forest monitoring system.
While two weeks training has been organized in Brazil last month on the satellite forest monitoring system, this training workshop focuses on the most important pillar, the GHG inventory. The training workshop provided (a) an overview on methods and guidance to be applied for preparing transparent, accurate, complete and consistent estimates, (b) method to prepare a GHG estimate in general and particularly for the forestry sector, and (c) information on the status of the preparation of the national communication in Cambodia. He emphasized that further trainings and workshops will certainly focuses on the NFI, the forest stratification and biomass assessment, including using tree allometric equations. He recognized this important training workshop through providing opportunity to share knowledge on GHG estimates, methods, data availability, current progresses and next steps to be achieved among participants. He expressed his sincere thank to all participants and whish the workshop be fruitful and successful.

Next to Dr. Henry, His Excellency Chea Sam Ang, National Programme Director for Cambodia UN- REDD, gave the plenary address. He noted that Cambodia is in a highly competitive world with other nations in the region gearing up for carbon trading. China’s national plan is to achieve a carbon trading scheme by 2013. South Korea has similar plan aimed at 2015. Many countries are imposing taxes on oil and coal imports or production as part of efforts to reduce their GHG emissions. “From 2013 onwards, the efforts of all countries in the world are aimed at reducing GHG. I mention this because we need to be prepare Capacity, he added, is very important for Cambodia. “We do not yet have the comprehensive capacity in the area of forestry to implement and carry out this work”. Legal documents, policy and political will are in place towards sustainable management and utilization of natural and forestry resources. “In the future we intend to take part in reducing the GHG thru the reduction of the forest degradation and to sell the carbon credit”. With legal documents in place, “we need to work on the technical affairs at well”. While Cambodian government is very grateful for assistance from JICA, UNDP, FAO, DANIDA and others, “we cannot rely on our development partners forever. We need to strengthen ourselves in the near future”. Other countries are in the carbon market, trading and learning at the same time while Cambodia does not yet know how to sell carbon credit. “We are concerned and would like to let you know that trading is merciless. Everyone wants to benefit from what they buy and sell. I would like to let you know that if we don’t go in the right direction, our name will be history. The ownership (of land) and capacity must be together”. He also talked about the need to update NFI knowledge to meet international standards. Many sub-national inventories have been done, there are codes of practices and manuals, but these documents seem to be out of date with international standards. “We are sort of out of date ourselves, trying to update ourselves and update our documents. We need to see what can be done in Cambodia that can be accepted at the international level. If it is not accepted in the region or the world, who are we going to sell the carbon credit to?” Cambodia needs to develop an inventory that works for the country but is acceptable at the international level. There is concern about choosing something too complicated and beyond the country’s capacity. “We need to look at our capacity and resource and what we can do. Inventory is technical if we have trouble with technical affairs, we could be in trouble”. In additionally, he reminded that developing an implementation plan for forest and GHG inventory depends on participants in the workshop. “We need to scale up implementation”. Future planning should consider beyond the resources available at the moment, consider the scope that is needed and decide on additional resources needed. “We can scale up our resource; update the knowledge at community/local level. This is the beginning. Full implementation depends on us at the moment”. Finally, he expressed his admiration to all team members who have made this important training workshop happened and to participants who are actively participated in the workshop.

After delivery of welcome remarks and opening remarks, a group photo was taken, and the workshop overview was briefed for participants. The workshop consists of 9 technical sessions, and each session presentation would be followed by Q&A; and at each day’s end would have a short group discussion.

Session 2: Basic Principles of GHG Inventory

Initially, Dr. Henry present objective of the GHG Inventory under the UNFCCC. Climate change is the main environmental crisis in the world. It is result of concentration of greenhouse gases (GHG) emitted into atmosphere. Nations that are parties to the e United Nations Framework Convention on Climate Changes must collect quantitative data on GHG emissions and removals to assess how much human activity in a party country contribute. Dr. Matieu gave a detailed review of elementary statistical concepts used in estimating GHG estimates. Participating countries choose how they meet reporting guidelines established by the Intergovernmental Panel on Climate Change. Countries can either provide yearly GHG inventory on emissions and removals or National Communication every four years with more generalized information on national circumstances, historic and projected emissions/removals under various scenarios, planned mitigation and adaptation, research and public awareness. UNFCCC uses this information to assess country progress towards commitments and to assess global trends of anthropogenic emissions and removals.

The Reporting principles and guidelines used for national communication were explained by Dr. Sandro Federici, FAO. He made a comprehensive description in great depth the five reporting principles: Transparency, consistency, comparability, completeness and accuracy. Carbon reporting is only for managed lands since anthropogenic (human caused) emissions are what is reported. Regarding the elements of a GHG Inventory, he explained that reporting obligations include NAMAs (National Appropriate Mitigation Actions) every two years. GHGs include carbon dioxides, methane, nitrous oxides, perfluorocarbons, hydro-fluorocarbons, and sulphur hexafluorides, along with indirect GHGs: carbon monoxide, nitrogen oxides, non-methane organic volatile compounds and sulphur oxides. Sectors to report include energy, industrial processes, product use, agriculture/forestry and other land uses. Three methodologies can be used: Tier 1 "IPCC default factors" include net change of carbon storage/emissions for each land use category; Tier 2 is country specific carbon data from field inventory; Tier 3 is highly disaggregated national inventory that reports carbon stocks in different pools and assesses any changes in pools.

Session 3: Background of GHG Inventory of Cambodia

GHG Inventory for Cambodian forestry sector was presented by Matieu Van Rijn (program director, biomass, GERES). Forests are important sector in driving GHG changes. Forests emit GHG about17% of global emissions from deforestation and forest degradation; store carbon in wood material and soils about 45% of terrestrial carbon stored in forests, 25% sequestered. Growing vegetation withdraws CO2 from atmosphere through photosynthesis, returns CO2 to atmosphere by respiration, decay of organic matter and removal/burning of biomass. Human activities and natural causes make changing global GHG emission. Natural include forest fires and growth and decay; human include land conversion for agriculture, logging (harvest), emissions from factories and vehicles. UNFCCC requires reports on changes in forest and other woody biomass stock (positive: forest growth/regrowth; negative: degradation and biomass stock removal); forest and grassland conversion to other uses; abandonment of croplands, pastures and other managed lands (where carbon may re-accumulate on land and in soil); and CO2 emissions and removals from soils. Cambodia's first Communication in 2002 reported its 1994 GHG level; the 2010 Communication which reports GHG for 2000 level and predicts future trends and mitigation options is in draft. These indicate land use change in forestry produced negative emissions (less carbon was emitted than removed) in 1996 of -17,906 and in 2000 of -24,565.67. The present forestry sink (carbon storage/sequestration) is estimated larger than total GHG emissions. However, with current practices the forecast is decrease in national emission uptake to less than 5,000 GHCO2e in 2050. Forest conversion is contributing the most to emissions. GHG can be reduced through improving current management, utilization efficiency and forest use; enlarging the sequestration surface or sink capacity (reforestation and conservation); and substitution or reduced use of wood resource.

The National GHG Inventory of Cambodia and the Way Forward was presented by Mr. Uy Kamal, GHG expert of MRV team. He revealed that in the past national GHG inventory, the 1996 revised software was applied. The software plugs in Tier 1 methodologies to estimate GHG emissions and removals. Some key issues were encountered during inventories such as lack activity data, database management system, and inadequate capacity of technical staff in applying software and inventory improvement planning, and lack of funding for research activities, etc. He suggested that cooperation with development partners, research institutes, academic universities, and NGOs is necessary in the context of sharing information/data for sectoral GHG inventory and funding availability for important research activities and improve management structure and work. Improving capacity building for local experts by bringing them regional knowledge and experience including most up-to-date GHG inventory software is not ignorable. He also recognized the important of a technical advisory group including both international and local expertise.

Session 4: Inventory Methodologies

IPCC methods for GHG inventory was presented by Dr. Sandro Federici. For forestry, GHG estimated on 6 carbon pools: (1) Biomass-above ground (stems, stumps, branches, bark, seeds, foliage); (2) below ground roots; (3). Dead organic matter (DOM) or deadwood (all nonliving biomass not contained in litter); (4) litter; (5) Soil organic matter (SOM) and (6) harvested wood products (HWP) with lifetime longer than 1 year. For each land use category, carbon stock changes are estimated for all strata or subdivisions of land area. Carbon stock changes within a stratum are estimated by considering carbon cycle processes between the carbon pools. Tier 1 methods simplest to use, equations and default parameter values (e.g., emission and stock change factors) are provided by IPCC. Country-specific activity data are needed, but can use globally available sources of activity data estimates (e.g. FAO). Tier 2 applies emission and stock change factors based on country- or region-specific data for most important land-use categories. Tier 3 used models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national level. Gain-Loss Method is an IPCC method for subtracting biomass carbon lost from biomass carbon gain in lieu of more elaborate methods using NFI and other data.

III. DAY TWO: Tuesday 6-November 2012

Session 4 (cont): Inventory Methodologies

IPCC methods for Land representation was presented by Dr. Sandro Federici. He explained the principles for classifying land: managed/unmanaged; disaggregation of strata to assign emission factors; complete representation of land across entire time series; consistent application and representation dates; estimate uncertainties. According to IPCC guideline, land uses are defined as forestland, cropland, grassland, wetland, settlement, other land. Three general methods for collecting activity data: (1) data not explicit, no tracking land use through time (2) data provides land use change through time though not spatially explicit; or (3) data provides land change through time and spatially explicit. General data sources include national census, surveys and maps, international datasets, remote sensing, data stored in GIS. "Confusion matrix" table (technical term for evaluating accuracy of remote sensing classifications by comparing to on-ground data).

Session 5: Data Compilation and Management

Data compilation, data management and archiving system was presented by Dr. Matieu Henry. He highlighted the reviewed steps including where to find data (national versus international) and data archiving. He suggested that engaging data suppliers in inventory compilation, develop contracts for data supply, and conduct informal updates on methods are the key elements in this work. Another important presentation was related to institutional arrangements for national systems. Dr. Sandro Federici explained that we need to have clear assignments to each actor that cooperate in doing the inventory. We need to clarify which entities, institutions, legal and procedural arrangements are needed by the NFI functions. There are three phases in institutional arrangement for national system as such inventory planning, preparation and management. "Institutional arrangements" are formal arrangements such as regulations, laws, decrees and Memorandum of understanding (MoU). There are some problems may face with such as conflict of responsibility (2 or more in charge), vacuum of responsibility (no one in charge), and loops (entities have other legal entitlements).

Session 6: Software Exercise

Presentation of the data and exercise on the 2006 IPCC software was made by Uy Kamal. Participants worked through IPCC software with example exercise in forestry sector. The main software that were highlighted in the workshop are 2006 IPCC software, and the Agriculture and Land Use National Greenhouse Gas Inventory Software (ALU Software), which was developed by Colorado State university of the United state of America. The both software are designed for higher tier (tier 2 or higher) that require comprehensive input data and need integration of agriculture sector and LULUCF sector together in order to minimize uncertainty and avoid double counting.

IV. DAY THREE: Wednesday 7-November 2012

Session 7: Forest Inventory

The first presentation for the third day was about the national forest inventories - status in the world. Dr. Henry described that the current status of national inventory is very different throughout the world in term of in steps, variables, focus, sampling strategy, plots (temporary or permanent, design, shape, size). U.S. and China have done the most frequent NFIs. Canada has done 4 times; Russia, India, Brazil and Australia about 2-3 times. Greenland, Turkey, most of Africa and Middle East do not have NFI. Cambodia has several sub-national forest inventories. Japanese NFI excludes forests on agricultural or residential lands, habitat for bamboo. Forestry Administration is responsible for all stages of NFI. Italian NFI focuses only on trees on forest land. Their responsibilities was split between 3 entities among that private company does archiving and documentation.

Planning for the Cambodia NFI was presented by Dr. David C. Chojnacky, International Inventory Expert from U.S. He noted that Cambodia UN-REDD has well developed management/coordination structure and much focus on REDD protocols and processes. He also paid much attention on operational concerns like field procedures, plot size, GHG measures. There is vital roles in middle that connect REDD requirements/ management need for NFI products to field with a strategy and overall inventory design. Without linkage, gaps may be possible to happen between desired product and field design. He proposed double sampling for stratification. There need to have two phases. Phase 1 is a remote sensing layer that consistently classifies landscape into (a) non-forest and (b) forest; phase 2: field plots that subsample phase-1 pixels in some pattern, usually a systematic grid for national-scale inventory. Re-measure every five years. Could also add LIDAR phase if more frequent sampling desired. Good inventory design will help determine database; not visa versa. Rather than complex messy database, possibly work with outside experts to develop online data extraction tools that minimize user need for complex database manipulation; perhaps train FA employee to manage database as part of capacity building. He also discussed some of his U.S. work in applying NFI statistics to a map in Nevada.

Remote Sensing for Assessing Forest Resources and Changes was presented by Ian Thomas, Remote Sensing Specialist. There many sectors use satellite imagery for different purposes particularly in detecting land mines, hydropower, border mapping, flood response, urban and land use planning, national defense, population census, topographic maps for Population Services International to help determine where malaria outbreaks are for delivering malaria nets and medicine. Forestry sector can share costs with other agencies that also use this technology. Factors in remote sensing include pixel size, resolution (need fine enough detail to see), price, spectral color, timing, clouds and seasons, licensing restrictions. Landsat is free but not good resolution and many satellites are dead. Clouds are a real problem. It is hard to see trees through cloud cover. The Landsat satellite only comes through every two weeks, but 80 percent of the time it is cloudy here. You must either use radar or go under clouds for aerial survey. High resolution imagery sometimes required to see forest plantation. Satellite imagery options are matter of cost versus resolution.

Toward Forest cover data preparation for establishment of Historical RELs (Sharing information and Experience) is another presentation made by Mr. Takeshi Yamase, CAM-REDD of JICA Cambodia. CAM-REDD is one of the supporting frameworks for implementing Cambodia REDD+ Roadmap. It has been comparing simulated RELs (Reference Emission Levels) of some province/provincial cluster, considering appropriate size of "sub-national scale" for REDD-plus implementation in Cambodia. This method to calculate historical trend of CO2 emissions and removals could be applied for any scale level such as national and sub-national level. He proposed that Cambodia REDD+ MRV Team should start simulating various scale of RELs using existing data, and start discussing the appropriate scale/size/areas for the sub-national level REDD+ implementation.

A forest area change matrix between 2002 and 2006 and between 2006 and 2010 of for all provinces should be prepared by FA or MRV Team. CAM-REDD can support this work, simulation and discussion, he added.

Design of NFI was a presentation made by Mr. Samreth Vanna, multipurpose national forestry inventory specialist of MRV Team. He made a comparison in FAO rapid survey of 18 countries. It was founded that 13 countries were collecting data at sub-national level; 15 countries collected data on publically owned forest and only 8 countries have included private forests. Frequency of NFI differed from every two to 10 or more years. All Asian countries surveyed are designing NFI for status and trends of forest resources. He also presented case studies of NFI in Cameroun, Philippines, Bhutan, Korea and China.

The last presentation was about 0 Tier for forest land, deforestation and afforestation for Cambodia. Dr. Sandro Federici highlighted steps include selecting time series for estimate to be reported, setting land categories to classify under forest degradation or deforestation, defining subcategories of land converted and defining subdivisions to stratify. For Tier 1 reporting, default factors are applied for assigning areas of forest categories, subcategories and subdivisions to IPCC forest types. If spatial data are not available, assign areas based on expert judgment or based on the proportion of the country area covered by each climate zone. He also presented the Tier 1 method for estimating GHG. In short, 0 Tier is basically used default values and where there is no or very limited local activity data for higher tier.

V. DAY FOUR: Thursday 8-November 2012

Session 8: Cambodia UN-REDD National Programme

Current status of Cambodian UN-REDD National Programme was presented by Ms. Ly Sophorn, Deputy Chief Cambodia REDD+ Secretariat. She informed that the Cambodia REDD programme evaluates 5 activities: deforestation, forest degradation, forest carbon resource conservation, sustainable forest management and improving forest carbon resource. REDD programme has included in the national development strategy programme (2009-2013) and the national forest programme (2010-2029). Cambodia REDD+ Roadmap has been under development since 2010, and now three REDD pilot projects have been implemented in the Oddar Meanchey province, Keo Sima protected forest in Mondulkiri province, and the Kulen Promteb wildlife sanctuary in Seam Reap province. The Cambodia UN-REDD Programme has received financial and technical support from FAO, the United Nations Development Programme (UNDP) and the United Nations Environmental Programme (UNEP). It is being implemented by the General Department of Administration for Nature Protection and Conservation (GDANPC) of MoE, and the Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries (MAFF). The UN-REDD National Programme is working on i) national REDD+ Readiness Management arrangements and stakeholder consultation, ii) national capacity building towards development of the REDD+ strategy and implementation framework, iii) Sub-national REDD+ capacity building and demonstration, and iv) support to develop the monitoring system.

Session 9: Closing Session

In this session, 3 activities were assigned: round table discussion, certification offering, and closing remarks. However, due to delay of certificate preparation and late receiving signatures of top management level, it caused certification ceremony was not available, therefore, it was suggested to circulate lately. Only round table discussion and closing remarks were offered.

Roundtable discussion

There are two concerns have been discussed among the participants during at the last session. The first one was focusing on the workshop contribution of workshop to their routine works, and the second one was about future activities that should be implemented. As institutional feedback to these concerns, a summary is made as following.

Regarding to the first concern, most participant representatives have acknowledged and highly evaluated the training workshop as its sharing knowledge and knowhow applied for NFI and GHG inventory preparation and reporting and its diversity of inventory software such as 2006 IPCC software and ALU software, knowledge on carbon credits and its market mechanism apply associate with REDD+ implementation activities, the updating on Cambodia national REDD programme, CAM-REDD programme and its activities. Some representatives have also recognized that the training workshop was a good opportunity to build relationship and sharing experience between among participants, provide capacity building to national and sub-national level stakeholders including NGOs as both sides need to work together closely. Additionally, the training workshop brought about national and international knowledge together for participants.

The second concern was also significantly commented. Participant representatives suggested to collect all existing data and to establish a database management system for NFI, to improve networking and information sharing information, the training material should be used for developing manual for university teaching, such training workshop should provide more opportunity to university students to learn about in order to engage them more actively in its activities, all training materials should be translated into national khmer language to make more better for easier understanding. Other ideas were focusing on workshop time management, be more focus and not lengthy. F And finally, most participants requested that for further training, and training materials and guideline development for NFI and GHG inventory should be made available in national khmer language, and future capacity building for key participants is important.

At the end of the workshop session, on behalf of workshop organizer, Dr. Henry provided a meaningful closing remark. The preparation of a GHG inventory is not easy because there are many variables has to be considered and no specific standards and guidelines are available. There is a need to collect data on the land use area and land use area changes, emission factor and carbon stock change factor to do a GHG inventory. The As these data are managed by different institutions, different stakeholders from national and international interests. Strong institutional collaborations and arrangements are will be necessary to ensure the preparation of the National the GHG inventory by the government institutions and also the stakeholder NGOs. A GHG inventory report needs to be submitted by December 2014. The Forestry Administration is responsible to develop institutional arrangements involved in REDD+: to provide data, emission factors and activities data that increase transparency, improve robustness of all data and reduce uncertainty to increase benefits from financial international markets. The workshop provided the role played by the GHG inventory in meeting UNFCCC commitments and the reporting principles which are elements of the GHG inventory, along with methods proposed under IPCC for how to compile data and how to select the appropriate method for different applications. We also saw how to develop the international GHG inventory, how to use IPCC software, the status of the GHG inventory in Cambodia, the progress, constraints, the available data and the missing data. Moreover, we also identified the different approaches to doing a national inventory and difference alternatives to consider. This training workshop is the part of Cambodia National REDD+ Road Map. Finally, I want to thank His Excellency Chea Sam Ang for his participation along with the open and active participation from the involved agencies and NGOs.

Appendices

Appendix I: Question and Answers

Q1 (Mr. Cheang Dany from FA): What does robust mean and are there kind of agreement on method standards and level of robustness for GHG Inventory system?

A1 (Dr. Matieu Henry): There is no standard to apply, the UNFCCC provide only guidelines. This is the responsibility of the country to decide which method to use. Regarding the robustness of the GHG estimation method, it is robust if by replication of the method or comparison, you obtain similar estimations. Dr. Sandro Federic added that the principle of robustness is included in the decision text of the UNFCCC.

Q2 (Mr. Cheang Dany from FA): What is the minimum level of acceptability for the reporting format? What could be the cost for Cambodia, What is the minimum standard required for baseline calculation?
A2 (Dr. Sandro Federici): There is no minimum needed but minimum are data are needed with or without a national forest inventory (some annex I countries do not have NFI implemented). The NFI can produce more useful data but a cost/benefit analysis has to be conducted.

Q3: When talking about the Tier1 or Tier2 levels are we considering only forest land or do we consider the forest types?
A3 (Dr. Sandro Federici): The Tier 1 level includes forest types. The Tier 2 level uses national disaggregation referring to AFOLU categories. Then these broad categories also contain sub-categories (Most often, one specific country only have 1 or 2 sub-categories represented).

Q4 (Matieu Henry): Your presentation mentions an increase in Forest Carbon Sink, is it related to changes in forest definition? Why the 2010 national communication is still a draft?
A4 (Uy Kamal): The national communication is under review and should be finalized by the end of the year 2012.

Q5 (Yeang Donal): What forest definition is used?
A5 (Mathieu V.R.): The national forest definition has been used. Mr. Leng Chivin added that actually there is not a formal national definition of the forest. All Cambodia have is a forest definition for CDM (the one that has been used for the communication).

Q6 (Mr. Leng Chivin from FA): About definition, how do you define forest degradation?
A6 (Mathieu V.R.): The forest degradation corresponds to a reduction of carbon stock but in that case the forest is remaining forest.

Q7 (Mr. Cheang Dany from FA): How do you consider new form of degradation such as rubber, palm oil plantations... should be the forest definition based on carbon stock or based on biodiversity criteria.
A7 (Mathieu V.R.): You can consider these to aspects to define the forest. DR. Sandro F. made a remark that there has been lot of discussions on how to define forest degradation but actually this definition is not needed. You only need to consider a forest definition to report

your GHG emissions due to deforestation, and then you need to consider 6 carbon pools, the final stage of the wood and/or long term storage of carbon.

Q8: What do you have in mind when you mention wood substitution?
A8 (Mathieu V.R.): Biogas can be one of these alternatives.

Q9 (Dr. Sandro Federici.): Why the forest definition has to be reviewed?
A9 (Dr. Stephane Brun): The review in progress is related to the existing forest definition and forest classification system in Cambodia. And yes, there is a need to review the possibility of adjusting some broad definition like considering some ecological criteria that are not yet considered by the actual definition.

Q10: Where do the equations come from?
A10 (Dr. Sandro Federici): The equations are provided in the IPCC guidelines. IPCC tables can provide Tier 1 data

Q11: These equations can be used everywhere in the world? What if there is no biomass inventory in a country
A11 (Dr. Sandro Federici): The gain loss method will be applied so you do not need information on carbon stock, most appropriate allometric equations will be used for estimations.

Q12 (Mr. Leng Chivin, FA): From your experience, emissions for all of the 6 carbon pools that you have mentioned need to be calculated? What if some are not estimated?
A12 (Dr. Sandro Federici): In the example of harvest wood product (HWP), at the Tier 1 level, if you assume that instantaneous oxidation does not account, you assume that the emissions related to this pool is 0. Same case would apply for the Dead Organic Matter and Soil Organic Matter. When you consider deforestation you can skip the HWP carbon pool and assume that everything has been loss.

Q13 (Mr. Leng Chivin, FA): For our forest cover assessment what are the consequences of changes in methodologies and classification?
A13 (Dr. Sandro Federici): If you have used different methods you need to evaluate the differences. If you updated your classification you may have to reclassify your whole map or if it is too complicated you may have to abandon this old map. You can also consider the raw data used for this map and recreate a new map then check the accuracy of the newly created map based on the raw data.

Q14: To establish a reference level, what year should be considered?
A14 (Dr. Sandro Federici): There is no rules related to this, but you should consider the availability of historical data (and the related consistency), the data on deforestation drivers can also guide you. Some Annex I countries use 1990 for establishing their Reference level but if you don't have accurate data for this period you should consider a different year.

Q15: A good forest cover map is the 2010 one, can with use this date?
A15 (Dr. Sandro Federici): Even if there is no clear rule, 2010 is a too recent year, you should look at the years 2000s and combine 2-3 additional years (such as 2005 and 2010).
Q16 (Mathieu V.R.): About the confusion matrix, for the calculation of the overall accuracy, in your example, what is the meaning of the number #526?
A16 (Dr. Sandro Federici): This corresponds to the number of correctly classified pixels.

Q17 (Mr. Soy Seng, FAO office): What does mean non-carbon dioxide?
A 17 (Dr. Sandro Federici): This is all GHG except the CO_2 (such as NO_2, CH_4).

Q18: Which Institution/Agency should provide land use data, the National Geography Department or Forestry Administration?
A18 (Dr. Sandro Federici): The country has to decide whether an institution is responsible for data provision. Institutional agreement needs also to exist for implementing a National Inventory System. Some approaches are not necessarily required maps and finally there is no mandatory about the source of the national map. Mathieu V.R. added that a map will always facilitate verifications and increase the accuracy of your estimations. But, the two previous Cambodian national communications were not based on any map.

Q19 (Mr. Uy Kamal): What level of data are the most appropriate in the context of REDD+?
A19 (Dr. Sandro Federici): To report emission in the context of REDD+ you have to consider the best data. You also need to know when and where deforestation is happening, so you need a Remote Sensing Monitoring system or a Ground level monitoring system for reporting. For a national communication on GHG emission you can deal without a map but for REDD+ you need spatio-temporal data, if you don't have these data it is like being blind.

Q20 (Mr. Samreth Vanna, FA): About the data storage, in the case of the Forestry Administration we have primary data stored in one place, sometime our data are not properly prepared for a specific objective such as GHG Inventory. What is the right format to maintain a database that can be ready for use? Is there any method to compile the data? Is there any kind of standard for database storage?
A20 (Dr. Matieu Henry): A good archiving system relies on someone responsible for it. Do you have someone responsible for the database management at the Forestry Administration?
A20 (Mr. Samreth Vanna): There is a responsible for the forest inventory data (no name mentioned)

Q21: The National Geography Department has the mandate for data management and data delivery, is that true?
A21 (Mr. Leng Chivin, FA): Yes, it is true but there has not been any cooperation so far.

Q22 (Mr. Samreth Vanna): The absence of cooperation between Ministries is a real situation in Cambodia and a real constraint. How to overcome this problem?
A22 (Dr. Matieu Henry): You need on archive in each institutions/agencies then MoU or legal agreement between ministries. Remark (U.K.): In my personal opinion, with the MRV REDD+ related activities actually implemented, FA is the most relevant agency for archiving the data.

Q23 (Mr. Uy Kamal) : it is very interesting information on institutional arrangements but I am not clear about the relationship between the Independent Entities and the other 3 entity responsible for producing, archiving and ensuring the functioning of the National Inventory system, is this legal arrangements?
A23 (Dr. Sandro Federici): Yes, these entities have signed specific MoU or legal agreements.

Q24 (Mr. Uy Kamal): In the case of the Climate Change unit of Cambodia, there is a sub-decree who invite the different ministries to participate in the GHG Inventory but it seems that there is no further MoU or other legal framework supported.

A24 (Dr. Sandro Federici): Then you should move from an invitation to a legal framework.

Q25 (Mr. Samreth Vanna.): In your country what are these entities and what legal framework exist between them? Is the schedule the same for the GHG inventory and for forest inventory?
A25 (Dr.Sandro Federici): In Italy, the Ministry of Environment, the protection agency are responsible and have MoU with the National Statistic office, other regional office and other agreements with the Forest Services as well. In reality, there is no legal basis, only agreements. We do have implemented a national forest inventory that should be updated every 5 years, but due to financing issues the forest service is unable to update it every 5 years. In the case your country do not have a NFI implemented, you should do with what you have for reporting your GHG emissions.

Q26 (Mr. Soy Seng): What is the difference between Inventory and Census?
A26 (Dr. Sandro Federici): Actually, an inventory is a census; an agricultural inventory is a census. In the case of the forest it is an inventory and not a census in the sense that a sampling approach is applied. In the case of the GHG Inventory (which is a census) you account all emissions related to all your forest but it is based on a sampling.

Q27 (Mr. Uy Kamal): In your country, do you have a specific budget allocated for the GHG inventory or can you rely on external funding such as GEF?
A27 (Dr. Sandro Federici): Italian GHG inventory can't be supported by GEF; there is a government budget specific for ensuring the functioning of the different entities (limited but existing!)

Q28 (Mr. Yeang Donal): In Cambodia, for the NFI design we are facing a challenge related to the harmonization of data from different plots, is it possible?
A28 (Dr. Matieu Henry): The major problem with the harmonization of different data is related to an increase of the uncertainty and to the propagation error of the different methods used for the inventory. Dr. David J.K added that harmonizing the data is maybe not the most important, what you need is the information of the plot.

Q29 (Mr. Leng Chivin): Is the shape of a plot (such as quadrant) specific to a forest type?
A29 (Dr. David C. Chojnacky): It is not important comparing to the way you design the NFI. A shape is just a shape. It is just a matter of surface, area. About forest type, yes it will affect the choice of a specific shape of plot. You can answer this question by testing and comparing data collected on various sizes of plots.

Q30 (Dr. Stephan Brun): About the hexagonal cells constituting the grids for representing the plot distribution?
A30 (Dr. Sandro Federici): This type of cell help to avoid having too much plots distributed outside the country boundaries. Dr. David C. Chojnacky added that it is practical and help to reach a better distribution of plots.

Q31 (Mr. Uy Kamal): according to the examples of Japan, France, Italy, what explain the choice of a specific crown cover threshold (10%-30%)?
A31 (Dr. Sandro Federici): The threshold is chosen according to the ecological characteristics of the forest, it depends of the level of density you observe in your country. It is also influenced by the sensor you will use to monitor your forest (10% variations of crown cover can't be detectable by a satellite).

Q32 (Mr. Matheiu V.R.): When you present a sampling in two phases, how can you estimate the sampling intensity of the second phase?
A32 (Dr. David C. Chojnacky): A minimum can be set by statistics analysis but it will also depend of the finance available.

Q33 (Mr. Mathieu V.R.): If you have satellite data available, why use a systematic sampling?
A33 (Dr. David C. Chojnacky): You are right, you can stratify your sampling, and the main reason to choose a systematic sampling is to design a simple and practical forest inventory.

Q34 (Mr. Kao Dana): How many percentages for sampling intensity are you expecting?
A34 (Mr. Samreth Vanna): Dr. David C. Chojnacky will assist us on the design of a NFI, double sampling for stratification is proposed, the use of Remote sensing and LIDAR as well. However the sampling intensity will be highly influenced by finance and time available.

Q35 (Dr. Stephan Brun): Isn't LIDAR too costly for being used in the context of Cambodia?
A35 (Dr. David C. Chojnacky): Space Lidar will considerably reduce the costs and should be soon operational.

Q36 (Mr. Leng Chivin): What does "keep it simple" means technically?
A36 (Dr. David C. Chojnacky): Field plots are complicated and right now it seems to me like enough information is available for the country. So why not choosing something easier to do and try to limit as much as possible the number of plots. Mr. Yeang Donal made a remark that for the Oddar Meanchey project we decided also to simplify the field work as we were thinking to work with the local communities, maybe it is the best option if in the future local communities are involved in the NFI/MRV.

Q37 (Dr. Sandro Federici): Different sensors can be used for Remote Sensing analysis, different applications need different strategies?
A37 (Ian Tomas): You can use low resolution sensor to identify your area of interest then you can buy high resolution images to collect accurate data. He added that the national geographic department is very transparent in the way they provide the data. There is an official way to access the data. As in Lao, transparency is the rule, the department of forestry decided to market the Forest Cover 2010 data at fixed price.

Q38 (Dr. Matieu Henry): Can you explain more about the methodology followed for the National Forest Cover 2010?
A38 (Mr. Ian Tomas): In Cambodia, I think it is visual interpretation of Landsat.
Mr. Leng Chivin remarked that he is using visual interpretation to correct the polygons of the previous year, which constitutes our base map. In term of transparency, the Forestry Administration has also mandate to report to the FAO Forest Resource Assessment so now our target is 2015.

Q39 (Dr. Stephane Brun): What about the methodology used in Lao PDR?
A39 (Mr. Ian Tomas): There is two phases of interpretation using Remote Sensing (High Resolution images) and Image Segmentation (eCognition software).

Q40 (Dr. Matieu Henry): With High-Resolution images, are you using Visual Interpretation or Semi-Automatic classification?
A40 (Mr. Ian Tomas): It is a combination as the method is visual recognition of object pixel

based interpretation. We can say that in that case, the software is reproducing the old stereoscopic analysis.

Q41 (Dr. Sandro Federici): How has been projected the deforestation, have you been considering the drivers of deforestation or others data?
A41 (Mr. Takashi Yamase): We've been using only data from forest cover and not have been considering other data related to the drivers of deforestation.

Q42 (Dr. Matieu Henry): How is it possible to assess the REL for forest degradation?
A42 (Mr. Takashi Yamase): In this study, we are only considering the actual mean Carbon stock between 2002, 2006 and 2010.

Q43 (Dr. Matieu Henry): Is there national data on forest degradation?
A43 (Mr. Takashi Yamase): There is no data on forest degradation.

Q44 (Dr. Matieu Henry): Have you done comparison with global dataset or national data?
A44 (Mr. Takashi Yamase): We've not yet compared the results of the simulation.

Q45 (Mr. Uy Kamal): Which method could provide the most accurate data? Which could be the most cost-efficient?

A45 (Mr. Samreth Vanna): Like Dr. David mentioned, a double sampling for stratification method could reduce the cost of the field work with the use of Remote Sensing. Time and Human Resources available have to be considered.

Q46 (Dr. Matieu Henry): You mentioned various countries who participated to the FAO rapid survey in 2007. How did those countries report their biomass stocks if they are not yet able to measure it? How did they proceed? Regarding biomass calculation, allometric equations may be used but in the case of Cambodia it seems very limited. Did the countries you mentioned used allometric equations of volume equations?
A46 (Mr. Samreth Vanna): As far as I know, Philippines have been reporting but they did not mention how they estimated the biomass.

Q47 (Mr. Yeang Donal): When will be the website ready?
A47 (Ms. Ly Sophorn): Right now we are still in the bidding process for procurement. We do hope the website will be ready soon.

Q48: Thank you for your clear presentation but what about the expectations?
A48 (Ms. Ly Sophorn): The expectations are to implement the REDD in Cambodia, to bring income from carbon sells, to develop the strategy for the implementation of the REDD+ Roadmap and also to provide National and Sub-national Capacity building. Other expectation is to establish the MRV system for the REDD+ policy in Cambodia.

Q49 (Dr. Matieu Henry): About the interaction between the four groups, is there any contact person, focal point to facilitate the communication between each group?
A49 (Ms. Ly Sophorn): Not yet, Term of Reference is in preparation.

Appendix II: Agenda

Day 1: Monday, 5 November 2012

Time	Topic	Speaker	MC/Facilitator
8:30-9:00	Registration		
Session 1: Opening Session			
9:00-9:10	-Announcement of Program -Invitation of Board of Chairmen -National Anthem		Mrs. Sar Sophyra
9:10-9:25	Welcome remarks	**Dr. Henry Matieu**, Lead Technical Officer, FAO **H.E Chea Sam Ang**, NPD, Cambodia UN REDD Programme	
9:25-9:35	Group Photo		
Session 2: Basic Principle of GHG Inventory			
9:35-9:45	Presentation of the content of the training	Mr. Uy Kamal	Mr. KhunVathana Dr. Sandro Federici
9:45-10:25	Objective of the GHG inventory under the UNFCCC	Dr. Henry Matieu	
10:25-10:40	Break		
10:40-11:20	Reporting principals and guidelines	Dr. Sandro Federici	Dr. Henry Matieu Mr. Leng Chivin
11:20-12:00	Elements of a GHG Inventory	Dr. Sandro Federici	
12:00-13:30	Lunch		
Session 3: Background of GHG Inventory of Cambodia			
13:30-14:30	GHG Inventory for Cambodian forestry sector.	Mr. Mathieu Van Rijn	Dr. David Chojnacky Mr. Samreth Vanna
14:30-15:30	National GHG inventory of Cambodia:	Mr. Uy Kamal	
15:30-15:45	Break		
Session 4: GHG Inventory Methodologies			
15:45:16:25	IPCC methods for GHG inventory	Dr. Sandro Federici	Dr. David Chojnacky Mr. Samreth Vanna
16:25-17:00	Open discussion		
18:00-20:00	Inception Dinner/Cook tail (TBC)		

Day 2: Tuesday, 6 November 2012

8:30-9:00	Registration		
9:00-9:15	Summary of the first day	Mr. Leng Chivin	Mr. Leng Chivin Mr. Mathieu V.R.
9:15-9:55	Choice of Method and steps for	Dr. Sandro	

	GHG inventory	Federici	
Session 5: Data compilation and management			
9:55-10-35	Data compilation	Dr.Matieu Henry	
10:35-10:40	Break		
10:40-11:20	Database management and archiving system	Dr. Henry Matieu	Mr. Leng Chivin Mr. Mathieu V.R.
11:20-12:00	National System for GHG Inventory	Dr. Sandro Federici	
12:00-13:30	Lunch		
Session 6: Software practise			
13:30-14:30	Presentation of the data for exercise (2006 IPCC Software)	Mr. Uy Kamal Mr. Mathieu V.R.	Dr. Sandro Federici Dr. Henry Matieu
14:30-14:45	Break		
14:45-16:30	Continue exercise	Mr. Uy Kamal Mr. Mathieu V.R.	Dr. Sandro Federici Dr. Henry Matieu
16:30-17:00	Open discussion		

Day 3: Wednesday, 7 November 2012

8:30-9:00	Registration		
9:00-9:15	Summary of the second day	Mr. Leng Chivin	Mr. Mathieu V.R. Mr. Uy Kamal
Session 7: Forest Inventory			
9:15-9:45	National forest inventories: status in the world.	Dr. Henry Matieu	
9:45-10:15	Planning for Cambodia National Forest Inventory	Dr. David Chojnacky	
10:15-10:45	Remote Sensing for Assessing Forest Resources and Changes	Ian Thomas	
10:45-11:00	Break		
11:00-11:30	Field research: Standard Operation Procedure of biomass inventory	Mr. Samreth Vanna	Mr. Mathieu V.R. Mr. Uy Kamal
11:30-12:00	Toward Forest cover data preparation for establishment of Historical REL (Sharing information and Experience)	Mr. Takeshi Yamase CAM-REDD	
12:00-13:30	Lunch		
13:30-14:00	REDD+ under the UNFCCC reporting framework	Dr. Henry Matieu	Ian Thomas Mr. Leng Chivin
14:00-14:30	0 Tier for forest land, deforestation and afforestation for Cambodia	Dr. Sandro Federici	
14:30-14:45	Break		
14:45-15:15	Identification of the best method to monitor REDD+ activities (By group of 5 person	Dr. Sandro Federici	Ian Thomas Mr. Leng Chivin
15:15-16:00	Estimate Preparation (QA&QC, verification) Description	Dr. Sandro Federici	

16:00-17:00	Open discussion		

Day 4: Thursday, 8 November 2012

8:30-9:00	Registration		
9:00-9:15	Summary of the third day	Mr. Leng Chivin	Mr. Khun Vathana Dr. Henry Matieu Mr. Uy Kamal Mr. Samreth Vanna
Session 8: Cambodia UN-REDD National Programme			
9:15-9:45	Current Status of Cambodia UN-REDD National Programme	Ms. Ly Sophorn UN-REDD Secretariat	
9:45-10:20	Open discussion and workshop wrap up.		
10:20-10:35	Break		
Session 9: Closing Session			
10:35-11:20	Certificate and Closing remarks	**Dr. Henry Matieu**, Lead Technical Officer **H.E Chea SamAng**, NPD, Cambodia UN REDD Programme	Mrs. Sar Sophyra
11:20-12:30	Lunch		

End

Appendix III: List of participants

No	Name	Position	Organizations	Contact	E-mail
1	Mr Son Bora	Officer	GDANCP	11817533	Borason.cpads@gmail.com
2	Mr Top Pich	Vice Dean	RUA/MAFF	16890441	Topich69@gmail.com
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4	Mr Sandro Federici	GHG Resource person	FAO		sandro.federici@gmail.com
5	Mr Yeang Donal	National Policy Advisor	FFI	12300921	Donal.yeang@faunaflora.org
6	Mr Stephane Brun	FAO GIS Expert	FAO		Stephane.brun@fao.org
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13	Ms Seng Limhun	RUA	RUA	12773322	limhum.tot@gmail.com
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15	Mr Ian Thomas	GIS/RS expert	FAO		Landmine_Mapper@hotmail.com
16	Mr Preap Sam	Chief office	FA	92858188	Sam_preap@yahoo.com
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20	Dr David Chojnacky	International consultant	DANIDA		dchojnac@vt.edu
21	Ms Cindy Chojnacky	Communication Advisor	DANIDA		cchoj@cox.net
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	Sopheak				
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36	Mr Samreth Vanna	consultant	FAO		Vanna.Samreth@fao.org
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41	Mr Khun Vathana	Chair of UNREDD Secretariat	National REDD Secretariat		vathana.khun@gmail.com
42	Mr Henry Matieu	LTO, Rome HQs	FAO		Matieu.Henry@fao.org
43	Mr Ben Vickers	Regional UNREDD Programme coordinator	FAO		Ben.Vickers@fao.org

Appendix IV: List of presentations

Objective of the GHG inventory under the UNFCCC

Sandro Federici, Matieu Henry

GHG Inventory Preparation for Forestry
November 5-8th 2012
Paradise Angkor Villa Hotel

UN-REDD

Why do we need knowledge about anthropogenic GHG fluxes (emissions and removals)?

- Climate change is the consequence of a change in the GHG concentration in the atmosphere due to anthropogenic emissions (mainly CO_2, CH_4 and N_2O)

↳ Climate change is the main environmental crisis

- Quantitative data on anthropogenic GHG emissions and removals are needed to assess the contribution of human activities to changes in the GHG concentration in the atmosphere

↳ Human activities are the main source of GHG

- Data on GHG fluxes have to be disaggregated by activity/category and a timeseries (e.g. from 1990 till now) is needed to assess trends

↳ Mitigation policies need to be monitored

UN-REDD

Why do we need knowledge about anthropogenic GHG fluxes (emissions and removals)?

- Mitigation potential = quantity of reduction in emissions OR enhancement in removals that could be achieved by a country/project activity in a timeframe.

E.g. if expected deforestation will cause 10 Mt CO_2 emissions / year

↳ the mitigation potential associated with an activity to halt deforestation would be 10 Mt CO_2

•Identifying sources of emissions and sinks of removals (i.e. activity/category, carbon pool) together with level and trend of emissions/removals helps to assess their drivers.

E.g. whether forest land are converted to grazing land the driver is husbandry for meat/milk/wool production for domestic and/or export.

↳ If GHG fluxes and trends and their drivers are known expected climate change can be forecasted and then adaptation planned

UN-REDD

How do we quantify anthropogenic GHG fluxes?

- The amount of GHG emitted or removed from an element (e.g. a carbon pool, a land category, transport etc.) is not measured directly (over time & space)

E.g. there is not an instrument capable to measure in continuous emissions and removals from the whole forest land area

↳ **An estimate is prepared to quantify emissions or removals produced by a source or sink in a year**

- An estimate is an approximation, a central value that has been inferred from either a proxy or a sample or both; it has therefore an associated degree of uncertainty within a confidence level (a probability)

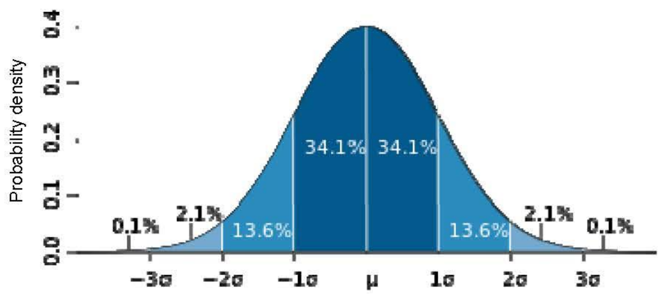
E.g. the average

↳ **The Probability Density Function is the statistical tool used to identify the distribution of the potential estimate according to probability thresholds.**

UN-REDD

An estimate and its uncertainty

The Probability Density Function (PDF) describes the range and relative likelihood of possible values of an estimate (i.e. its uncertainty); where μ is the central value of the distribution and σ is the standard deviation (SD).



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An estimate and its uncertainty

The standard deviation, σ, shows how much variation or "dispersion" exists from the mean (central) value. A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data points are spread out over a large range of values.

The standard deviation is the square root of the variance σ^2 (which is the sum of the square difference, between each sampled value and the average of the sampled values, divided by the number of sampled values minus 1)

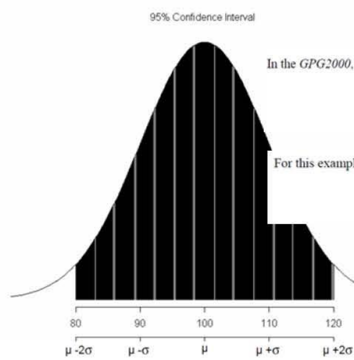
$$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

The uncertainty formula is $\% \text{ uncertainty} = \frac{\frac{1}{2}(95\% \text{ Confidence Interval width})}{\mu} \times 100$

UN-REDD

An estimate and its uncertainty

EXAMPLE OF UNCERTAINTY EXPRESSION



In the *GPG2000*, the percentage uncertainty is defined as:

$$\% \text{ uncertainty} = \frac{\frac{1}{2}(95\% \text{ Confidence Interval width})}{\mu} \times 100$$

For this example:

$$\% \text{ uncertainty} = \frac{\frac{1}{2}(4\sigma)}{\mu} \times 100 = \frac{2\sigma}{\mu} \times 100 = \frac{20}{100} \times 100 = 20\%$$

Where:

σ = standard deviation

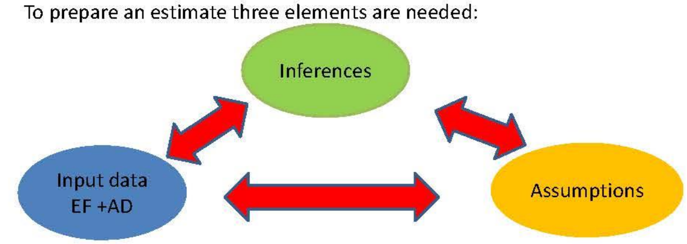
$\sigma = \sqrt{\text{variance}} = 10$

μ = the mean of the distribution

UN-REDD

Preparing a GHG estimate

- To prepare an estimate three elements are needed:



E.g. to estimate aboveground biomass carbon losses due to harvesting the following elements are needed:

- Assumption: carbon losses are proportional to harvested wood
- Activity data on roundwood and fuelwood
- Expansion factors to whole aboveground biomass, including WD and % C
- Inference to deal with incompleteness of activity data (e.g. illegal logging)

Preparing a GHG estimate

- An **assumption**: has to be proven reliable.

- **Inferences**: grows in complexity from IPCC methods to country-specific methods -i.e. from a simple multiplicative models (with constant factors) to complex models with numerous parameters

- **Input data** may be divided in

Activity Data (AD): significant change yr by yr according to changes in the activity.

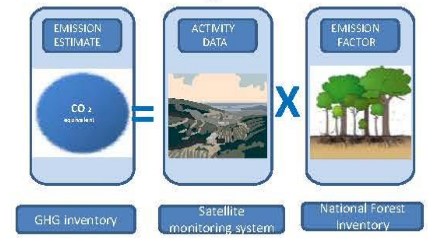
E.g.1 Area subject to a specific management activity such as no-tillage practice

E.g.2. Harvested timber volume for total forest harvesting

Emission (or Carbon-Stock-Change) factors (EF – CSCF): allow the inference of emissions/removals from the AD and tend not to change significantly YR by YR.

Preparing a GHG estimate: the method

The most simple method for estimating GHG fluxes from a source/sink is:



Activity Data * Emission Factor = annual GHG flux

For C pools

Activity Data * Carbon Stock Change Factor = annual carbon stock change

- Or *proxy data* * *factor of correlation* with variable to be assessed (i.e. CO_2 emissions/removals)

Preparing a GHG estimate: the method

- Assumption: there is a constant relation (the CSCF) between the GHG flux caused by an activity (e.g. deforestation) and another element of that activity (e.g. area deforested).
- It is assumed that the CSCF is, as far as can be judged, an unbiased estimator of carbon stock of lands before these lands were deforested (in the case of deforestation).

- The inference: is the simple multiplication: **Activity Data * Constant Factor**

>>> So that the variable of interest i.e. CO_2 emissions/removals is inferred by the data of a proxy variable

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E.g. GHG estimate of deforestation

Assumption: All carbon contained in the forest is lost because of conversion (this is a reliable assumption)

Activity data = area deforested in the year e.g. 10,000 ha

Carbon stock change factor = average carbon stock contained in the forest before conversion e.g. 100 tC ha^{-1}

Inference = area deforested * average carbon stock contained in the forest before conversion = 10,000 ha * 100 tC ha^{-1} = 100,000 tC

UN-REDD

IPCC Guidelines

IPCC Guidelines provides **default** methods for each source/sink category;

(So-called tier 1 methods)

An IPCC default method is based on assumptions and inferences considered as:

- Being robust;
- Applicable in any country in the world;
- With an acceptable level of uncertainties (deemed at producing accurate assessment of trends).

An IPCC method does not set a standard.

An IPCC method is built on good practices, it provides a viable option, as robust as possible

UN-REDD

Preparing a GHG estimate: the method

What is a standard?

- rigid threshold that excludes everything does not match it;
- fixed element which does not allow every national circumstance to pass through;
- does not accommodate scientific and technologic progress until the standard is set at a new level.

A GPG is an instruction that could be followed for achieving the target **(preparing national GHG estimates)** by anybody under any different national circumstances

↳ gives instructions to the Parties + free to choose their own way.

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A standard

UN-REDD

Good practices

UN-REDD

GHG-estimate's methods

What's the best method to be applied?

The method that provides GHG estimates:

- with the highest accuracy, and
- Adapted to national Financial, human and technical capacities

Potentially, there are no limited number of methods for preparing GHG estimates;

However, to be used under the UNFCCC, estimates should have some characteristics (the 5 principles).

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IPCC Guidelines

IPCC Good Practice Guidance for LULUCF

http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html

2006 IPCC Guidelines for National GHG Inventories

http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

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Reporting GHG estimates under the UNFCCC

- Under the UNFCCC there are 2 channels for GHG data acquisition:

(1) GHG Inventory, annually submitted by Annex I Parties only (it is mandatory). A GHGI contains information on GHG emissions and removals, as:

- estimated values and associated uncertainties,
- background data
- information on methods
- their relevance in the national balance,
- Information on all activities implemented to ensure a proper and sustainable development of the GHGI

– Subject to review,

– ...and accounting procedure under the KP

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Reporting GHG estimates under the UNFCCC

- Currently, under the UNFCCC there are 2 channels for GHG data acquisition:
  - National Communication, submitted by all Parties (however it is mandatory, every 4 years, for Annex I Parties only). A NC contains information on:
    - national circumstances
    - historical emission and removals
    - projected emissions and removals under BAU and mitigation-actions scenarios
    - Information on planned and ongoing mitigation and adaptation policies and measures
    - Information on research, cooperation (including capacity building) and public awareness on climate change

Subject to review

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Future requirements under the UNFCCC. Coming soon…

- Annex I Parties should submit:

A biennial update report on their progress in achieving emission reductions, including information on implemented mitigation actions, emission reductions and projected emissions

The first biennial update report due by 1 January 2014 and then every 2 years

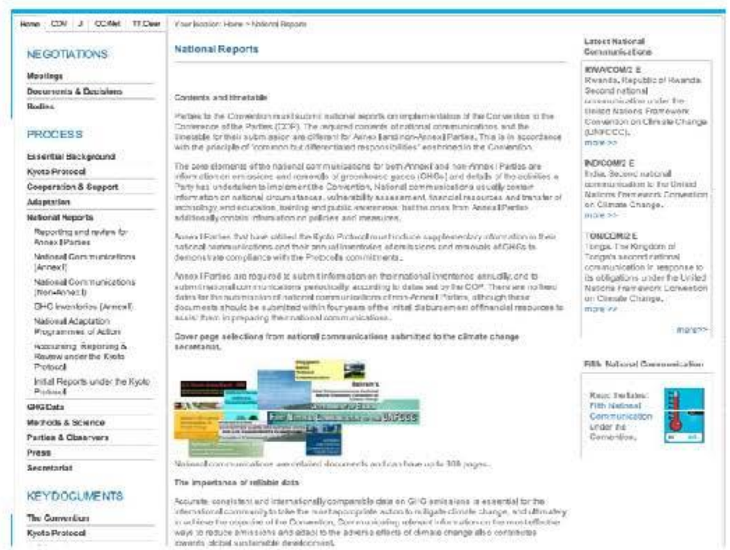
Subject to an International assessment and review process that will be conducted through a technical review of information and a multilateral assessment of the implementation of quantified economy-wide emissions reduction targets

Coming soon

- Non-Annex I Parties (consistent with their capabilities and the level of support provided for reporting) should submit:
  - A biennial update report containing updates of national greenhouse gas inventories, including a national inventory report and information on mitigation actions.
  - The first biennial update reports due by December 2014 and then every 2 years
  - Subject An international consultations and analysis will aim to increase transparency of mitigation actions and their effects, through analysis by technical experts in consultation with the Party concerned and through a facilitative sharing of views, and will result in a summary report;

Data publication

- Data are published on the UNFCCC website http://unfccc.int/national_reports/items/1408.php
- Data published are official data of the Party
- Their consistency with other official statistics prepared by the Party under other national (e.g. statistical yearbook) and international initiative (e.g. FRA) has to be ensured
- Published data are used by the UNFCCC to assessing country progresses towards commitments and for assessing global trends of anthropogenic emissions and removals; whose trends are the basis for discussions on the development and implementation of any mitigation and adaptation instruments



The purpose of the review

To assist Annex I Parties in improving the quality of their reports

To examine reports consistency with relevant UNFCCC and IPCC guidelines

To ensure that the Conference of the Parties (COP) has adequate and reliable information on:

- trends of anthropogenic GHG emissions and removals;
- mitigation and adaptation needs and ongoing actions.

To ensure comparability of estimates among countries i.e. that estimates are transparent, complete, consistent and accurate

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Thank you for your attention

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Training course on:
GHG estimates for the forest sector

Reporting principles and guidelines:

Transparency, Consistency, Completeness, Comparability, Accuracy

Sandro Federici, Matieu Henry

GHG Inventory Preparation for Forestry
November 5-8th 2012
Paradise Angkor Villa Hotel

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Content

1. Reporting principles
2. Transparency
3. Consistency
4. Comparability
5. Completeness
6. Accuracy
7. Managed land

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Reporting principles

The UNFCCC reporting framework has been designed to allow any Party under any national circumstances to provide an assessment of its level and trends of anthropogenic emissions and removals.

Assessments should be comparable to allow:

- Assess global estimates,
- Evaluating contribution of each Party to the final goal of the Convention

UNFCCC Article2: The ultimate objective […] is to achieve […]
the stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

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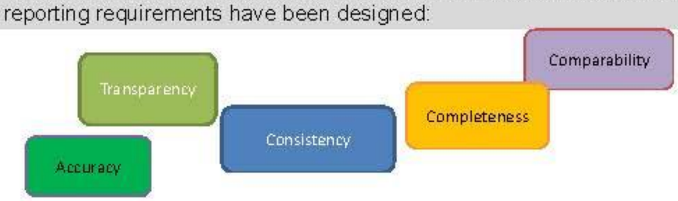
Reporting principles

To ensure such a comparability five principles have been set on which reporting requirements have been designed:



Each estimate, should be compared with other estimates of other sectors and/or other countries.

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Transparency

>> means that the data sources, assumptions and methodologies used for an inventory should be **clearly explained**, in order to facilitate the replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of the information;

ALL needed information should be provided and structured in a clear way (for Annex I Parties NIR -national inventory report- and CRF -common reporting format tables).

An estimated value alone, even if associated with a low uncertainty, is NOT sufficient.

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Transparency

Does the GHG-estimate actually estimate the category as the category has been defined?

E.g. a forest definition is applied, however data are collected according to another forest definition, no corrections are applied;

E.g.2. A portion of forest territory subject to human activities is left out.

Does the GHG-estimate represents the correct time period?

E.g. the data cover a portion of the year only,

E.g.2. the data collected in a portion of the year are extrapolated to the whole year without considering seasonality.

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Transparency

Input data are consistent with technical requirements of the model applied?

E.g. net increment is applied while the gross increment is the input data requested by the model

To answer to all those questions it is fundamental to know how the estimate has been prepared and which are:

- The assumptions;
- The inferences;
- The input data.

↳ ALL the methodological and data information that allows to prepar the estimation and to reconstruct the estimate.

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Transparency

Transparency is the MOST important principle to be followed when preparing estimates;

- A non-transparent estimate = non-estimate
- Without transparency, it cannot be assessed whether an estimate follows good practices and reporting principles.
- There are not national circumstances that may justify a lack of transparency

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Consistency

>>> means that an annual GHG inventory should be internally consistent for all reported years in all its elements across sectors, categories and gases.

An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks.

An inventory 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 2006 IPCC Guidelines for National Greenhouse Gas Inventories or the GPG for the LULUCF (2003).

Difference among annual GHG emissions and removals must not be determined by differences in methods used or in the quality of data used

Consistency

- A timeseries of estimates is said consistent if same data quality and methodology are applied along the timeseries or, when differences occurs among years, methods are applied to avoid that differences in data quality and/or methodology are counted as changes in emissions/removals;
- Inconsistencies among data and methods of different annual inventories always result in differences in the amount of reported estimates and therefore in the trend of the timeseries;
- Considering that the timeseries of estimates is needed to assess the impact of implemented policies and measures, inconsistencies may deeply undermine the efficiency of monitoring mitigation actions.

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Consistency

- To ensure consistency, the IPCC guidelines provide different methods:
  - Overlap method: estimates obtained with two different methods are used to calculate the estimates for the same time period;
  - Surrogate data: data from a proxy can be used to estimate the level and trend of emissions/removals of the source/sink to be estimated;
  - Interpolation: spatial and temporal gap-filling;
  - Extrapolation: spatial and temporal projection;
  - A combination of those methods;
  - Or customized approaches

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Comparability

Comparability means:

Estimates of emissions and removals reported should be comparable among Parties. For that purpose, Parties should use the methodologies and formats agreed by the COP for making estimations and reporting their inventories. The allocation of different source/sink categories should follow the Common Reporting Formats provided by UNFCCC.

IPCC default methods and data build the first step of comparability (all countries with same methods and factors);

However higher level of comparability can be achieved by improving completeness, consistency and accuracy of estimates by applying country-specific methods and data that better cope with IPCC

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Comparability

For REDD+, Parties are requested to use (decision 4/CP.5)

IPCC Good Practice Guidance for LULUCF

(http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html)

2006 IPCC Guidelines for National GHG Inventories

http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

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Completeness

Completeness means that an annual GHG inventory covers at least all sources and sinks, as well as all gases, for which methodologies are provided in IPCC Guidelines.

- Estimates have to have full spatial (geographical) and time (annual) coverage
- A timeseries of annual GHG inventory should be provided (to have trends)

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Completeness

The estimate has to fit the category/pool boundaries set by the definition .

- Are all carbon stocks been included in the pool?
  E.g. does dead biomass includes dead standing and ground biomass?
- Are all carbon pools reported?
  Live Aboveground – Live Belowground – SOC – litter – Dead wood – H &WP
- Does the estimates cover all the land area?
- Do all the gains and losses occurred in the pool considered?

The estimate has to include all emissions/removals from the category/pool

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Accuracy

Accuracy means that emission and removal estimates should be accurate in the sense that they are **systematically neither over nor under true emissions or removals**, as far as can be judged, and that **uncertainties are reduced as far as practicable**.

- Appropriate methodologies should be used, in accordance with the IPCC Guidelines, to promote accuracy in inventories.
- Accuracy of inventories tend to improve year by year because at each inventory cycle more data and knowledge may be available.

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Accuracy

The final goal when preparing an estimate is to "reproduce" the true value, without directly measuring it.

- Accuracy measures how far the estimate is from the true value;
- Differences between the true value and the estimate are due to:

  (1) biases in the method and in the data,
  (2) random errors may cause deviation from the true value (even if they tend to cancel out)

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Accuracy

- When the true value is unknown, avoiding biases in methods and input data allows us to have an accurate estimate (an estimate that coincide with the true value) as far as can be judged (we assume random errors cancelling out);

- Or when the true value is known, even if only for a subset of the population (this is the case when ground truthing remotely sensed classified images), it can be used to calculate the accuracy of an estimate (i.e. verification).

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Accuracy

Inaccuracies may stem from methods, activity data and emissions factors

1. **Inaccuracies related to method stem from:**

- Assumptions;

Are the assumptions reliable? Have assumptions an impact on calculated estimates (e.g. equilibrium models)?

- Inferences;

Do inferences capture real dynamic and magnitude of carbon stocks?

- Parameters;

Are the parameters appropriate for the selected inferences? Have the parameters validated?

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Accuracy

2. **Inaccuracies related to activity data stem from:**

- Definition of the Categories

Do the definitions overlaps? Does the categories cover the all variability?

- Classification methodology

Does the methodology avoid double classification of any land?
Does the methodology avoid the exclusion of any land?

- Data consistency

Are the data in a timeseries consistent each other?
Are the data consistent with method needs?

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Accuracy

2. Inaccuracies related to activity data stem from:

- Data co-registration

Are the different sources of data, -e.g. remotely sensed, ground data- correctly referred to the area where they have been collected?

- Sampling design

Are the samples collected in order to properly represent the whole variability? Are errors minimized?

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Accuracy

3. Inaccuracies related to emission factors stem from:

- Measurement instruments and methods

Are the instruments properly working?
Are instruments properly used?

- Consistency

Are the factors in a timeseries consistent each other?
Are the factors consistent with method needs?

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Accuracy

3. Inaccuracies related to emission factors stem from:

- Sampling design

Are the samples collected in order to properly represent the whole variability? Are errors minimized?

- Association to category/land

Are factors compensating the whole variability of the category/land to which they are applied?

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Accuracy

Without considering here biases due to measuring variables
(e.g. systematic errors in the instruments, systematic errors when using the instruments, systematic errors in the measurement protocol)

- Sampling means measuring a small portion of the whole to derive information on the whole (this make possible to obtain information in an economic, feasible, and accurate way;
- The sampling design is one of the most relevant element for achieving accuracy of estimates;
- Sampling design provides the information on:
  How sample are selected (including considerations on re-sampling)?
  How many sample?

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Accuracy

The average value of a set of samples is an unbiased estimator of the population average if:

- The set of samples have been collected from the population with a sampling design that ensures that each single element of the population has a positive probability to be extracted
- The sample size is large enough, so that the probability density function of the variable represents the actual distribution of frequency and values (i.e. the variance of the sample is an unbiased estimator of the variance of the population)

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Accuracy

- **So, determining sample size is an important issue, samples that are too large may waste resources, including time, while samples that are too small may lead to inaccurate results**
- **In many cases, it is possible to determine the minimum sample size needed to estimate a variable, such as the population mean μ**
- **The sample mean $\bar{x}$ is different from the population mean μ (which is the true value and is the limit of the sample mean as sample size grows to whole population)**

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Accuracy

This difference between the sample and population means can be thought of as an error. The margin of error E is the maximum difference between the observed sample mean and the true value of the population mean that we wish to have.

$$E = z_{\frac{\alpha}{2}} * \frac{\sigma}{\sqrt{n}}$$

where:

$z_{\frac{\alpha}{2}}$ = is known as the critical value, the positive z value that is at the vertical boundary for the area of $\frac{\alpha}{2}$ in the right tail of the standard normal distribution

σ = is the population standard deviation

n = is the sample size

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Accuracy

Rearranging the equation $n = \left[\frac{z_{\frac{\alpha}{2}}\sigma}{E}\right]^2$ that is the sample size necessary to produce results accurate to a specified confidence level and margin of error

This formula is used when, known σ, it is intended to calculate the sample size needed to estimate the mean value μ, with a margin error ± E with a confidence level 1-α.

Of course since is very unlikely that you know σ you may derive an estimate of it from a pre-sampling

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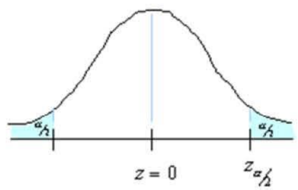
Accuracy

A 95% confidence level corresponds to α=0.05; therefore each of the tales has an area of 0.025. the area within the confidence interval to the left and to the right of the central value has an area of 0.475. In the table of the Standard Normal (z) Distribution, an area of 0.475 corresponds to a value of 1.96.

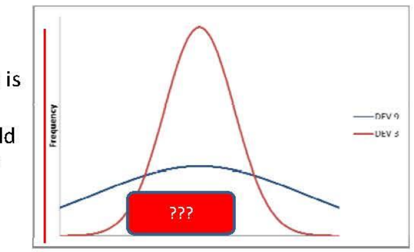
$Z\frac{\alpha}{2}=1.96$



Accuracy

Assuming that for both (blue and brown) distributions the average value is an unbiased estimator, they are both accurate and therefore reliable/trustable

Of course for the red distribution the uncertainty is higher and therefore it is likely that the country should prioritize improvements for that estimate.



Managed lands

A final principle that applies to the AFOLU/LULUCF sector is that to discriminate between natural and anthropogenic emissions and removals:

- **Only** and all emissions and removals occurring on **managed lands have to be reported**;
- All emissions and removals occurring in **unmanaged** lands **should not be reported**, only area of unmanaged lands should be.

Because in managed lands the direct impact of human activities on the C stocks dynamic is assumed to be prevalent,

& C emissions from unmanaged lands is assumed to be largely smaller than that of natural variables.

Managed land is a land with ongoing human activities or, if abandoned, where annual carbon stocks dynamic is still impacted by previous human activities.

Thank you for your attention

Training course on:
GHG estimates for the forest sector

Elements of a GHG Inventory

Sandro Federici, Matieu Henry

GHG Inventory Preparation for Forestry
November 5-8th 2012
Paradise Angkor Villa Hotel

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Content

1. Reporting obligations for non-Annex I Parties
2. Greenhouse gases
3. Timing for reporting
4. Sectors and categories
5. AFOLU categories
6. Estimates: 3 approaches for land representation
7. Methodological choices: Key categories
8. Uncertainty analysis

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Reporting obligations for non-Annex I Parties

New mechanisms for mitigation actions in non-Annex I Parties (*Cancun agreements*)

National appropriate mitigation actions (NAMAs)

→ national communications have to be enhanced + every two years update reports

→ mitigation actions will be measured, reported and verified and subject to international verification

Policy approaches and positive incentives on issues relating to REDD+

→ To implement robust and transparent national forest monitoring system for reporting of the REDD+ activities.

→ To develop resulted-based actions that are fully measured, reported and verified (MRV).

→ To develop national strategies, policies and measures and capacity building.

Greenhouse gases

As a minimum, inventories have to include the following GHGs:

- ***Carbon dioxide*** **(CO_2)**
- ***Methane*** **(CH_4)**
- ***Nitrous oxide*** **(N_2O)**
- *Perfluorocarbons* (PFCs)
- *Hydrofluorocarbons* (HFCs)
- *Sulphur hexafluoride* (SF_6)

Estimates should also include the following indirect GHGs:
Carbon monoxide (CO), *nitrogen oxides* (NOx), *non-methane organic volatile compounds* (NMVOC) and *sulphur oxides* (SO_2)

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Timing for reporting

- Annual emissions and removals;
- For a timeseries of year, including the reference level;
- For developing countries, currently expected to be submitted every 2 years within the biannual update report;
- First Biennial Update Report (BUR) by 2014.

Sectors and categories

The inventory must cover the following sectors:

1. Energy
2. Industrial Processes and Product Use (IPPU)
3. Agriculture, Forestry and Other Land Use (AFOLU)
4. Waste

International aviation and marine bunker fuel emissions are not to be included in national totals, but reported separately

Each of these sectors is subdivided into different source/sink categories. Emissions and removals have to be reported at the most disaggregated level of each source/sink category

Content of the volume 4 of the IPCC 2006

3A Livestock
- 3A1 Livestock
- 3A2 Manure Management

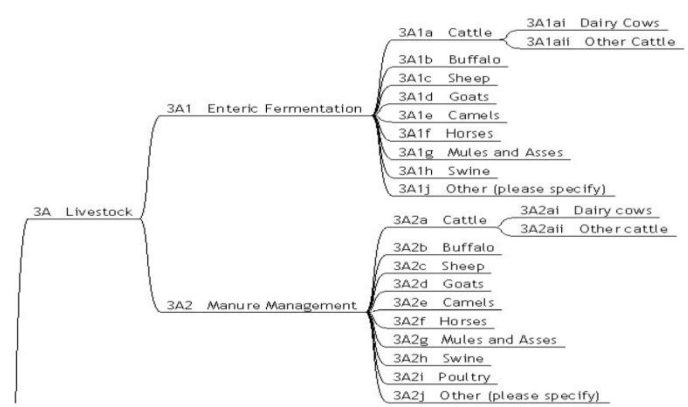
Chapt. 10

3B Land
- 3B1 Forest Land
- 3B2 Cropland
- 3B3 Grassland
- 3B4 Wetlands
- 3B5 Settlements
- 3B6 Other land

3C Aggregate sources and non CO_2 emissions sources on land
- 3C1 GHG emissions from biomass burning (Chapt. 4, 5, 6)
- 3C2 Liming
- 3C3 Urea application
- 3C4 Direct N_2O emissions from managed soils
- 3C5 Indirect N_2O emissions from managed soils (Chapt. 11)
- 3C6 Indirect N_2O emissions from manure management (Chapt. 10)
- 3C7 Rice cultivation (Chapt. 5)
- 3C8 Other
- 3D1 Harvested Wood Products
- 3D2 Other

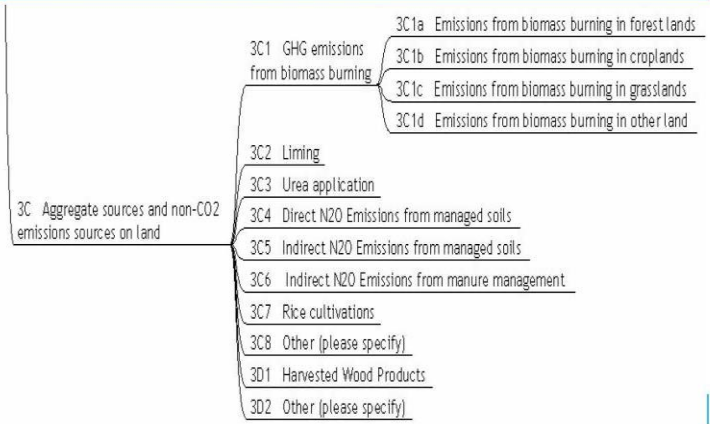
AFOLU categories

CH_4 and N_2O emissions



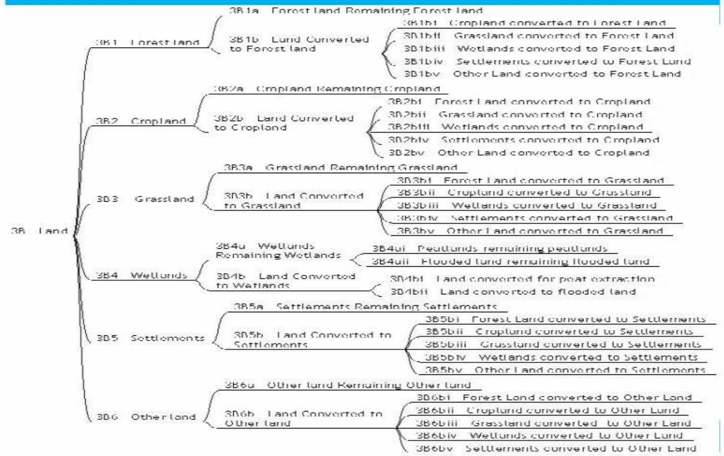
AFOLU categories

CO_2, CH_4 and N_2O emissions



AFOLU categories

C stock Changes, CO_2, Emissions and Removals



Estimates: three approaches for land representation

Different levels of methodological complexity

For Land representation 3 approaches exist:

Approach 1

>>> identifies the total area for each land category - typically from non-spatial country statistics - but does not provide information on the nature and area of conversions between land uses, i.e. it only provides “net” area changes (e.g. deforestation minus forestation).

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Estimates: three approaches for land representation

TABLE 3.2
EXAMPLE OF APPROACH 1: AVAILABLE LAND USE DATA WITH COMPLETE NATIONAL COVERAGE

Time 1			Time 2			Net land-use conversion between Time 1 and Time 2		
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	O	=	2	Other Land	=	0
Sum	=	140	Sum	=	140	Sum	=	0

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

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Estimates: three approaches for land representation

Approach 2

>>> involves tracking of land conversions between categories, resulting in a non-spatially explicit land-use conversion matrix.

Approach 3

>>> extends Approach 2 by using spatially explicit land conversion information, derived from sampling or wall-to-wall mapping techniques.

Similarly to current requirements under the Kyoto Protocol, it is likely that under a REDD+ mechanism that land use changes will be required to be identifiable and traceable in the future.

i.e. it is likely that Approach 3, or Approach 2 with additional information on land use dynamic, can be useful for REDD+ implementation.

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Estimates: three approaches for land representation

TABLE 3.4
ILLUSTRATIVE EXAMPLE OF TABULATING ALL LAND-USE CONVERSION FOR APPROACH 2 INCLUDING NATIONALLY DEFINED STRATA

Initial land use	Final land use	Land area, Mha	Inclusions/Exclusions
Forest Land (Unmanaged)	Forest Land (Unmanaged)	5	Excluded from GHG inventory
Forest Land (Managed, temperate continental)	Forest Land (Managed, temperate continental)	4	Included in GHG inventory
Forest Land (Managed, temperate continental)	Grassland (Unimproved)	2	Included in GHG inventory
Forest Land (Managed, temperate continental)	Settlements	1	Included in GHG inventory
Forest Land (Managed, boreal coniferous)	Forest Land (Managed, boreal coniferous)	6	Included in GHG inventory
Grassland (Unimproved)	Grassland (Unimproved)	61	Included in GHG inventory
Grassland (Unimproved)	Grassland (Improved)	2	Included in GHG inventory
Grassland (Unimproved)	Forest Land (Managed, temperate continental)	1	Included in GHG inventory
Grassland (Unimproved)	Settlements	1	Included in GHG inventory
Grassland (Improved)	Grassland (Improved)	17	Included in GHG inventory
Grassland (Improved)	Forest Land (Managed, temperate continental)	2	Included in GHG inventory

Estimates: three approaches for land representation

TABLE 3.6
SIMPLIFIED LAND-USE CONVERSION MATRIX FOR APPROACH 2 EXAMPLE

Net land-use conversion matrix

Final \ Initial	F	G	C	W	S	O	*Final sum*
F	15	3	1				*19*
G	2	80					*82*
C			29				*29*
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
Numbers represent area units (Mha in this example).

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Estimates: three Tier levels

Different levels of methodological complexity:

For carbon stock changes calculation 3 Tiers:

Tier 1 uses IPCC **default** factors (i.e. biomass in different forest biomes, carbon fraction etc.);

Tier 2 requires some **country-specific** carbon data (i.e. from field inventories, permanent plots);

Tier 3 highly **disaggregated national inventory-type data** of carbon stocks in different pools and assessment of any change in pools through repeated measurements also supported by **modeling**.

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Estimates: three Tier levels

Tier 1 methods for all categories are designed to use readily available national or international statistics in combination with the provided default emission factors and additional parameters that are provided, and therefore should be feasible for all countries.

Moving from Tier 1 to Tier 3 should increases the accuracy and precision of the estimates, but also increases the complexity and the costs of monitoring.

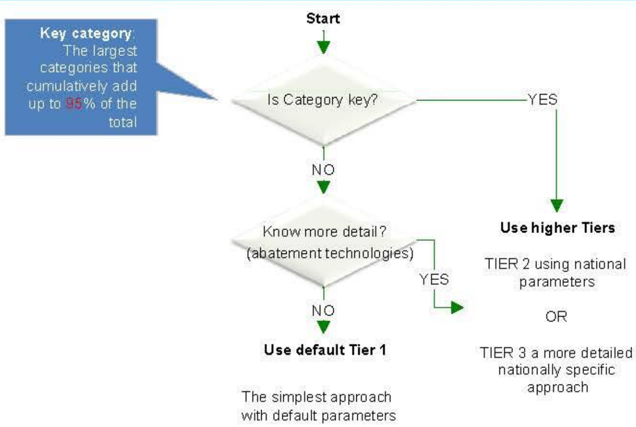
Methodological choices: Key categories

Key category is used to identify the categories that have a **significant influence** on a country's total inventory of GHG in terms of the absolute level, of trend, or uncertainty in emissions and removals;

During inventory resource allocation for data collection, methodological complexity of estimates, quality assurance/quality control,

↳ **the key categories should be prioritized.**

Methodological choices: Key categories



Uncertainty analysis

- Uncertainty estimates are an essential element of a complete inventory;
- Uncertainties should be addressed to avoid the potentially severe consequences of inaccurate information and ensure the monitoring against targets (i.e accurate and comparable);
- When focusing efforts to reduce uncertainty, priority should be given to those inputs that have the most impact on the overall uncertainty of the inventory.

Uncertainty analysis

- The IPCC 2006 Guidelines define two approaches to estimating uncertainties:
  - ➢ Approach 1: error propagation equations
  - ➢ Approach 2: Monte Carlo simulations
- When measurements are not available to quantify uncertainties every approach is highly affected by expert judgement
- Approach 1 is simple enough and transparent for the purpose of an emission inventory

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Uncertainty analysis: approach 1

General approach:

- Consider:
  - standard deviations (when measurements are available)
  - information by national statistical or other institutes (e.g. verification data)
  - information provided in the IPCC Guidelines
- Otherwise use an expert judgement

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Uncertainty analysis: approach 1

Activity data

- low uncertainty (e.g. 3-5%) to activity data derived from national forest inventories;
- medium-high uncertainty (20-50%) related to the data from official statistics derived from administrative surveys or estimated data

Italian GHG Inventory 1990-2008

Uncertainty		
Growing stock	E_{NFI}	3.2%
Current Increment	E_{NFI}	51.6%
Harvest	E_H	30%
Fire	E_F	30%
Drain and grazing	E_D	30%
Mortality	E_M	30%

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Uncertainty analysis: approach 1

Emission factors

IPCC default uncertainty values are used when the emission factor is a default value or no information on the country specific value is available

Italian GHG Inventory 1990-2008

Uncertainty		
Bef	E_{BEF1}	30%
R	E_{BEF2}	30%
DCF	E_{DEF}	30%
Litter	E_L	161%
Soil	E_S	152%
Basic density	E_{BD}	30%
C Conversion factor	E_{CF}	2%

Uncertainty values are high if emission factors are deduced from model assumptions (i.e. litter or soils)

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Uncertainty analysis: approach 1

If uncertain quantities are to be combined by multiplication (i.e. ADxEF)

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

where:

U_{total} = percentage uncertainty in the product of the quantities
U_i = percentage uncertainty associated with source/sink *i*

If uncertain quantities are to be combined by addition or subtraction, as when deriving the overall uncertainty in national estimates:

$$U_E = \frac{\sqrt{(U_1 \cdot E_1)^2 + (U_2 \cdot E_2)^2 + \ldots + (U_n \cdot E_n)^2}}{|E_1 + E_2 + \ldots + E_n|}$$

where:

U_E = percentage uncertainty of the sum
U_i = percentage uncertainty associated with source/sink *i*
E_i = emission/removal estimate for source/sink *i*

Category by category description

Transparency is the key principle; completeness of information reported is an essential requirement to achieve transparency.

- The assumptions and methodologies used should be clearly explained for each source or sink category to ensure transparency;
- The uncertainties in the data used for all source and sink categories must be quantitatively estimated;
- Any methodological or data gaps should be documented in a transparent manner to facilitate an assessment of completeness;
- A QA/QC plan is required from each Party, as well as general, for each source/sink category and specific for key categories, control procedures.

Category by category description

In category description, the information to be reported and documented, for each category, are:

- Category information ;
- Methodological information;
- Data information;
- Estimate's assessment

Category by category description

- Sector affiliation;
- Gas(es);
- Relevance (*is it a key category?);*
- Category description, definition and boundaries;
- Related human activities/practices and impacts;
- Impacts of indirectly human-induced and natural disturbances;
- Historical trends in emissions and removals;
- Any other national circumstance;

Category by category description: method

- Method description;
- Reasons for having selected the method;

then, in case of country-specific method, description of:

- Assumptions;
- Equations and related processes;
- Inputs;
- Sensitivity analysis
- Outputs;
- verification
- Reference(s);

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Category by category description: method

then, in case of country-specific method, description of:

→ Parameters and country specific factors
  - Unit
  - Source and date
  - Methods for collecting and elaborating data
  - Uncertainty
  - QA/QC checks
  - Verification with independent datasets;
  - References

→ Intermediate Output Data (outputs by an equation used as inputs in a next-step equation):
  - Unit
  - Uncertainty
  - QA/QC checks
  - Verification with independent datasets;

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Category by category description: input data

→ Input Data:

- Activity data:
- Emissions factors/carbon stock change factors/other parameters:
  - Unit
  - Source and date
  - Methods for collecting and elaborating data
  - Uncertainty
  - QA/QC checks
  - Verification with independent datasets;
  - References

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Category by category description: example

→ *Category information*

- Sector: LULUCF
- Gases: *CO_2, CH_4, N_2O*
- Relevance: *key category*
- Category description, definition and boundaries:
  - *GHG emissions from living biomass, dead organic matter and soils, from forest land remaining forest land have been reported.*
  - *Forest definition used by Country is the same definition applied by the FAO for its Global Forest Resource assessment (FAO FRA 2000). This definition is consistent with definition given in Decision 16/CMP.1*
  - *The reporting area boundaries have been identified with the administrative boundaries of Italian regions.*

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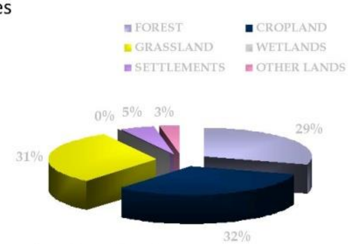
Category by category description: example

→ *Category information*

- Italy's national circumstances

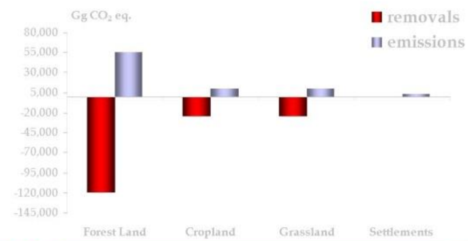


- *Forest Area: 8,838,665 ha, 30% ca of national territory*
- *Steady increase since the 70's, rate 77.000 ha· yr-1; + 1.7 milion ha from 1985 to 2008*
- *All forests are managed*

Category by category description: example

→*Category information*

- *Italy has committed to 6.5% reduction below base year GHG emission levels*
- *LULUCF sector is responsible for 87.3 Mt of CO_2 net removals from the atmosphere in 2008*



Category by category description: example

→ Category information

- Related human activities/practices and impacts;
  - *Information on current forestry activities have been reported.*
- Impacts of indirectly human-induced and natural disturbances;
  - *Information on fire occurrences have been reported.*
- Historical trends in emissions and removals;
  - *Time series of emissions and removals for different pools and subcategories have been reported.*

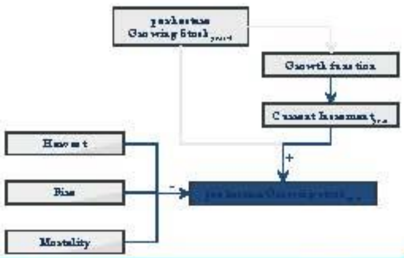
Category by category description: example

- Methodological information:
  - *A model (for-est) has been used to assess data concerning the growing stock and the related carbon, estimating the evolution in time of the Italian forest carbon pools, according to the GPG classification and definition: living biomass, both aboveground and belowground, dead organic matter, including dead wood and litter, and soils as soil organic matter;*
  - *It was conceived on an eco-physiological basis since it uses growing stock as drive variable, growth relationships and measured forest parameters*
  - *The model has been applied at regional scale because of availability of forest-related statistical data at that scale;*
  - *Flowchart, equations, uncertainty analysis and verification data of the model are provided in National Inventory Report.*

Category by category description: example

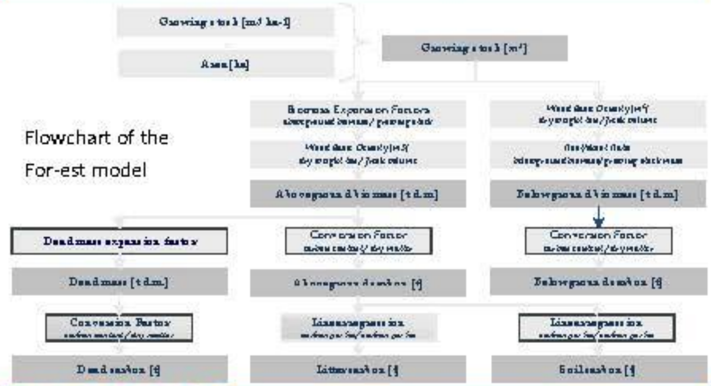
***STEP 1**. from initial growing stock volume reported in the First Italian National Forest Inventory, for each year, the current increment is computed with the derivative Richards function, for every specific forest typology;*

***STEP 2.** for each year, growing stock per hectare [m³ha⁻¹] is computed from the previous year growing stock volume adding the calculated current increment and subtracting losses due to harvest, mortality and fire occurred in the current year.*



Category by category description: example

Flowchart of the For-est model



Category by category description: example

- Data Information
  - *National Forest Inventories data were input data for the forest area, per region and inventory typologies;*
  - *Total commercial harvested wood and forest fires data have been obtained from national statistics;*
  - *Biomass Expansion Factors which expands growing stock volume to volume of aboveground woody biomass, Root/shoot ratios which converts growing stock biomass in belowground biomass and Wood Basic Density for conversions from fresh volume to dry weight have been used and referred in National Inventory Report.*

Category by category description: example

- Data Information: List of parameters and data source

Parameter	Source
ABOVEGROUND BIOMASS	
growing stock	From Forest Inventory
biomass expansion factor	From Forest Inventory
wood basic density	From Literature
BELOWGROUND BIOMASS	
root-shoot ratio	From Literature
LITTER	
mass of aboveground litter	From Literature (CANIF project)
SOIL	
soil organic C content	From Literature (CONECOFOR project)
DEAD MASS	
dead mass expansion factor	From Literature (IPCC GPG 2003)

Category by category description: example

- Information on data sources, uncertainty, QA/QC checks, references are provided

Aboveground biomass	$tCO2_{eq} ha^{-1}$	137.8
Belowground biomass	$tCO2_{eq} ha^{-1}$	31.5
Dead mass	$tCO2_{eq} ha^{-1}$	20.8
Litter	$tCO2_{eq} ha^{-1}$	27.4
Soil	$tCO2_{eq} ha^{-1}$	264.7
Growing stock	E[illegible]	3.2%
Current increment	E[illegible]	51.6%
Harvest	E_H	30%
Fire	E_F	30%
Drain and grazing	E_D	30%
Mortality	E_M	30%
Bef	E[illegible]	30%
R	E[illegible]	30%
DCF	E_{DCF}	30%
Litter	E_L	161%
Soil	E_S	152%
Basic density	E_{BD}	30%
CConversion factor	E_{CF}	2%

Data archiving

The archiving of all information related to the methods and data used for estimating the emissions/removals from the category is essential.

All the reference material, estimates and calculation sheets, as well as the documentation on scientific papers and the basic data needed for the estimates from the category, should be stored and archived.

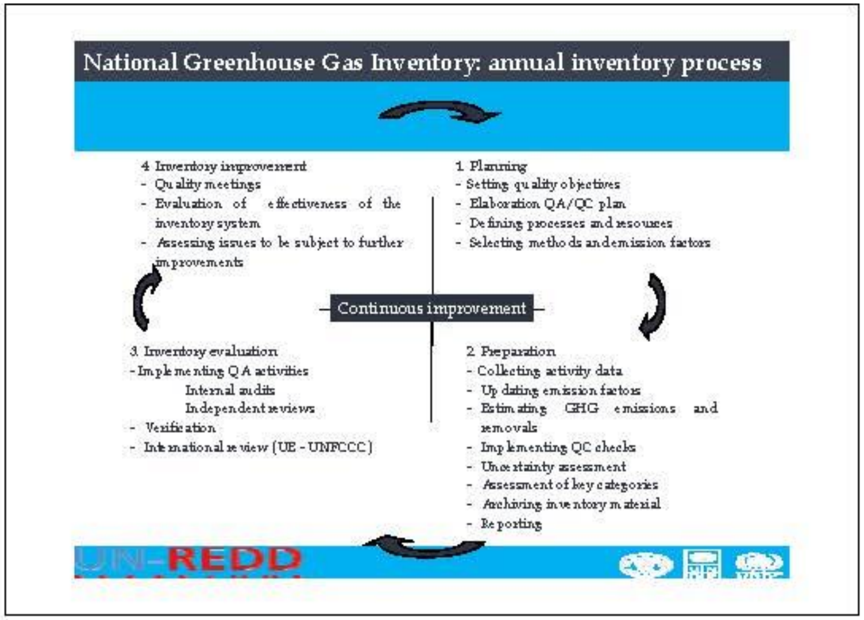
This information shall also include internal documentation on QA/QC procedures, external and internal reviews, documentation on annual key categories and key category identification and planned improvements.

Data archiving

- A good archive serves as the "institutional memory"
  - quality of documentation on inventory preparation key issue
  - easy access and clarity in the information stored important – single location
- Starting point for new teams or new team members
  - learning from previous experience and using already developed "tools"
  - less duplication of work – efficient use of resources
- A library/data source for the team during preparation
  - previous inventory the basis for the next one: check, compare with previous calculations, references, etc.
- Information base for reviews, enquires, etc.
  - transparency
  - reproduction of the inventory estimates

Data archiving

- An archiving system needs:
  - A responsible person
  - A database where all information is stored (paper and electronic data):
    - The database should be conserved in two separate sites and composed by two instruments (hard disk and filing cabinet)
    - Information stored in the database should be accessible but not modifiable (i.e. any change/update should be tracked)


National Greenhouse Gas Inventory: annual inventory process
1. Planning
- Setting quality objectives
- Elaboration QA/QC plan
- Defining processes and resources
- Selecting methods and emission factors
2. Preparation
- Collecting activity data
- Updating emission factors
- Estimating GHG emissions and removals
- Implementing QC checks
- Uncertainty assessment
- Assessment of key categories
- Archiving inventory material
- Reporting
3. Inventory evaluation
- Implementing QA activities
Internal audits
Independent reviews
- Verification
- International review (UE - UNFCCC)
4. Inventory improvement
- Quality meetings
- Evaluation of effectiveness of the inventory system
- Assessing issues to be subject to further improvements
Continuous improvement
UN-REDD

Status GHG Inventory for Cambodian forestry sector (LULUCF)

Prepared for Training Workshop on 'GHG Inventory Preparation for Forestry'
Cambodia UN-REDD National Programme

Presentation Outline

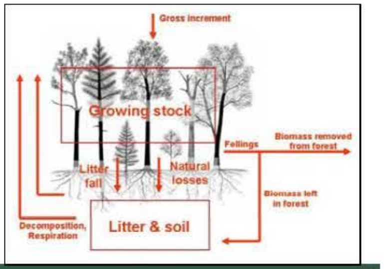
1. Forest GHG role explained
2. Reporting guidelines (LULUCF GHG mechanisms)
3. Cambodia Forest GHG Situation
4. Predicted GHG Development
5. Proposed GHG mitigation options
6. Potential improvements in Accounting

Forest GHG role explained

- **Forests (UNFCCC : 'Land Use, Land Use Change & Forestry – LULUCF') constitute and important sector in driving Greenhouse Gas (GHG) changes.**
- **This can be contributed to the fact that forests are both 1) emitting, 2) storing, as well as 3) sequestering GHG's.**
  - 1) Forest emit GHG to the atmosphere.
    - Approx 17.4% of global emissions stem from deforestation and forest degradation.
  - 2) Forests store carbon in woody material and soils.
    - Approx 45% of terrestrial carbon is stored in forests.
  - 3) Forest sequester GHG from the atmosphere.
    - Approx 25% of Global GHG emissions on an annual basis.

Forest GHG role explained

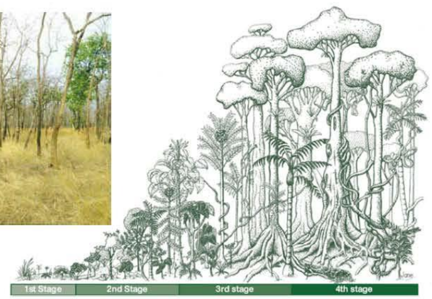
- Growing vegetation withdraws CO_2 from the atmosphere through the process of photosynthesis (Sequestration)
- Carbon dioxide is returned to the atmosphere by the respiration of the vegetation, the decay of organic matter in soils and litter, removal and eventually burning of biomass through various processes (harvest, fuel wood extraction, etc.)
- Carbon is stored in living vegetation, dead organic matter, and soil (Biomass Carbon Pool)



Forest GHG role explained

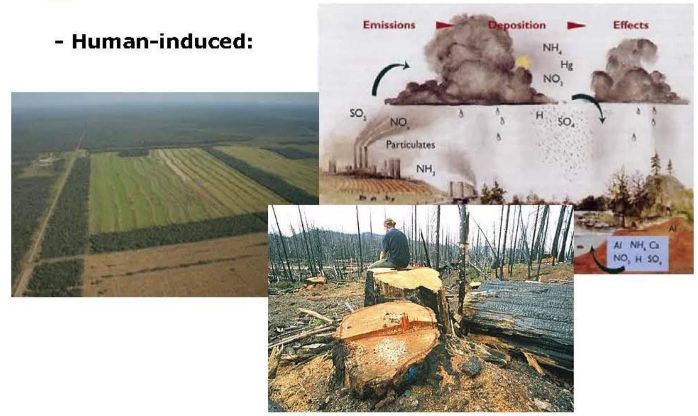
Forest GHG sector changes relate to both Natural as Human-induced factors

- **Natural:**



Forest GHG role explained

- **Human-induced:**



GHG reporting, Good Practice guidelines GPG (LULUCF GHG mechanisms)

- **UNFCCC requires parties to report in LULUCF sector on:**

1. Changes in forest and other woody biomass stocks

- Changes in carbon stocks of forest land remaining forest land
  1. Positive changes: Sequestration
  2. Negative changes: Forest degradation (negative flux from Carbon pool)

  → Calculated using: biomass stock removal, biomass growth of existing forests and or re-growth of non-forest stands.

2. Forest and grassland conversion

- Conversion of existing forests and natural grasslands to other land uses, such as agriculture
  1. Forest clearing

  → A change in Forest cover area, leading to subsequent emissions from the biomass removal, and the future capacity to sequester carbon.

Reporting guidelines (LULUCF GHG mechanisms)

3. Abandonment of croplands, pastures, or other managed lands

- If managed lands, e.g., croplands and pastures, are abandoned, carbon may re-accumulate on the land and in the soil.

  → According to the IPCC land abandoned grows at a higher rate towards their natural state during the first 20 years. Abandoned lands are not to be subject to ongoing human intervention after abandonment.

4. Co2 emissions and removals from soils

- Changes in the amount of organic carbon stored in soils
  1. Land-use practices affect soil carbon stocks by modifying carbon inputs to soil as well as the decomposition rate of soil organic matter.

  (This GHG emission source is not addressed in Cambodia's reporting to the convention).

Cambodia Forest GHG Situation

- **National Forest (LULUCF) GHG emission estimations:**
  - **Initial National Communication (2002)**
    - Reporting 1994 GHG levels
  - **Second National Communication (2010 draft)**
    - Reporting 2000 levels as well as predicting the trend for future GHG emission
    - Reviewing potential Mitigation options

GHG Emissions

- **Initial National Communication**
  - 1994 Greenhouse Gas Inventory of Cambodia (Gg)

Sector and Source Categories	CO2	CH4	N2O	NOx	CO
V. LAND USE CHANGE AND FORESTRY					
A. Change in forest/woody biomass	-64,850.23				
B. Forest/land use change	45,214.27	74.77	0.51	18.58	654.2
SUB TOTAL (A+B)	-19,635.96	74.77	0.51	18.58	654.20
CO2 EQUIVALENT	-19,635.96	1,570.08	159.34		
TOTAL CO2 EQUIVALENT	**-17,906.54**				

GHG Emissions

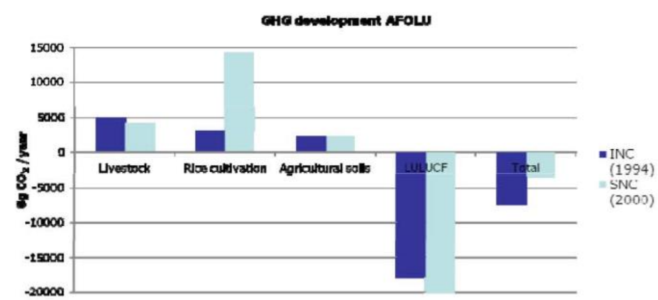
- **Second National Communication**
  - Emissions Land-Use Change and Forestry for the year 2000 (Gg)

LUCF Greenhouse Gas Source and Sink Categories	**CO2 Emissions**	**CO2 Removals**	CH4	N2O	Total CO2eq
Changes in forest and woody biomass stocks		-27,208.26			-27,208.26
Forest and grassland conversion	22,858.73		32.06	0.22	23,600.19
Abandonment of managed lands		-20,957.60			-20,957.60
Total	**22,858.73**	**-48,165.86**	32.06	0.22	**-24,565.67**

→LULUCF functions as both source and GHG sink, net sink GHG estimated at -24565.67 GgCO2e for the year 2000 in the SNC inventory

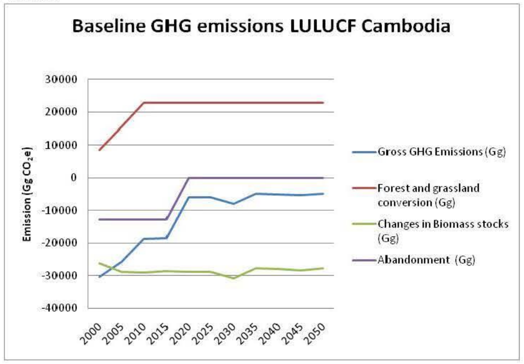
Compared to agricultural and LUCF emissions

LULUCF in the INC and SNC calculated to be a net sink, larger than the total of GHG emissions



2000 – 2050 Emission development

However the Business as Usual (BAU) scenario forecasts an decrease in national emission uptake to less then 5,000 GgCO2e in 2050.



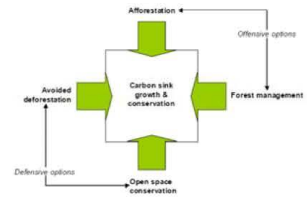
GHG mitigation options identified

- **The main mechanisms of reducing GHG reside in:**

1) Improvement of current management, utilisation efficiency, land under forest use

2) Enlarging sequestration surface, or sink capacity

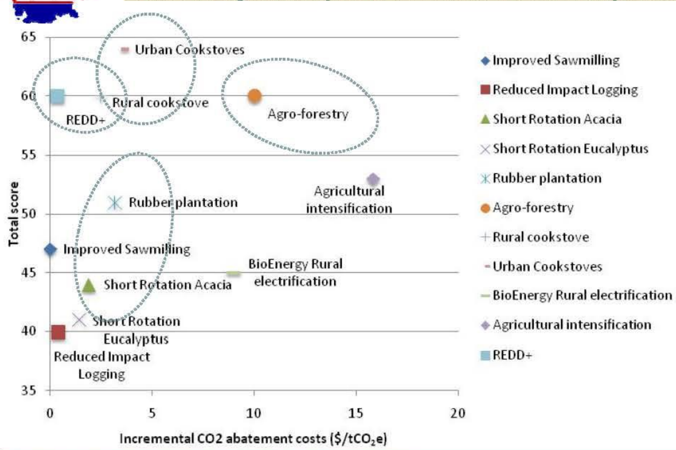
3) Wood resource substitution and use reduction



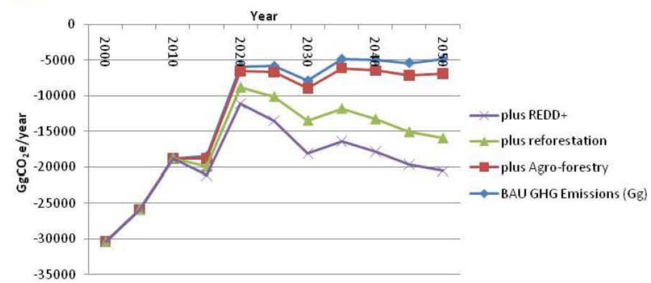
GHG MITIGATION OPTIONS IN SUBSECTOR LAND USE CHANGE & FORESTRY

Measure	*GHG mitigation option*
1. Forest protection and management (Increased efficiency)	Reduced Impact Logging (or SFM)
	Product conversion and utilization efficiency
	REDD+
2. Sink enhancement and management (Increased production)	Afforestation and Reforestation
	Agro-forestry
3. Carbon substitution or reduction (Increased efficiency)	Efficient cookstoves
	BioEnergy plantations

GHG mitigation options: 11 have been compared



GHG Mitigation Scenario Agro-forestry, Reforestation of degraded lands, Forest protection through REDD+



- Compared to a predicted uptake of less than 5,000 GgCO2e in 2050 under the BAU baseline scenario, an uptake of over 20,000 GgCO2e is estimate to possible with implementation of the mitigation options Agro-forestry, Reforestation and REDD+

GHG Inventory Potential Improvements

Data Gaps, Estimations, definition changes..

- **Abandonment lands**
  - Included in the GHG emission calculations, but:
    - Can we verify there are no ongoing human activities?
- **Forest cover changes**
  - Mathematical model: How do we calculate for i.e. forest definition changes, changes between categories, increase in forest cover in a category

Forest Cover (KHa)					
Year	1992	1996	2000	2002	2006
Evergreen	4040	3987	3129	3720	3669
Semi-Evergreen	1535	1505	1253	1455	1363
Deciduous	4350	**4281**	3873	**4834**	4692
Inundated	229	219	212	314	300
Mangrove	78	73	69	65	60

Thank you for your attention

Training Workshop on "GHG Inventory Preparation for Forestry"

National GHG Inventories and the way forward

Presented by Uy Kamal

5-8 November 2012
Angkor Paradise Hotel, Siem Reap, Cambodia

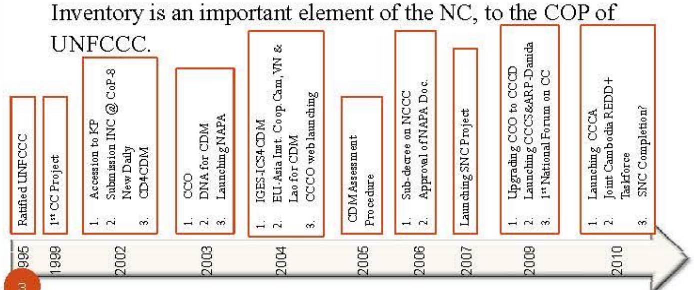
1

Outline

1. Background
2. National Level Actors
3. National GHG Inventory Process
4. National GHG Inventory Methodology for SNC
5. Comparing GHG Inventory 1994 and 2000
6. A New GHG Inventory Software Program
7. Major GHG Inventory Problem/Issues
8. Recommendation/Suggestions

1. Background

- Cambodia ratified the UN Framework Convention on Climate Change on 18 December 1995. As party to the UNFCCC and with reference to article 12, Cambodia has committed to prepare its National Communication (NC), where National GHG Inventory is an important element of the NC, to the COP of UNFCCC.



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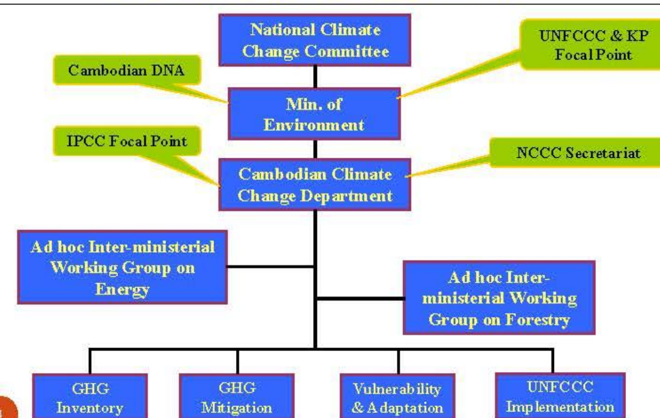
2. National Level Actors

2.1 Climate Change Institutional Framework



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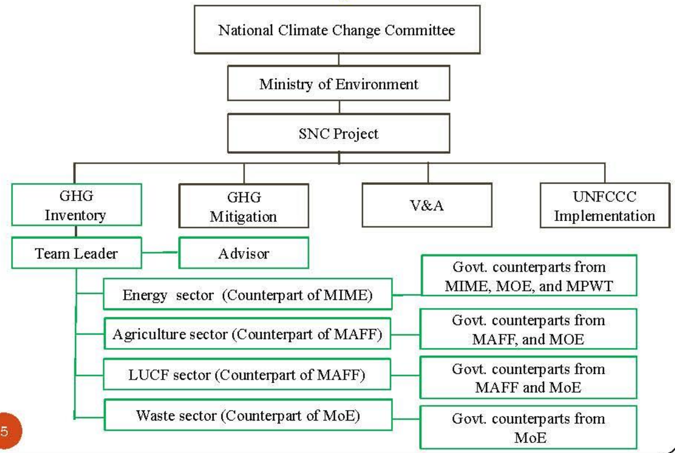
2. National Level Actors

2.2 GHG Inventory Framework



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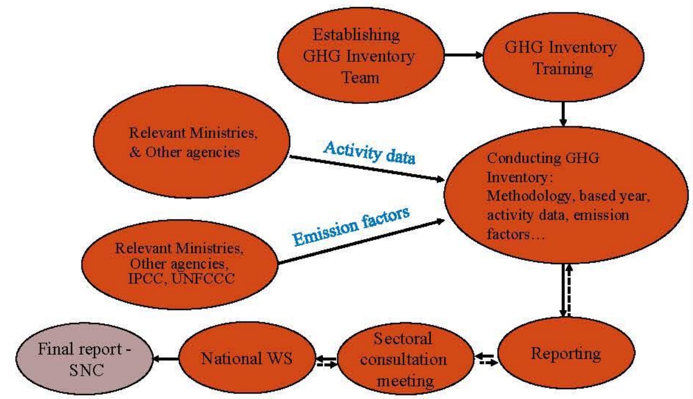
3. Process of National GHG Inventory



3. Process of National GHG Inventory (Con't)

- The first three Greenhouse Gases are the most common GHG among others: CO_2, CH_4, N_2O, PFCs, HFCs, SF_6, and other indirect greenhouse gases such as SO_2, NOx, CO and NMVOC.
- The Cambodia's Initial National Communication (INC) was prepared from 1999-2001 and subsequently submitted to the COP-8 of the UNFCCC in 2002.
- The Initial National Communication was started in Jan 1999 and submitted to COP-8 of UNFCCC in 2002.
- SNC is going to finished in late 2010.

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4. National GHG Inventory Methodology

- UNFCCC Software has been used. The **software** package consists of the following files:
  - **START.XLS**
  - OVERVIEW.XLS
  - MODULE1.XLS (Energy)
  - MODULE2.XLS (Industrial Processes)
  - MODULE4.XLS (Agriculture)
  - MODULE5.XLS (LULUCF)
  - MODULE6.XLS (Waste)
- In general, this software uses **Tier 1** methodologies for estimating GHG emissions and removals for all source categories described in the *Revised 1996 IPCC Guidelines*.

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5. Comparing GHG Inv. 1994 and 2000

Greenhouse Gas by Source and Sink	Total CO_2eq (Gg)	
	GHG Inventory 1994*	GHG Inventory 2000**
Energy	1,881	3,444
Agriculture	10,560	21,112
Land Use Change & Forestry	-17,907	-24,565
Waste	273	229
Industry (Cement)	50	-
TOTAL NAT'L CO2-eq.	-5,142	220

* Used 1996 IPCC Guideline, UNFCCC Software Version ??? (year?)
** Used Revised 1966 IPCC Guidelines and UNFCCC Software Version 1.3.2 (2007)

- Projection of GHG emissions based on 1994 data: by 2000 Cambodia would already be a net emitter with total net emissions of approximately 6,244 Gg of CO2-eqv, and LUCF would be the main source of GHG emissions followed by agriculture by 2020.

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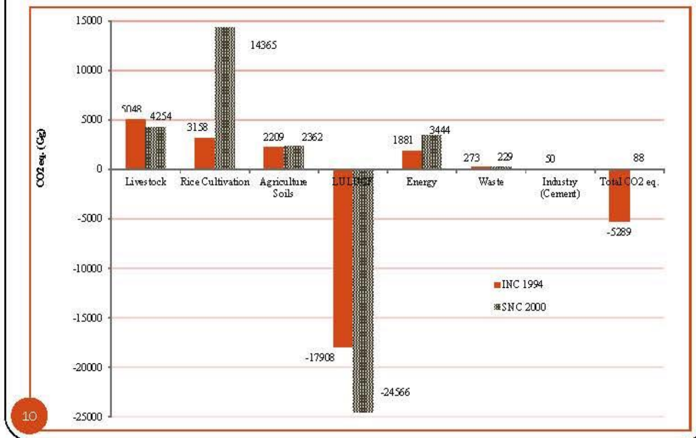
5. Comparing GHG Inv. 1994 and 2000



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6. A New GHG Inventory Software Program

The Agriculture and Land Use (ALU) National Greenhouse Gas Inventory Software Program was introduced to Cambodia GHG Inventory Team in February 2010 and have a follow up meeting July 2010 in Phnom Penh.

As result, we have finished ALU Case study with much data assumption due to data limitation.

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6. A New GHG Inventory Software Program (Con't)

ALU required sophisticated data ranging from climatic data, soil data to agriculture crop management systems, which all of these lead to improvement of input data including national statistic database.

Cambodia, however, is interested in this new tool, and intend to use it in the next National GHG Inventory.

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7. Major GHG Inventory Issues

- Lack of sustainable national GHG inventory system within the country. The inventory was prepared on a project basis for National Communications.
- Lack of activity data. e.g., energy balance sheet in the country, livestock, water management for paddy, soil carbon, etc.…)
- Lack of database management system for GHG inventory
- Inadequate capacity of local staff
- Lack of financial support to do researches/studies and update the inventory, establishment of database system and management

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8. Recommendation/suggestion

- Cooperate with the concerned government institutions/NGOs or OI to promote researches/studies for developing reliable local activity data and emission factors
- Establish data management systems for national GHG inventory
- Need more support to build the capacity of local experts
- Use on-the-job training approach to build technical capacity of local experts
- Establish the national inventory system/network with the involvement of concerned government ministries
- Widely networking within the regional experts/institutions
- Encourage and Improve national/local expert practice activities

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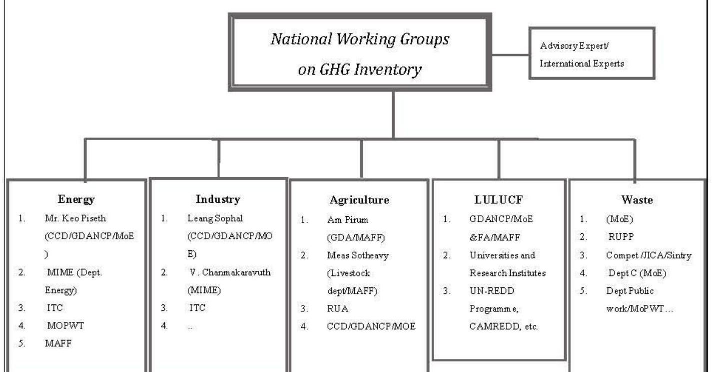
Proposed workplan for future inventory working groups



15

Thank You Very Much

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Training course on:
GHG estimates for the forest sector

IPCC methods for carbon stock changes

by Sandro Federici & Matieu Henry

UN-REDD

Carbon pools

6 carbon pools have to be reported under the UNFCCC:

- Above-ground Biomass, Below-ground Biomass } Biomass
- Dead Wood, Litter } Dead Organic Matter (DOM)
- Soil Organic Matter (SOM) { mineral soils, organic soils
- Harvested Wood Product (HWP)

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biomass

Aboveground biomass
All biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage.

Note: In cases where forest understory is a relatively small component of the above-ground biomass carbon pool, it is acceptable for the methodologies and associated data used in some tiers to exclude it, provided the tiers are used in a consistent manner throughout the inventory time series.

Belowground biomass
All biomass of live roots. Fine roots of less than (suggested) 2mm diameter are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.

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dead organic matter (DOM)

Dead wood
Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps, larger than or equal to 10 cm in diameter (or the diameter specified by the country).

Litter
Includes all non-living biomass with a size greater than the limit for soil organic matter (suggested 2 mm) and less than the minimum diameter chosen for dead wood (e.g. 10 cm), lying dead, in various states of decomposition above or within the mineral or organic soil. This includes the litter layer as usually defined in soil typologies. Live fine roots above the mineral or organic soil (of less than the minimum diameter limit chosen for below-ground biomass) are included in litter where they cannot be distinguished from it empirically.

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soil organic matter (SOM)

Soil organic matter

Includes organic carbon in mineral soils to a specified depth chosen by the country and applied consistently through the time series. Live and dead fine roots and DOM within the soil, that are less than the minimum diameter limit (suggested 2 mm) for roots and DOM, are included with soil organic matter where they cannot be distinguished from it empirically. The default for soil depth is 30 cm.

1 Includes organic material (living and non-living) within the soil matrix, operationally defined as a specific size fraction (e.g., all matter passing through a 2 mm sieve). Soil C stock estimates may also include soil inorganic C if using a Tier 3 method. CO2 emissions from liming and urea applications to soils are estimated as fluxes using Tier 1 or Tier 2 method.

2 Carbon stocks in organic soils are not explicitly computed using Tier 1 or Tier 2 method, (which estimate only annual C flux from organic soils), but C stocks in organic soils can be estimated in a Tier 3 method. Definition of organic soils for classification purposes is provided in Chapter 3.

harvested wood products (HWP)

harvested wood products

Any wooden product with a lifetime longer than 1 year

IWPs could be reported applying instantaneous oxidation

carbon stock changes in land use categories

- For each land-use category, carbon stock changes are estimated for all *strata* or subdivisions of land area
- Subdivisions should be done according to differences in the carbon dynamic and in the magnitude of ecosystem C stocks (e.g. forest typology, ecotype, soil type, management regime etc.) within a land-use category.

EQUATION 2.2
ANNUAL CARBON STOCK CHANGES FOR A LAND-USE CATEGORY AS A SUM OF CHANGES IN EACH STRATUM WITHIN THE CATEGORY

$$\Delta C_{LU} = \sum_i \Delta C_{LU_i}$$

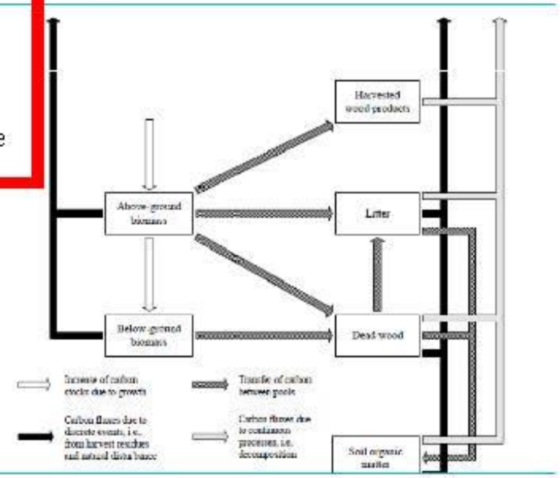
Where:

ΔC_{LU} = carbon stock changes for a land-use (LU) category as defined in Equation 2.1.

i = denotes a specific stratum or subdivision within the land-use category (by any combination of species, climatic zone, ecotype, management regime etc., see Chapter 3), i = 1 to n.

Carbon stock changes within a stratum are estimated by considering carbon cycle processes between the five carbon pools

Generalized carbon cycle of terrestrial AFOLU ecosystems showing the flows of carbon into and out of the system as well as between the five C pools within the system.



carbon stock changes

The carbon cycle includes changes in carbon stocks due to both continuous processes (i.e., growth, decay) and discrete events (i.e., disturbances like harvest, fire, insect outbreaks, land-use change and other events).

Continuous processes can affect carbon stocks in all areas in each year, while discrete events (i.e., disturbances) cause emissions and redistribute ecosystem carbon in specific areas (i.e., where the disturbance occurs) and in the year of the event.

carbon stock changes in carbon pools

Carbon stock changes are summarized by the following equation

$$\Delta C_{LUi} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO} + \Delta C_{HWP}$$

Where

ΔC_{LUi} = carbon stock changes for a stratum of a land-use category

Subscripts denote the following carbon pools:

AB = above-ground biomass

BB = below-ground biomass

DW = deadwood

LI = litter

SO = soils

HWP = harvested wood products

framework of tiers for AFOLU methods

Tier 1 methods are designed to be the simplest to use, for which equations and default parameter values (e.g., emission and stock change factors) are provided by IPCC. Country-specific activity data are needed, but there are often globally available sources of activity data estimates (e.g. FAO), although these data are usually spatially coarse.

Tier 2 can use the same methodological approach as Tier 1 but applies emission and stock change factors that are based on country- or region-specific data, for the most important land-use or livestock categories. Higher temporal and spatial resolution and more disaggregated activity data are typically used in Tier 2.

At **Tier 3**, higher order methods are used, including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national level.

Tier 1

Because of limitations to deriving default data sets for supporting estimates of some stock changes, Tier 1 methods include several simplifying assumptions:

- change in below-ground biomass C stocks are assumed to be zero under Tier 1 (under Tier 2, country-specific data on ratios of below-ground to above-ground biomass can be used to estimate below-ground stock changes);

- under Tier 1, dead wood and litter pools are often lumped together as 'dead organic matter'; and

- dead organic matter stocks are assumed to be zero for non-forest land-use categories under Tier 1. For Forest Land converted to another land use, default values for estimating dead organic matter losses are provided in Tier 1.

Tier 1

- Disturbances may also have long-lasting effects, such as decay of burnt trees. For practicality, Tier 1 assumes that all post-disturbance emissions (less removal of harvested wood products) are estimated as part of the disturbance event, i.e., in the year of the disturbance.

For example, rather than estimating the decay of dead organic matter left after a disturbance over a period of several years, all lost biomass is estimated as oxidized in the year of the event.

- Under Tier 1, it is assumed that the average transfer rate into dead organic matter (dead wood and litter) is equal to the average transfer rate out of dead organic matter, so that the net stock change is zero.
Countries experiencing significant changes in forest types or disturbance or management regimes should use higher Tier

CO2 emissions and removals

- All estimates of changes in carbon stocks, i.e., growth, internal transfers and emissions, are in units of carbon to make all calculations consistent.

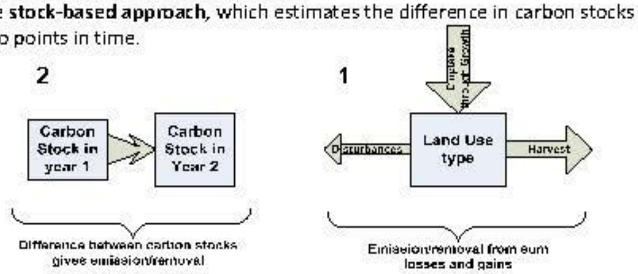
Carbon gains (removals and transfer to the accounted pool) have a positive sign (+) while losses (emissions and transfers from the accounted pool) have negative sign (-)

Data on biomass stocks, increments, harvests, etc. can initially be in units of dry matter that need to be converted in units of carbon before using for carbon stock changes estimation.

- However, emissions and removals are then converted in Gg of CO_2 equivalent to make these comparable with the GHG fluxes of other sectors. The conversion factor is -44/12
So that removals are negative quantities while emissions are positive

Carbon stock changes estimation

- There are two fundamentally different and equally valid approaches to estimating stock changes:
1) the **process-based approach**, which estimates the net balance of additions to and subtraction from a carbon stock;
2) the **stock-based approach**, which estimates the difference in carbon stocks at two points in time.



Carbon stock changes estimation

If the C stock changes are estimated on a per hectare basis, then the value is multiplied by the total area within each stratum to obtain the total stock change estimate for the pool

When using the Stock-Difference Method, it is important to ensure that the area on which carbon stock at time t_1 is calculated is identical at that on which carbon stock has been calculated at time t_2

It is good practice to use the area at the end of the inventory period (t_2) to define the area of land remaining in the land-use category

Gain and loss method

EQUATION 2.4
ANNUAL CARBON STOCK CHANGE IN A GIVEN POOL AS A FUNCTION OF GAINS AND LOSSES (GAIN-LOSS METHOD)

$$\Delta C = \Delta C_G - \Delta C_L$$

Where:

ΔC = Annual carbon stock change in the pool, tonnes C yr^{-1}

ΔC_G = Annual gain of carbon, tonnes C yr^{-1}

ΔC_L = Annual loss of carbon, tonnes C yr^{-1}

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Stock difference method

EQUATION 2.5
CARBON STOCK CHANGE IN A GIVEN POOL AS AN ANNUAL AVERAGE DIFFERENCE BETWEEN ESTIMATES AT TWO POINTS IN TIME (STOCK-DIFFERENCE METHOD)

$$\Delta C = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$

Where:

ΔC = Annual carbon stock change in the pool, tonnes C yr^{-1}

C_1 = Carbon stock in the pool at time t_1, tonnes C

C_2 = Carbon stock in the pool at time t_2, tonnes C

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Biomass stock changes

Biomass is present in both aboveground and below-ground parts of annual and perennial plants.

Biomass associated with annual and perennial herbaceous (i.e., non-woody) plants and tissues (e.g. leaves) is relatively ephemeral, i.e., it decays and regenerates annually or every few years. So emissions from decay are balanced by removals due to re-growth making overall net C stocks in biomass rather stable in the long term.

Thus, the methods focus on stock changes in biomass associated with woody plants and trees, which can accumulate large amounts of carbon over their lifespan

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Biomass stock changes

Increases in the biomass pools are due to photosynthesis;

While losses are caused by;
- human activities (i.e. harvesting) and disturbances (mainly fires);
- natural processes (i.e. disturbances) and mortality

For inventory purposes, changes in C stock in biomass are estimated for
(i) land remaining in the same land-use category;
(ii) land converted to a new land-use category.

All emissions and removals associated with a land-use change are reported in the new land-use category.

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gain-loss method

The **Gain-Loss Method** requires the biomass carbon loss to be subtracted from the biomass carbon gain (increment).

For Tier 1 method default values for calculation of increment are provided in the 2006 IPCC Guidelines. Higher tier methods use country-specific data.

For all tiers, country-specific activity data are required, although for Tier 1 these can be obtained from global databases (e.g. FAO statistics).

gain-loss method

EQUATION 2.7
ANNUAL CHANGE IN CARBON STOCKS IN BIOMASS
IN LAND REMAINING IN A PARTICULAR LAND-USE CATEGORY (GAIN-LOSS METHOD)

$$\Delta C_B = \Delta C_G - \Delta C_L$$

Where:

ΔC_B = annual change in carbon stocks in biomass (the sum of above-ground and below-ground biomass terms in Equation 2.3) for each land sub-category, considering the total area, tonnes C yr^{-1}

ΔC_G = annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tonnes C yr^{-1}

ΔC_L = annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tonnes C yr^{-1}

gain-loss method

EQUATION 2.9
ANNUAL INCREASE IN BIOMASS CARBON STOCKS DUE TO BIOMASS INCREMENT
IN LAND REMAINING IN THE SAME LAND-USE CATEGORY

$$\Delta C_G = \sum_{i,j} (A_{i,j} \bullet G_{TOTAL_{i,j}} \bullet CF_{i,j})$$

Where:

ΔC_G = annual increase in biomass carbon stocks due to biomass growth in land remaining in the same land-use category by vegetation type and climatic zone, tonnes C yr^{-1}

A = area of land remaining in the same land-use category, ha

G_{TOTAL} = mean annual biomass growth, tonnes d. m. ha^{-1} yr^{-1}

i = ecological zone (i = 1 to n)

j = climate domain (j = 1 to m)

CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

EQUATION 2.10
AVERAGE ANNUAL INCREMENT IN BIOMASS

Tier 1

$$G_{TOTAL} = \sum \{G_W \bullet (1+R)\}$$ Biomass increment data (dry matter) are used directly

Tiers 2 and 3

$$G_{TOTAL} = \sum \{I_V \bullet BCEF_I \bullet (1+R)\}$$ Net annual increment data are used to estimate G_W by applying a biomass conversion and expansion factor

G_{TOTAL} = average annual biomass growth above and below-ground, tonnes d. m. ha^{-1} yr^{-1}

G_W = average annual above-ground biomass growth for a specific woody vegetation type, tonnes d. m. ha^{-1} yr^{-1}

R = ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$. R must be set to zero if assuming no changes of below-ground biomass allocation patterns (Tier 1).

I_V = average net annual increment for specific vegetation type, m^3 ha^{-1} yr^{-1}

$BCEF_I$ = biomass conversion and expansion factor for conversion of net annual increment in volume (including bark) to above ground biomass growth for specific vegetation type, tonnes above ground biomass growth (m^3 net annual increment)$^{-1}$, (see Table 4.5 for Forest Land). If $BCEF_I$ values are not available and if the biomass expansion factor (BEF) and basic wood density (D) values are separately estimated, then the following conversion can be used:

$$BCEF_I = BEF_I \bullet D$$

gain-loss method

EQUATION 2.11
ANNUAL DECREASE IN CARBON STOCKS DUE TO BIOMASS LOSSES IN LAND REMAINING IN THE SAME LAND-USE CATEGORY

$$\Delta C_L = L_{wood-removals} + L_{fuelwood} + L_{disturbance}$$

Where:

ΔC_L = annual decrease in carbon stocks due to biomass loss in land remaining in the same land-use category, tonnes C yr^{-1}

$L_{wood-removals}$ = annual carbon loss due to wood removals, tonnes C yr^{-1} (See Equation 2.12)

$L_{fuelwood}$ = annual biomass carbon loss due to fuelwood removals, tonnes C yr^{-1} (See Equation 2.13)

$L_{disturbance}$ = annual biomass carbon losses due to disturbances, tonnes C yr^{-1} (See Equation 2.14)

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EQUATION 2.12
ANNUAL CARBON LOSS IN BIOMASS OF WOOD REMOVALS

$$L_{wood-removals} = \{H \bullet BCEF_R \bullet (1+R) \bullet CF\}$$

Where:

$L_{wood-removals}$ = annual carbon loss due to biomass removals, tonnes C yr^{-1}

H = annual wood removals, roundwood, m^3 yr^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$. R must be set to zero if assuming no changes of below-ground biomass allocation patterns (Tier 1).

CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

$BCEF_R$ = biomass conversion and expansion factor for conversion of removals in merchantable volume to total biomass removals (including bark), tonnes biomass removal (m^3 of removals)$^{-1}$, (see Table 4.5 for Forest Land). However, if $BCEF_R$ values are not available and if the biomass expansion factor for wood removals (BEF_R) and basic wood density (D) values are separately estimated, then the following conversion can be used:

$$BCEF_R = BEF_R \bullet D$$

If country-specific data on roundwood removals are not available, the inventory experts should use FAO statistics on wood harvest. FAO statistical data on wood harvest exclude bark. To convert FAO statistical wood harvest data without bark into merchantable wood removals including bark, multiply by default expansion factor of 1.15.

EQUATION 2.13
ANNUAL CARBON LOSS IN BIOMASS OF FUELWOOD REMOVAL

$$L_{fuelwood} = [\{FG_{trees} \bullet BCEF_R \bullet (1+R)\} + FG_{part} \bullet D] \bullet CF$$

Where:

$L_{fuelwood}$ = annual carbon loss due to fuelwood removals, tonnes C yr^{-1}

FG_{trees} = annual volume of fuelwood removal of whole trees, m^3 yr^{-1}

FG_{part} = annual volume of fuelwood removal as tree parts, m^3 yr^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$; R must be set to zero if assuming no changes of below-ground biomass allocation patterns. (Tier 1)

CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

D = basic wood density, tonnes d.m. m^{-3}

$BCEF_R$ = biomass conversion and expansion factor for conversion of removals in merchantable volume to biomass removals (including bark), tonnes biomass removal (m^3 of removals)$^{-1}$, (see Table 4.5 for Forest Land). If $BCEF_R$ values are not available and if the biomass expansion factor for wood removals (BEF_R) and basic wood density (D) values are separately estimated, then the following conversion can be used:

$$BCEF_R = BEF_R \bullet D$$

Biomass Expansion Factors (BEF_R) expand merchantable wood removals to total aboveground biomass volume to account for non-merchantable components of the tree, stand and forest. BEF_R is dimensionless.

EQUATION 2.14
ANNUAL CARBON LOSSES IN BIOMASS DUE TO DISTURBANCES

$$L_{disturbance} = \{A_{disturbance} \bullet B_W \bullet (1+R) \bullet CF \bullet fd\}$$

Where:

$L_{disturbances}$ = annual other losses of carbon, tonnes C yr^{-1} (Note that this is the amount of biomass that is lost from the total biomass. The partitioning of biomass that is transferred to dead organic matter and biomass that is oxidized and released to the atmosphere is explained in Equations 2.15 and 2.16)

$A_{disturbance}$ = area affected by disturbances, ha yr^{-1}

B_W = average above-ground biomass of land areas affected by disturbances, tonnes d.m. ha^{-1}

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$. R must be set to zero if no changes of below-ground biomass are assumed (Tier 1)

CF = carbon fraction of dry matter, tonne C (tonnes d.m.)$^{-1}$

fd = fraction of biomass lost in disturbance (see note below)

Note: The parameter fd defines the proportion of biomass that is lost from the biomass pool: a stand-replacing disturbance will kill all (fd = 1) biomass while an insect disturbance may only remove a portion (e.g. fd = 0.3) of the average biomass C density. Equation 2.14 does not specify the fate of the carbon removed from the biomass carbon stock. The Tier 1 assumption is that all of $L_{disturbances}$ is emitted in the year of disturbance. Higher Tier methods assume that some of this carbon is emitted immediately and some is added to the dead organic matter pools (dead wood, litter) or HWP.

Stock difference method

The **Stock-Difference Method** requires biomass carbon stock inventories for a given land area, at two points in time.

Annual biomass change is the difference between the biomass stock at time t_2 and time t_1, divided by the number of years between the inventories.
Factors are provided in the 2006 IPCC Guidelines to convert fresh wood

EQUATION 2.8
ANNUAL CHANGE IN CARBON STOCKS IN BIOMASS
IN LAND REMAINING IN THE SAME LAND-USE CATEGORY (STOCK-DIFFERENCE METHOD)

$$\Delta C_B = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)} \qquad \text{(a)}$$

Where:

ΔC_B = annual change in carbon stocks in biomass (the sum of above-ground and below-ground biomass terms in Equation 2.3) in land remaining in the same category (e.g., *Forest Land Remaining Forest Land*), tonnes C yr^{-1}

C_{t_2} = total carbon in biomass for each land sub-category at time t_2, tonnes C

C_{t_1} = total carbon in biomass for each land sub-category at time t_1, tonnes C

Stock changes associated with land conversion

EQUATION 2.15
ANNUAL CHANGE IN BIOMASS CARBON STOCKS ON LAND CONVERTED TO OTHER LAND-USE CATEGORY (TIER 2)

$$\Delta C_B = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

Where:

ΔC_B = annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_G = annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr^{-1}

$\Delta C_{CONVERSION}$ = initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr^{-1}

ΔC_L = annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tonnes C yr^{-1}

Conversion to another land category may be associated with a change in biomass stocks, e.g., part of the biomass may be withdrawn through land clearing, restocking or other human-induced activities. These initial changes in carbon stocks in biomass ($\Delta C_{CONVERSION}$) are calculated with the use of Equation 2.16 as follows:

Stock changes associated with land conversion

EQUATION 2.16
INITIAL CHANGE IN BIOMASS CARBON STOCKS ON LAND CONVERTED TO ANOTHER LAND CATEGORY

$$\Delta C_{CONVERSION} = \sum_i \{(B_{AFTER_i} - B_{BEFORE_i}) \bullet \Delta A_{TO\_OTHERS_i}\} \bullet CF$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C yr^{-1}

B_{AFTER_i} = biomass stocks on land type *i* immediately after the conversion, tonnes d.m. ha^{-1}

B_{BEFORE_i} = biomass stocks on land type *i* before the conversion, tonnes d.m. ha^{-1}

$\Delta A_{TO\_OTHERS_i}$ = area of land use *i* converted to another land-use category in a certain year, ha yr^{-1}

CF = carbon fraction of dry matter, tonne C (tonnes d.m.)$^{-1}$

i = type of land use converted to another land-use category

Mass conservation

TABLE 2.1
EXAMPLE OF A SIMPLE MATRIX (TIER 2) FOR THE IMPACTS OF DISTURBANCES ON CARBON POOLS

From: \ To:	Above ground biomass	Below ground biomass	Dead wood	Litter	Soil organic matter	Harvested wood products	Atmo sphere	Sum of row (must equal 1)
Above ground biomass	A		B	C	D	E	F	1
Below-ground biomass								1
Dead wood								1
Litter								1
Soil organic matter								1

Enter the proportion of each pool on the left side of the matrix that is transferred to the pool at the top of each column. All of the pools on the left side of the matrix must be fully populated and the values in each row must sum to 1.
Impossible transitions are blacked out
Note: Letters A to F are cell labels that are referenced in the text.

Mass conservation

It is good practice to develop and use a disturbance matrix (Table 2.1) for each biomass, dead organic matter and soil carbon pool, the proportion of the carbon remaining in that pool, and the proportions transferred to other pools, to harvested wood products and to the atmosphere, during the disturbance event.

The proportions in each row always sum to 1 to ensure conservation of carbon. The value entered in cell A is the proportion of above-ground biomass remaining after a disturbance (or 1 – fd) and the remainder is added to cells B and C in the case of fire, and B, C, and E in the case of harvest.

The Tier 1 assumption is that all of fd is emitted in the year of disturbance: therefore the value entered in cell F is fd.

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Dead mass stock changes

EQUATION 2.17
ANNUAL CHANGE IN CARBON STOCKS IN DEAD ORGANIC MATTER

$$\Delta C_{DOM} = \Delta C_{DW} + \Delta C_{LT}$$

Where

ΔC_{DOM} = annual change in carbon stocks in dead organic matter (includes dead wood and litter), tonnes C yr^{-1}

ΔC_{DW} = change in carbon stocks in dead wood, tonnes C yr^{-1}

ΔC_{LT} = change in carbon stocks in litter, tonnes C yr^{-1}

The Tier 1 assumption for both dead wood and litter pools for all land-use categories is that their stocks are not changing over time if the land remains within the same land-use category

UN-REDD

Dead mass stock changes

EQUATION 2.18
ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD OR LITTER (GAIN-LOSS METHOD)

$$\Delta C_{DOM} = A \bullet \{(DOM_{in} - DOM_{out}) \bullet CF\}$$

Where

ΔC_{DOM} = annual change in carbon stocks in the dead wood/litter pool, tonnes C yr^{-1}

A = area of managed land, ha

DOM_{in} = average annual transfer of biomass into the dead wood/litter pool due to annual processes and disturbances, tonnes d.m. ha^{-1} yr^{-1} (see next Section for further details).

DOM_{out} = average annual decay and disturbance carbon loss out of dead wood or litter pool, tonnes d.m. ha^{-1} yr^{-1}

CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

UN-REDD

Dead mass stock changes

EQUATION 2.20
ANNUAL CARBON IN BIOMASS TRANSFERRED TO DEAD ORGANIC MATTER

$$DOM_{in} = \{L_{mortality} + L_{slash} + (L_{disturbance} \bullet f_{BLol})\}$$

Where:

DOM_{in} = total carbon in biomass transferred to dead organic matter, tonnes C yr^{-1}

$L_{mortality}$ = annual biomass carbon transfer to DOM due to mortality, tonnes C yr^{-1} (See Equation 2.21)

L_{slash} = annual biomass carbon transfer to DOM as slash, tonnes C yr^{-1} (See Equations 2.22)

$L_{disturbance}$ = annual biomass carbon loss resulting from disturbances, tonnes C yr^{-1} (See Equation 2.14)

f_{BLol} = fraction of biomass left to decay on the ground (transferred to dead organic matter) from loss due to disturbance. As shown in Table 2.1, the disturbance losses from the biomass pool are partitioned into the fractions that are added to dead wood (cell B in Table 2.1) and to litter (cell C), are released to the atmosphere in the case of fire (cell F) and, if salvage follows the disturbance, transferred to HWP (cell E).

Note: If root biomass increments are counted in Equation 2.10, then root biomass losses must also be counted in Equations 2.20, and 2.22.

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Dead mass stock changes

EQUATION 2.21
ANNUAL BIOMASS CARBON LOSS DUE TO MORTALITY

$$L_{mortality} = \sum (A \bullet G_W \bullet CF \bullet m)$$

Where:

$L_{mortality}$ = annual biomass carbon loss due to mortality, tonnes C yr^{-1}

A = area of land remaining in the same land use, ha

G_w = above-ground biomass growth, tonnes d.m. ha^{-1} yr^{-1} (see Equation 2.10)

CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

m = mortality rate expressed as a fraction of above-ground biomass growth

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EQUATION 2.22
ANNUAL CARBON TRANSFER TO SLASH

$$L_{slash} = \left[\{H \bullet BCEF_R \bullet (1+R)\} - \{H \bullet D\}\right] \bullet CF$$

Where:

L_{slash} = annual carbon transfer from above-ground biomass to slash, including dead roots, tonnes C yr^{-1}

H = annual wood harvest (wood or fuelwood removal), m^3 yr^{-1}

$BCEF_R$ = biomass conversion and expansion factors applicable to wood removals, which transform merchantable volume of wood removal into above-ground biomass removals, tonnes biomass removal (m^3 of removals)$^{-1}$. If $BCEF_R$ values are not available and if BEF and Density values are separately estimated then the following conversion can be used:

$$BCEF_R = BEF_R \bullet D$$

- D is basic wood density, tonnes d.m. m^{-3}
- Biomass Expansion Factors (BEF_R) expand merchantable wood removals to total aboveground biomass volume to account for non-merchantable components of the tree, stand and forest. BEF_R is dimensionless.

R = ratio of below-ground biomass to above-ground biomass, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)$^{-1}$. R must be set to zero if root biomass increment is not included in Equation 2.10 (Tier 1)

CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

Fuelwood gathering that involves the removal of live tree parts does not generate any additional input of biomass to dead organic matter pools and is not further addressed here

Dead mass stock changes

EQUATION 2.19
ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD OR LITTER (STOCK-DIFFERENCE METHOD)

$$\Delta C_{DOM} = \left[A \bullet \frac{(DOM_{t_2} - DOM_{t_1})}{T}\right] \bullet CF$$

Where:

ΔC_{DOM} = annual change in carbon stocks in dead wood or litter, tonnes C yr^{-1}

A = area of managed land, ha

DOM_{t1} = dead wood/litter stock at time t_1 for managed land, tonnes d.m. ha^{-1}

DOM_{t2} = dead wood/litter stock at time t_2 for managed land, tonnes d.m. ha^{-1}

T = $(t_2 - t_1)$ = time period between time of the second stock estimate and the first stock estimate, yr

CF = carbon fraction of dry matter (default = 0.37 for litter), tonne C (tonne d.m.)$^{-1}$

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Stock changes associated with land conversion

EQUATION 2.23
ANNUAL CHANGE IN CARBON STOCKS IN DEAD WOOD AND LITTER DUE TO LAND CONVERSION

$$\Delta C_{DOM} = \frac{(C_n - C_o) \bullet A_{on}}{T_{on}}$$

Where:

ΔC_{DOM} = annual change in carbon stocks in dead wood or litter, tonnes C yr^{-1}

C_o = dead wood/litter stock, under the old land-use category, tonnes C ha^{-1}

C_n = dead wood/litter stock, under the new land-use category, tonnes C ha^{-1}

A_{on} = area undergoing conversion from old to new land-use category, ha

T_{on} = time period of the transition from old to new land-use category, yr. The Tier 1 default is 20 years for carbon stock increases and 1 year for carbon losses.

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Stock changes associated with land conversion

Inventories using a Tier 1 method assume that all carbon contained in biomass killed during a land-use conversion event (less harvested products that are removed) is emitted directly to the atmosphere and none is added to dead wood and litter pools.

Tier 1 methods also assume that dead wood and litter pool carbon losses occur entirely in the year of the transition.

The Tier 1 assumption is that DOM pools in non-forest land categories after the conversion are zero, i.e., they contain no carbon.

Soil organic matter stock changes

Soils are classified in order to apply reference C stocks and stock change factors for estimation of soil C stock changes, as well as the soil N_2O emissions (i.e., organic soils must be classified to estimate N_2O emissions following drainage). Organic soils are found in wetlands or have been drained and converted to other land-use types (e.g., Forest Land, Cropland, Grassland, Settlements). Organic soils are identified on the basis of criteria 1 and 2, or 1 and 3 listed below (FAO 1998):

1. Thickness of organic horizon greater than or equal to 10 cm. A horizon of less than 20 cm must have 12 percent or more organic carbon when mixed to a depth of 20 cm.
2. Soils that are never saturated with water for more than a few days must contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).
3. Soils are subject to water saturation episodes and has either:
   a. At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soil has no clay, or
   b. At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soil has 60% or more clay, or
   c. An intermediate, proportional amount of organic carbon for intermediate amounts of clay.

Soil organic matter stock changes

EQUATION 2.24

ANNUAL CHANGE IN CARBON STOCKS IN SOILS

$$\Delta C_{Soils} = \Delta C_{Mineral} - L_{Organic} + \Delta C_{Inorganic}$$

Where

ΔC_{Soils} = annual change in carbon stocks in soils, tonnes C yr^{-1}

$\Delta C_{Mineral}$ = annual change in organic carbon stocks in mineral soils, tonnes C yr^{-1}

$L_{Organic}$ = annual loss of carbon from drained organic soils, tonnes C yr^{-1}

$\Delta C_{Inorganic}$ = annual change in inorganic carbon stocks from soils, tonnes C yr^{-1} (assumed to be 0 unless using a Tier 3 approach)

For Tier 1 and 2 methods, soil organic C stocks for mineral soils are computed to a default depth of 30 cm.

mineral soils

Mineral soils

For mineral soils, the default method is based on changes in soil C stocks over a finite period of time. The change is computed based on C stock after the management change relative to the carbon stock in a reference condition (i.e., native vegetation that is not degraded or improved). The following assumptions are made:

(i) Over time, soil organic C reaches a spatially averaged, stable value specific to the soil, climate, land-use and management practices; and

(ii) Soil organic C stock changes during the transition to a new equilibrium SOC occurs in a linear fashion.

EQUATION 2.25

ANNUAL CHANGE IN ORGANIC CARBON STOCKS IN MINERAL SOILS

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$$SOC = \sum_{c,s,i} \left(SOC_{REF_{c,s,i}} \bullet F_{LU_{c,s,i}} \bullet F_{MG_{c,s,i}} \bullet F_{I_{c,s,i}} \bullet A_{c,s,i} \right)$$

(Note: T is used in place of D in this equation if T is ≥ 20 years, see note below)

Where:

$\Delta C_{Mineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 = soil organic carbon stock in the last year of an inventory time period, tonnes C

$SOC_{(0-T)}$ = soil organic carbon stock at the beginning of the inventory time period, tonnes C

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation in the box where the reference carbon stocks and stock change factors are assigned according to the land use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)

T = number of years over a single inventory time period, yr

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr. Commonly 20 years, but depends on assumptions made in computing the factors F_{LU}, F_{MG} and F_I. If T exceeds D, use the value for T to obtain an annual rate of change over the inventory time period (0-T years)

c = represents the climate zones, s the soil types, and i the set of management systems that are present in a country.

SOC_{REF} = the reference carbon stock, tonnes C ha^{-1} (Table 2.3)

F_{LU} = stock change factor for land-use systems or sub-system for a particular land-use, dimensionless

[Note: F_{ND} is substituted for F_{LU} in forest soil C calculation to estimate the influence of natural disturbance regimes.

F_{MG} = stock change factor for management regime, dimensionless

F_I = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated, ha. All land in the stratum should have common biophysical conditions (i.e., climate and soil type) and management history over the inventory time period to be treated together for analytical purposes.

organic soils

EQUATION 2.26

ANNUAL CARBON LOSS FROM DRAINED ORGANIC SOILS (CO_2)

$$L_{Organic} = \sum_c (A \bullet EF)_c$$

Where:

$L_{Organic}$ = annual carbon loss from drained organic soils, tonnes C yr^{-1}

A = land area of drained organic soils in climate type c, ha

Note: A is the same area (F_{os}) used to estimate N_2O emissions in Chapter 11, Equations 11.1 and 11.2

EF = emission factor for climate type c, tonnes C ha^{-1} yr^{-1}

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IPCC methods for non-CO_2 emissions

by Sandro Federici & Matieu Henry

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N_2O emissions from managed land

Nitrous oxide is generated in managed soils through microbial processes (nitrification – aerobic, and denitrification – anaerobic).

Methodology is based on additions of net N to soils by humans from: synthetic and organic fertilizers, animal waste or deposited manure, crop residues, sewage sludge or other organic N additions

N_2O emissions can occur in the form of direct emissions (directly from the soil to which N was added/released) or indirect emissions (volatilization and deposition, or leaching and runoff).

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N_2O emissions from managed land

Direct and indirect N_2O emissions are estimated separately, but same set of activity data is used.

Direct N_2O emissions

Main N sources

- Synthetic N fertilizers (F_{SN})
- organic N applied as fertilizer (animal manure, compost, sewage sludge, etc) (F_{ON})
- urine & dung N deposited on pastures by grazing animals (F_{PRP})
- N in crop residues (F_{CR})
- N mineralization from loss of soil organic matter due to changes in land use or management practices (F_{SOM})
- drainage/management of organic soils (F_{OS})

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CO_2 emissions from liming

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests.

$$CO_2 - C\ Emission = (M_{Limestone} \cdot EF_{Limestone}) + (M_{Dolomite} \cdot EF_{Dolomite})$$

where:

CO_2-C Emission = *annual C emissions from lime application, tonnes C yr^{-1}*

M = *annual amount of calcic limestone ($CaCO_3$) or dolomite ($CaMg(CO_3)_2$), tonnes yr^{-1}*

EF = *emission factor, tonne of C per tonne of limestone or dolomite*

The overall emission factor (EF) for limestone is equal to 0.12 and 0.13 for dolomite.

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CO_2 emissions from urea

Adding urea to soils during fertilization leads to a loss of CO_2 that was fixed in the industrial production process.

$$CO_2\text{-}C\ Emission = M \cdot EF$$

where:

- CO_2-C Emission = *annual C emissions from urea application, tonnes C yr*$^{-1}$
- M = *annual amount of urea fertilisation, tonnes yr*$^{-1}$
- EF = *emission factor, tonne of C (tonne of urea)*$^{-1}$

The overall emission factor (EF) for urea is equal to 0.20, which is equivalent to the carbon content of urea on an atomic weight basis (20% for $CO(NH_2)_2$).

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emissions from biomass burning

Emissions from fire include not only CO2, but also other GHG, or precursors of greenhouse gases, that originate from incomplete combustion of the fuel. These include carbon monoxide (CO), methane (CH4), non-methane volatile organic carbon (NMVOC) and nitrogen (e.g. N2O, NOx) species,

In the 2006 Guidelines, fire is treated as a disturbance that impacts not only the biomass (in particular, above-ground), but also the dead organic matter (litter and dead wood).

For cropland and grassland having little woody vegetation, reference is usually made to biomass burning, since biomass is the main pool affected by the fire.

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emissions from biomass burning

Coverage of reporting: Emissions need to be reported for all fires on managed lands. Emissions from wildfires in unmanaged lands do not need to be reported, unless are followed by a land-use change (become managed land).

Equivalence (synchrony) of CO2 emissions and removals: CO2 emissions should be reported where they are not equivalent in the inventory year to CO2 removals. For grassland biomass burning and burning of agriculture residues, the assumption of equivalence is generally reasonable. For Forest land equivalence (synchrony) is generally not applicable.

Fuels available for combustion: elements that reduce the amount of fuels available for combustion (e.g., from grazing, decay, removal of biofuels, livestock feed, etc.) should be accounted for. A mass balance approach should be adopted to account for residues, to avoid underestimation or double counting

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emissions from biomass burning

Methods and related elements (e.g. decision trees, basic equation, combustion and emission factors, etc.) are generic across land-use categories

$$L_{fire} = A \cdot M_B \cdot C_f \cdot G_{ef} \cdot 10^{-6}$$

where:

- L_{fire} = *amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH_4, N_2O, etc.*
- A = *area burned, ha*
- M_B = *mass of fuel available for combustion, tonnes ha*$^{-1}$*. This includes biomass, ground litter and deadwood. When Tier 1 methods are used then litter and dead wood pools are assumed zero, except where there is a land-use change.*
- C_f = *combustion factor, dimensionless (default values in Table 2.6)*
- G_{ef} = *emission factor, g kg*$^{-1}$ *dry matter burnt (default values in Table 2.5)*

Note: Where data for MB and Cf are not available, a default value for the amount of fuel actually burnt (the product of M_B and C_f) can be used (Table 2.4) under Tier 1 methodology

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TABLE 2.4

FUEL (DEAD ORGANIC MATTER PLUS LIVE BIOMASS)BIOMASS CONSUMPTION VALUES (TONNES DRY MATTER HA^{-1}) FOR FIRES IN A RANGE OF VEGETATION TYPES

(To be used in Equation 2.27 , to estimate the product of quantities ' $M_B \cdot C_f$ ' , i.e., an absolute amount)

Vegetation Type	Sub-category	Mean	SE	References
Primary Tropical Forest (slash and burn)	Primary tropical forest	83.9	25.8	7, 15, 66, 3, 16, 17, 45
	Primary open tropical forest	163.6	52.1	21,
	Primary tropical moist forest	160.4	11.8	37, 73
	Primary tropical dry forest	-	-	66
All primary tropical forests		**119.6**	**50.7**	
Secondary tropical forest (slash and burn)	Young secondary tropical forest (3-5 yrs)	8.1	-	61
	Intermediate secondary tropical forest (6-10 yrs)	41.1	27.4	61, 35
	Advanced secondary tropical forest (14-17 yrs)	46.4	8.0	61, 73
All secondary tropical forests		**42.2**	**23.6**	66, 30
All Tertiary tropical forest		**54.1**	-	66, 30
All Shrublands		**14.3**	**9.0**	
Savanna Woodlands (early dry season burns)*	Savanna woodland	2.5	-	28
	Savanna parkland	2.7	-	57
All savanna grasslands (mid/late dry season burns)*		10.0	10.1	

TABLE 2.5

EMISSION FACTORS (g kg^{-1} DRY MATTER BURNED) FOR VARIOUS TYPES OF BURNING. VALUES ARE MEANS ± SD AND ARE BASED ON THE COMPREHENSIVE REVIEW BY ANDREAE AND MERLET (2001)

(To be used as quantity 'G_{ef}' in Equation 2.27)

	CO_2	CO	CH_4	N_2O	NO_X
Savanna and grassland	1613 ± 95	65 ± 20	2.3 ± 0.9	0.21 ± 0.10	3.9 ± 2.4
Agricultural residues	1515 ± 177	92 ± 84	2.7	0.07	2.5 ± 1.0
Tropical forest	1580 ± 90	104 ± 20	6.8 ± 2.0	0.20	1.6 ± 0.7
Extra tropical forest	1569 ± 131	107 ± 37	4.7 ± 1.9	0.26 ±0.07	3.0 ± 1.4
Biofuel burning	1550 ± 95	78 ± 31	6.1 ± 2.2	0.06	1.1 ± 0.6

Note: The "extra tropical forest" category includes all other forest types.

Note: For combustion of non-woody biomass in Grassland and Cropland, CO_2 emissions do not need to be estimated and reported, because it is assumed that annual CO_2 removals (through growth) and emissions (whether by decay or fire) by biomass are in balance (see earlier discussion on synchrony in Section 2.4.

TABLE 2.6

COMBUSTION FACTOR VALUES (PROPORTION OF PREFIRE FUEL BIOMASS CONSUMED) FOR FIRES IN A RANGE OF VEGETATION TYPES

(Values in column 'mean' are to be used for quantity C_f in Equation 2.27)

Vegetation Type	Sub-category	Mean	SD	References
Primary Tropical Forest (slash and burn)	Primary tropical forest	0.32	0.12	7, 8, 15, 56, 66, 3, 16, 53, 17, 45,
	Primary open tropical forest	0.45	0.09	21
	Primary tropical moist forest	0.50	0.03	37, 73
	Primary tropical dry forest	-	-	66
All primary tropical forests		**0.36**	**0.13**	
Secondary tropical forest (slash and burn)	Young secondary tropical forest (3-5 yrs)	0.46	-	61
	Intermediate secondary tropical forest (6-10 yrs)	0.67	0.21	61, 35
	Advanced secondary tropical forest (14-17 yrs)	0.50	0.10	61, 73
All secondary tropical forests		**0.55**	**0.06**	56, 66, 34, 30
All Tertiary tropical forest		**0.59**	-	66, 30
All Shrublands		**0.72**	**0.25**	
Savanna Woodlands (early dry season burns)*	Savanna woodland	0.22	-	28
	Savanna parkland	0.73	-	57
	Other savanna woodlands	0.37	0.19	22, 29

Training course on: GHG estimates for the forest sector

IPCC methods for land representation

by Sandro Federici & Matieu Henry

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overview

- AFOLU sector require land representation to estimate emissions and removals
  - C Stocks Changes
    - Biomass, DOM and SOM
  - Non-CO_2 emissions e.g. from Biomass Burning
    - Grassland, forestland, and crop residues
- Emission factors are assigned based land representation, i.e., stratification of land
  - Typical strata include current land use, climate, soil types, ecological zones, management and, where relevant, past land use

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principles

- Represent land uses as provided by IPCC (to ensure comparability between countries in reporting)
  - Managed (land influenced by direct human intervention) and unmanaged
- Further disaggregation by strata as needed to assign emission factors
- Complete representation of land across the whole timeseries
- Consistent application land representation data
  - Definitions and classifications are applied consistently
- Estimate uncertainties

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Land use definitions

Forest land: land with woody vegetation, consistent with national definition.

Cropland: arable land (annual and perennial crops), that is not categorized as forest.

Grassland: Pasture and rangeland (and possibly shrubland), that is not categorized as forest or cropland.

Wetland: land covered by water all or part of the year, that is not categorized as forest, cropland or grassland.

Settlement: 'developed' land (human habitation and transportation infrastructure), that is not categorized as forest, cropland, grassland or wetland.

Other land: bare soil, rock, ice, etc. and other unmanaged land not categorized as forest, cropland, grassland, wetland or settlement.

Further develop definitions to meet national circumstances

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approaches

Three general methods for collecting activity data

Approach 1: Data that is not spatially explicit and does not track land use through time

Approach 2: Data that provides land use change through time but is not spatially explicit

Approach 3: Data that provides land use change through time and is spatially explicit

Mixed approaches can be used for different regions of the country

Approach 1

Land uses represented within a particular area, such as a political unit

Land use change is not explicitly represented

Categories: Forestland, Cropland, Grassland, Settlements, Wetlands, Other Lands

Sources:

Maps, surveys, and census

Approach 1

TABLE 3.2
EXAMPLE OF APPROACH 1: AVAILABLE LAND USE DATA WITH COMPLETE NATIONAL COVERAGE

Time 1			Time 2			Net land-use conversion between Time 1 and Time 2		
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	O	=	2	Other Land	=	0
Sum	=	140	Sum	=	140	Sum	=	0

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

Approach 2

Land use and land use change represented within a particular area, such as a political unit

Emission factors can be assigned to represent rates that vary depending on prior land use and time since the land use conversion

Categories: 36 categories for land use remaining in a category and conversions between categories

Cropland, Grassland, Settlements, Wetlands, Other Lands

Sources

Surveys or census

Approach 2

TABLE 3.6
SIMPLIFIED LAND-USE CONVERSION MATRIX FOR APPROACH 2 EXAMPLE

Net land-use conversion matrix

Final \ Initial	F	G	C	W	S	O	*Final sum*
F	15	3	1				*19*
G	2	80					*82*
C			29				*29*
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
Numbers represent area units (Mha in this example).

Approach 3

Spatially-explicit representation of land use and land use change

Similar to Approach II, emission factors can represent rates that vary by prior land use and time since the land use conversion

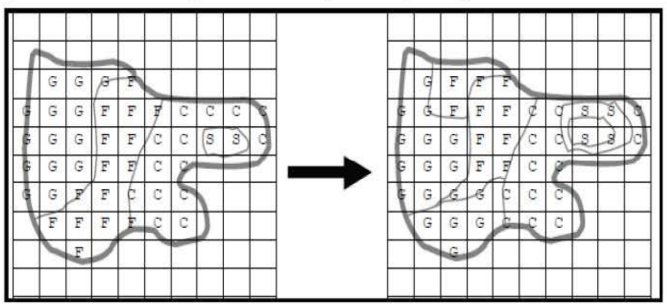
Same as Approach II, 36 categories of land use remaining in a category and conversions between categories

Sources
Geo-referenced surveys, map products (e.g., remote sensing data)

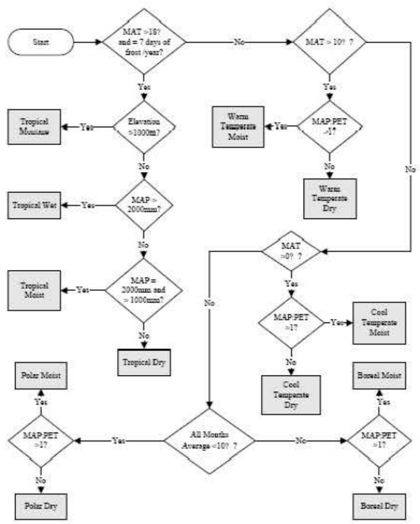
Approach 3

Time 1 Time 2

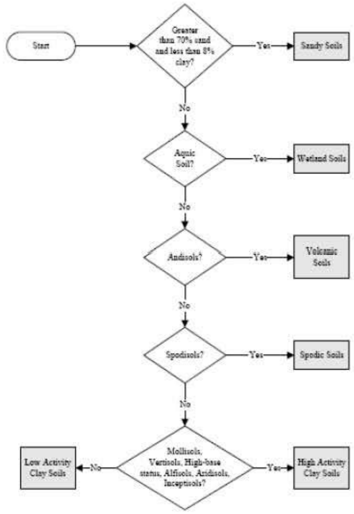
Figure 3A.4.1A Remote sensing can also enable complete coverage of all grid cells.



IPCC Climate Classification



IPCC Soil Classification



Forest types

Subdivide by ecological zone

Further subdivide by forest types

Natural forest types and plantation types

Management of forests
Fuelwood gathering
Wood removals
Forest disturbance
Fire, pest, disease, fire
Shifting cultivation
Drainage of organic soils (i.e., Histosols)

Data sources

Existing data from a national census, surveys and map products
Use these data as much as possible

International datasets and map products
Surveys such as FAO Statistics
Remote sensing products

New data collection
Census, surveys and map products

Should fill gaps in activity data with expert knowledge
Priorities for future data collection

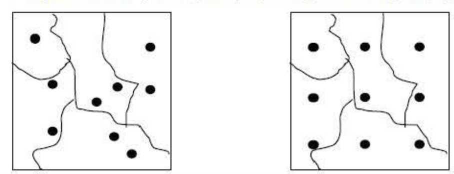
Possibly stored (analyzed, managed) into a Geographic Information System (GIS)

surveys

Sampling population
- Simple random
- Random stratified
- Systematic

Temporary and/or permanent sample plots

Simple random layout of plots (left) and systematic layout (right)



uncertainties

Quantify uncertainties

- Data sources
- Definitions and classifications
- Sampling design and sampling error
- Remote sensing processing
- Interpretation of samples

Reduce uncertainties

- Improve/apply statistically-designed survey, increase sample size
- Ensure definitions/classifications are consistent and appropriate
- Refine remote sensing processing methods and classification algorithms
- Refine approach/rules for sample interpretation (be objective)

Confusion matrix

Accuracy Assesment	Reference									
EarthSat 2000 Value	2	3	4	5	6	7	9	11	13	Column Total
Forest- Evergreen (2)	**218**	2		3		3				226
Scrub/Shrub (3)	52	**115**		13	1	6	2			189
Grassland (4)	4	3	**39**	1		5				52
Barren/Sparsely Veg. (5)			3	**4**		1		2		10
Man-made/Other (6)					**10**					10
Agriculture (7, 8)	4		5	1		**36**				46
Wetlands (9,10)							**20**			20
Water (11)								**21**		21
Clouds/Shadows/drops (13)	7		2	1		2	1		**63**	76
Column Total	285	120	49	23	11	53	23	23	63	**650**
Overall Accuracy:	526 / 650	81%								

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Training course on:
GHG estimates for the forest sector

Data compilation, data management and archiving system

Sandro Federici, Matieu Henry

GHG Inventory Preparation for Forestry
November 5-8th 2012
Paradise Angkor Villa Hotel

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Content

1. Steps in data compilation
2. Principles in data compilation
3. Starting data compilation
4. National/International data compilation
5. Survey/Census data compilation
6. Completeness and consistency data compilation
7. Extrapolation
8. Recalculation
9. Data archiving

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Steps in data compilation

•Overview of data available in the country;

•Selection of method (including approach and tier) to be applied in consistency with the IPCC Guidelines;

•Collection and processing of data from different data sources (including from the IPCC guidelines) at a level of spatial and temporal aggregation as requested by the model;

↳ to produce consistent timeseries of data;

•Further analysis of gaps, uncertainties and consequent planning of additional activities for data collection and/or changes in current activities;

↳ to improve data quality (avoid systematic errors, reduce random errors, achieve completeness in time coverage, synchronizing)

Principles in data compilation

1. Collect the needed data to 'improve' estimates of ***key categories*** which are the largest, have the greatest potential to change, or have the greatest uncertainty;

2. Choose data collection procedures that improve the quality of the inventory in line with the data quality objectives;

3. Put in place data collection activities (resource prioritisation);

4. Collect data at a level of detail appropriate to the method used;

5. Review data collection activities and methodological needs on a regular basis;

6. Introduce agreements with data suppliers to support consistent and continuing information flows.

Starting data compilation

Where to find the data?

- National Institutes of Statistics
- Universities and research institutes
- Sectoral experts, stakeholder organisations
- International organisations publishing statistics e.g., UN, FAO,
- Scientific and technical articles in environmental books, journals and reports
- International experts
- IPCC Emission Factor Database (http://www.ipcc-nggip.iges.or.jp/EFDB/)
- National Inventory Reports from Parties to the UNFCCC

National vs International data compilation

•It is preferable to use **national data** since national data sources are typically **more up to date** and provide better links to the originators of the data;

•Countries are encouraged to develop and **improve national sources** of data to avoid being reliant on international data;

•Most international datasets rely on **nationally-derived data**, and in some cases data from reputable international bodies may be more accessible and more applicable to the inventory;

•Cross-checking national data sets with any available international data can help to **assess completeness** and identify possible problems with either data set.

Survey/Census data compilation

Survey and census information provide the best data that can be used for GHG inventories;

Generally these data are compiled by national statistical agencies
OR
relevant ministries for national policy purposes (agriculture and forestry)

↳ to comply with international demand for data;

the needs of the inventory can sometimes influence surveys or censuses;

Unless they can be consistently repeated, surveys only give measurements relating to one point in time.

Literature and measurements data compilation

Literature

Countries should **use** their **own**, (if possible) peer-reviewed, published **literature**
(should provide the most accurate representation of the country's practices and activities);

If there are no country-specific studies available, the inventory compiler can use:

•Neighbouring countries data or IPCC default factors and data from the Emission Factor Database,

•Other literature values e.g., modelled/estimated data from international bodies that reflect national circumstances, other countries' experiences;

Measurements

Ensure the consistency among the data and with selected methods.

Completeness and consistency data compilation

Gaps in data sets

For a complete and consistent time series, it is necessary to determine the availability of data for each year.

↳ Missing data for 1 or >1 Year OR the data do not represent the year OR do not cover the national coverage required.

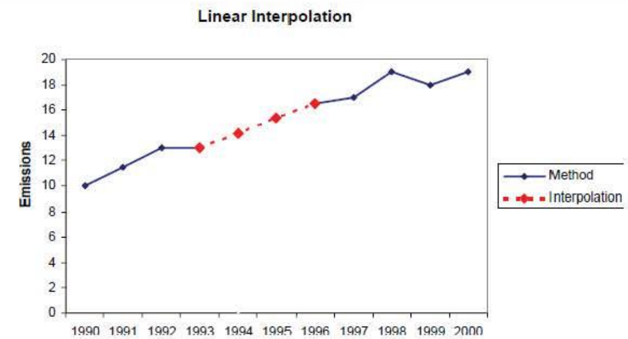
E.g. Time consuming + expensive surveys - such as national forest inventories - are compiled at intervals of every 5 OR 10 years.

Time series data may need to be inferred to compile a complete annual estimate for the years between surveys, and for fore- and back- casts.

↳ Interpolation, Extrapolation, recalculation.

Interpolation

Estimates for the intermediate years in the time series can be developed by interpolating between the detailed estimates.



Extrapolation

When detailed estimates have not been prepared for the base year or the most recent year, **it may be necessary to extrapolate from the closest detailed estimates.**

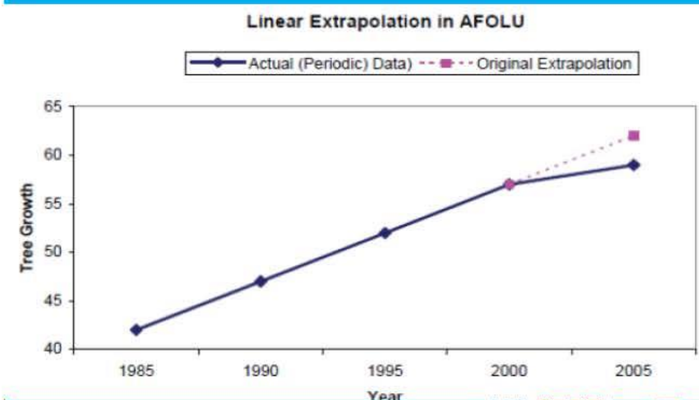
Simple trend extrapolation simply assumes that the observed trend remains constant over the period of extrapolation.

↳ The method should **not be used** if the change in **trend** is **not constant** over time

OR

over long periods of time **without detailed checks** to confirm the continued validity of the trend.

Extrapolation



Extrapolation

Use of surrogate data

To relate Emissions or removals to underlying activity or other indicative data;

- then changes in these data are used to simulate the trend.

Expert judgement

Ultimately the basis to inventory estimation;
Expert judgment should be elicited using an appropriate protocol.

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Recalculations

The availability of data is a critical determinant of the appropriate method:

- Changes in data may lead to +/- changes in the estimation process.
- Extrapolated figures can be recalculated when new data become available.

The ability of countries to collect data **generally improves** over time.

E.g. New method can be developed to take advantages of new technologies or scientific information (e.g remote sensing).

A new categories can be added but the addition of a new category

- Requires the calculation of an entire time series;

  Estimates should be included in the inventory from the year emissions or removals start to occur.

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Recalculations

Overlap

The overlap technique can be used when a new method is introduced but data are not available to apply it to the earlier years;

The time series can be constructed by assuming that there is a **consistent relationship between the results of the previously used and new method;**

The emission or removal estimates for those years when the new method cannot be used directly are developed by proportionally adjusting the previously developed estimates, based on the relationship observed.

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Data archiving

The **archiving of all information** related to the methods and data used for estimating the emissions/removals from the category **is essential!!!**

All the reference material*, estimates and calculation sheets, as well as the documentation on scientific papers and the basic data needed for the estimates from the category,* ***should be stored and archived.***

This information shall also **include internal documentation on QA/QC procedures**, external and internal reviews, documentation on annual key categories and key category identification and planned improvements.

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Data archiving

- A good archive serves as the **"institutional memory"**;
  - quality of documentation on inventory preparation key issue;
  - easy access and clarity in the information stored important – single location;
- Starting point for new teams or new team members;
  - learning from previous experience and using already developed "tools"
  - less duplication of work – efficient use of resources
- A library/data source for the team during preparation;
  - previous inventory the basis for the next one: check, compare with previous calculations, references, etc.
- Information base for reviews, enquires, etc.;
  - transparency
  - reproduction of the inventory estimates

Data archiving

- **An archiving system needs:**
  - A responsible person;
  - A database where all information is stored (paper and electronic data):

➢The database should be conserved in **two separate sites** and composed by two instruments (hard disk and filing cabinet)

➢Information stored in the database **should be accessible but not modifiable** (i.e. any change/update should be tracked)

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Conclusion

➢It is important **to maintain supply of inventory data;**

➢**Engage data suppliers in the process** of inventory compilation and improvement by involving them in activities such as:

➢**Assess** an initial estimate for the category, **pointing out** the potentially high **uncertainties** and **invite** potential **data suppliers** to collaborate **to improve** estimates;

➢Scientific or statistical workshops on the inventory inputs and outputs to **increase the robustness of the data;**

➢**Specific contracts or agreements** for regular data supply;

➢**Regular/annual informal updates** on the methods that use their data;

➢Establishment of **TORs or MoU** to clarify what is needed for the inventory, **how it is derived and provided** to the inventory compiler and when.

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Example on land use data

→ The basis of estimating and reporting greenhouse gas emissions and removals from land use and land-use conversions IS:

The ***classification*** of national territory into the six ***land-use categories*** (*forest land, cropland, grassland, wetlands, settlements, other land*).

↳ Further, categories are divided in subcategories:

→Land remaining under the same land use in the last 20-years

→Land converted to that land use category

→The categories may be further ***stratified*** (e.g., by climate or ecological zones).

→The categories (and sub-categories) are intended to be identified through use of Approaches for representing land-use area data before described

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Example on land use data

→ Care needs to be taken in inferring ***land use*** from the ***land cover*** characteristics and vice versa;

→ Countries will use their own ***definitions of these categories***, which may or may not refer to internationally accepted definitions, such as those by FAO, Ramsar, etc.;

→ Countries should describe the methods and definitions used to determine areas of ***managed and unmanaged lands.***

→ All land definitions and classifications should be specified at the national level, described in a transparent manner, and be applied consistently over time.

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Example on land use data

Land-use databases:

1. Databases prepared for other purposes

- national databases;

typical sources of data include forest inventories, agricultural census and other surveys, censuses for urban and natural land, land registry data and maps.

- international databases;

Several projects have been undertaken to develop international land-use and land cover datasets at regional to global scales (almost all are raster data).

↳ *These datasets can be used to estimate spatial distribution of land-use categories and assess reliability of the existing land-use datasets.*

Example on land use data

Land-use databases:

2. Collection by sampling

- Sampling techniques for estimating areas and area changes are applied in situations **where direct measurements in the field or assessments by remote sensing techniques are not feasible** or would provide inaccurate results;
- **Sampling usually involves a set of sampling units that are located on a regular grid within the inventory area.** Where sampling for areas is repeated at successive occasions, area changes over time can be derived to construct land-use conversion matrices.

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Example on land use data

3. Complete land inventory

- A complete inventory of land use of all areas in a country will entail **obtaining maps of land use throughout the country at regular intervals.** This can be achieved by using remote sensing techniques.
- A complete inventory can also be achieved by **surveying all landowners.** Inherent problems in the method include obtaining data at scales smaller than the size of the owner's land as well as difficulties with ensuring complete coverage with no overlaps.

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Example on land use data

Tools for Data Collection

→ Remote sensing techniques

*A **complete remote sensing system** (aerial photographs, satellite imagery using visible and/or near-infrared bands, satellite or airborne radar imagery and lidar) for tracking land use conversions can include **many sensor** and data type **combinations at a variety of resolutions**.*

→ Ground-based surveys

May be used to gather and record information on land use, and for use as independent ground-truth data for remote sensing classification.

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Training course on:
GHG estimates for the forest sector

Institutional Arrangements for National Inventory Systems

Sandro Federici, Matieu Henry

GHG Inventory Preparation for Forestry
November 5-8th 2012
Paradise Angkor Villa Hotel

UN-REDD

Content

1. Scope of Presentation
2. What is a National Inventory System (NIS)?
3. Institutional Arrangements (IA)
4. IA for the National System for GHG Inventory
5. Inventory Planning
6. Inventory Preparation
7. Inventory Management

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Scope of Presentation

- To clarify which kind of entities and institutional, legal and procedural arrangements are requested by the National Inventory System functions
- (to be continued...)

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What is a National Inventory System (NIS)?

A *National Inventory System* (NIS) incorporates all the elements necessary to estimate GHG emissions and sinks, including institutional, legal and procedural arrangements

Practically, the NIS consists of a set of relations between institutions and other subjects meant to ensure sustainability of the inventory preparation, consistency of reported estimates, and standard quality results

Institutional Arrangements (IA)

By **IA** we mean "institutional, legal and procedural arrangements"

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

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… Institutional Arrangements (IA)

- For each NIS function an appropriate IA (within/among entity/ies) shall be set up in order to ensure efficient performance of the function itself
- An implementing entity must be identified for each of the functions
- In order for the entity to perform the assigned function, it must have sufficient capacity in terms of:
  - financial and human resources and technical expertise
  - legal authority

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… Institutional Arrangements (IA)

Be aware of:

Conflict of Responsibility

- Two entities are assigned the same level of power of intervention on one of the functions.

Vacuum of Responsibility

- A function is not assigned to any entity.

Loops

- An entity is assigned a function that it exerts on another entity, and the latter can, in turn, condition the first entity.

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Institutional Arrangements (IA)

A well functioning IA identifies (where available) and/or sets up appropriate* entities to which it assigns the various NIS functions.

Each entity is liable for performing its function.

* An "appropriate" entity has at its disposal the necessary financial resources, facilities, skilled personnel and legal authority to deal with the assigned function.

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Institutional Arrangements (IA) for the National System for GHG Inventory

Functions to be assigned through IA

3 Areas:

- ➢Inventory Planning
- ➢Inventory Preparation
- ➢Inventory Management

(***Guidelines for national systems - Decision 19/CMP.1***)

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Functions relating to Inventory Planning

1. "***Establish and maintain*** *the institutional, legal and procedural arrangements necessary to perform the functions, as appropriate, between the government agencies and other entities responsible for the performance of all functions*"

This function applies:

- at the general level to the entity which sets up the country's NIS (e.g. Ministry, Prime Minister Cabinet, Agency)
- at the single level to the entity which sets up a single IA with another entity/ies to perform one of its assigned functions

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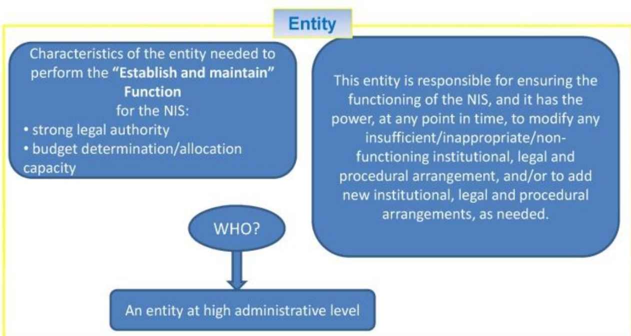
… Functions relating to Inventory Planning

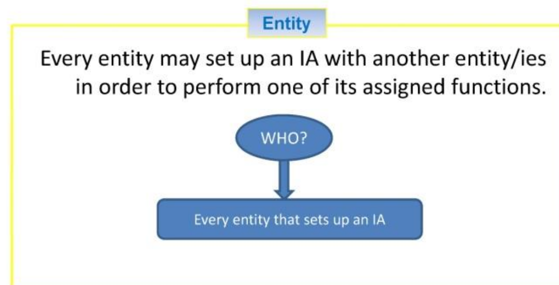
"Establish and maintain" Function at the general level



Type of needed IA: Institutional-Legal Arrangement

… Functions relating to Inventory Planning

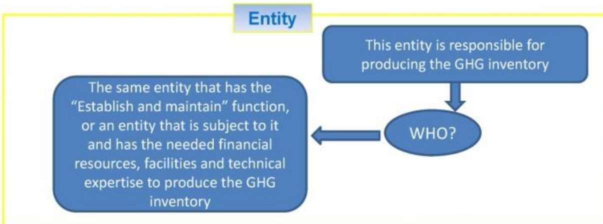
"Establish and maintain" Function at the single level



Type of needed IA: Legal Arrangement

... Functions relating to Inventory Planning

2. "***Ensure*** *sufficient capacity for timely performance of the inventory functions, including data collection for estimating anthropogenic GHG emissions by sources and removals by sinks and arrangements for technical competence of the staff involved in the GHG inventory development process*"



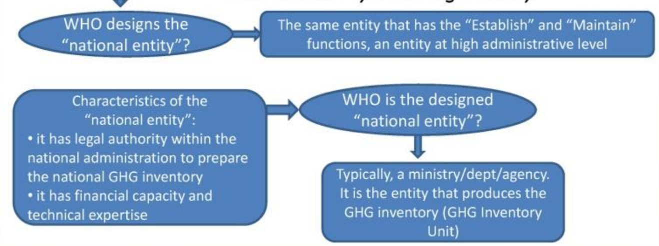
Type of needed IA: Institutional-Legal Arrangement

... Functions relating to Inventory Planning

3. "***Designate*** *a single national entity with overall responsibility for the national GHG inventory.*"

Entity

"Hierarchy" Function: A ***pyramidal hierarchy*** *which assigns the overall liability to a single entity.*



Type of needed IA: Institutional-Legal Arrangement

... Functions relating to Inventory Planning

4. "*Make available the postal and electronic addresses of the national entity responsible for the inventory*"

Entity

"Identification" Function: *Make public the identity of the entity overall responsible for the GHG inventory, and provide the channel to access it.*

Type of needed IA: Institutional-Legal Arrangement

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... Functions relating to Inventory Planning

5. "*Define and allocate specific responsibilities in the GHG inventory development process, including those relating to choice of methods, data collection, particularly activity data and emission factors from statistical services and other entities, processing and archiving, and QC and QA. In defining responsibilities, the role of each involved entity shall be specified, and institutional, legal and procedural arrangements shall be clarified.*"

The ***"Liability" Function*** applies:

- at the general level to the entity responsible for the NIS (e.g. Ministry, Prime Minister Cabinet, Agency)
- at the single level to each entity to which a single function has been assigned

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… Functions relating to Inventory Planning

"Liability" Function at the general level

Entity

A well functioning NIS identifies (where available) and/or sets up appropriate entities to which it assigns the various functions. These entities then become responsible for the functions they have been assigned. Therefore, all needed functions shall be assigned and responsibilities shall be unequivocally allocated.

WHO? → The same entity that establishes and maintains the National Inventory System

Type of needed IA: Institutional-Legal Arrangement

… Functions relating to Inventory Planning

"Liability" Function at the single level

Entity

Each entity to which a function has been assigned may set up IA with other entities in order to obtain all needed elements for performing the function. Therefore, the entity which should provide the needed element is responsible for doing so.

WHO? → The same entity that establishes and maintains the IA

Type of needed IA: Institutional-Legal Arrangement

… Functions relating to Inventory Planning

6. *"Elaborate an inventory QA/QC plan which describes specific QC procedures to be implemented during the inventory development process, facilitate the overall QA procedures to be conducted, to the extent possible, on the entire GHG inventory and establish quality objectives"*

Entity

"Evaluation" Function: *Evaluation of the functioning and outcomes of the GHG inventory*

Characteristics of the entity:
- Involved in the inventory development process
- Technical expertise
- Capacity of allocating the necessary budget for an independent quality assessment

→ WHO? → Possibly the entity that produces the GHG inventory (GHG Inventory Unit)

Type of needed IA: Institutional-Legal Arrangement

… Functions relating to Inventory Planning

7. *"Establish processes for the official consideration and approval of the inventory, including any recalculations, prior to its submission and to respond to any issues raised by the inventory review process"*

Entity

"Official status" Function: *the system set through IA shall produce official national statistics*

WHO? → An entity at high administrative level. The same entity that has the "Hierarchy" and "Accessibility" functions.

Type of needed IA: Institutional-Legal Arrangement

… Functions relating to Inventory Planning

8. *"As part of its inventory planning, the Party should consider ways to **improve the quality** of activity data, emission factors, methods and other relevant technical elements of inventories. Information obtained from the implementation of the QA/QC programme and any review process should be considered in the improvement of the GHG inventory (and its national system)."*

The ***"Improvement" Function*** applies:

- at the general level to the entity which sets up the NIS (e.g. Ministry, Prime Minister Cabinet, Agency)
- at the single level to the entity which sets up a single IA with another entity/ies to perform one of its assigned functions

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… Functions relating to Inventory Planning

"Improvement" Function at the general level:

Entity

IA should be set up in a manner that guarantees the improvement of the NIS. It should be ensured that inputs coming from quality assessment processes (such as the inventory review, the QA and the QC procedures internal to the process of inventory production) are implemented in the inventory improvement process.

WHO?

The entity which established and maintained the NIS

Type of needed IA: Institutional-Legal Arrangement

… Functions relating to Inventory Planning

"Improvement" Function at the single level:

Entity

IA should be set up in a manner that guarantees the improvement of the IA. It should be ensured that inputs coming from quality assessment processes (such as the inventory review, the QA and the QC procedures internal to the process of inventory production) are implemented in the inventory improvement process.

WHO?

Every entity that has been assigned the function that should be improved.

Type of needed IA: Institutional-Legal Arrangement

Functions relating to Inventory Preparation

9. *"Identify key categories following the methods described in the IPCC Guidelines"*

Entity

"Analysis" Function: *the most relevant sources/sinks shall be identified in order to channel resources and to properly frame IA (indeed IA are fundamental among entities able to provide needed data for estimating relevant source/sink, and the entity entitled to produce the GHG inventory).*

WHO? → GHG Inventory Unit

Type of needed IA: Procedural Arrangement

… Functions relating to Inventory Preparation

10. *"Prepare estimates in accordance with the methods described in the IPCC guidelines, and ensure that appropriate methods are used to estimate emissions from key categories"*

Entity

"Estimating" Function: *the estimates of GHG fluxes shall be prepared in a consistent way with the adopted good practices.*

WHO? → GHG Inventory Unit

Type of needed IA: Procedural Arrangement

… Functions relating to Inventory Preparation

11. *"Collect sufficient activity data, process information and emission factors as are necessary to support the methods selected for estimating anthropogenic GHG emissions by sources and removals by sinks"*

Entity

"Completeness" Function: *the IA shall ensure the needed flux of information/data/resources for the production of the national GHG inventory.*

WHO? → GHG Inventory Unit

Type of needed IA: Procedural Arrangement

… Functions relating to Inventory Preparation

12. *"Make a quantitative estimate of inventory uncertainty for each category and for the inventory in total, following the IPCC guidelines"*

Entity

"Assessment" Function: *the likelihood of reported GHG values for fluxes is estimated; this information should drive further improvements of the national inventory system.*

WHO? → GHG Inventory Unit

Type of needed IA: Procedural Arrangement

… Functions relating to Inventory Preparation

13. *"Compile the national GHG inventory"*

Entity

"Reporting" Function

WHO? → GHG Inventory Unit

Type of needed IA: Procedural Arrangement

… Functions relating to Inventory Preparation

14. *"Implement inventory QC procedures in accordance with its QA/QC plan following the IPCC Guidelines"*

Entity

"Control" Function: *internal routine checks in order to ensure that no errors will occur during the workflow*

WHO? → GHG Inventory Unit

Type of needed IA: Procedural Arrangement

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… Functions relating to Inventory Preparation

15. *"Provide for a **review of the inventory** by personnel that have not been involved in the inventory development, preferably an independent third party, before the submission of the inventory, in accordance with the planned QA procedures"*

Entity

"Review" Function: *external checking of errors and assessment of transparency, completeness, accuracy, comparability and consistency of the GHG inventory.*

WHO? → An external entity (national or international) with the necessary technical expertise

Type of needed IA: Procedural Arrangement

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… Functions relating to Inventory Preparation

16. *"Based on the QA results and QC outputs, the Party shall re-evaluate the inventory planning process in order to meet the established quality objectives"*

Entity

"Improving" Function: *Every entity to which a function has been assigned has to implement the outputs coming from quality assessment procedures (QA, QC and other review processes)*

WHO? → Every entity to which the function that should be improved has been assigned

Type of needed IA: Procedural Arrangement

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Functions relating to Inventory Management

17. *"**Archive inventory information** for each year. This information shall include all disaggregated emission factors, activity data, and documentation about how these factors and data have been generated and aggregated for the preparation of the inventory. This information shall also include internal documentation on QA/QC procedures, external and internal reviews, documentation on annual key categories and key category identification and planned inventory improvements"*

Entity

"Archiving" Function: *a rigorous system for storing all information on GHG estimates and processes employed to achieve them is necessary for ensuring sustainability of the inventory process.*

WHO? → Possibly the GHG Inventory Unit

Type of needed IA: Institutional-Legal Arrangement

… Functions relating to Inventory Management

18. "*Provide **access** to all archived information used by the Party to prepare the GHG inventory*"

Entity

"Accessibility" Function

WHO? → The same entity that has the "Archiving" function

Type of needed IA: Procedural Arrangement

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… Functions relating to Inventory Management

19. "*Respond to requests for clarifying inventory information resulting from the different stages of the review process of the inventory information, and information on the national system, in a timely manner*"

Entity

"Transparency" Function: *Interaction with stakeholders and sharing of information (Q raised by stakeholders shall be properly and timely answered)*

WHO? → GHG Inventory Unit

Type of needed IA: Procedural Arrangement

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… Functions relating to Inventory Management

20. "*As part of its inventory management, each Party should make the archived information accessible by collecting and gathering it at a single location*"

Entity

"Security" Function: *One single access policy is necessary for ensuring safe management of stored information, including tracking access and potential modification of stored information*

WHO? → The same entity that has the "Archiving" function

Type of needed IA: Procedural Arrangement

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Thank you for your attention!!

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Training Workshop on "GHG Inventory Preparation for Forestry"

Exercise Introduction

Uy Kamal

GHG Inventory Preparation for Forestry
November 5-8th 2012
Paradise Angkor Hotel

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What is Greenhouse Gas (GHG) Inventory?

- A GHG inventory is an accounting of GHGs emitted to or removed from the atmosphere over a period of time.
- Policy makers use inventories to establish a baseline for tracking emission trends, developing mitigation strategies and policies, and assessing progress.
- An inventory is usually the first step taken by entities that want to reduce their GHG emissions.

An inventory can help local governments:
•Identify the sectors, sources, and activities within their jurisdiction that are responsible for greenhouse gas emissions
•Understand emission trends
•Quantify the benefits of activities that reduce emissions
•Establish a basis for developing a local action plan
•Track progress in reducing emissions
•Set goals and targets for future reductions

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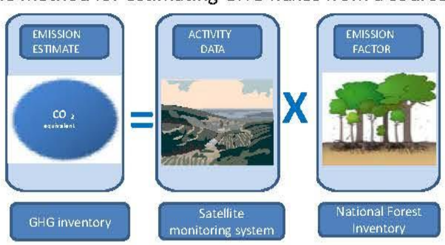
Preparing a GHG estimate: the method

The most simple method for estimating GHG fluxes from a source/sink is:



Activity Data * Emission Factor = annual GHG flux

For C pools

Activity Data * Carbon Stock Change Factor = annual carbon stock change

- Or *proxy data* * *factor of correlation* with variable to be assessed (i.e. CO_2 emissions/removals)

Evolution of IPCC Guidelines for National Greenhouse Gas Inventories

Revised 1996 Guidelines ➡ *2006 Guidelines*

LUCF ➡ *LULUCF* ➡ *AFOLU*

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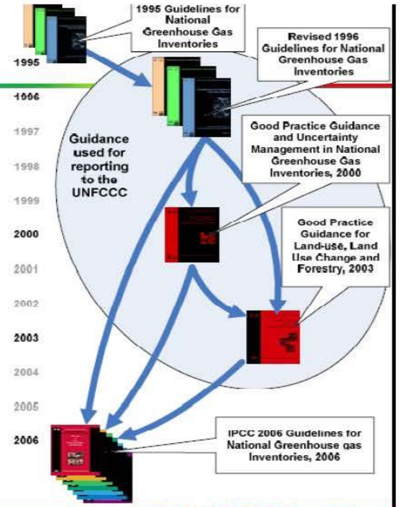
History

- Revised 1996 Guidelines approach – Land-Use Change and Forestry (LUCF)
  - Identifies major likely land use sources
- 2000 Good Practice Guidance and Uncertainty Management
  - Defines GPG and applies it to Agriculture
- Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG LULUCF)
  - Expanded Guidance covering all carbon pools
  - Guidance on the representing Land Areas
- 2006 IPCC Guidelines for National Greenhouse Gas Inventories
  - Now Agriculture, Forestry and Other Land Use (AFOLU)
  - Essentially the same as to GPG LULUCF but integrating Agriculture and LULUCF sectors
  - Extended default values & some improved methods



Source: Simon & Nalin, 2008

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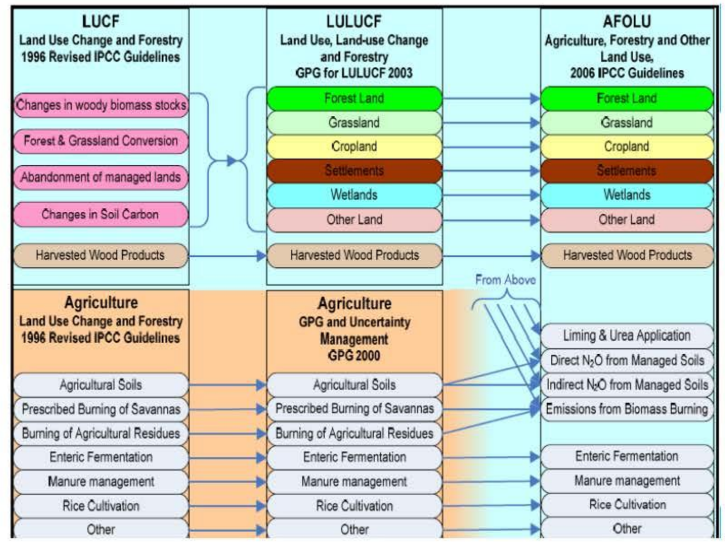

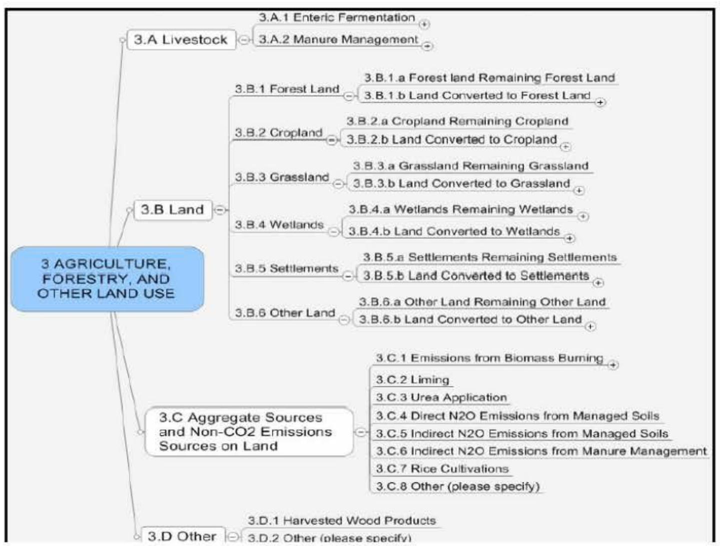

Thank You

More info on GHG inv. &software, please go to http://www.ipcc.ch/

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National Forest Inventories

Status in the world

Matieu Henry, Sandro Federici

GHG Inventory Preparation for Forestry
November 5-8th 2012
Paradise Angkor Villa Hotel

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Content

1. National Forest Inventory: Definition and objectives
2. The different steps to implement an NFI
3. Different sampling strategy in the world
4. Issues to be considered in the context of REDD+
5. Conclusion

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1. National Forest Inventory: Definition and objectives

Accurate, up-to-date information about the size, distribution, composition and condition of our forests and woodlands is essential for developing and monitoring policies and guidance to support their sustainable management. To gather this information and keep it up to date, we carry out periodic surveys of forests and woodlands across the country.

NFI definition of Great Britain

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1. National Forest Inventory: Definition and objectives

The national forest inventory is the assessment, at national scale, of forest variables at a certain point in time. Repeated inventories may provide trends over time of such variables. Among variables the most relevant has historically been biomass, other carbon stocks are currently being added to modern inventories as well as variables related to the socio-economic use of forest.

Proposed NFI definition

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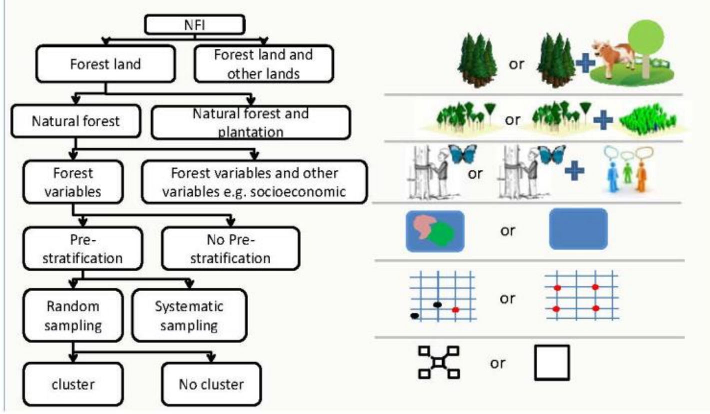
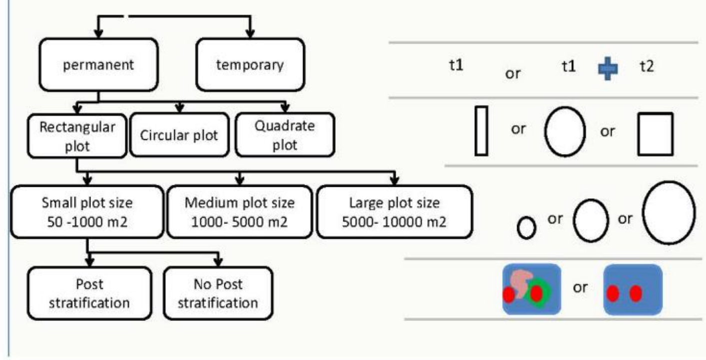
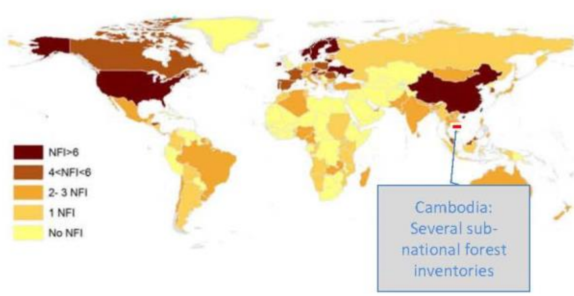
2. Different elements to be considered during the design of the NFI



2. Different elements to be considered during the design of the NFI



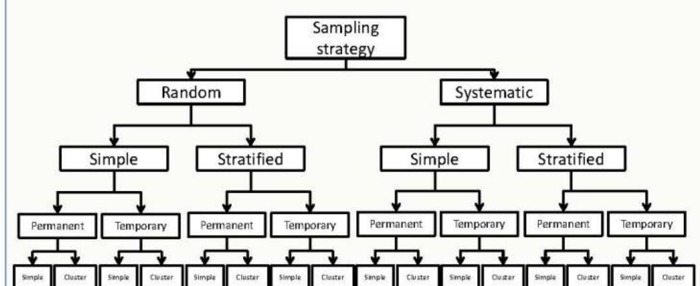
3. Different sampling strategies in the world



Unpublished data – based on the data collected from 128 countries who have already implemented an NFI

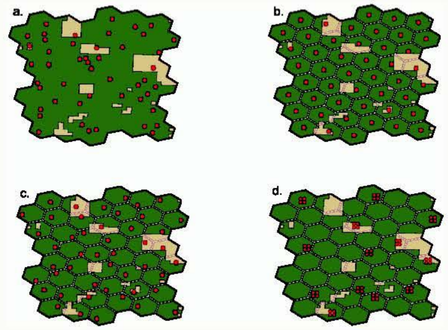
3. Different sampling strategies in the world

Different sampling strategies used for NFI

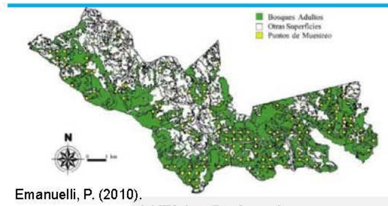


Unpublished data – based on the data collected from 128 countries who have already implemented an NFI

Different sampling strategies used for NFI



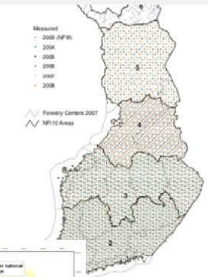
(a) simple random sample design, (b) aligned systematic sample design, (c) unaligned systematic sample design, (d) unaligned, clustered, systematic sample design with the same number of plots but grouped into clusters.



Emanuelli, P. (2010).

NFI in Salvador

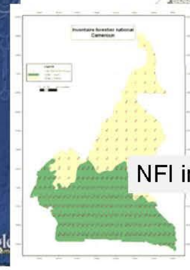
NFI in Finland



Tomppo, 2005

NFI in Tanzania

NFI in Cameroon



FAO, 2004

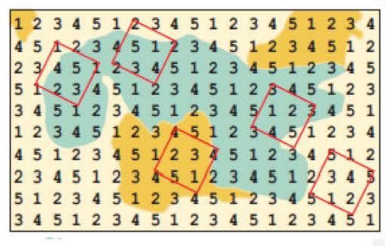
3. Forest Definition– the case of France

NFI Forest Definition:

Forest cover> 10%, minimum land area = 0.5 ha, minimum tree height = 5m in situ.

Un territoire occupant une superficie d'au mois 50 ares, avec des essences forestières [arbres poussant en forêt] capables d'atteindre une hauteur supérieure à 5 m, avec un couvert arboré de plus de 10 % et une largeur moyenne d'au moins vingt mètres. La forêt se subdivise en bois et boqueteaux, ne comprend pas les bosquets, mais inclut les peupleraies.

3. Sampling strategy – the case of France



All Land Cover/Land Use Classes

Total Forest Area = 15,954 Kha

Systematic Sampling: Aligned clustered permanent plots

Number of plots = 55,000 plots

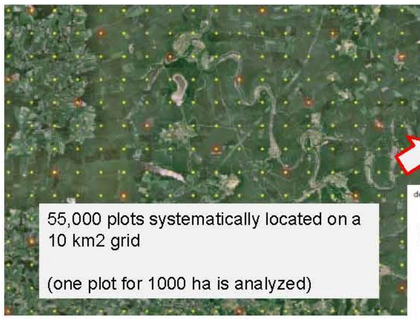
Plot size = 1962.5 m² (25 m radius)

First NFI: 1960

NFI cycle= 5 years

3. Sampling strategy – the case of France

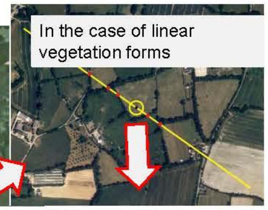
Photo-interpretation

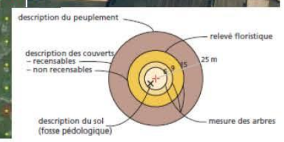


55,000 plots systematically located on a 10 km2 grid

(one plot for 1000 ha is analyzed)

In the case of linear vegetation forms





2-3 hours to measure 1 plot by 2-3 technicians

3. Institutions with clear mandate to implement the NFI – the case of France

Institution with clear mandate to:

Inventory planning = > Institut national de l'information géographique et forestière (IGN)
Data collection (RS) = > IGN
Data collection (field data) = > Division de l'inventaire forestier des différentes directions interrégionales
Data management and analysis => IGN
QA/QC => IGN
Improvement plan => IGN
Archiving and Documentation => IGN
Uncertainty analysis = > IGN

Hardcopy manuals/books= yes http://inventaire-forestier.ign.fr/spip/

3. Measured field variables – the case of France

Age	Y
Canopy cover	Y
Soil properties	Y
Standing Deadwood, Lying dead wood: Decay status	Y
Saplings/Seedlings , Herbs, Biodiversity, Commercial value/timber	Y
Genetics resources, drought	N
Slope	Y
Data for RS calibration	Y
Rocks cover	Y
Fires, Disturbances, Diseases, Erosion, Grazing, fellings	Y
Shrubs, Moss, Lichens, Litter, Liana, Palm and others, socio-economic variables, Voids (Roads, lake, water bodies etc.	'Na'

3. Use of remote sensing– the case of France

Variables assessed using RS are specific for the NFI?	Yes
Variables assessed by RS: Land-use/ Land-cover	Yes
Variables assessed by RS: Forest classes (stratum)	Yes
Variables assessed by RS: Forest area	Yes
Variables assessed by RS: Volume	No
Variables assessed by RS: Height	No
Variables assessed by RS: Deforestation	Yes
Variables assessed by RS: Forest degradation	No
Variables assessed by RS: Disease	No
Variables assessed by RS: Forest Growth	No
Type of remote sensing adopted: Photographs	Yes
Type of remote sensing adopted: SAR	No

3. Forest Definition– the case of Japan

Forest Definition:

Forest cover> 30%, minimum land area = 0.3 ha, minimum tree height = 5m in situ.

In this law, FOREST shall be defined as listed below. The definition, however, shall exclude lands used for agriculture, housing, or equivalent purposes and standing trees and bamboo upon those lands. (1) Lands with trees and bamboo in groups and standing tree and bamboo upon the lands. (2) Besides the lands mentioned in the paragraphs, lands that serve as habitats for trees and bamboo.

UN-REDD

3. Sampling strategy – the case of Japan

Only Trees in FL

Total Forest Area
= 24,979 Kha

Systematic Sampling:
permanent plot

Number of plots = 15,675 plots

Plot size = 1,000 m²

First NFI: 1999,
NFI cycle= 5 years

UN-REDD

3. Institutions with clear mandate to implement the NFI – the case of Japan

Institution with clear mandate to:

Inventory planning = > Forestry Agency
Data collection (RS) = > Forestry Agency
Data collection (field data) = > Forestry Agency
Data management and analysis => Forestry Agency
QA/QC => Forestry Agency
Improvement plan => Forestry Agency
Archiving and Documentation => Forestry Agency
Uncertainty analysis = > Forestry Agency

Hardcopy manuals/books= yes

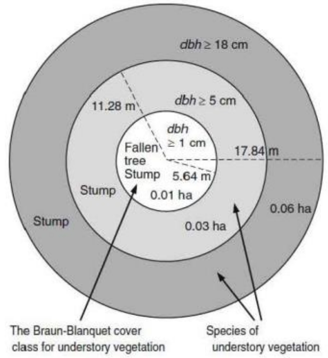
UN-REDD

3. Measured field variables – the case of Japan

Age	Y
Canopy cover	Y
Soil properties	Y
Standing Deadwood, Lying dead wood: Decay status	Y
Shrubs, Herbs, Litter	Y
Genetics resources	N
Commercial value/timber	Y
Voids (Roads, lake, water bodies etc.), Slope	Y
Disturbances	Y
Diseases, Insects	Y
Fires, Disturbances, Diseases, Erosion, Grazing	Y
Biodiversity, Moss, Lichens, Liana, Palm and others, fellings, socio-economic variables, Saplings/Seedlings , Data for RS calibration Rocks cover	'Na'

UN-REDD

3. Plot design – the case of Japan



UN-REDD

3. Use of remote sensing– the case of Japan

The variables assessed using RS are specific for the NFI?	Yes
Variables assessed by RS: Land-use	Yes
Variables assessed by RS: Forest classes (stratum)	Yes
Variables assessed by RS: Forest area	Yes
Variables assessed by RS: Volume	No
Variables assessed by RS: Height	No
Variables assessed by RS: Deforestation	Yes
Variables assessed by RS: Forest degradation	No
Variables assessed by RS: Disease	No
Variables assessed by RS: Forest Growth	No
Type of remote sensing adopted: Photographs	?
Type of remote sensing adopted: SAR	No

UN-REDD

3. Forest Definition– the case of Italy

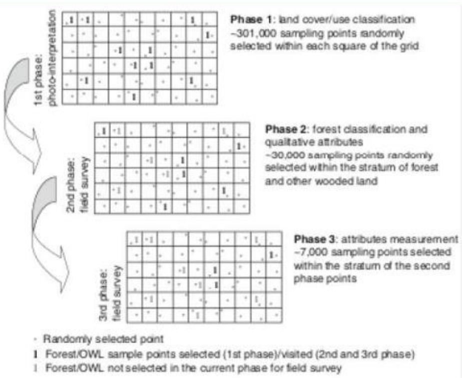
Forest Definition:

Forest cover> 10%, minimum land area = 0.5 ha, minimum tree height = 5m in situ.

Può trattarsi di formazioni chiuse o aperte. Soprassuoli forestali giovani, anche se derivati da piantagione, o aree temporaneamente scoperte per cause naturali o per l'intervento dell'uomo, ma suscettibili di ricopertura a breve termine secondo i requisiti sopra indicati, sono inclusi nella definizione di bosco. Sono inoltre inclusi: vivai forestali e arboreti da seme (che costituiscono parte integrante del bosco); strade forestali, fratte tagliate, fasce tagliafuoco e altre piccole aperture del bosco; boschi inclusi in parchi nazionali, riserve naturali e altre aree protette; barriere frangivento e fasce boscate di larghezza superiore a 20 m, purchè maggiori di 0,5 ha. Sono incluse anche le piantagioni finalizzate a scopi forestali comprese quelle di alberi da gomma e le sugherete.

UN-REDD

3. Sampling strategy – the case of Italy



Only Trees in FL

Total Forest Area = 9,149 Kha

Number of forest classes = 23

Stratified Systematic Random Sampling: Unaligned permanent plot

Number of plots = 30,000 plots

Plot size = 530 m²

First NFI: 1983,
NFI cycle= 5 years

UN-REDD

3. Institutions with clear mandate to implement the NFI – the case of Italy

Institution with clear mandate to:

Inventory planning = > National Forest Service
Data collection (RS) = > National Forest Service, Mountain Information System
Data collection (field data) = >National Forest Service
Data management and analysis => Agricultural Research Council – Forest Monitoring and Planning Research Unit
QA/QC => Agricultural Research Council – Forest Monitoring and Planning Research Unit
Improvement plan => University of Siena
Archiving and Documentation => Private company
Uncertainty analysis = > Agricultural Research Council – Forest Monitoring and Planning Research Unit

Hardcopy manuals/books= yes http://www.sian.it/inventarioforestale/jsp/home.jsp

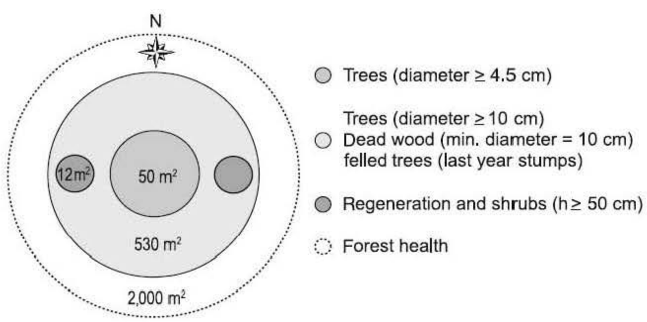
UN-REDD

3. Measured field variables – the case of Italy

Age	Y
Canopy cover	Y
Soil properties	Y
Standing Deadwood, Lying dead wood: Decay status	Y
Saplings/Seedlings	Y
Genetics resources	N
Commercial value/timber	Y
Voids (Roads, lake, water bodies etc.), Slope	Y
Data for RS calibration	Y
Rocks cover	Y
Fires, Disturbances, Diseases, Erosion, Grazing	Y
Biodiversity, Shrubs, Herbs, Moss, Lichens, Litter, Liana, Palm and others, fellings, socio-economic variables	'Na'

UN-REDD

3. Plot design – the case of Italy



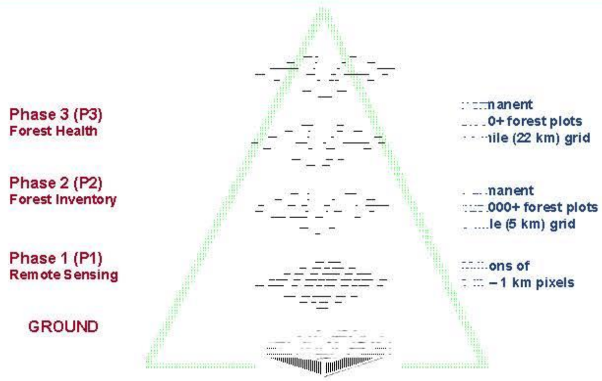
UN-REDD

3. Use of remote sensing– the case of Italy

The variables assessed using RS are specific for the NFI?	Yes
Variables assessed by RS: Land-use/ Land-cover/ Elevation/ Slope	Yes
Variables assessed by RS: Forest classes (stratum)	Yes
Variables assessed by RS: Forest area	Yes
Variables assessed by RS: Volume	No
Variables assessed by RS: Height	No
Variables assessed by RS: Deforestation	No
Variables assessed by RS: Forest degradation	No
Variables assessed by RS: Disease	No
Variables assessed by RS: Forest Growth	No
Type of remote sensing adopted: Photographs	Yes
Type of remote sensing adopted: SAR	No

UN-REDD

3. Different sampling strategies in the world – the case of the US

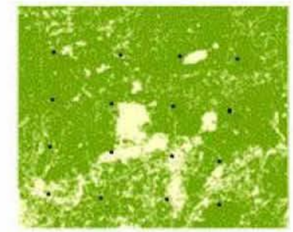


UN-REDD

3. Different sampling strategies in the world – the case of the US

Phase 1 – Stratification

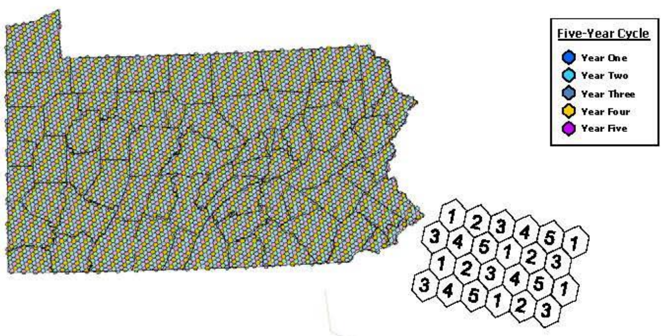
- Previously stratified photo points
- Now use satellite imagery to stratify forest/nonforest and more
- Post-stratification allows flexible issue analysis



UN-REDD

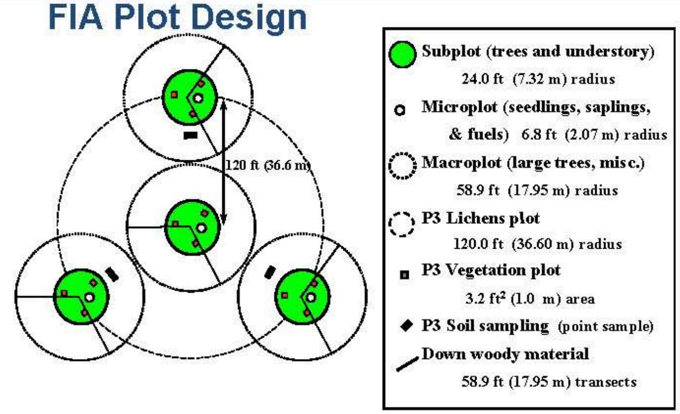
3. Different sampling strategies in the world – the case of the US

Phase 2 – Traditional Forest Inventory



3. Different sampling strategies in the world – the case of the US

FIA Plot Design



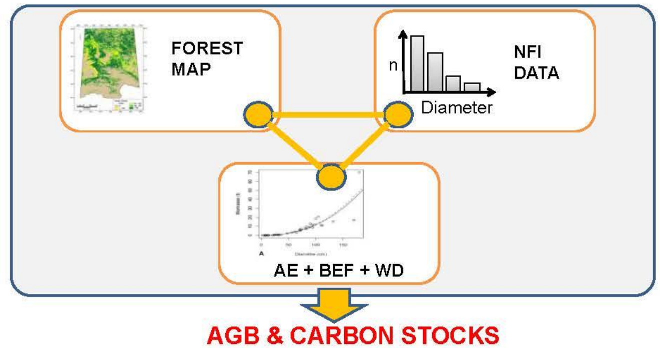
3. Different sampling strategies in the world – the case of the US

Phase 3 Forest Health Indicators

- Crown measures are taken to assess tree health.
- Down woody material transects
- Vegetation plots are used to identify all vegetation to the species level, thus including information on exotic or invasive plants.
- Soil samples are analyzed for basic soil nutrient parameters.
- Lichen diversity is an indicator of air pollution and old growth conditions.
- Ozone bioindicator plant data are collected separately for air pollution impacts.

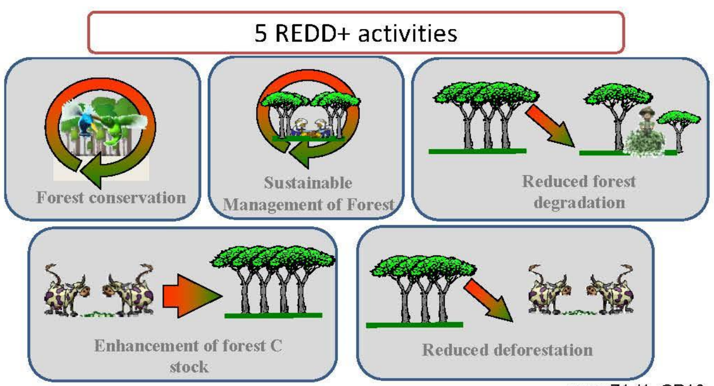
UN-REDD

4. Issues to be considered in the context of REDD+



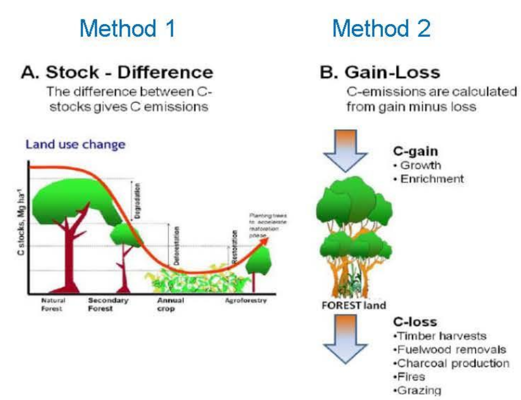
AE: Allometric equations, BEF: biomass expansion factor, WD: wood density, NFI: National Forest Inventory

4. Issues to be considered in the context of REDD+



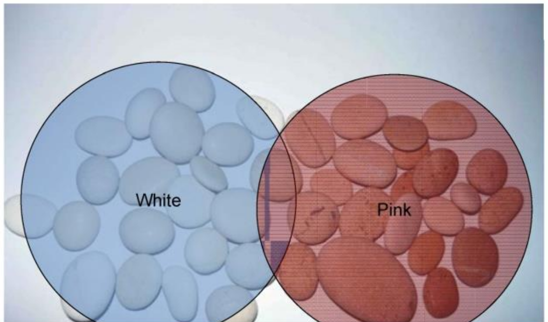
para 71 /1. CP16

4. Issues to be considered in the context of REDD+



4. Issues to be considered in the context of REDD+

Stratification



Which are the forest classifications that will allow us to estimate carbon stock and carbon change?

4. Issues to be considered in the context of REDD+

Stratification

Which are the forest classifications that will allow us to estimate carbon stock and carbon change?

4. Issues to be considered in the context of REDD+

TABLE 3.1
EXAMPLE STRATIFICATIONS WITH SUPPORTING DATA FOR TIER 1 EMISSIONS ESTIMATION METHODS

Factor	Strata
CLIMATE (see Annex 3A.5)	Boreal Cold temperate dry Cold temperate wet Warm temperate dry Warm temperate moist Tropical dry Tropical moist Tropical wet
SOIL (see Annex 3A.5)	High activity clay Low activity clay Sandy Spodic Volcanic Wetland Organic
BIOMASS (ECOLOGICAL ZONE) (see Figure 4.1, in Chapter 4 Forest Land)	Tropical rainforest Tropical moist deciduous forest Tropical dry forest Tropical shrubland Tropical desert Tropical mountain systems Subtropical humid forest Subtropical dry forest Subtropical steppe Subtropical desert Subtropical mountain systems Temperate oceanic forest Temperate continental forest Temperate steppe Temperate desert Temperate mountain systems Boreal coniferous forest Boreal tundra woodland Boreal mountain systems Polar
MANAGEMENT PRACTICES (more than one may be applied to any land area)	Intensive tillage/Reduced till/No-till Long term cultivated Perennial tree crop Liming High/Low/Medium Input Cropping Systems

Countries should ensure that land is not accounted for in more than one category or sub-category, in order to **avoid double-counting of land areas**.

Once land use and land-use conversion areas have been established, it is necessary **to consider the capacity and need for further stratification**.

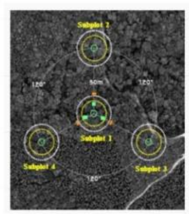
Unless all land-use area and stratification data are spatially-explicit (Approach 3)**, the development of rules for allocations to strata may be required.** (IPCC, 2006)

4. Issues to be considered in the context of REDD+

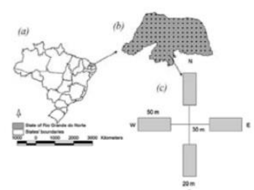
Choosing a plot configuration

The plot configuration consists of the plot size and shape and determines what to measure at each sample plot location.

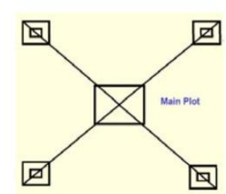
Rep. of Korea



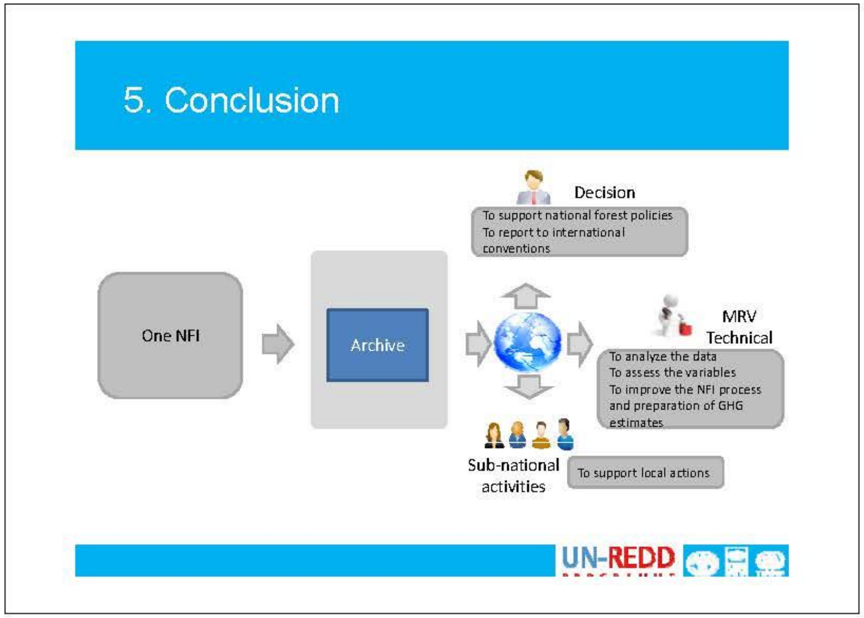
Brazil



India



References: Kim (2009), de Freitas et al (2006), Pandey (2008)


5. Conclusion
Decision
To support national forest policies
To report to international conventions
One NFI
Archive
MRV
Technical
To analyze the data
To assess the variables
To improve the NFI process and preparation of GHG estimates
Sub-national activities
To support local actions
UN-REDD

Planning for Cambodia National Forest Inventory

David C. Chojnacky, PhD
Forest Biometrician
Virginia Tech
Washington, DC USA

International Consultant:
MRV Team (FA/FAO)

Funded by: DANIDA

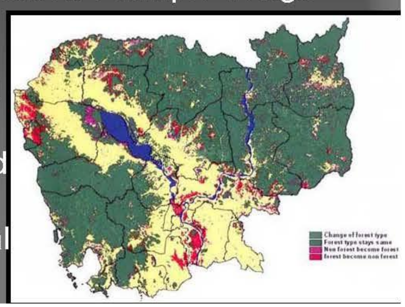
VirginiaTech
Invent the Future

My Inventory Background

- Inventory fieldwork for summer jobs during college studies in math and forestry
- PhD/ research interests: NFI design, using NFI data beyond timber—wildlife, carbon..
- U.S. NFI: 120,000 plots, 100s of variables, very *complicated* database.
- Cambodia opportunity: *simple* NFI design.

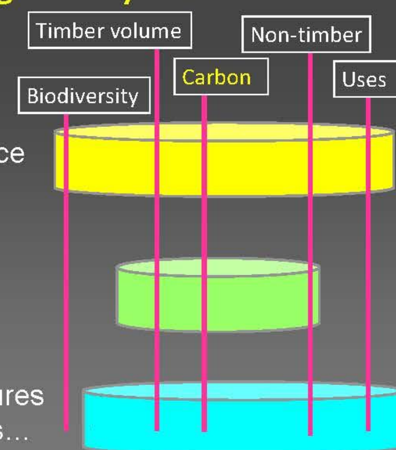
Outline

1. Thoughts on importance of NFI in UN-REDD MRV process
2. Good starting point: NFI sample design
3. Other topic: USA study on mapping forest inventory plot data…method for combining statistical & spatial data



NFI Design: Key To MRV

- All stakeholders agree on importance of NFI…
- Inventory Design Key linkage…
- Many field procedures complicate choices…

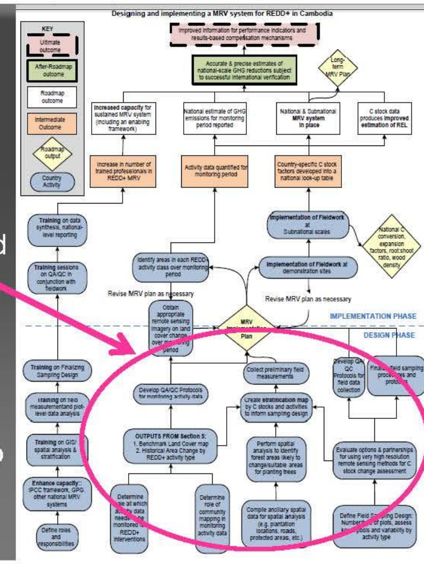


NFI More Than Carbon Inventory

- Biomass and Carbon
- Forest area/land uses
- Timber production/allowable cut
- Biodiversity
- Non-timber forest products
- Environmental services
- Environmental problems
- Use/management/local governance
- Recreation/tourism

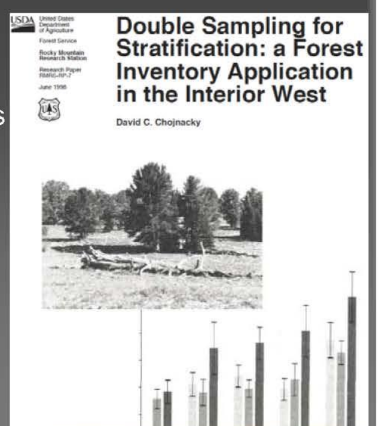
"ROADMAP": MRV System

- Inventory protocol compartmentalized into 13 boxes
- Although 13 important steps…
- No overall sampling design to guide connection of boxes



Suggested Sample Design..

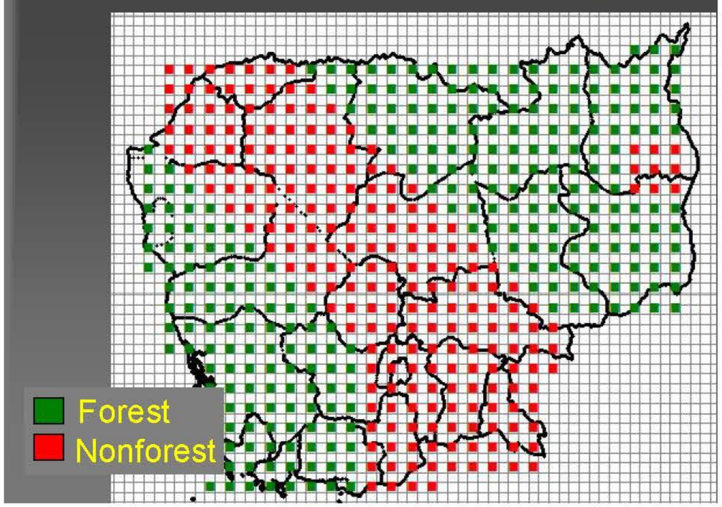
- 2 phases: remote sensing & field plots
- Neyman (1938); 1950s aerial photos/forestry
- Chojnacky, USA NFI
- Phase 1: consistent nonforest and forest classes
- Phase 2: field plots subsample phase 1


USDA United States Department of Agriculture
Forest Service
Rocky Mountain Research Station

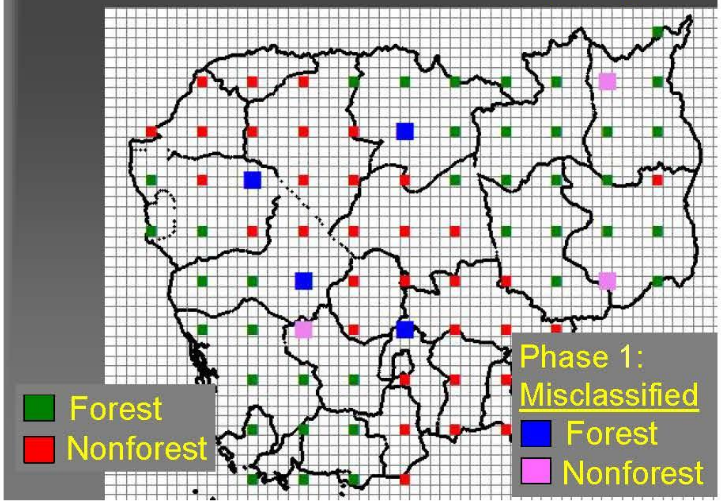
Double Sampling for Stratification: a Forest Inventory Application in the Interior West

David C. Chojnacky

Phase 1: Remote Sensing

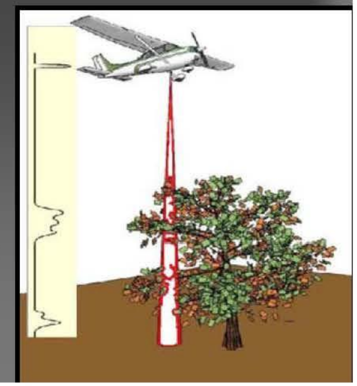


Phase 2: Field Plot Sampling



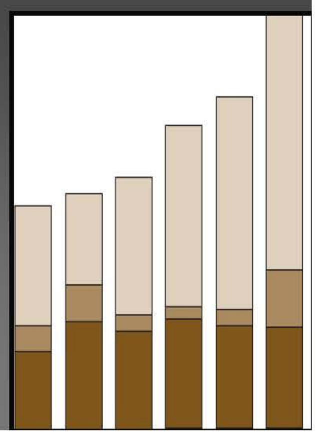
Too Reduce Number Field Plots …add LIDAR Phase

- Phase 1: Remote Sensing
- Phase 2: LIDAR …subsample phase 1
- Phase 3: Field Plots …subsample phase 2 LIDAR



Monitoring

- Permanently established field plots
- Re-measure about every 5 year
- Perhaps remote sensing imagery and/or LIDAR could update inventory between cycles
- Annual re-measurement of some plots each year not recommended; analysis too complex

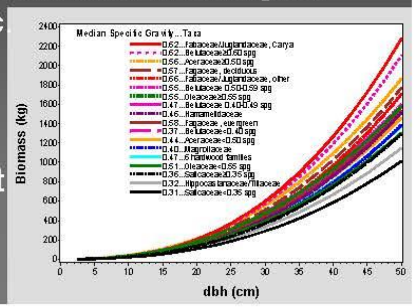


Field Plot Design

- Much info from FA and NGOs on plot design …use it!
- Sensitivity analysis to consider reduced plot size, if data readily available.
- Plot size large enough to sample "pixel" in design
- Measure live/dead standing/down material & multi-purpose variables

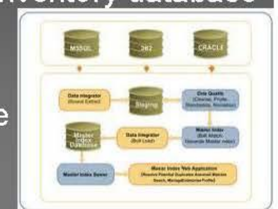
Ancillary or Additional Data

- Cannot directly measure everything…models & equations needed
- Biomass equations very important equations
- Also, volume equations, site & ecological classifications, etc.
- Very important to carefully evaluate all ancillary data; difficult to account for prediction errors



Data Analysis/Management/Reporting

- Inventory design determines analysis if good initial design
- However, tree- and plot-level data, stratification and shear volume of measurements complicate inventory database structure
- Alternative is online data delivery developed by single entity
- Determine specific reports



Budget

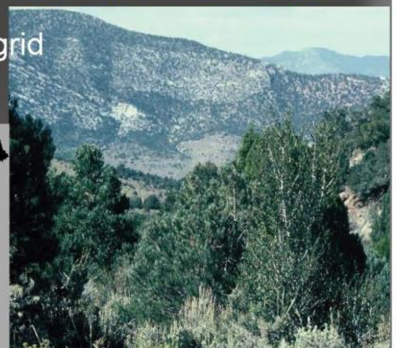
- Cost is limiting factor on number of field plots that can be sampled
- Cost per plot is a good planning tool
- Will cost per plot average $100 or $500 or $1000 or more?
- In the U.S., NFI plots cost $1000 to $4000 depending upon travel access.

Summary On NFI Planning

- Essential to choose overall sample design… propose "double sampling for stratification"
- Cost/plot and sample size to plan sample/budget
- Don't over-focus on plot design…use FA/ NGO experience & keep it simple!
- Ancillary biomass equations important; assemble/develop
- Focus on carbon for planning; identify multi-products soon
- Analysis follows good-design
- Consider online data delivery
- Determine reports needed

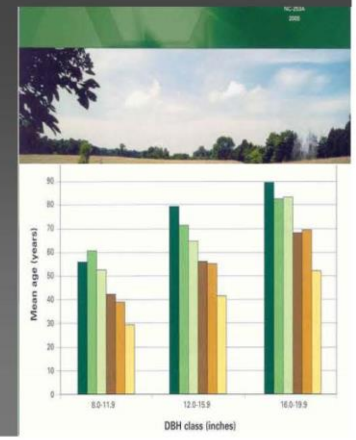
Linking Field Plot Data to Maps

- 14,000 plots, 5 km grid
- 1,600 forested



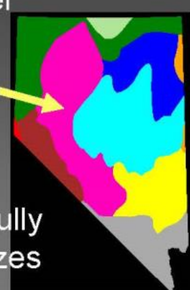
Double-Sampling for Stratification (DSS) Good for Statistical Summary

- DSS can produce charts and tables of biomass/carbon, tree size distribution, volume by species, etc.
- But can DSS be extended produce to spatial statistics for mapping?

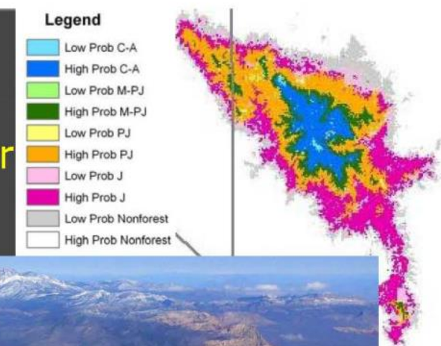


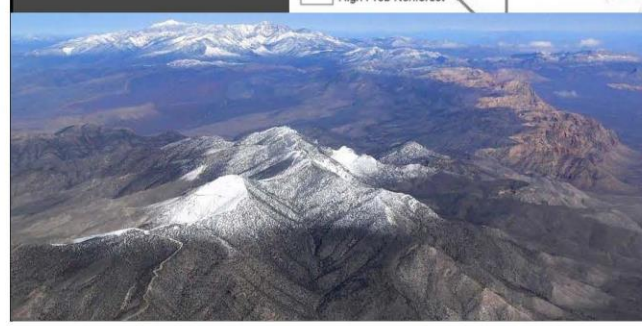
Need to Devise Spatial Variables from Inventory/Ancillary GIS data

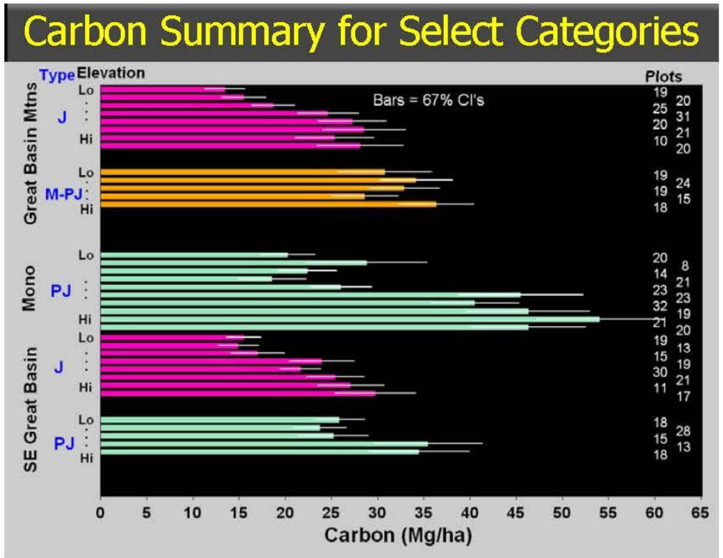
- Cover map was devised from remote sensing/field data model
- Elevation
- Ecoregion (10 sections for NV)
- Land ownership
- Process is a post stratification: Spatial variables must be carefully selected to sufficient sample sizes (or number plots)

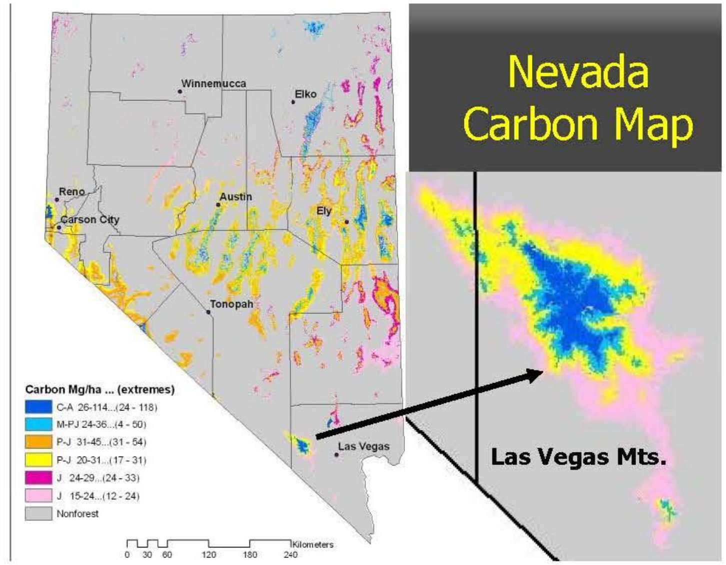


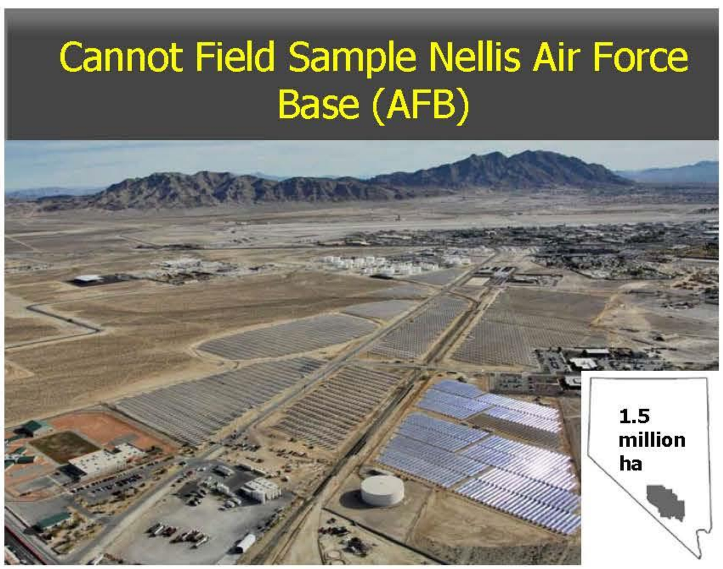
Cover Model Estimates for Mountains near Las Vegas...





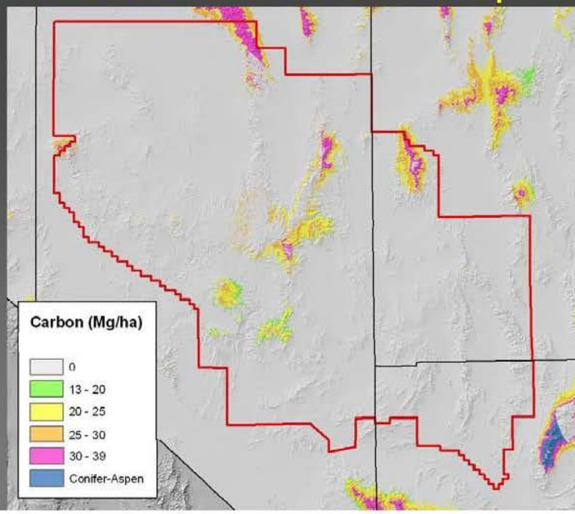

Carbon Summary for Select Categories
Type
Elevation
Plots
Bars = 67% CI's
Great Basin Mtns
Mono
SE Great Basin
J
M-PJ
PJ
Lo
Hi
Carbon (Mg/ha)


Nevada Carbon Map
Carbon Mg/ha ... (extremes)
C-A 26-114...(24 - 118)
M-PJ 24-36...(4 - 50)
P-J 31-45...(31 - 54)
P-J 20-31...(17 - 31)
J 24-29...(24 - 33)
J 15-24...(12 - 24)
Nonforest
Kilometers
Las Vegas Mts.


Cannot Field Sample Nellis Air Force Base (AFB)
1.5 million ha


No Mines! ...But other Hazardous: Bombing Range, Training Maneuvers, etc.

Nellis AFB Forest Carbon Extrapolated



Planning for Cambodia National Forest Inventory

David C. Chojnacky
(dchojnac@vt.edu)

Virginia Tech
Department of Forest Resources and Environmental Conservation
Blacksburg, VA, U.S.A.

Presented at:

Training Workshop on "GHG Inventory Preparation for Forestry"
MRV Team, Cambodia UN-REDD National Programme
Siem Reap Province, Cambodia
5-8 November 2012

presenting…
Wednesday, 7 November 2012
9:45-10:15 (30 min)

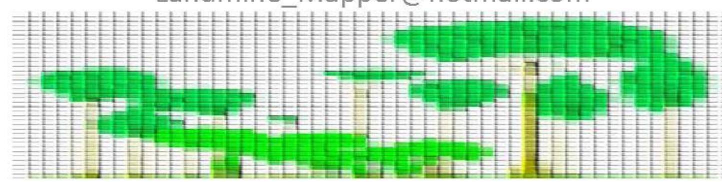
Remote Sensing for Assessing Forest Resources & Changes

Ian Thomas
Landmine_Mapper@hotmail.com

Welcome to the world of pixels!

Remote Sensing for Assessing Forest Resources & Changes

Ian Thomas
Landmine_Mapper@hotmail.com



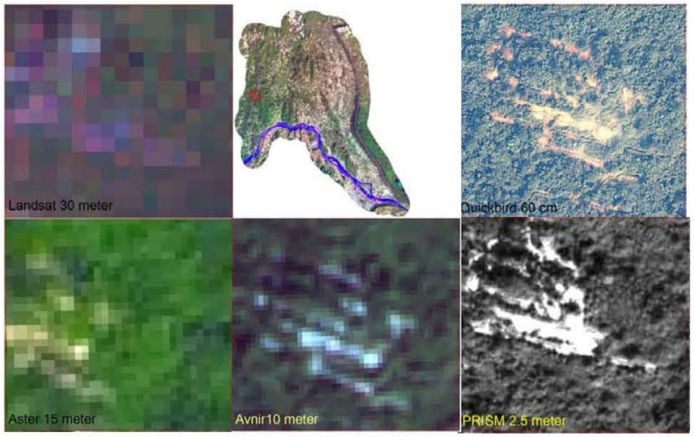
Why Do We Need Remote Sensing?

HYDROPOWER
Landmine & UXO Clearance
Border Mapping
National Defense
Forestry
POPULATION CENSUS
FLOOD RESPONSE
Urban & Landuse Planning
Etc…etc…

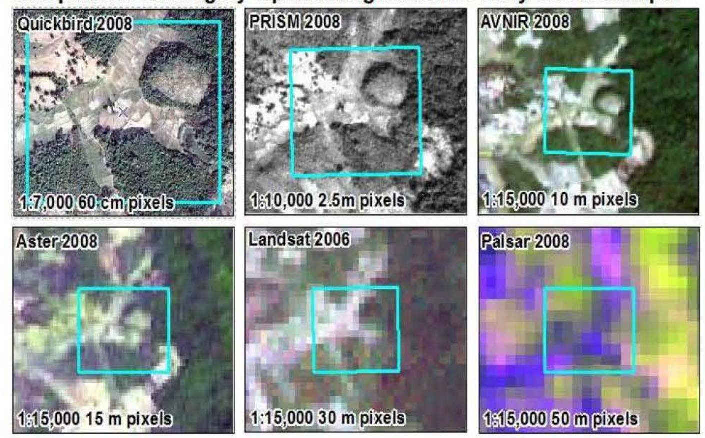
What are the factors to think about when choosing satellite imagery for Cambodia?

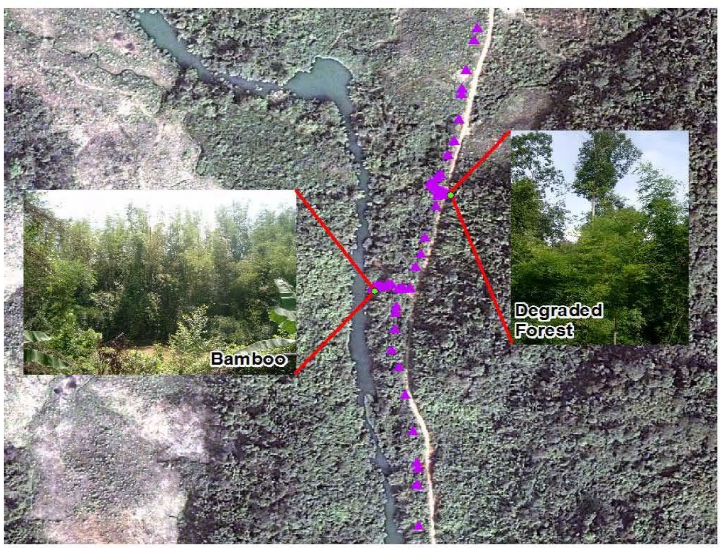
Scene Footprint Size
$ Pricing
Lidar?
Radar?
UAV/Aerial?
RESOLUTION
License Restrictions
Timing, Clouds & Seasons
SPECTRAL COLOUR

So What Resolution Imagery Do We Need?

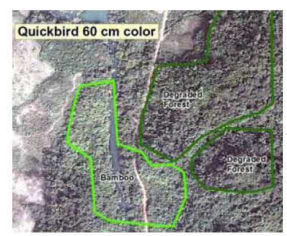


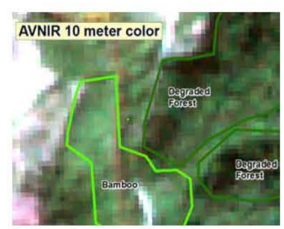
Comparison of Imagery Options: Agriculture Paddy Field Example

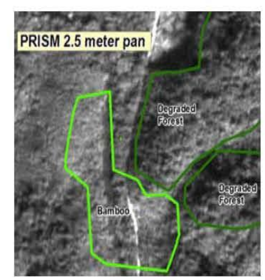




Comparison of Satellite Imagery

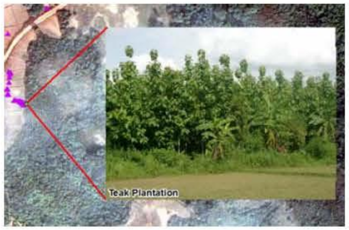




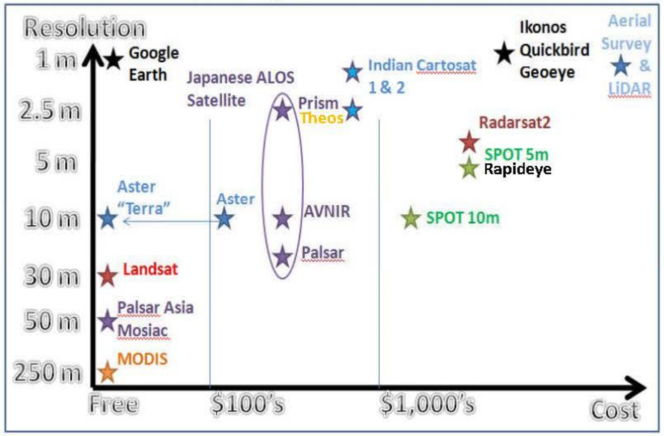


High Resolution Imagery sometimes required to detect forest plantation

and sometime requires manual interpretation



Satellite Imagery Options "Cost vs. Resolution"



Satellite Imagery Options "Cost vs. Resolution"

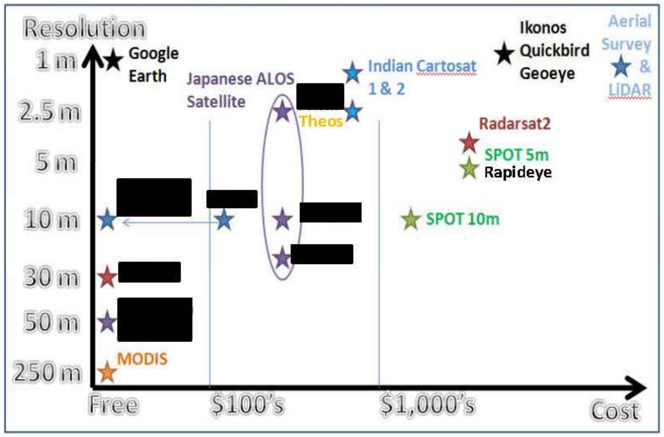
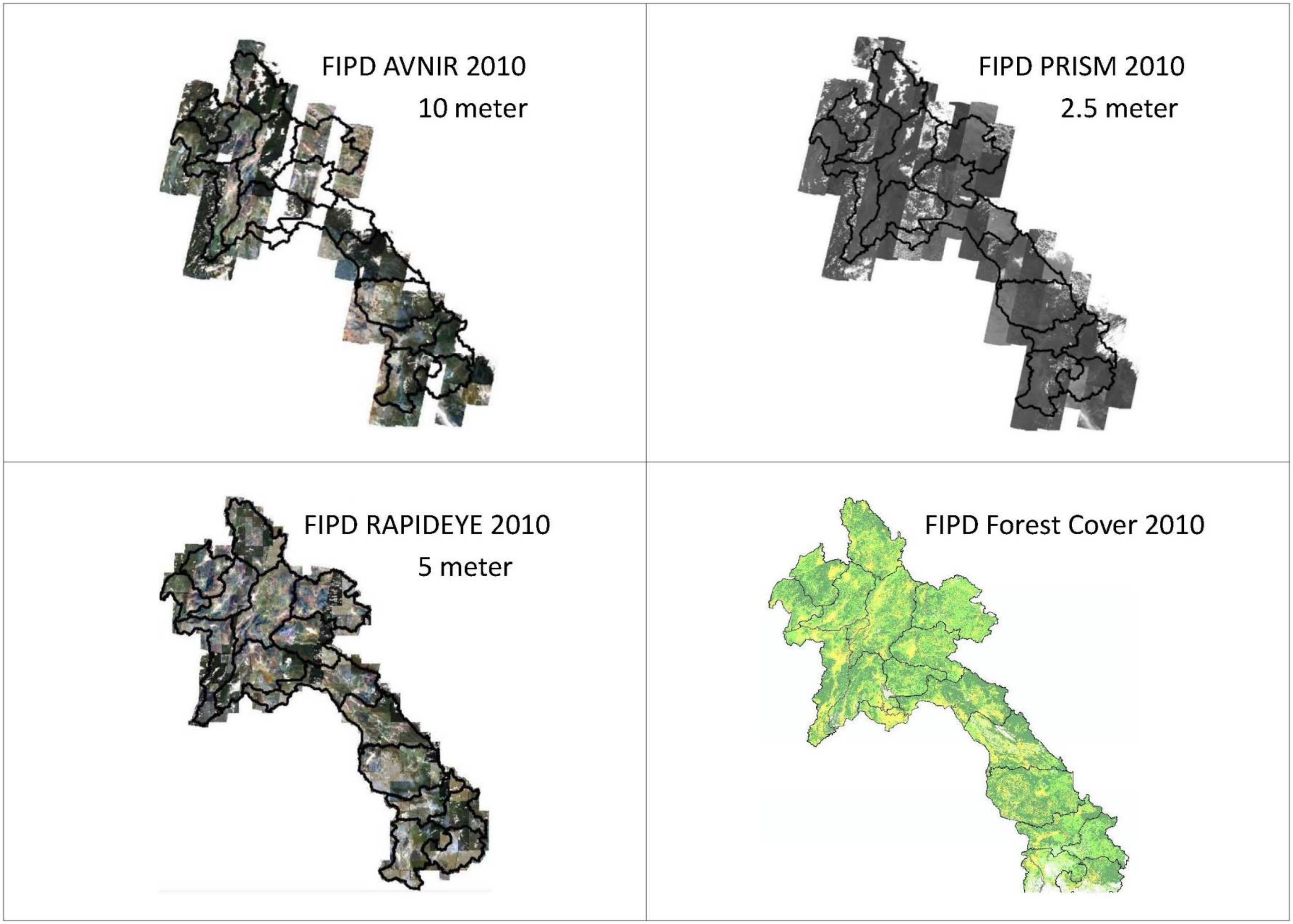
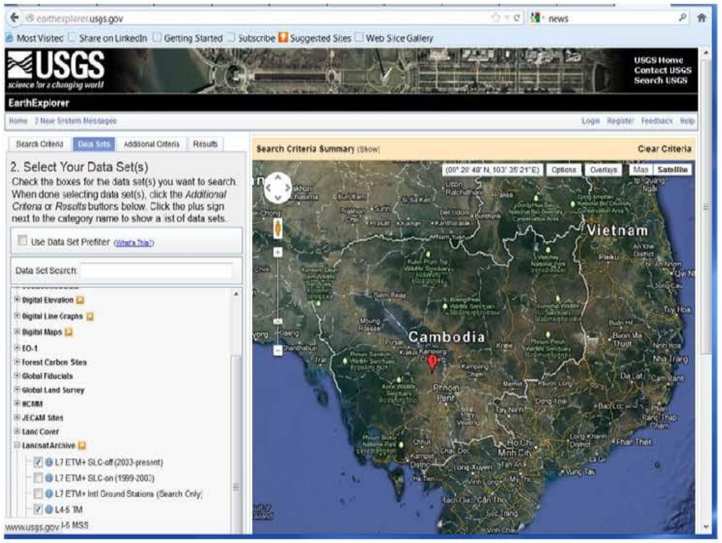


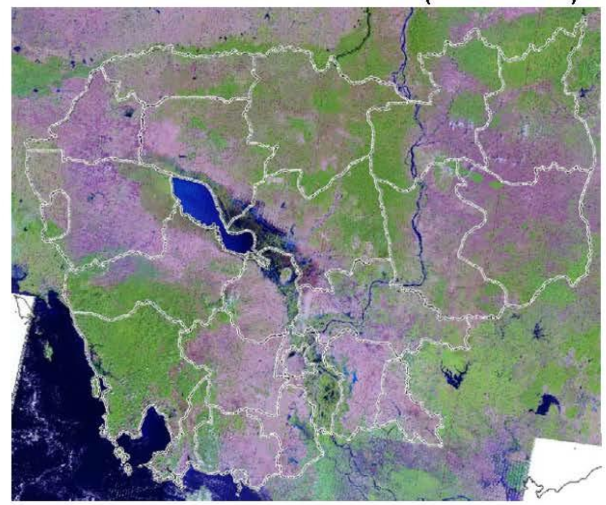
Table 2.1.2. Present availability of optical mid-resolution (10-60 m) sensors.

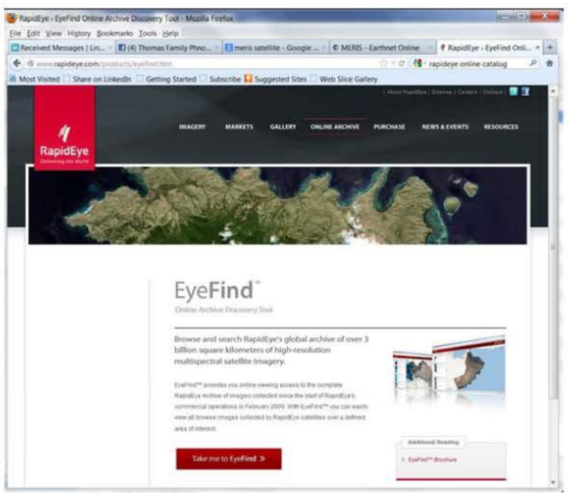
Nation	Satellite & sensor	Resolution & coverage	Cost for data acquisition (archive[17])	Feature
USA	Landsat-5 TM	30 m 180×180 km^2	All data archived at USGS are free	Images every 16 days to any satellite receiving station. Operating beyond expected lifetime.
USA	Landsat-7 ETM+	30 m 60×180 km^2	All data archived at USGS are free	On April 2003 the failure of the scan line corrector resulted in data gaps outside of the central portion of images, seriously compromising data quality
USA/ Japan	Terra ASTER	15 m 60×60 km^2	60 US$/scene 0.02 US$/km^2	Data is acquired on request and is not routinely collected for all areas
India	IRS-P2 LISS-III & AWIFS	23.5 & 56 m		After an experimental phase, AWIFS images can be acquired on a routine basis.
China/ Brazil	CBERS-2 HRCCD	20 m	Free in Brazil and potentially for other developing countries	Experimental; Brazil uses on-demand images to bolster their coverage.
Algeria/ China/ Nigeria/ Turkey/ UK	DMC	32 m 160×660 km^2	3000 €/scene 0.03 €/km^2	Commercial; Brazil uses alongside Landsat data
France	SPOT-5 HRVIR	10-20 m 60×60 km^2	2000 €/scene 0.5 €/km^2	Commercial Indonesia & Thailand used alongside Landsat data


FIPD AVNIR 2010
10 meter
FIPD PRISM 2010
2.5 meter
FIPD RAPIDEYE 2010
5 meter
FIPD Forest Cover 2010



Latest Landsat National Mosaic (2010-2012)

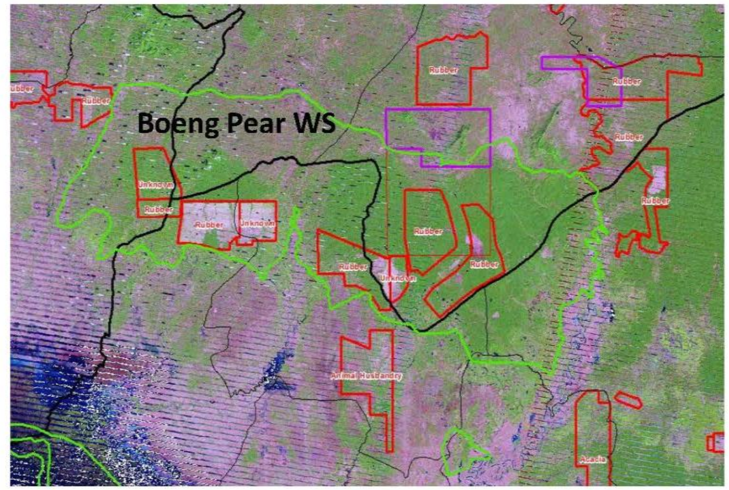




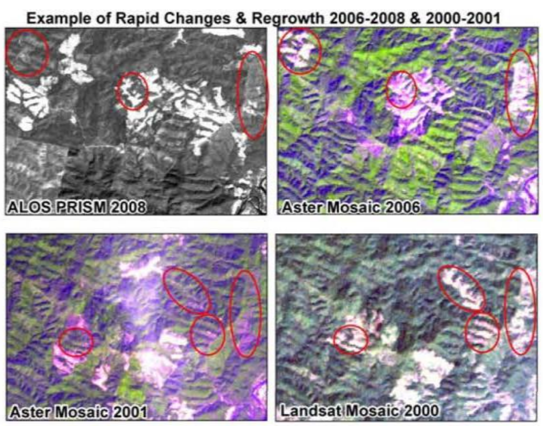
2011 Rapideye

2012 Landsat7

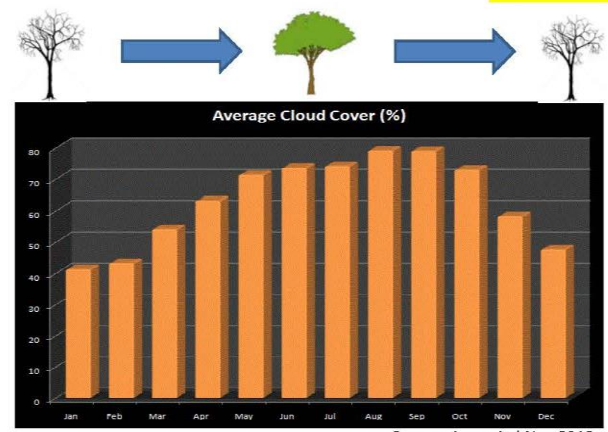
Very good way to monitor concessions



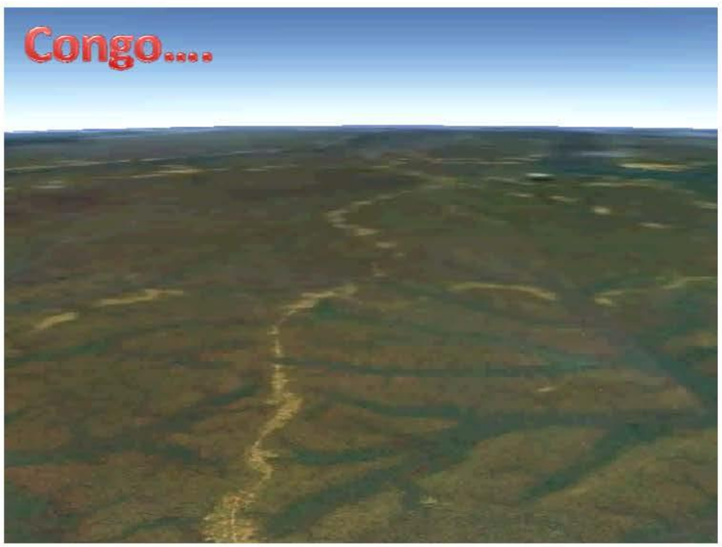
Re-growth back is very fast…very rapid changes. Only two years to three years after clear cutting disturbance, rapid re-growth of vegetation causes the disturbance to become quite hard to detect on medium resolution imagery (Aster 15 m, AVNIR 10m).



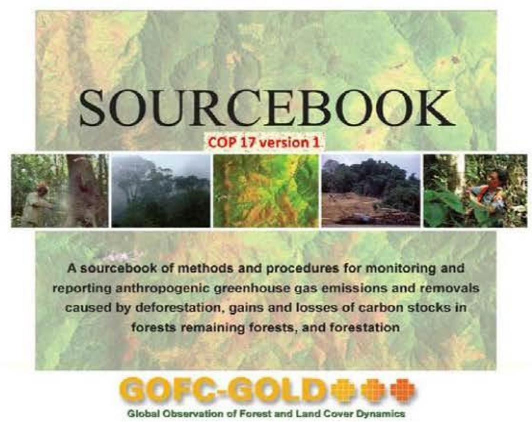
Clouds are quite a problem… Radar!

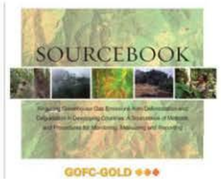


Source: Aruna Ltd Nov 2012



What to do? Which methods to use?
http://www.gofcgold.wur.nl/redd/index.php

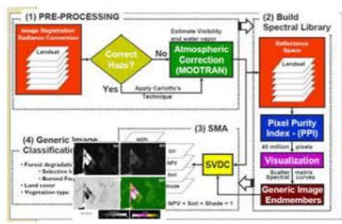


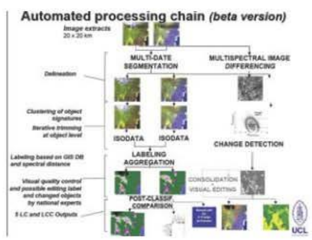


For Forest Mapping the GOFC-GOLD Source Book use to recommend two clear choices for remote sensing methods:

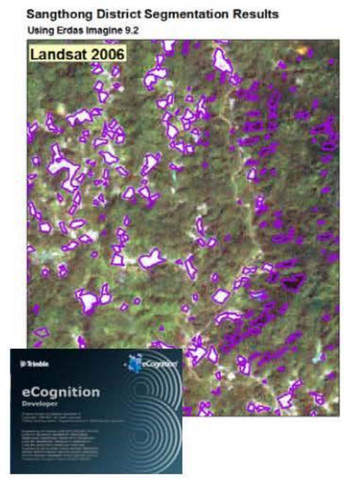
1. Sub-pixel Analysis

2. Multi-date Image Segmentation

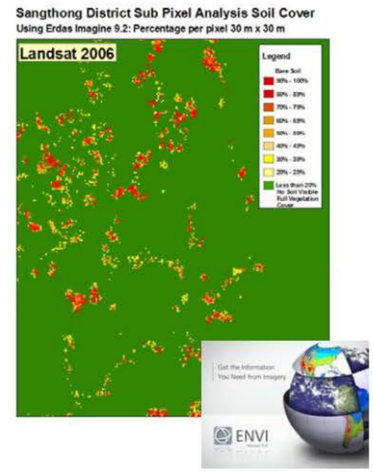




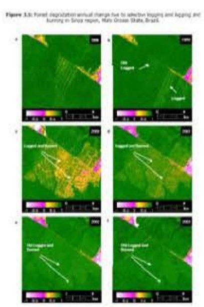
Segmentation



Sub-Pixel Analysis



Sub-pixel Analysis (NDFI)

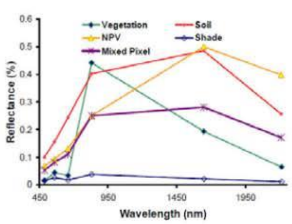


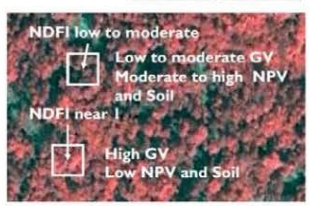
Normalized Difference Fraction Index

$$NDFI = \frac{GV_{Shade} - (NPV + Soil)}{GV_{Shade} + NPV + Soil}$$

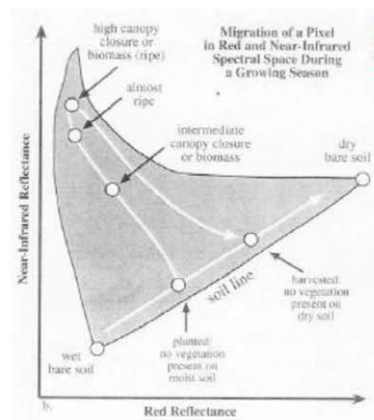
$$GV_{Shade} = \frac{GV}{100 - Shade} \qquad -1 \leq NDFI \leq 1$$

Landsat Spectral Signatures



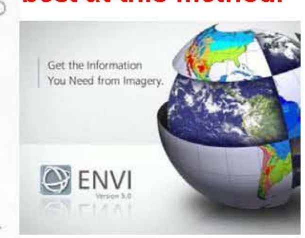


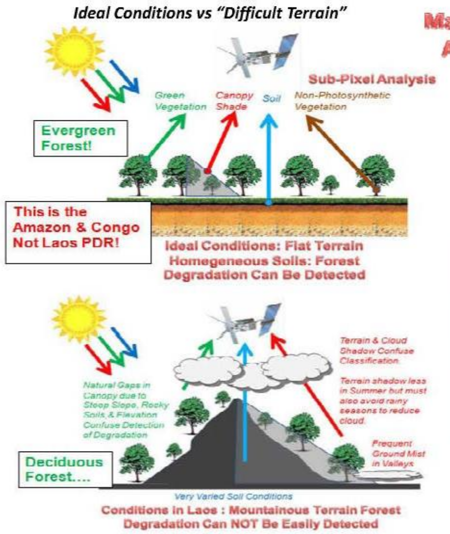
Sub-pixel Analysis (NDFI)



Not easy to find the "Endpoints"

ENVI software was the best at this method.





Maybe OK to use Sub-Pixel Analysis in flat areas of Cambodia

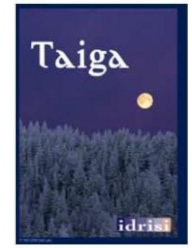
Canopy shadow can be very variable between images depending on time of year and day and haze

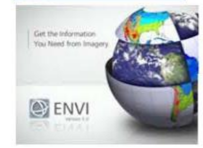
Which software to use?

ArcGIS ESRI

PCI Geomatics

erdas an Intergraph brand



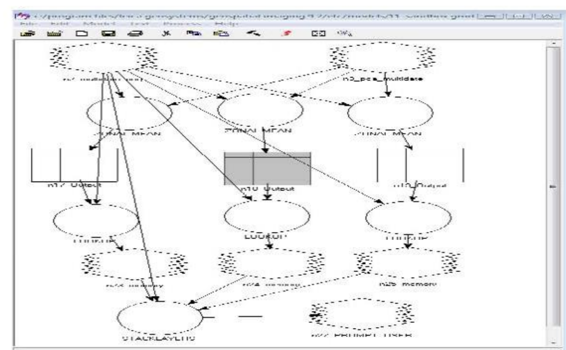


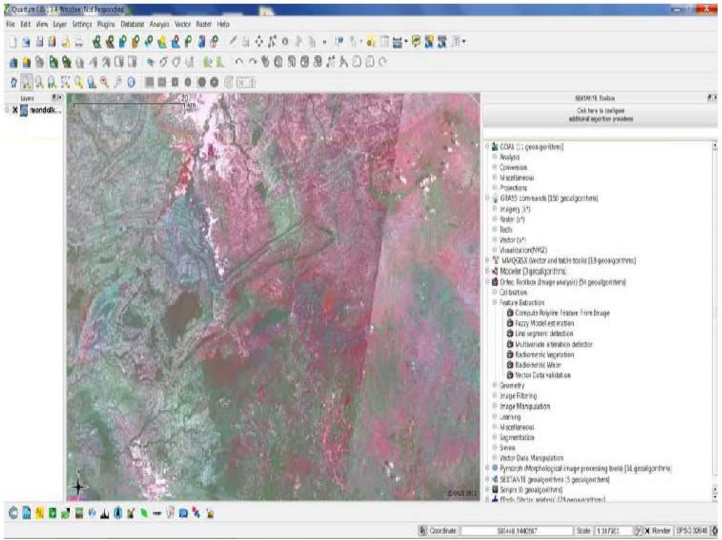
Or Open Source?

Criteria to evaluate the Remote Sensing Software

- **Must be flexible.**
- **Must be fully compatible with GIS.**
- **Must be able to automate the processing.**
- **Must be able to implement the GOLD-GOFC sourcebook methods.**

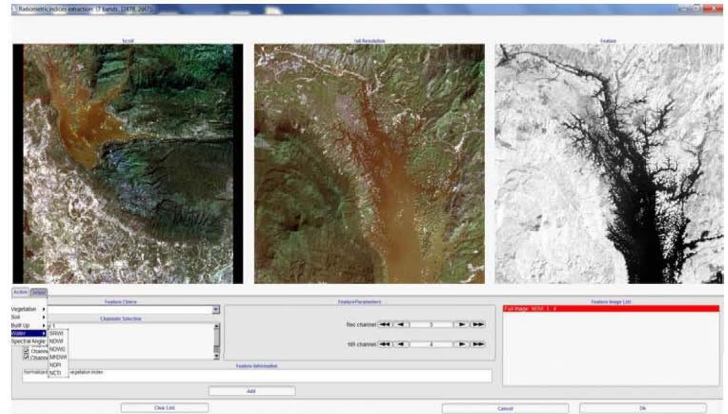
Erdas has a very powerful Visual Modeler Programming Interface.





Sometimes Now Open Source is the Best!

Monteverdi Index Browser



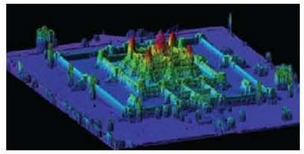
Status of Evolving Technologies from the GOFC-GOLD Sourcebook:

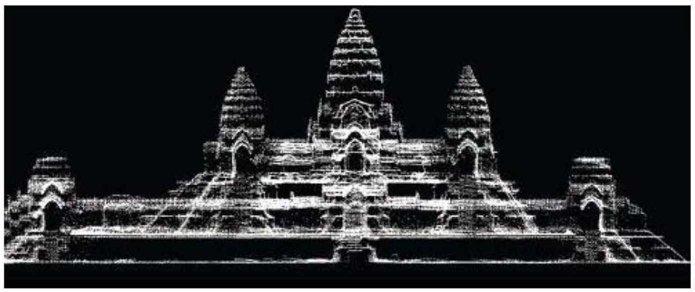
"Optical mid-resolution data have been the primary tool for deforestation monitoring. Other, newer, types of sensors, e.g. **Radar** (ERS1/2 SAR, JERS-1, ENVISAT-ASAR and ALOS PALSAR) and **Lidar**, are potentially useful and appropriate. Radar, in particular, alleviates the substantial limitations of optical data in persistently cloudy parts of the tropics.

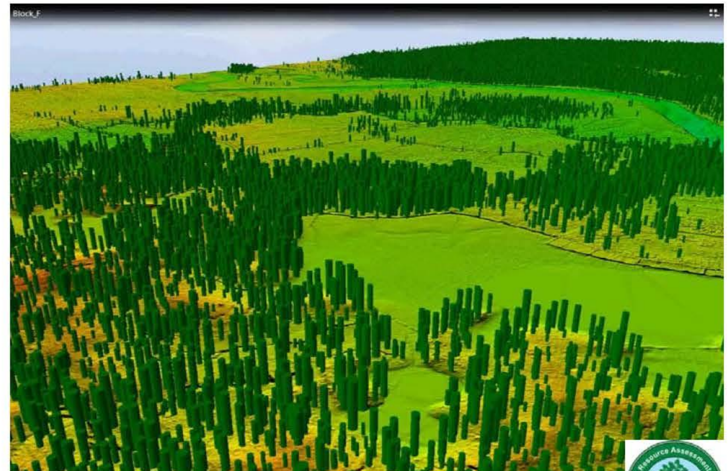
Data from **Lidar** and **Radar** have been demonstrated to be useful in project studies, but so far, they are not widely used operationally for forest monitoring over large areas. Over the next five years or so, the utility of radar may be enhanced depending on data acquisition, access and scientific developments."

The Lost Art of The Stereoscope

Greater Angkor Wat Area Lidar



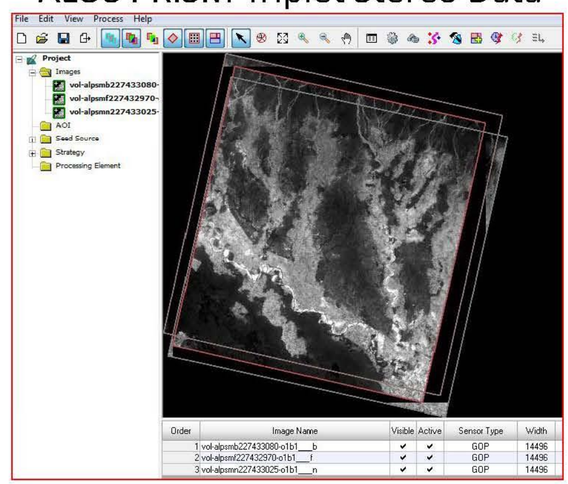




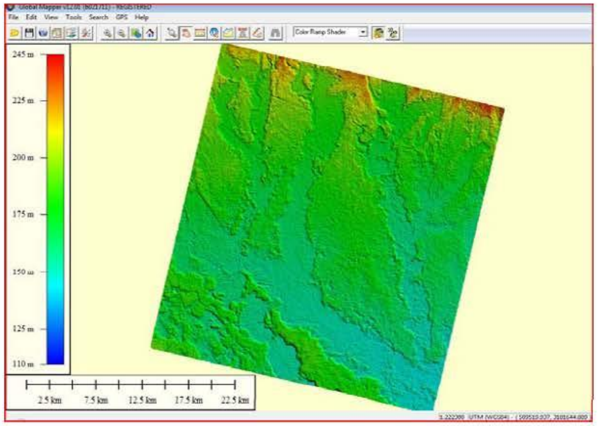
Nepal LiDAR Analysis

Forest Resources Assessment Nepal
Using SAR Radar Polarimetry & Stereo Analysis
for Forest Biomass Estimation

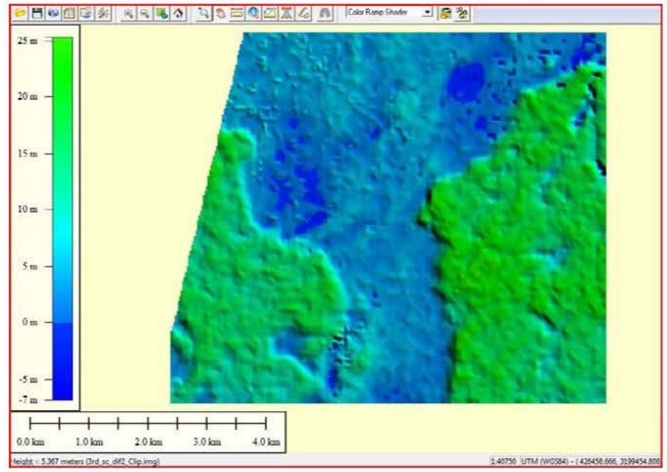
ALOS PRISM Triplet Stereo Data



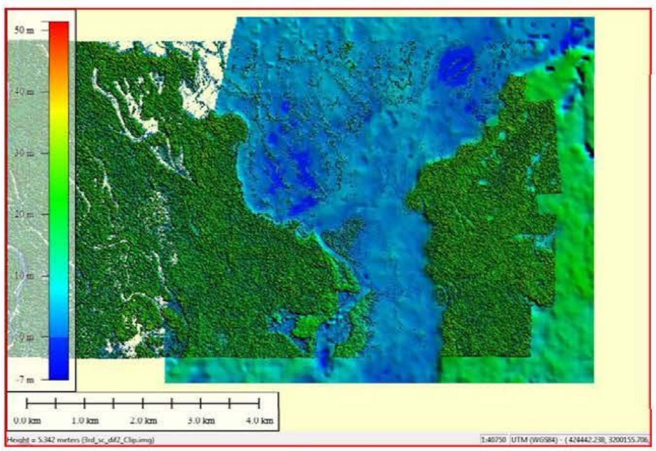
DSM Extraction from ALOS PRISM

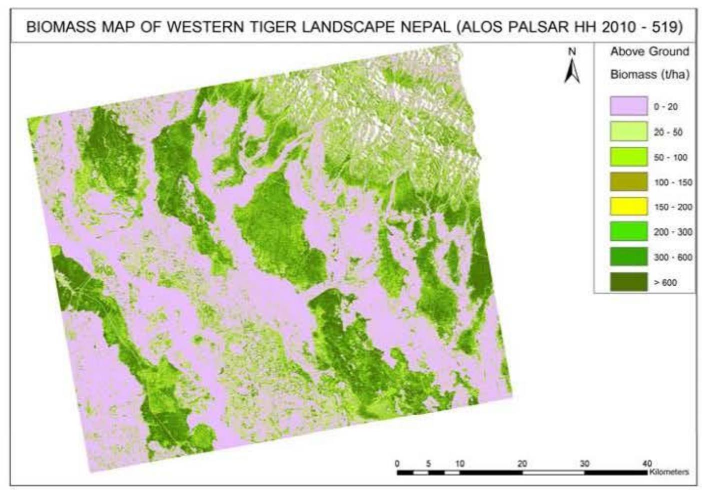


Tree Height Derived from PRISM DSM and Survey Dept. DEM



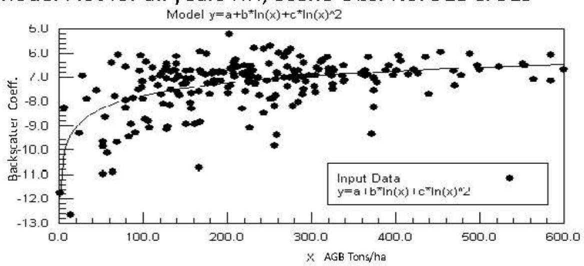
Tree Height from LiDAR overlay with height from PRISM





The problem of "Saturation"

Model Plot for all years HH, Scene Obs. No. 518 & 519



(R^2) = 0.296
No. of Obs = 212

Regression Variable Results

Variable	Value	Standard Error	t-ratio	Prob(t)
a	-11.9048081672687	0.809288869021644	-14.71020871	0.0
b	1.02908210496182	0.348841837462818	2.949996229	0.00354
c	-2.83E-02	3.91492536245297E-02	-0.724112339	0.46981

Estimation of Above Ground Forest Biomass in a Tiger Habitat of the Western Nepal Using ALOS Data and Field Inventory

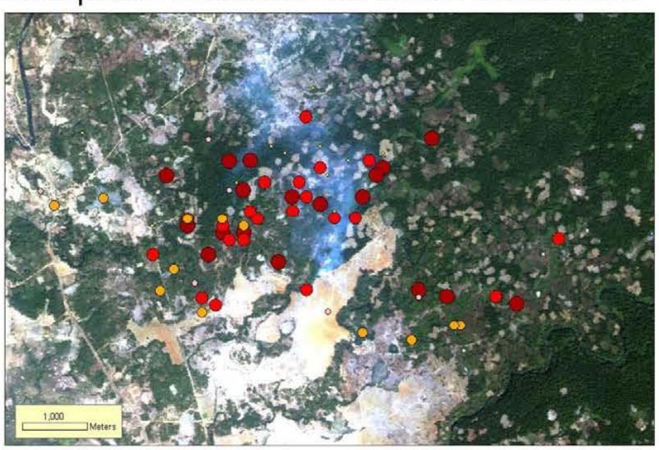
Conclusions:

L-Band PALSAR data can be used to develop biomass models.
The best-fit model for HH is:
AGB = -17.875 + 0.738 * ln (Backscatt. Coeff.) + 0.027 * ln (Backscatt. Coeff.)^2,

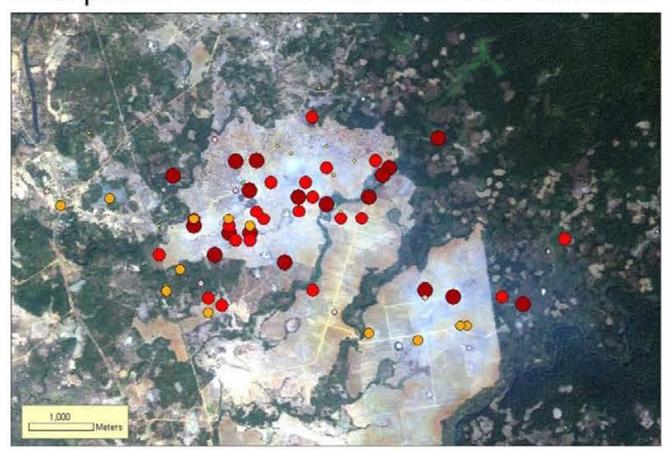
The best-fit model for HV is:
HV is AGB = -11.905 + 1.029 * ln (Backscatt. Coeff.) - 0.028 * ln (Backscatt. Coeff.)^2.

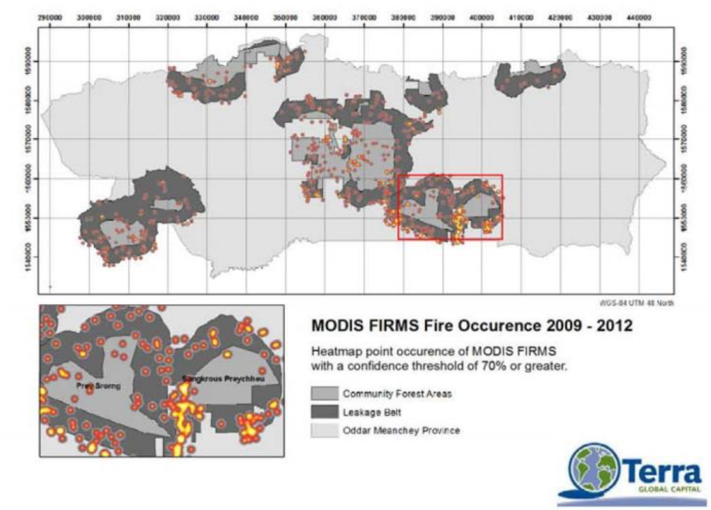
The biomass model successfully derived a biomass map.
Like any other similar research, use of L Band also has a constraint in terms of biomass saturation (around 100-150t/ha).

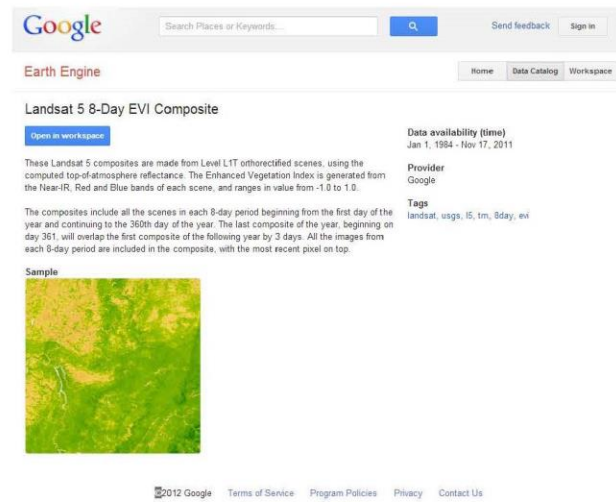
Champasak AVNIR 2007 with Modis Fire Data 2008



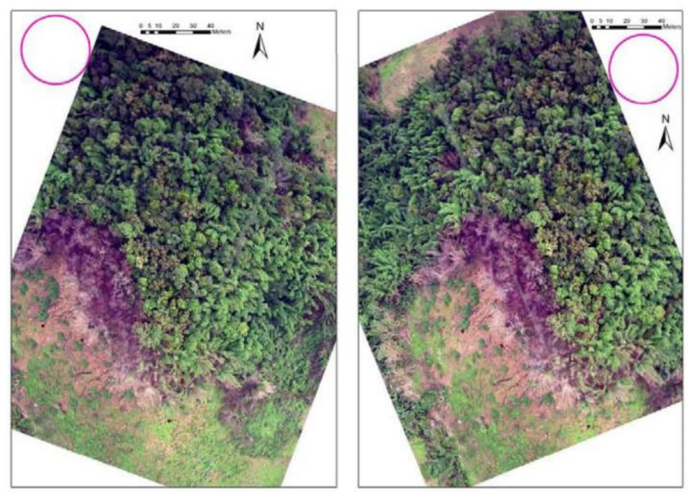
Champasak AVNIR 2008 with Modis Fire Data 2008



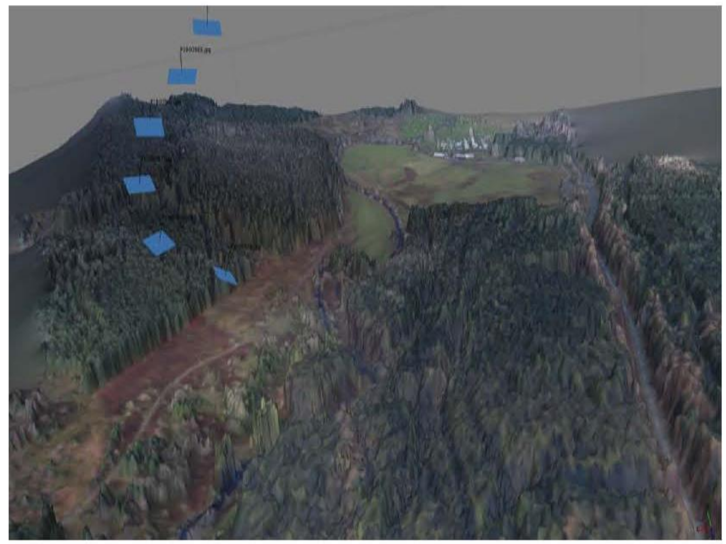

MODIS FIRMS Fire Occurence 2009 - 2012
Heatmap point occurence of MODIS FIRMS
with a confidence threshold of 70% or greater.
Community Forest Areas
Leakage Belt
Oddar Meanchey Province
WGS-84 UTM 48 North
Terra
GLOBAL CAPITAL


Google
Search Places or Keywords...
Send feedback
Sign in
Earth Engine
Home
Data Catalog
Workspace
Landsat 5 8-Day EVI Composite
Open in workspace
These Landsat 5 composites are made from Level L1T orthorectified scenes, using the computed top-of-atmosphere reflectance. The Enhanced Vegetation Index is generated from the Near-IR, Red and Blue bands of each scene, and ranges in value from -1.0 to 1.0.
The composites include all the scenes in each 8-day period beginning from the first day of the year and continuing to the 360th day of the year. The last composite of the year, beginning on day 361, will overlap the first composite of the following year by 3 days. All the images from each 8-day period are included in the composite, with the most recent pixel on top.
Data availability (time)
Jan 1, 1984 - Nov 17, 2011
Provider
Google
Tags
landsat, usgs, l5, tm, 8day, evi
Sample
©2012 Google
Terms of Service
Program Policies
Privacy
Contact Us


UAVs! Unmanned Aerial Vehicles

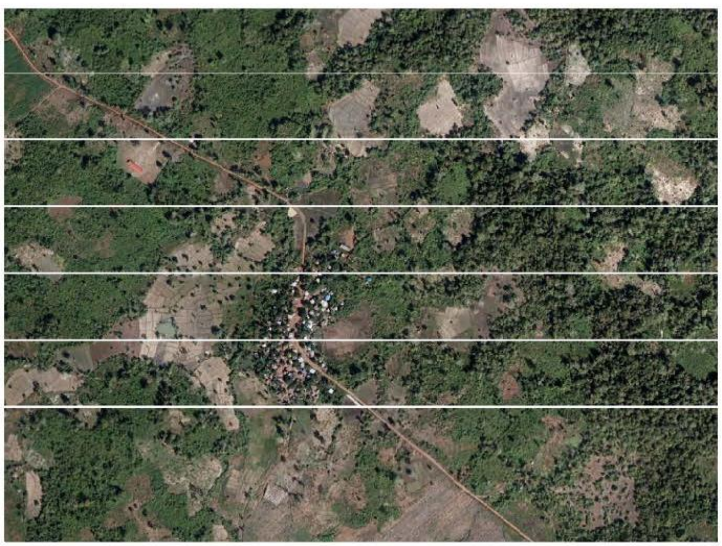

N
Meters
N

Five Square Kilometers in One Hour!




Digital Elevation of A1/A192 Junction near Morpeth


Low Resolution 3D Model of Chevington Crossing 21 July 2011
© Nigel King 2011 Blue River Studios



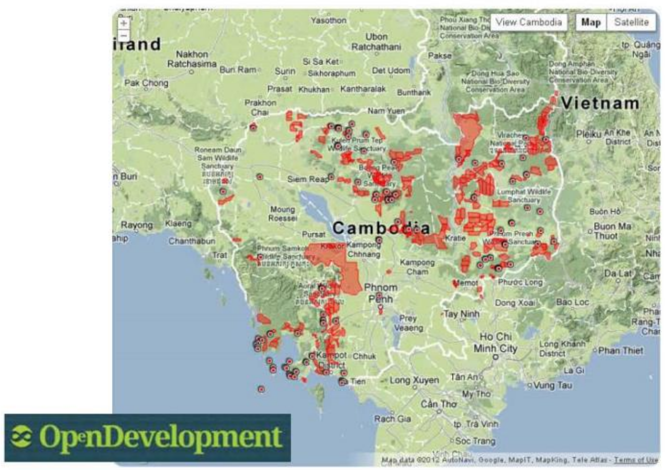
Sharing Data with Communities

Communities reviewed 2008 and 2012 satellite maps and provided valuable feedback on the situation on the ground.

2008

2012

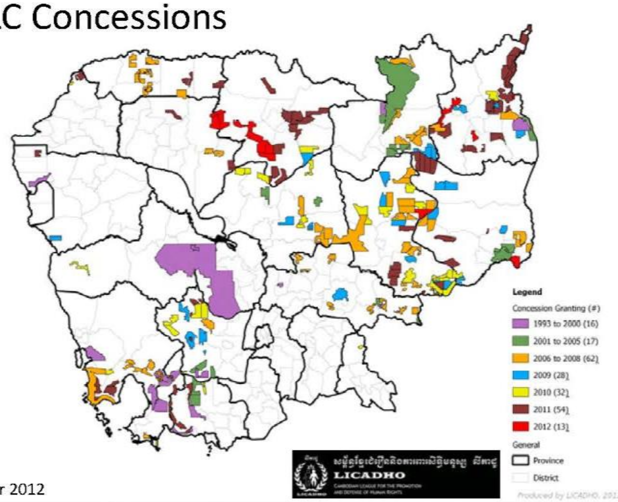
Economic Land Concessions



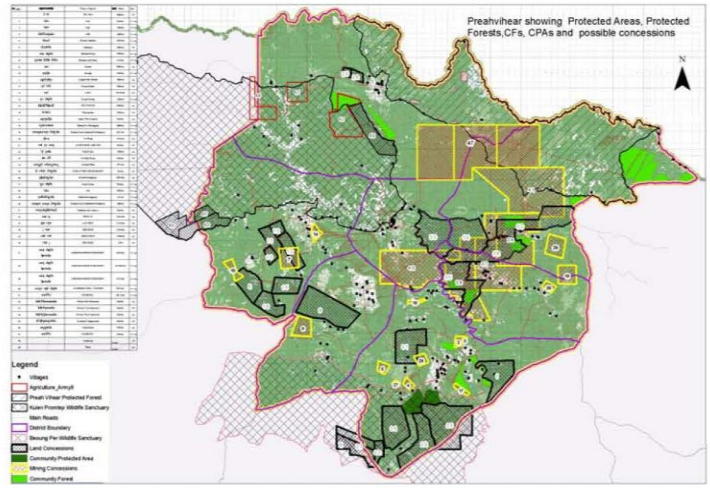
New Map Classifications

Government data partial ELCs :123 concessions

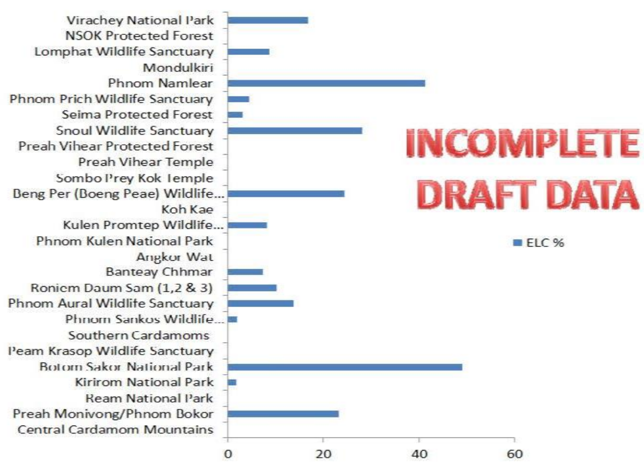
ELC Concessions



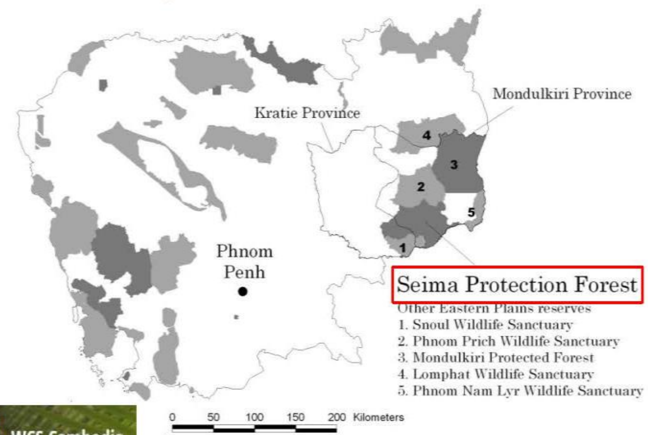
September 2012



Percentage of Economic Land Concession (ELC) in Protected Areas, Cambodia.



Seima has been the site of a joint program between the Forestry Administration and WCS since 2001



WCS Cambodia

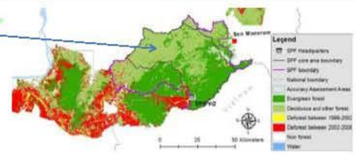
Seima Protection Forest, Cambodia

WCS Cambodia

Cambodia's second REDD demonstration site and the first in a conservation area

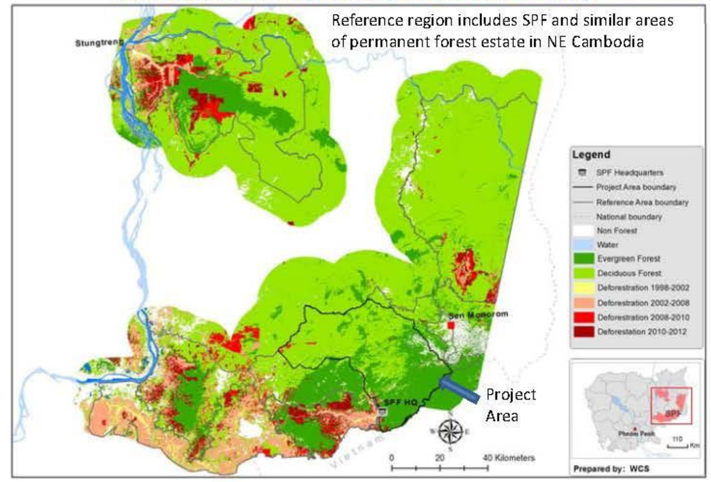
- → The site was formerly production forest
- → Seima Protection Forest created Aug. 2009
- → Carbon sequestration is one of stated goals
- → c.293,000 ha site
- →REDD within c.187,000 ha Core Area

→ Approx 300,000 t CO_2 per year of emissions reductions expected

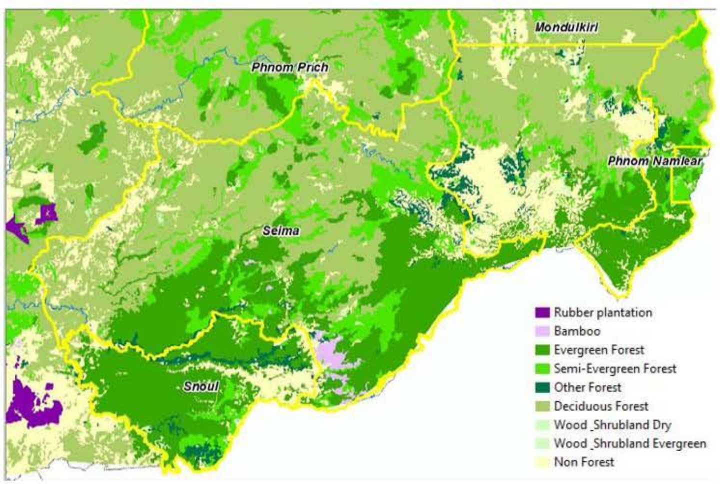


Deforestation in REDD Project Areas (1998-2002-2008-2010-2012)

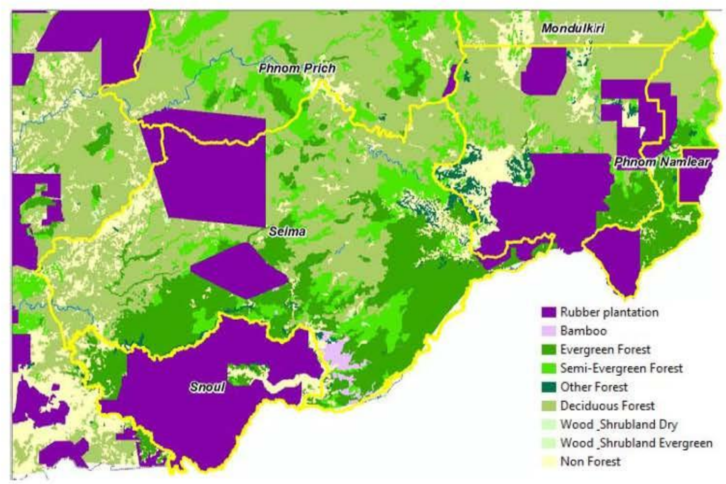
WCS Cambodia



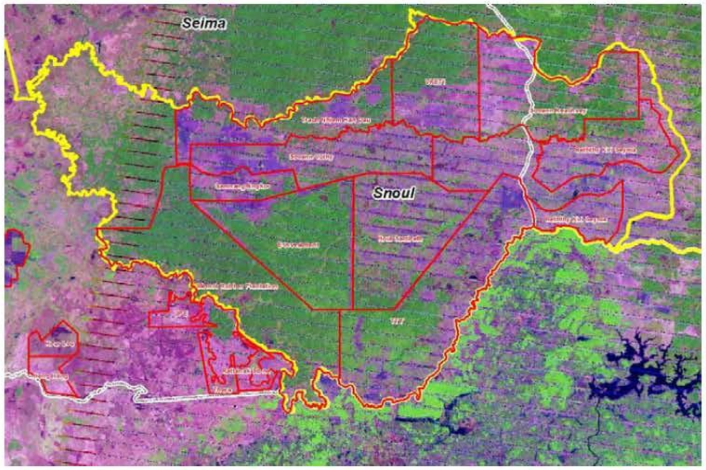
WCS Seima Area Forest Cover 2010



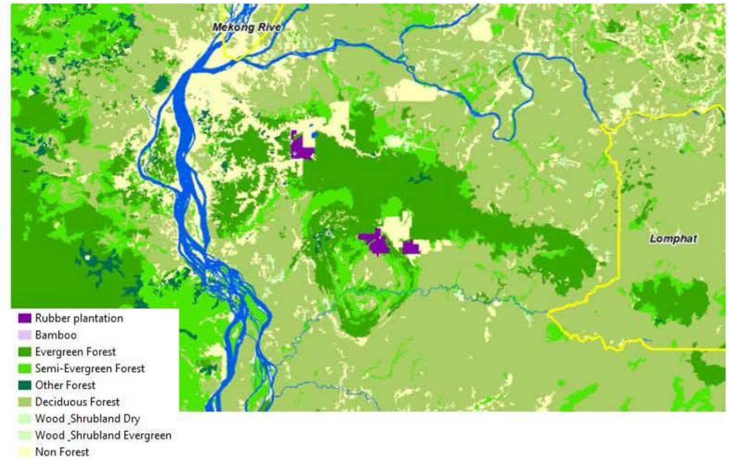
WCS Seima Area Forest Cover 2015?



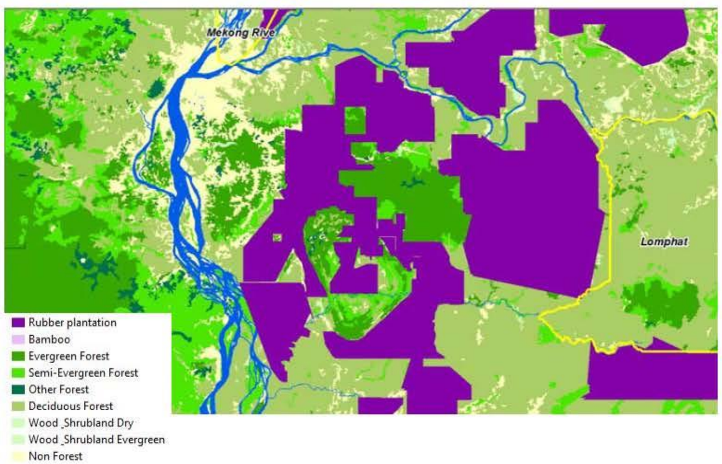
Snoul Protected Forest Area



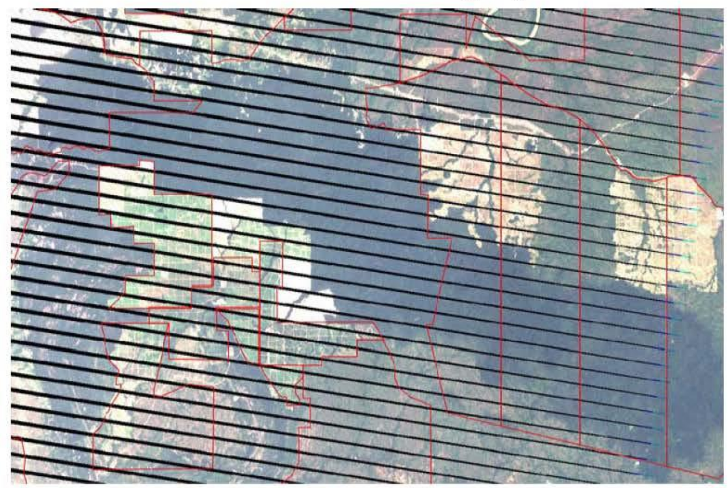
WCS Reference Area Forest Cover 2010

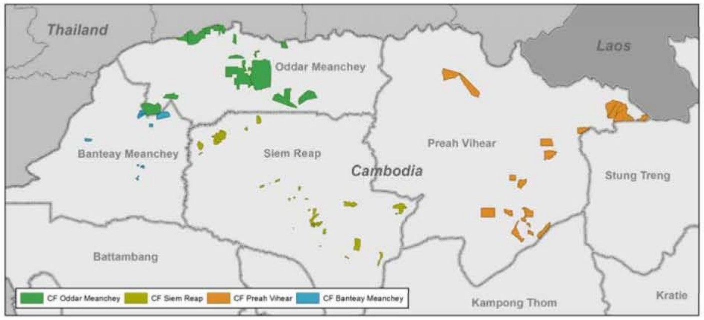


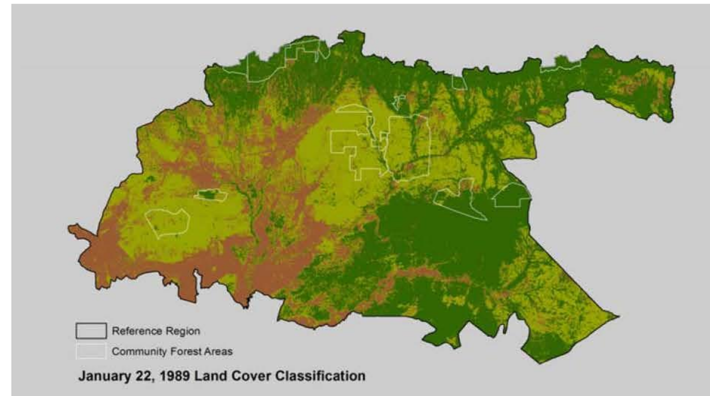
WCS Reference Area Forest Cover 2015?



Latest Landsat Imagery

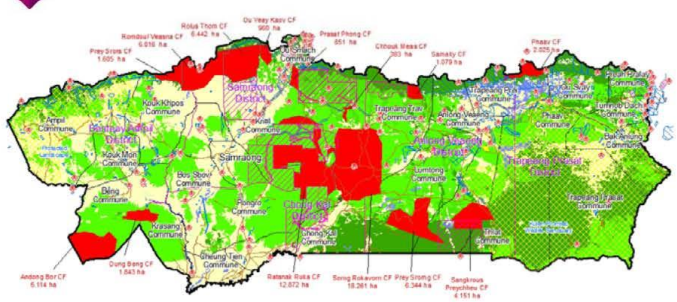


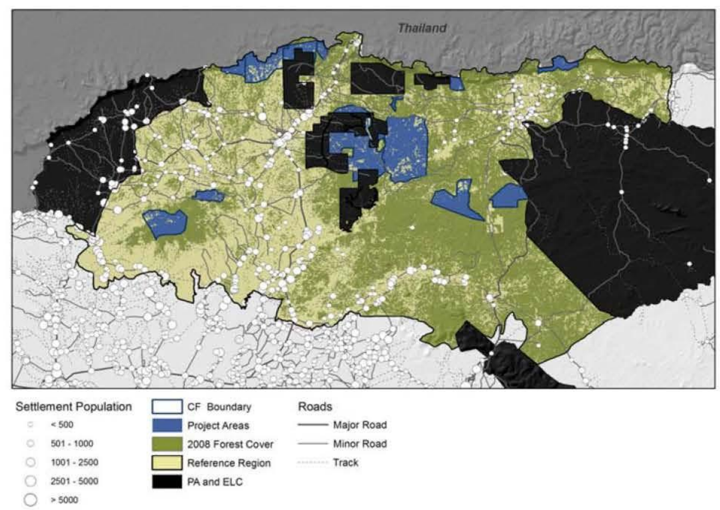


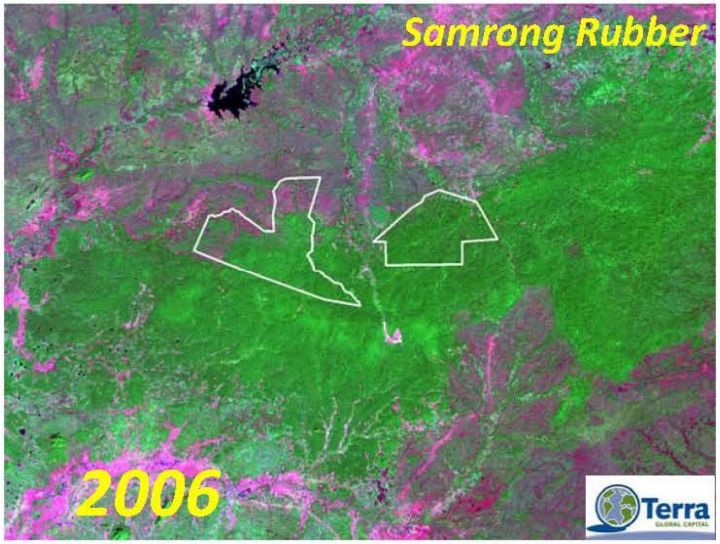


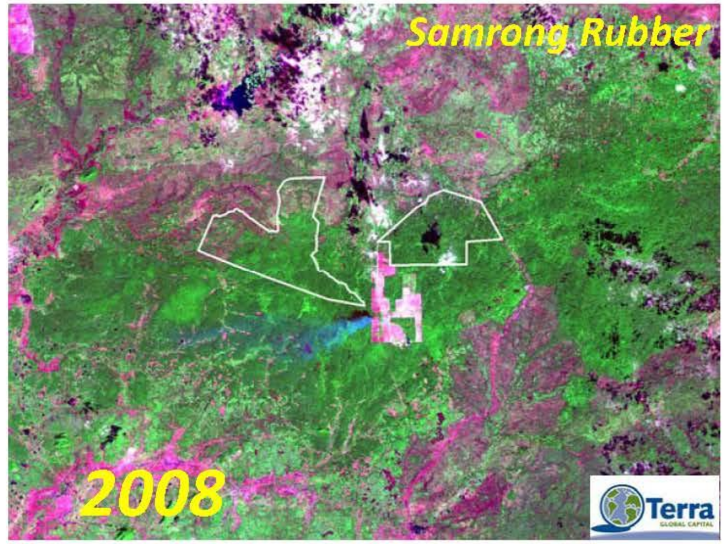
Terra
GLOBAL CAPITAL

pact
building
local
promise.






Samrong Rubber
2006
Terra


Samrong Rubber
2008
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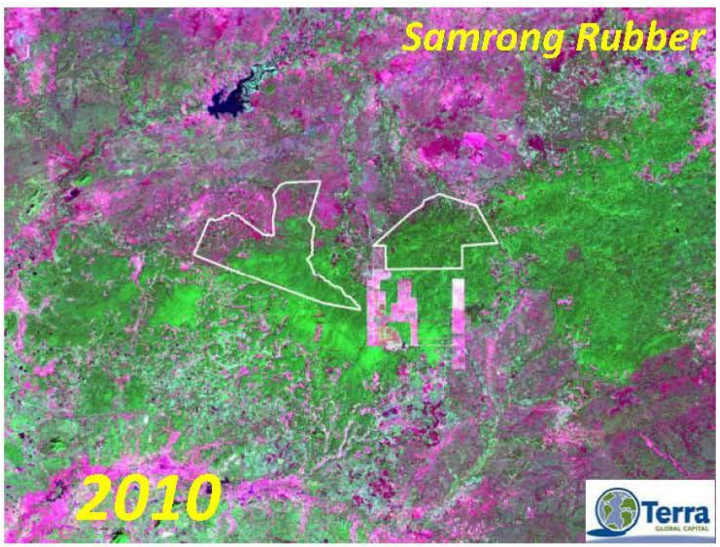
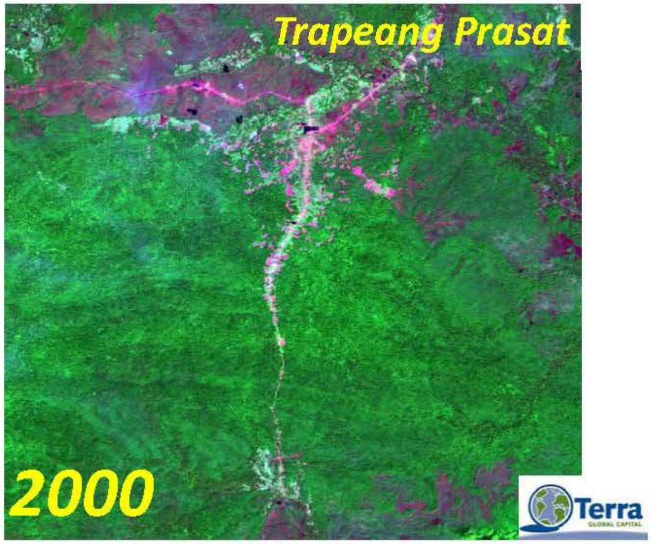
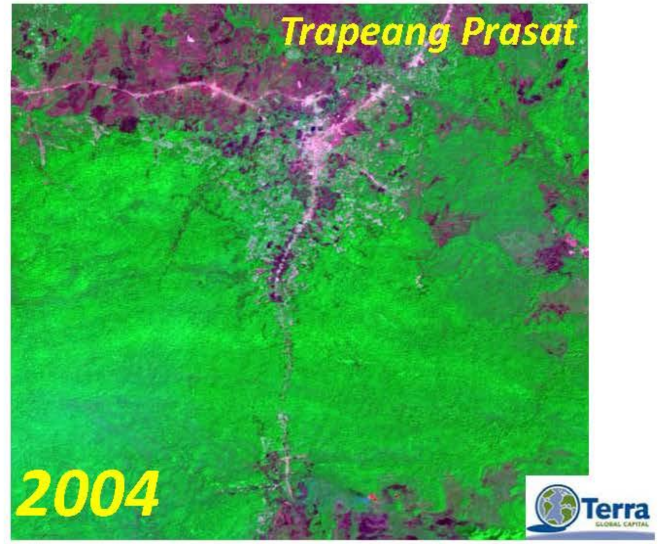

Samrong Rubber
2010
Terra


Trapeang Prasat
1990
Terra


Trapeang Prasat
2000
Terra


Trapeang Prasat
2004
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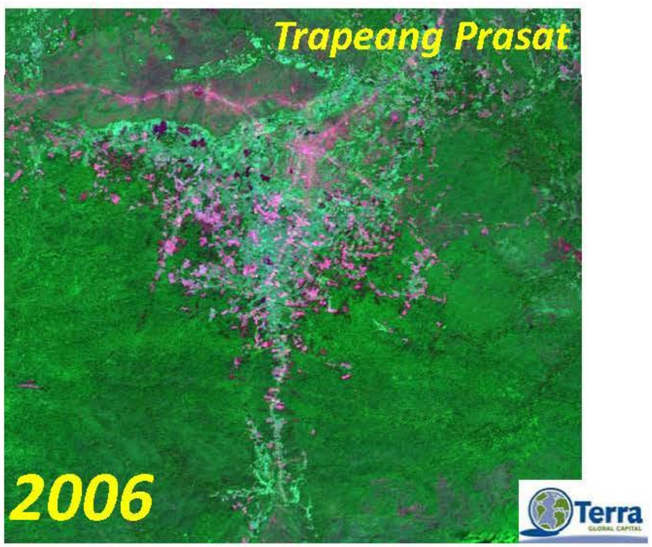
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2006
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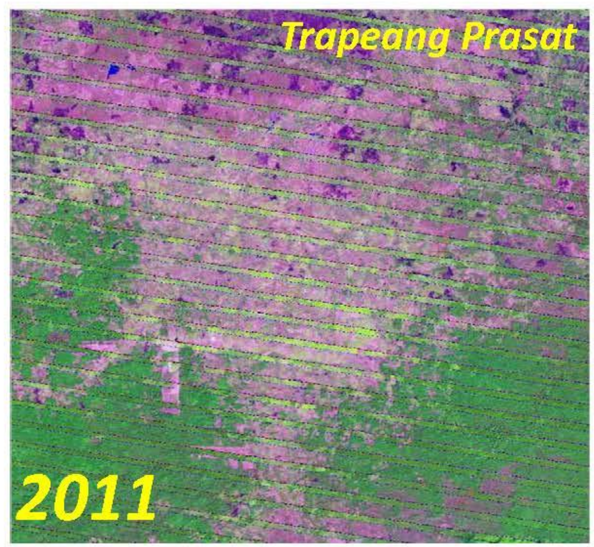
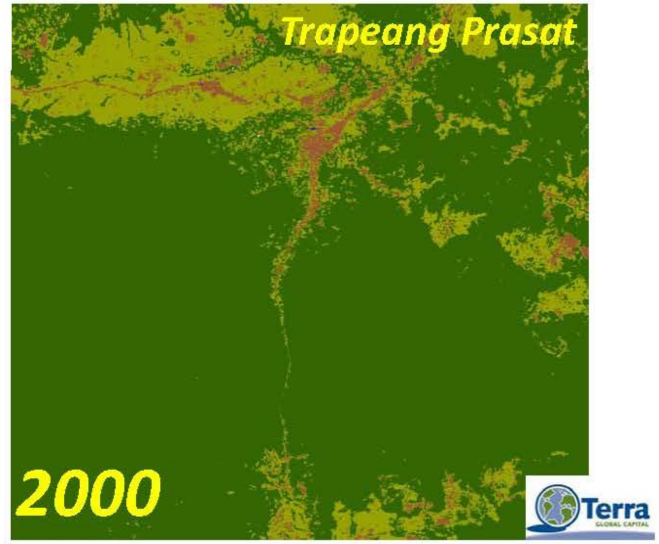

Trapeang Prasat
2011


Trapeang Prasat
1990
Terra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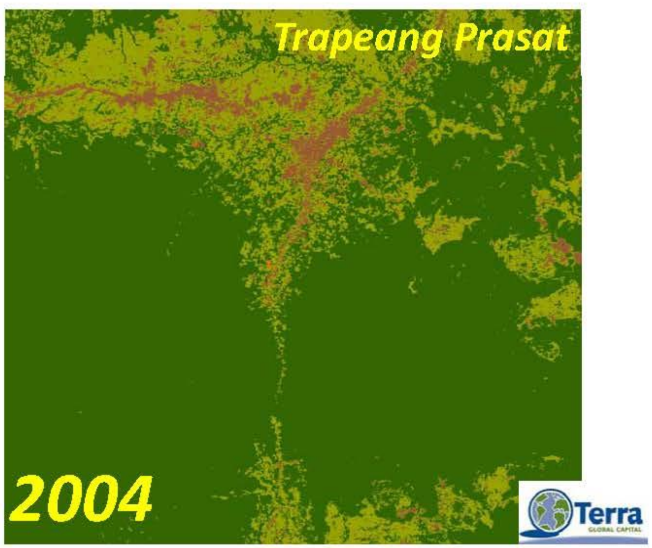
2000
Terra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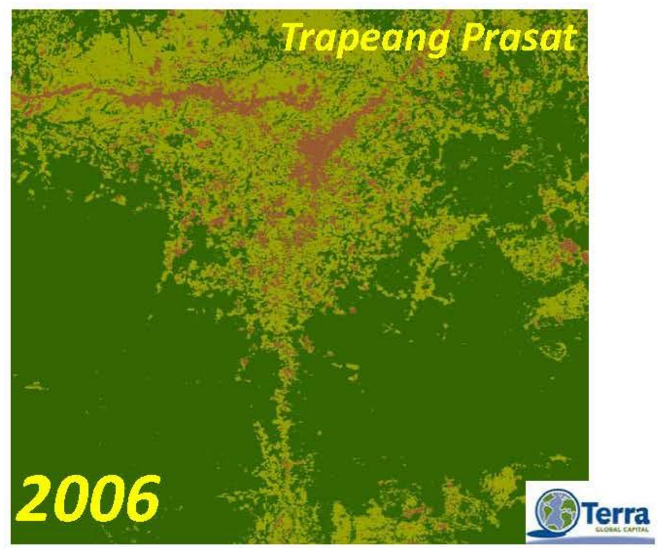
2004
Terra


Trapeang Prasat
2006
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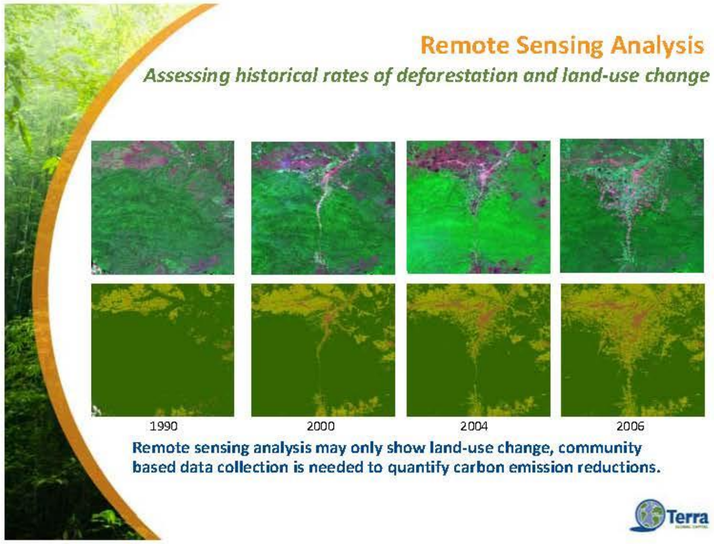
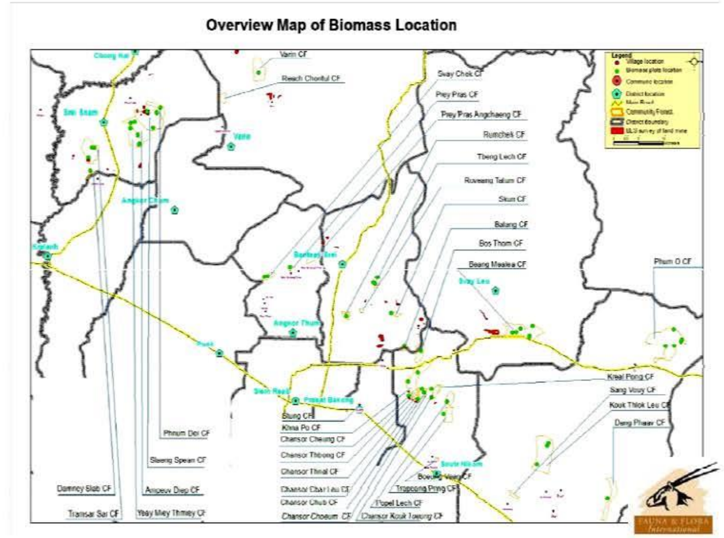




SR CF REDD+ at a quick glance:

- Project site area: 15,649 Hectares.
- Number of CFs: 34
- Biomass Inventory plots completed: 50
- HHS completed: 136
- PRAs completed: 34
- CF members: 19,000 (Approximate)
- Possible applicable standards: VCS, CCB & Plan Vivo.

1

TOWARD FOREST COVER DATA PREPARATION FOR ESTABLISHMENT OF HISTORICAL REL (SHARING INFORMATION AND EXPERIENCE)

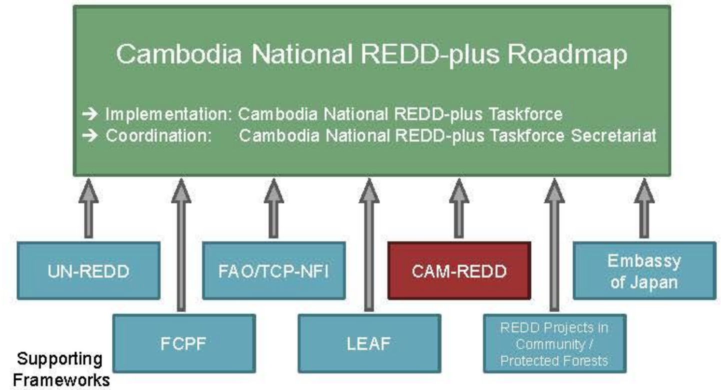
for Training Workshop on
"GHG Inventory Preparation for Forestry "

11:30-12:00, November 07th, 2012 (Day 3)
Takeshi YAMASE,

CAM-REDD MRV TA Team
(Asia Air Survey Co., Ltd.)

2

CAM-REDD is one of the Supporting Frameworks toward Cambodia REDD+ Roadmap



3

INTRODUCTION OF CASE 1

4

Case 1

Title

- Simulation / Trial Calculation of RELs (Reference Emission Levels) of Cambodia with Different Scale Approach

Subject

- Comparing simulated RELs of some Province / Provincial Cluster, consider appropriate size of "sub-national scale" for REDD-plus implementation in Cambodia.

Case 1

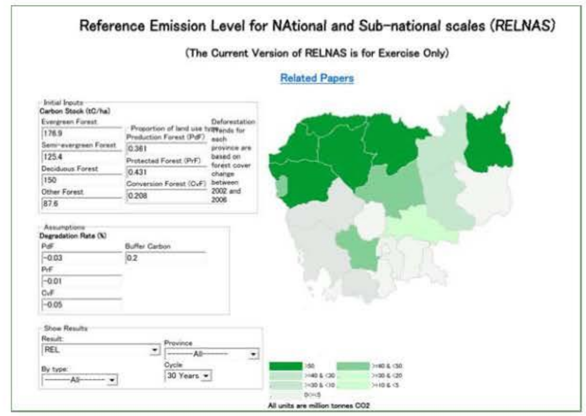
Tools

- RELNAS (Reference Emission Level for National and Sub-national scales), a REDD+ Software, developed by Associate Professor Nophea K. SASAKI, University of Hyogo, JAPAN (http://www.reddplusoft.com/index.php)

Notes

- The Current version of RELNAS is for Exercise Only.
- Deforestation trends for each province are based on forest cover change between 2002 and 2006.

Top page of RELNAS (image)



Factors for Simulation

Factors	Value
Carbon Stock of Evergreen Forest	176.9 t C / ha
Carbon Stock of Semi-evergreen Forest	125.4 t C / ha
Carbon Stock of Deciduous Forest	150 t C / ha
Carbon Stock of Other Forest	87.6 t C / ha
Proportion of land use type / Production Forest (PdF)	0.361
Proportion of land use type / Protected Forest (PrF)	0.431
Proportion of land use type / Conversion Forest (CvF)	0.208
Assumption / Degradation Rate of Production Forest (PdF)	-0.03 %
Assumption / Degradation Rate of Protected Forest (PrF)	-0.01 %
Assumption / Degradation Rate of Conversion Forest (CvF)	-0.05 %
Assumption / Buffer Carbon	0.2

- Default values on RELNAS web-site set by Assoc. Prof. N. K. SASAKI are used for each factor.

Procedure of Simulation

(1)
- Calculate sub-national (provincial) level RELs by each forest type for 10 years cycle (from 2002 to 2011).

(2)
- Make graphs of each provincial level RELs.

(3)
- Grouping by several conditions.

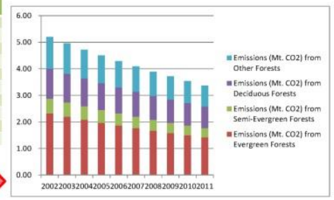
(4)
- Consider appropriate scale for Cambodian RELs under this simulation / trial calculation.

Example: Siem Reap Province Case

Scale: Sub-National Unit: Province Name of Unit: Siem Reap

Year	Evergreen Forest				Semi-Evergreen Forest				Deciduous Forest				Other Forest			
	REL	Project	Credit_D1	Credit_D2	REL	Project	Credit_D1	Credit_D2	REL	Project	Credit_D1	Credit_D2	REL	Project	Credit_D1	Credit_D2
2002	2.32	2.32	0.00	0.00	0.56	0.56	0.00	0.00	1.12	1.12	0.00	0.00	1.20	1.20	0.00	0.00
2003	2.20	2.04	0.13	0.01	0.53	0.50	0.03	0.00	1.08	1.00	0.06	0.05	1.15	1.06	0.07	0.01
2004	2.08	1.47	0.49	0.04	0.51	0.36	0.12	0.01	1.04	0.74	0.25	0.10	1.09	0.77	0.26	0.04
2005	1.97	0.78	0.96	0.09	0.48	0.19	0.23	0.02	1.01	0.40	0.49	0.17	1.04	0.41	0.51	0.07
2006	1.87	0.54	1.06	0.13	0.45	0.13	0.26	0.03	0.97	0.28	0.55	0.23	1.00	0.29	0.56	0.10
2007	1.77	0.33	1.15	0.18	0.43	0.08	0.28	0.05	0.94	0.17	0.61	0.29	0.95	0.18	0.62	0.13
2008	1.67	0.30	1.09	0.20	0.41	0.07	0.27	0.05	0.90	0.16	0.59	0.33	0.91	0.16	0.59	0.15
2009	1.58	0.28	1.05	0.23	0.39	0.07	0.26	0.06	0.87	0.15	0.58	0.38	0.87	0.15	0.57	0.17
2010	1.50	0.25	1.00	0.25	0.37	0.06	0.25	0.06	0.84	0.14	0.56	0.42	0.83	0.14	0.55	0.19
2011	1.42	0.19	0.99	0.28	0.35	0.05	0.24	0.07	0.81	0.11	0.57	0.47	0.79	0.10	0.55	0.21

Year	Emissions (Mt. CO_2) from Evergreen Forests	Emissions (Mt. CO_2) from Semi-Evergreen Fores	Emissions (Mt. CO_2) from Deciduous Forests	Emissions (Mt. CO_2) from Other Forests
2002	2.32	0.56	1.12	1.20
2003	2.20	0.53	1.08	1.15
2004	2.08	0.51	1.04	1.09
2005	1.97	0.48	1.01	1.04
2006	1.87	0.45	0.97	1.00
2007	1.77	0.43	0.94	0.95
2008	1.67	0.41	0.90	0.91
2009	1.58	0.39	0.87	0.87
2010	1.50	0.37	0.84	0.83
2011	1.42	0.35	0.81	0.79

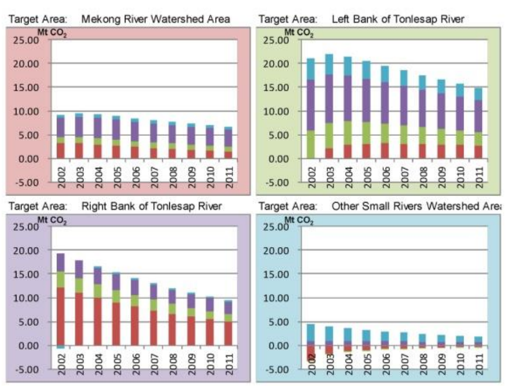


Example: RELs of Some Provinces

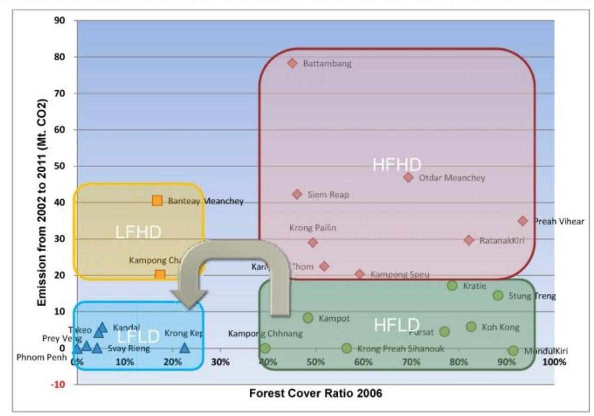
- Note:
  This map was revised from the original map of "Administrative divisions of Cambodia - Wikipedia, the free encyclopedia (http://en.wikipedia.org/wiki/Administrative_divisions_of_Cambodia)".

Grouping Sample 1: Watershed Area

- Note:
  This map was revised from the original map of "Administrative divisions of Cambodia - Wikipedia, the free encyclopedia (http://en.wikipedia.org/wiki/Administrative_divisions_of_Cambodia)".



Grouping Sample 2: Classification between forest cover ratio and emissions



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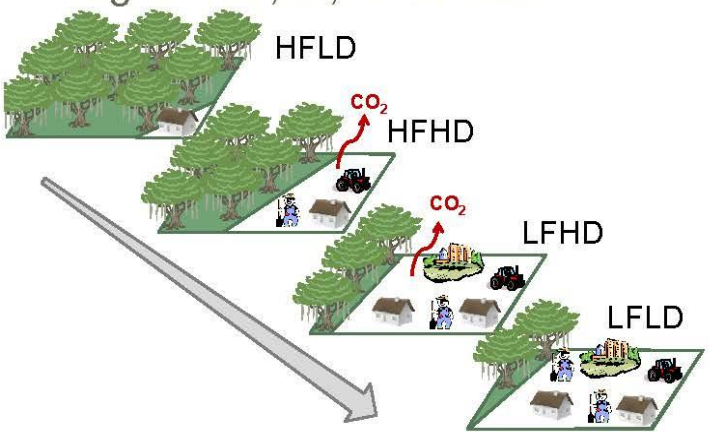
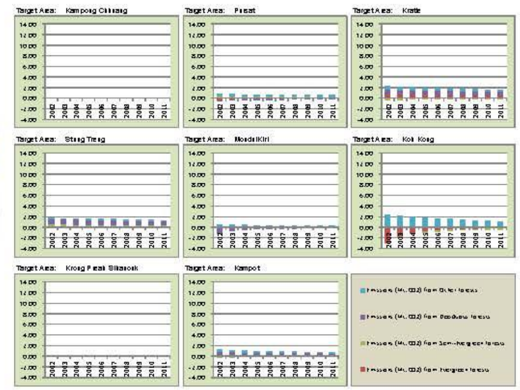
Images of HF, LF, HD and LD



14

Grouping Sample 2: Provincial Level RELs of HFLD Provinces

- Note:
  This map was revised from the original map of "Administrative divisions of Cambodia - Wikipedia, the free encyclopedia (http://en.wikipedia.org/wiki/Administrative_divisions_of_Cambodia)".



15

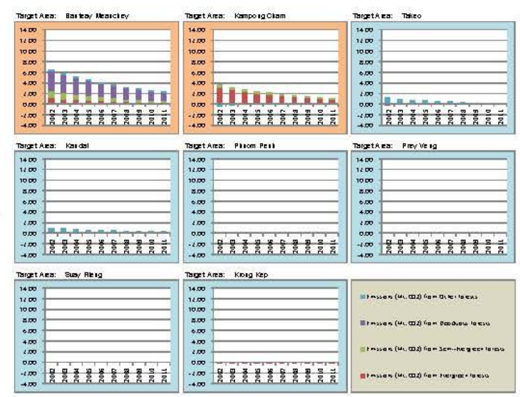
Grouping Sample 2: Provincial Level RELs of HFHD Provinces

- Note:
  This map was revised from the original map of "Administrative divisions of Cambodia - Wikipedia, the free encyclopedia (http://en.wikipedia.org/wiki/Administrative_divisions_of_Cambodia)".

16

Grouping Sample 2: Provincial Level RELs of LFHD & LFLD Provinces

- Note:
  This map was revised from the original map of "Administrative divisions of Cambodia - Wikipedia, the free encyclopedia (http://en.wikipedia.org/wiki/Administrative_divisions_of_Cambodia)".



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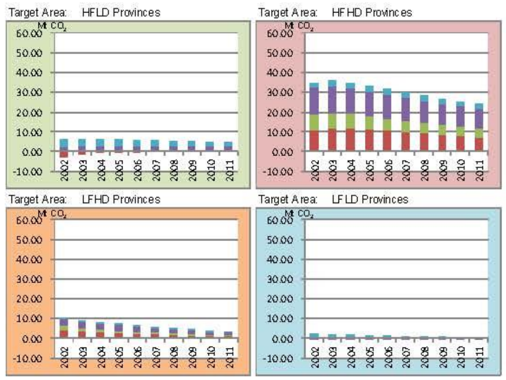
Grouping Sample 2: Provincial Cluster Level RELs

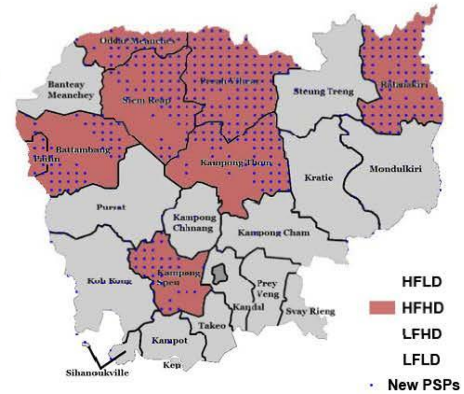


- Note:
This map was revised from the original map of "Administrative divisions of Cambodia - Wikipedia, the free encyclopedia (http://en.wikipedia.org/wiki/Administrative_divisions_of_Cambodia)".

18

Image of Sub-National Scale for REDD-plus implementation in Cambodia.

1st Step Target: 8 HFHD Provinces



19

Image of Sub-National Scale for REDD-plus implementation in Cambodia.

1st Step Target: 8 HFHD Provinces

2nd Step Target: 8 HFLD Provinces

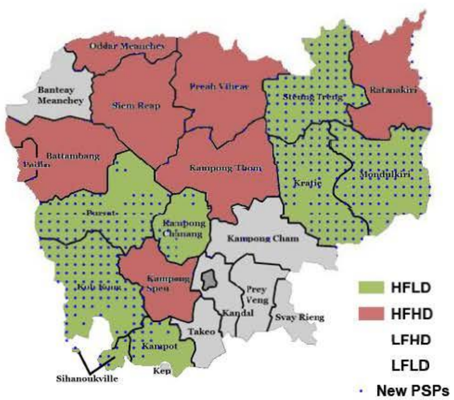


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Image of Sub-National Scale for REDD-plus implementation in Cambodia.

1st Step Target: 8 HFHD Provinces

2nd Step Target: 8 HFLD Provinces

3rd Step Target: Remaining 2 LFHD and 6 LFLD Provinces

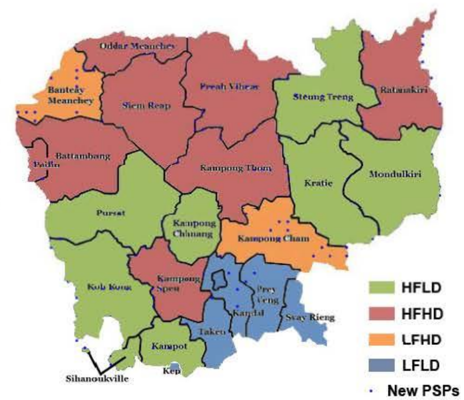


Image of Sub-National Scale for REDD-plus implementation in Cambodia.

1. These considerations are just trials.
2. So-called "Black Box" is used for these trial calculations, not actual data. ➔ We should calculate them using actual data, because FA Cambodia has them.
3. Actual data means "Activity Data" and "Mean Carbon Stock by Forest Type".
4. "Activity Data" could be created by RS/GIS unit in FA Cambodia, because they implemented Forest Cover Assessment at 2002, 2006 and 2010.
5. "Mean Carbon Stock by Forest Type" can be calculated by NFI staff of FA Cambodia, because they implemented NFI and PSPs survey at 1998, 2000/2001, 2003-2005 and 2011.

INTRODUCTION OF CASE 2

Case 2

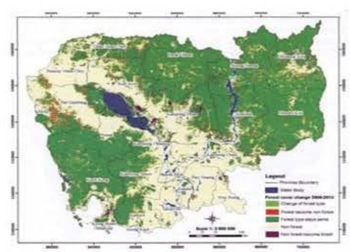
Title

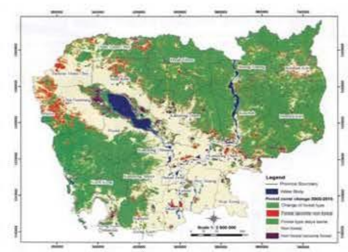
- Trial Calculation of Historical Trend of Annual CO_2 Emissions / Removals in order to Understand Cambodian Nationwide RELs (Reference Emission Levels)

Subject

- Implementation to calculate actual RELs of National level using existing published materials.

Actual Activity Data (LULUCF Data)





- The source of actual activity data is the booklet titled "CAMBODIA FOREST COVER 2010" issued by KINGDOM OF CAMBODIA and supported by ITTO and DANIDA in 2011.
- Left: Map of Forest Cover Change between 2006 and 2010
- Right: Map of Forest Cover Change between 2002 and 2010

Actual Activity Data (LULUCF Data)

Forest types		2010 (Ha) EF	SE	DF	OF	NF	Total 2006 (Ha)
2006 (Ha)	EF	3,498,427	221	5	17240	153009	3,668,902
	SE	233	1,274,292	56	5,282	82,775	1,362,638
	DF	35	87	4,478,724	8,641	204,611	4,692,098
	OF	128	20	10	889,497	117,487	1,007,142
	NF	362	169	2,419	187,940	7,239,003	7,429,893
Total 2010 (Ha)		3,499,185	1,274,789	4,481,214	1,108,600	7,796,885	18,160,674

Forest Types		2010 (Ha) EF	SE	DF	OF	NF	Total 2002 (Ha)
2002 (Ha)	EF	3,339,632	12,955	3,659	30,179	334,068	3,720,493
	SE	62,389	1,179,487	36,467	17,738	159,101	1,455,183
	DF	7,337	49,010	4,338,617	28,650	410,273	4,833,887
	OF	69,597	19,163	6,462	747,988	251,524	1,094,728
	NF	20,234	14,175	96,010	284,045	6,641,919	7,056,383
Total 2010 (Ha)		3,499,185	1,274,789	4,481,214	1,108,600	7,796,885	18,160,674

- The source of actual activity data is the booklet titled "CAMBODIA FOREST COVER 2010" issued by KINGDOM OF CAMBODIA and supported by ITTO and DANIDA in 2011.
- Left: Result of Forest Pattern Change data 2006 - 2010
- Right: Result of Forest Pattern Change data 2002 - 2010

Actual Mean Carbon Stock by Forest Type

Forest Type		Mean Carbon Stock of Living Biomass (AGB & BGB)	Standard Error
Evergreen Forest	(EF)	163.8 tC/ha	±7.8 tC/ha
Semi-evergreen Forest	(SE)	163.8 tC/ha	±7.8 tC/ha
Deciduous Forest	(DF)	56.2 tC/ha	±6.7 tC/ha
Other Forest	(OF)	N/A tC/ha	N/A tC/ha
Non Forest	(NF)	N/A tC/ha	N/A tC/ha

- The source of these values is the monograph titled "Tree Biomass Carbon Stock Estimation using Permanent Sampling Plot Data in Different Types of Seasonal Forests in Cambodia (V. Samreth et al. 2012)".
- Mean and standard error values were calculated using PSPs data of 2nd NFI (2000-2001) and allometric equation developed by Dr. Kiyono of FFPRI.

Change Matrix between 2006 and 2010

Forest Area Change Matrix between 2006 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: hectare

Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2006	EF	3,498,427	221	5	17,240	153,009	3,668,902	20.2%
	SE	233	1,274,292	56	5,282	82,775	1,362,638	7.5%
	DF	35	87	4,478,724	8,641	204,611	4,692,098	25.8%
	OF	128	20	10	889,497	117,487	1,007,142	5.5%
	NF	362	169	2,419	187,940	7,239,003	7,429,893	40.9%
Total		3,499,185	1,274,789	4,481,214	1,108,600	7,796,885	18,160,673	100.0%
		19.3%	7.0%	24.7%	6.1%	42.9%	100.0%	

Change Matrix between 2006 and 2010

Carbon Stock Change Factors (CSCF) between 2006 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: tC/ha

Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2006	EF	0.0	0.0	-107.6	-163.8	-163.8		
	SE	0.0	0.0	-107.6	-163.8	-163.8		
	DF	107.6	107.6	0.0	-56.2	-56.2		
	OF	163.8	163.8	56.2	0.0	0.0		
	NF	163.8	163.8	56.2	0.0	0.0		
Total								

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Change Matrix between 2006 and 2010

Forest Living Biomass Carbon Stock Change Matrix between 2006 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: t C

Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2006	EF	0	0	-538	-2,823,912	-25,062,874	-27,887,324	51.6%
	SE	0	0	-6,026	-865,192	-13,558,545	-14,429,762	26.7%
	DF	3,766	9,361	0	-485,624	-11,499,138	-11,971,635	22.2%
	OF	20,966	3,276	562	0	0	24,804	0.0%
	NF	59,296	27,682	135,948	0	0	222,926	-0.4%
Total		84,028	40,319	129,946	-4,174,728	-50,120,557	-54,040,992	100.0%
		-0.2%	-0.1%	-0.2%	7.7%	92.7%	100.0%	

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Change Matrix between 2006 and 2010

CO_2 Emission / Removal Matrix between 2006 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: t CO_2

Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2006	EF	0	0	-1,973	-10,354,344	-91,897,205	[illegible]	51.6%
	SE	0	0	-22,094	-3,172,369	-49,714,665	[illegible]	26.7%
	DF	13,809	34,324	0	-1,780,622	-42,163,507	[illegible]	22.2%
	OF	76,877	12,012	2,061	0	0	90,949	0.0%
	NF	217,417	101,501	498,475	0	0	817,394	-0.4%
Total		308,103	147,838	476,469	[illegible]	[illegible]	[illegible]	100.0%
		-0.2%	-0.1%	-0.2%	7.7%	92.7%	100.0%	

Black: Removal

Red: Emission

31

Change Matrix between 2002 and 2010

Forest Area Change Matrix between 2002 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: hectare

Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2002	EF	3,339,632	12,955	3,659	30,179	334,068	3,720,493	20.5%
	SE	62,389	1,179,487	36,467	17,738	159,101	1,455,182	8.0%
	DF	7,337	49,010	4,338,617	28,650	410,273	4,833,887	26.6%
	OF	69,592	19,163	6,462	747,988	251,524	1,094,729	6.0%
	NF	20,234	14,175	96,010	284,045	6,641,919	7,056,383	38.9%
Total		3,499,184	1,274,790	4,481,215	1,108,600	7,796,885	18,160,674	100.0%
		19.3%	7.0%	24.7%	6.1%	42.9%	100.0%	

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Change Matrix between 2002 and 2010

Carbon Stock Change Factors (CSCF) between 2002 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: t C/ha

Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2006	EF	0.0	0.0	-107.6	-163.8	-163.8		
	SE	0.0	0.0	-107.6	-163.8	-163.8		
	DF	107.6	107.6	0.0	-56.2	-56.2		
	OF	163.8	163.8	56.2	0.0	0.0		
	NF	163.8	163.8	56.2	0.0	0.0		
Total								

Change Matrix between 2002 and 2010

Forest Living Biomass Carbon Stock Change Matrix between 2002 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: t C

Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2002	EF	0	0	-393,708	-4,943,320	-54,720,338	-60,057,367	70.1%
	SE	0	0	-3,923,849	-2,905,484	-26,060,744	-32,890,077	38.4%
	DF	789,461	5,273,476	0	-1,610,130	-23,057,343	-18,604,535	21.7%
	OF	11,399,170	3,138,899	363,164	0	0	14,901,233	-17.4%
	NF	3,314,329	2,321,865	5,395,762	0	0	11,031,956	-12.9%
Total		15,502,960	10,734,240	1,441,369	-9,458,935	-103,838,425	-85,618,790	100.0%
		-18.1%	-12.5%	-1.7%	11.0%	121.3%	100.0%	

Change Matrix between 2002 and 2010

CO2 Emission / Removal Matrix between 2002 and 2010

Target Area: Whole Country of the Kingdom of Cambodia

Unit: t CO_2

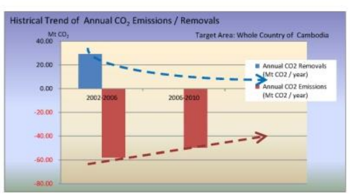
Forest Type		Year 2010 EF	SE	DF	OF	NF	Total	
Year 2002	EF	0	0	-1,443,597	-18,125,507	-200,641,241	[illegible]	70.1%
	SE	0	0	-14,387,447	-10,653,443	-95,556,061	[illegible]	38.4%
	DF	2,894,691	19,336,079	0	-5,903,810	-84,543,590	[illegible]	21.7%
	OF	41,796,955	11,509,298	1,331,603	0	0	54,637,856	-17.4%
	NF	12,152,540	8,513,505	19,784,461	0	0	40,450,506	-12.9%
Total		56,844,187	39,358,881	5,285,019	[illegible]	[illegible]	[illegible]	100.0%
		-18.1%	-12.5%	-1.7%	11.0%	121.3%	100.0%	

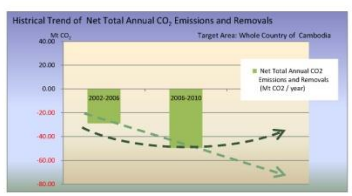
Black: Removal

Red: Emission

Result of National Level REL calculation

Period (year to year)	2002-2006	2006-2010
Annual CO_2 Removals (t CO_2 / year)	29,090,664	239,119
Annual CO_2 Emissions (t CO_2 / year)	-58,036,979	-49,776,695
Net Total Annual CO_2 Emissions and Removals (t CO_2 / year)	-28,946,315	-49,537,576





Findings

1. Annual CO_2 removal (sink) of 2006-2010 has decreased drastically as 8 % of the value of 2002-2006. This gives us a suggestion that forest carbon stock enhancement such as forest restoration, forest recovery, afforestation and reforestation would disappeared rapidly in Cambodia from 2002 to 2010.
2. Annual CO_2 emissions are also decreasing certainly. This gives us a suggestion that deforestation and/or forest degradation would be also decreasing in Cambodia from 2002 to 2010.
3. Net total annual CO_2 emissions and removals are increasing remarkably. This notable increase would be caused by drastic decease of forest carbon stock enhancement.
4. RL (Reference Level) made from right graph would be different from RL made from left graph in case using historical trend mainly. This gives us a suggestion that we should handle CO_2 emissions and removals separately when we calculate RL/RELs.
5. This method to calculate historical trend of CO_2 emissions and removals could be applied for any scale level such as national and sub-national level.

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For Further Steps

1. Cambodia REDD+ MRV Team should start simulating various scale of RELs using existing data, and also start discussing/considering the appropriate scale/size/areas for the sub-national level REDD+ implementation.

2. For instance, forest area change matrix between 2002 and 2006 as well as between 2006 and 2010 of all provinces should be prepared by FA Cambodia or MRV Team. CAM-REDD can support this work, simulation and discussion.

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fin

Thank you for your attention

Training Workshop on GHG Inventory Preparation for Forestry

Design of National Forest Inventory

Samreth Vanna

November 5-8th 2012
Paradise Angkor Hotel

Outlines

- Information on forest and trees
- Geographical coverage of the Rapid Survey, FAO 2007
- Overview of data collected
- Frequency
- Purpose & main uses
- Main users and distribution
- Overall information collected
- Biomass & Carbon stock
- Design Sampling
- Develop protocols, accuracy & precision standards
- Field measurement plan
- Field measurement plan components
- Inventory Equipment
- Conclusion

Information on forest and trees

- Number of trees, per species, totally and per hectare
- Volumes, totally, per species and per hectare
- Biomass, totally and per species for the most common species
- Height of trees, totally and per species
- Quality of the trees and damages, i.e. possibilities for economic utilization in the form of volume (m3), log length etc
- The phenology, i.e. ratio of trees having leaves, fruit or flowers
- The canopy cover of trees
- Specific data on woodlands of interest.

Geographical coverage of the Rapid Survey, FAO 2007

- Bhutan
- Brunei Darussalam
- Cambodia
- China
- India
- Indonesia
- Japan
- Rep. of Korea
- Laos
- Malaysia
- Mongolia
- Myanmar
- Nepal
- Pakistan
- Philippines
- Sri Lanka
- Thailand
- Viet Nam

Overview of data collected

- National level: 17 countries
- Subnational level: 13c.
- Classes covered:
  - Forest : all countries
  - Trees outside forest : only 6 c.
  - Privately owned: 15 c.
  - Publicly owned: 8 c.
  - Forest plantations: 12 c.
  - Protected areas : 14 c.

Frequency

- **National level**
  - Forest area survey:

  <5 years: 3 countries

  =5 years: 4 countries

  ≥10 years: 8 countries
  - Bio-phisical data ≠

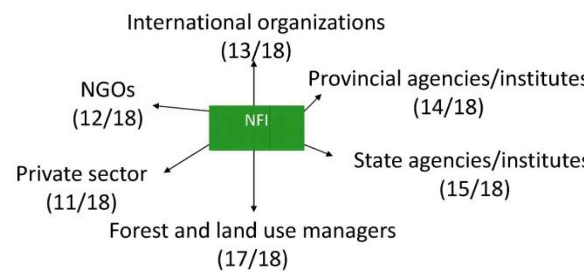
  range between 2 and 10 years
- **Sub National level**
  - Forest area survey & Bio-phisical data

  ≠ National level (2y, 5y, 10y)

Purpose & main uses

- To provide new qualitative and quantitative information on the state and trends of forest resources
- Harvesting of timber
- For strategic planning.and macro-level decision making from the ministry level
- Change of land use
- Meet increasing requests from international processes and conventions

Main users and distribution



Distribution:

Hardcopy manuals/books

Web: only 9/18 countries

Overall information collected

- **Most recorded:**

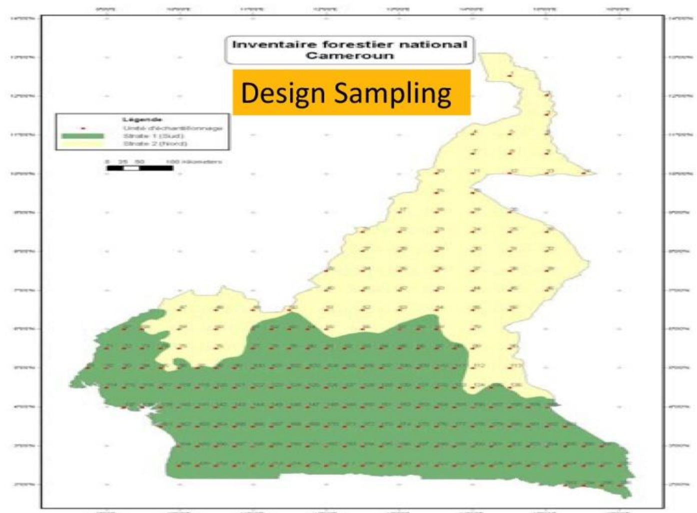
Geo-physical, Bio-Physical data, Forest extent, Naturalness, Use of forests, Mapping, Biodiverstity, Policy, legal and institution framework

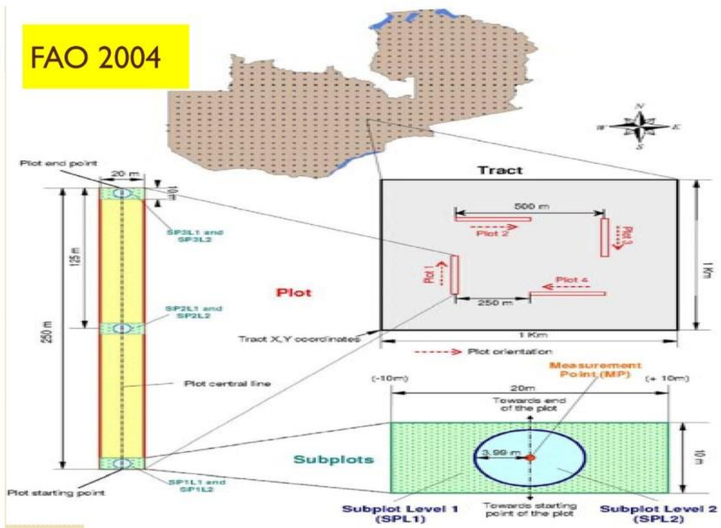
- **Less recorded**

Social Services, Biomass, Carbon stock, Status of the forest and disturbances, Beneficiaries of goods and services, and economic value

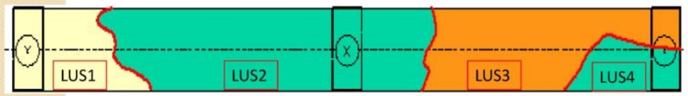
Biomass & Carbon stock

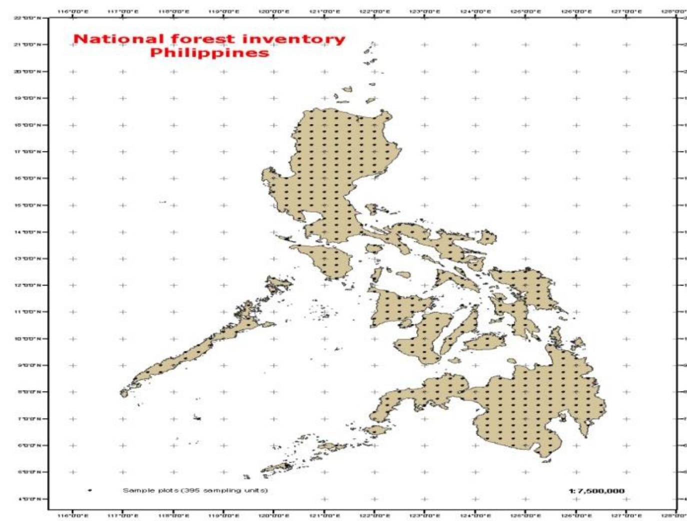
- Recorded in very few countries





Example of land use sections (LUS) distribution within a plot

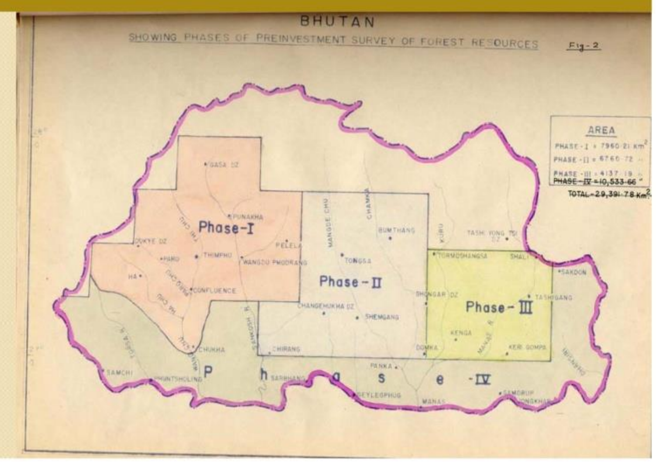


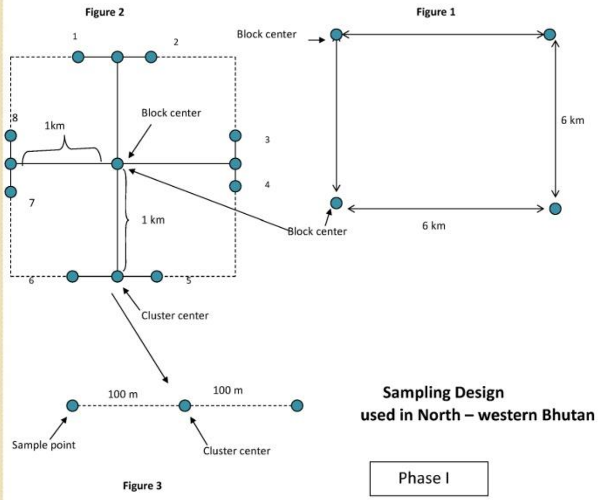


Inventory Design

- systematic sampling method
- Tracts measuring 1 km x 1 km were established in a national grid at 15' longitude and 15' latitude.
- Each tract consists of a cluster of 4 rectangular sample plots measuring 20 m x 250 m.

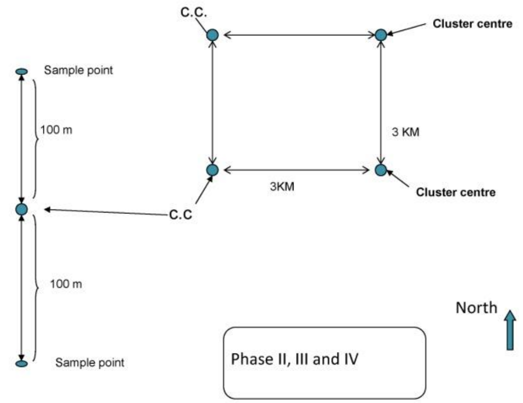
Sampling Design (BHUTAN)





Sampling Design

Southern Bhutan
and Central & Eastern Bhutan



Sampling Design (Phase I)

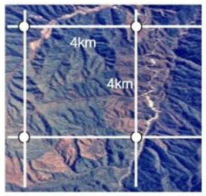
- The National Forest Inventory was done in 4 phases, namely (1) Phase I, II, III and IV). See map provided in the slide.
- In all the phases Cluster Sampling was used with some modification in the subsequent phases.
- In phase I -----sampling blocks (6 km x 6 km). Each sampling block consisted of 4 sampling clusters with 2 sample points at each cluster.
- The cluster centre are located around the block center in north, east, south & west direction at a distance of 1 km from block center.
- Each cluster have 2 sample points situated at 100 meter from cluster center.
- The sample points are serially numbered from 1 to 8 in a clockwise direction starting from the western sample point of the northern cluster.

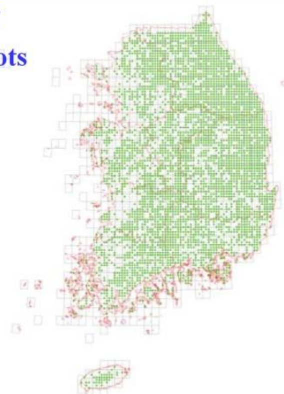
Sampling Design (Phase II, III & IV)

- Two point single cluster sampling was adopted.
- This was a slight modification from phase I sampling design.
- The clusters were spaced at 3 km x 3 km distance.
- Cluster had two sample points situated at 100 meters from the cluster center, in north-south direction.
- The cluster centers were marked on 1:50,000 grided map sheets with random start and identified by serial numbers and grid reference of the map sheet.

sampling design(Korea)

Systematic layout of
Permanent Sample Plots

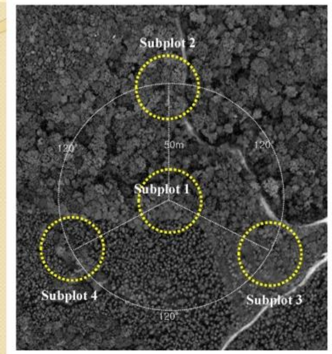




✓ Total plot : 4,000 plots
✓ Vegetation and Soil Plot
: 1,000 plots(25%)

sampling design(Korea)

Field Plot Design



- Sampling unit : cluster plot consisting of four subplots
- Plot size : 0.16ha
  subplot : 0.04ha
- Subplot 2,3,4 :
  50m away at azimuth of
  360°,120°,240°
  from subplot 1

Tree Measurements(Korea)

- All trees are or inventoried
- Tree that are not inventoried consist of those less than 1.0cm in diameter
- Measured trees are geo-referenced
- Permanent sample plots are maintained
- Growing stock is estimated by using mean tree volume/ha over forest area

Biomass Estimation(Korea)

- It is done (in Kyoto protocol report)
- Amount of leaves per tree is estimated
- Amount of twigs per tree is estimated
- Species-wise Wood density is not estimated
- Biomass Expansion Factor (BEF) are developed
- BEF are not developed for each species
- BEF are developed for each forest types
- BEF are not developed for each ecological zone

China NFI: Serve as a powerful information resources and a tool for forestry and related decision making policies, as well as for regional, national and international forest statistic.

Sampling Design: PSPs system sampling plots. 1998 two stage sampling(UNDP)

Interval Measurement: 5 years each, 1/5 of provinces every year.

Number of NFI: Total 7 NFIs

- -NFI 1:1973-1976
- -NFI 2:1977-1981
- -NFI 3:1984-1988
- -NFI 4:1989-1993
- -NFI 5:1994-1998
- -NFI 6:1999-2003
- -NFI 7:2004-2008 (Parameters increased: ecology, forest health, ecosystem diversity, forest disturbance, forest function.

China NFI:

Temporary Plots: Most of province used random sampling plots(Xiao 2005).

Shape of Plots: Rectangular or Square

Size of Plots: Ranging from 0.08-0.1ha

5 Pools:

- -DW: Min. Leng=1,3m, Min. Diameter=10cm
- -Carbon in AGB biomass ($Pg=10^{15}g$)
- -Carbon in BGB biomass ($Pg=10^{15}g$)
- -Carbon in DW ($Pg=10^{15}g$)

RS data sources: Most applicable Lansat 5-TM, Lansat 7-ETM

Output: Official release every 5 years.

Inventory	Year	methods	No. of field Plots	No. of RS Plots
NFI 1	1973-1976	Random sampling method, temporal plots.	-	RS plot determined by the density & pattern of field plot. No of RS is no less than 4 times of number of field plots.
NFI 2	1977-1981	Systematic sampling using permanent and temporal plots.	140.000	
NFI 3	1984-1988	Systematic sampling using permanent and temporal plots.	256,000	
NFI 4	1989-1993	Systematic sampling using permanent and temporal plots.	184,479	90,227
NFI 5	1994-1998	Two stage stratified sampling	227,200	106,300
NFI 6	1999-2003	Two stage stratified sampling	415,000	2,844,400
NFI 7	2004-2008			

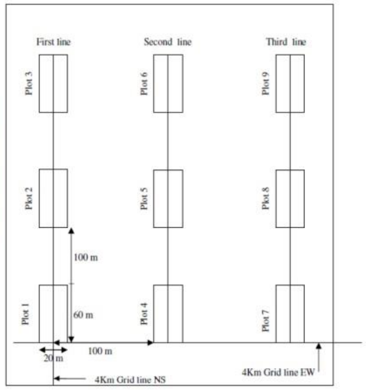
Plot and Nest Size (China)

Stem Diameter	Circular Plot	Rectangular Plot	
	Radius	Side Length	Diagonal Length
Sapling	2m	3 m x 3 m	4.2 m
DBH = 5-10cm	4m	7 m x 7 m	9.9 m
DBH = 20-50cm	14m	25 m x 25 m	35.3 m
DBH >50	20m	35 m x 35 m	49.5 m

Designed Sampling Plots(Cambodia)

DFW-FAO/UNDP
March 1998

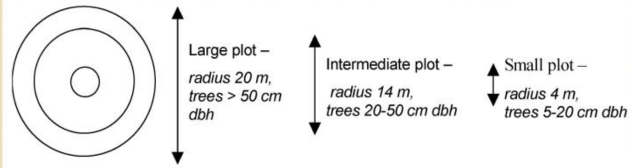
D. Plots	PS(ha)	SC(cm)
20m x 60m	0.12	>30
20m x 20m	0.04	10-30
10m x10m	0.01	5-10
5m x 5m	0.025	Sapling
2m x 2m	0.0004	Seedling



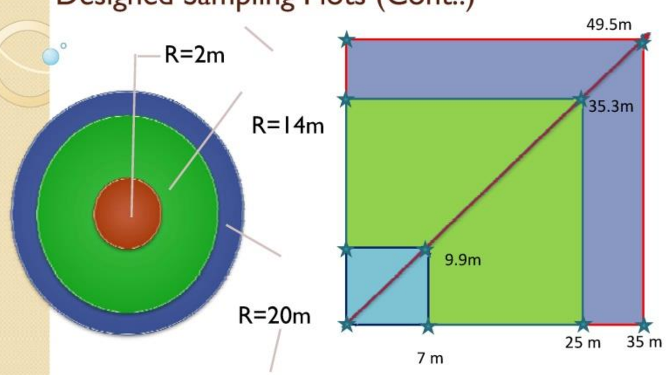
Designed Sampling Plots (Cont..)

- FA-WCS Seima Protection Forest
  March-November 2009

The schematic diagram below represents a three-nest circular sampling plot.

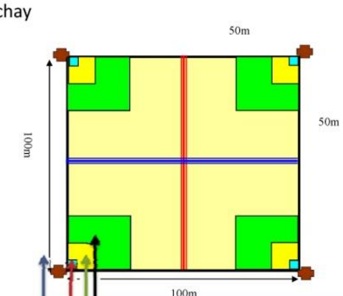


Designed Sampling Plots (Cont..)



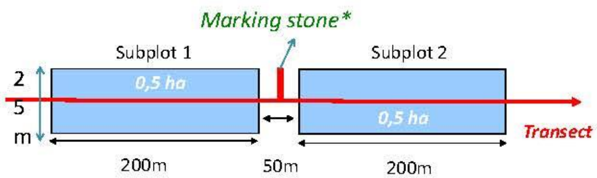
Designed Sampling Plots (Cont..)

-Oddarmeanchay
-PSPs

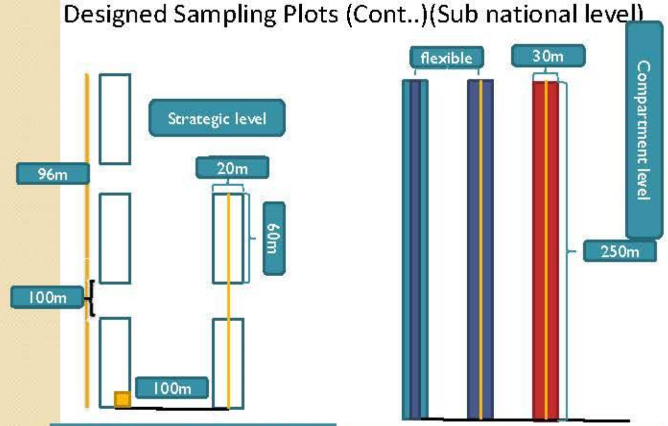


Dimension of Sample Plots	Plot size(ha)	Size classes(cm)
50m x 50m	0.25	> 30
20m x 20m	0.04	> 7.5-29.9
5m x 5m	0.0025	sapling
2m x 2m	0.0004	seedling

Designed Sampling Plots (Cont..)



Designed Sampling Plots (Cont..)(Sub national level)



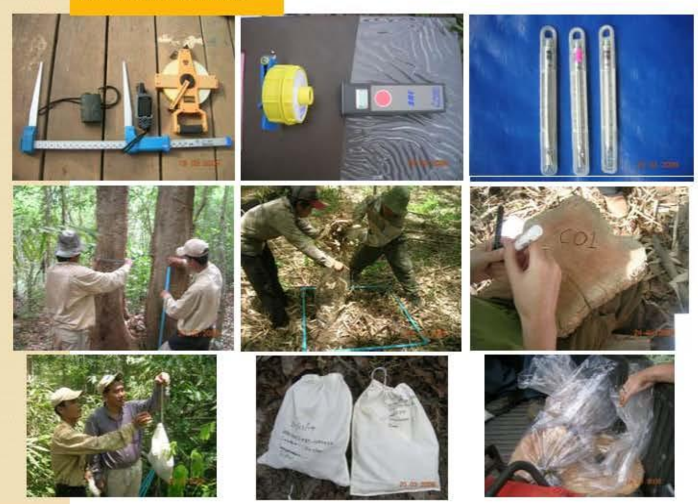
D. Plots	PS(ha)	SC(cm)
20m x 60m	0.12	>30
20m x 20m	0.04	>10-30
10m x 10m	0.01	5-10
5m x 5m	0.0025	<5

D. Plots	PS(ha)	SC(cm)
30m x 250m	0.75	≥ 60
10m x 250m	0.25	30-60
10m x 50m	0.05	10-30

Parameters to be collected

-Oddar Mean Chay
-PSPs

Seima Protection Forest



Develop protocols, accuracy & precision standards

- Develop Standard Operating Procedures (SOPs) for all aspects of field and laboratory activities
- Develop formal procedures to verify methods used to collect field data and ensure same procedures are used over time
- Develop techniques to enter and analyze data
- Develop formal procedures for archiving data

Develop protocols, accuracy & precision standards

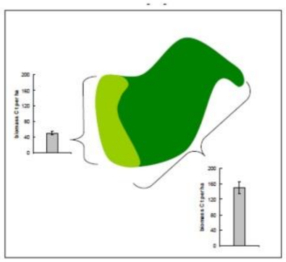
- Laboratory measurements
  - check equipment and measurement with known quantity samples added blindly
- Data entry
  - test of out of range values
  - recheck proportion for errors
- Archiving
  - off-site storage of data

Field measurement plan

- Determine historic/future LU transitions
  - Collaborate with RS/GIS
  - Determine LU classes where change significant (deforestation, degradation, enhancement)
  - LU classes where no / little change → not important for REDD+ accounting, sampling intensity may be lower
- Create sampling design for each LU class to be measured
- Conduct training
- Implement sampling plan
  - Most land use classes – estimate carbon stocks
  - Some land use classes – estimate emission/removals taking place directly (e.g. selective logging).

Stratification

- Reduces sampling effort while maintaining accuracy and precision in estimates

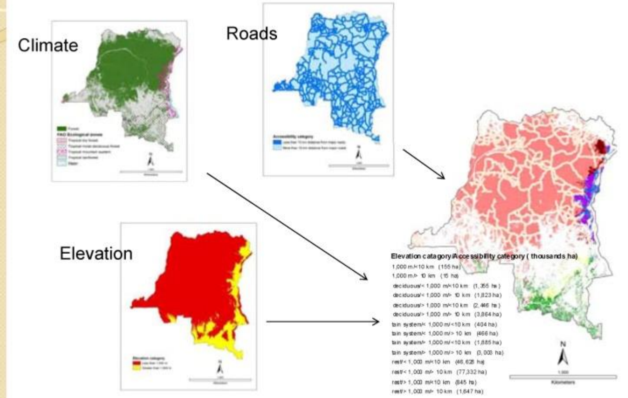


From GOFC-GOLD 2009

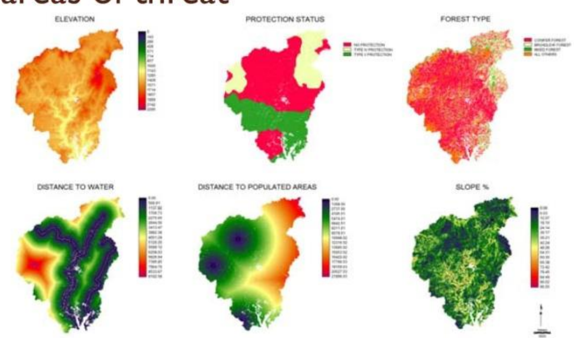
Stratification

- Use existing data to identify and divide land cover types into relatively homogenous strata
- Requires detailed collaboration with remote sensing and GIS team creating land cover maps

Identify strata where change in forest cover occurred



Use spatial modeling to identify areas of threat

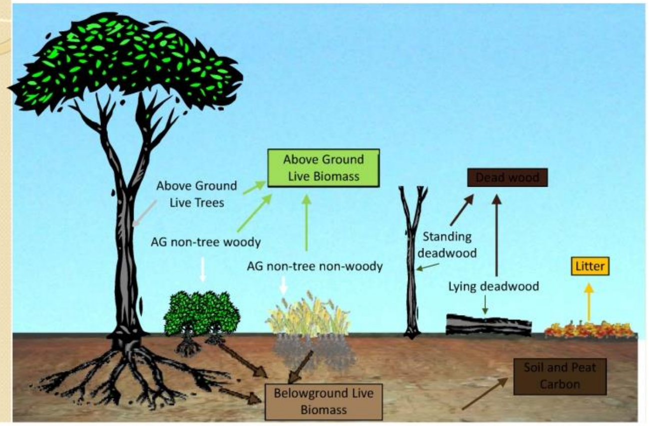


Example of factor maps that are commonly used to assess the threat of deforestation

Field measurement plan components

- Stratification
- Carbon pool selection
- Plot design and location
- Quality assurance and quality control plans
  - Standard operating procedures for measurement methods, data analysis, data archiving, etc.

Identifying key carbon pools for measurement and monitoring



Selecting carbon pools for measurement and monitoring

- Selection of pools depends on:
  - Magnitude of pool
  - Rate of change of pools in response to human disturbance
  - Expected direction of change
  - Cost to measure
  - Method available to measure
  - Attainable accuracy and precision

Identifying key carbon pools for measurement and monitoring

- Guidance on selection of key carbon pools:
  - Cost – benefit analysis based on expected net emissions vs cost of measurement
    - Use existing data / preliminary data to do preliminary analysis of emission factors + costs
  - Include all pools that likely significantly changed in historic period
    - Selected pools could vary by land cover types
  - Soil carbon does not have to be measured if land use to which it is converted does not cause it to decrease (e.g. forests to grasslands, selective logging)
  - All pools included in REL must be included in MRV plan

Selecting key carbon pools for measurement and monitoring

- Soils will represent a key category in peat swamp forests and mangrove forests
- Conversion of forests on mineral soils with high carbon content to cropland can result in large emissions from soil
- Dead wood is a key category in old growth forests

Plot design: number of plots for other pools if needed

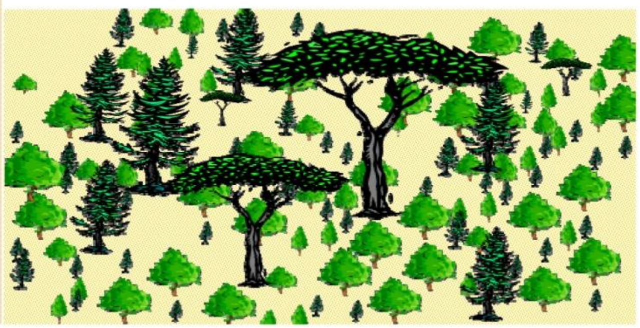
- Non-tree biomass pools:
  - Use plot calculator OR
  - # non-tree plots in proportion to # tree plots
  - For every tree plot, sample:
    - Single 100 m line transect for dead wood
    - 4 sub-plots for herbaceous, forest floor, soil
  - May result in large variance, but overall carbon in non-tree pools is small compared to tree pool

Plot design: size of plots for aboveground tree pool

- Important to sample large trees – most carbon in landscape stored in the largest trees
- If large trees are very spread out:
  - If no mixed slopes, can do large plots
  - If mixed slopes, can do "clumped" plots
    - Need statistical expertise to complete uncertainty analysis

Plot design: shape of plots

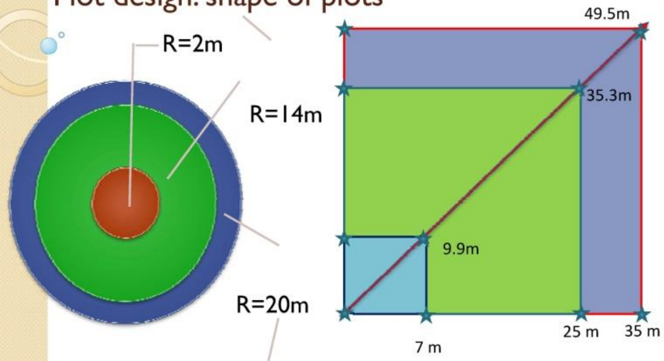
- Trees
  - Large trees: few, very spread out
  - Small trees: many, close together



Plot design: shape of plots

- Nested plots
  - efficient for regenerating forests with trees growing into new size classes
  - Plots can be either circular or square
  - 'Rule of thumb' for determining plot size: ~10 stems per nest – but, most important to adequately sample large trees

Plot design: shape of plots



Estimate number of sampling plots needed

- The number of plots needed is predetermined to ensure precision
- Estimate variability of carbon stocks from either existing data or new preliminary data
- 10% of mean at 95% confidence interval is common and appropriate
- Focus on variance of dominant carbon pool (i.e. trees)

Estimate number of sampling plots needed

- Also informs landscape stratification
  - The more variable the carbon stocks, the more plots that are needed to achieve the desired level of precision
  - If stratified area requires more sample plots than unstratified area, removed one stratum

Estimate number of sampling plots needed

- Estimate variability of carbon stocks from either existing data or new preliminary data:
  - Existing data: forest inventories, scientific studies
  - New preliminary data:
    - Locate ~10 plots within each stratum
    - Collect field measurements using same methods will use for actual measurements

Plot location: distribution of plots

- Sample units must be located without bias → randomly distribute plots using GIS
- Stratified random
- Stratified systematic-preferred
- Stratified random systematic
- Will need assistance to ensure distribution is statistically correct

Assessing regional default factors and regression equations

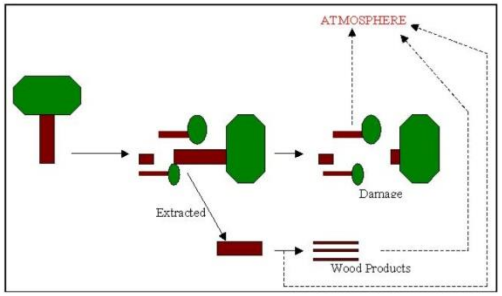
- Need to verify existing allometric equations for key forest strata
- Can use different allometric equations for each stratum
- Alternatively, may need to create local equations

Assessing regional default factors and regression equations

- Can be based on a few, easily measured tree properties (DBH)
- Can be developed over time – start with generic allometric equation
- Regional default factors and regression equations can be developed

Gathering measurements to establish emission factors for forest degradation

- Emissions from removals by selective timber extraction in tropical forests



Inventory Equipments

Conclusion

- National Forest Inventory Design need to consider with well prepare of manual or guideline for implementation.
- What is sampling design suitable for Cambodia ?.

Thank you

បទបង្ហាញស្តីពីកម្មវិធីUN-REDD កម្ពុជា

ដោយ លី សុភ័ណ្ឌ
អនុប្រធានលេខាធិការដ្ឋានក្រុមការងារ REDD+កម្ពុជា
E-mail: sophorn_ly@yahoo.com

ស្ថានភាពកម្មវិធី REDD នៅកម្ពុជា

- ជាកម្មវិធីមួយដែលអាចនាំមកនូវចំណូលបន្ថែមពីវិស័យព្រៃឈើ តាមរយៈការទប់ស្កាត់ការបាត់បង់ និងរេចរិលព្រៃឈើ ដោយមានប្រទេសដែលបញ្ចេញឧស្ម័នច្រើនទៅបរិយាកាស អាចជាអ្នកទិញឥណទានកាបូន
- សកម្មភាពរបស់កម្មវិធី REDD មាន ៥ ដូចខាងក្រោម៖
  - ការកាត់បន្ថយការបាត់បង់ព្រៃឈើ
  - ការកាត់បន្ថយភាពរេចរិលព្រៃឈើ
  - ការអភិរក្សធនធានកាបូនព្រៃឈើ
  - ការគ្រប់គ្រងព្រៃឈើអោយមាននិរន្តរភាព
  - ការបង្កើនធនធានកាបូនព្រៃឈើ។
- កម្មវិធី REDD ត្រូវបានបញ្ចូលទៅក្នុងផែនការយុទ្ធសាស្រ្តអភិវឌ្ឍន៍ជាតិ (២០០៩-២០១៣) និងនៅក្នុងកម្មវិធីព្រៃឈើជាតិ (២០១០-២០២៩)
- កម្ពុជា ជាសមាជិកនៃកម្មវិធី REDD របស់មូលនិធិភាពជាដៃគូកាបូនព្រៃឈើ (FCPF) កាលពីខែមីនា ឆ្នាំ២០០៨, UN-REDD នៅខែតុលា ឆ្នាំ២០០៩ និងជាសមាជិកក្នុងភាពជាដៃគូស្តីពី REDD (REDD+ Partnership) នៅខែឧសភា ឆ្នាំ២០១០
- មានគម្រោង REDD បី កំពុងអនុវត្តៈ ខេត្តឧត្តរមានជ័យ, កែវសីមា ខេត្តមណ្ឌលគីរី, ដែនជម្រកសត្វព្រៃគូលែន-ព្រហ្មទេព ខេត្តព្រះវិហារ
- ផែនទីបង្ហាញផ្លូវស្តីពី REDD (Cambodia REDD+ Roadmap , ២០១០)

ស្ថានភាពថវិកាជំនួយ

- ជំនួយពីរាជរដ្ឋាភិបាលជប៉ុន
- អង្គការ JICA
- UN-REDD (UNDAP, FAO, UNEP)
- FCPF
- USAID, EU, LEAF, etc.

កម្មវិធី UN-REDD កម្ពុជា

- កម្មវិធី UN-REDD កម្ពុជា ត្រូវបានរៀបចំឡើងដោយផ្អែកលើឯកសារផែនទីបង្ហាញផ្លូវស្តីពី REDD (២០១០)
- កម្មវិធី UN-REDD កម្ពុជា គាំទ្រថវិកា និងបច្ចេកទេសដោយស្ថាប័នសហប្រជាជាតិ (United Nation) ចំនួនបី រួមមាន: FAO, UNDP និង UNEP
- កម្មវិធី UN-REDD កម្ពុជា អនុវត្តដោយ: អគ្គនាយកដ្ឋានរដ្ឋបាលការពារ និងអភិរក្សធម្មជាតិ នៃក្រសួងបរិស្ថាន និងរដ្ឋបាលព្រៃឈើ រដ្ឋបាលជលផល នៃក្រសួងកសិកម្ម រុក្ខាប្រមាញ់ និងនេសាទ
- កម្មវិធី UN-REDD កម្ពុជា ផ្តោតសំខាន់លើការអភិវឌ្ឍស្ថាប័ន គោលនយោបាយ និងសមត្ថភាព ដើម្បីត្រៀមរៀបចំជាស្រេចក្នុងការអនុវត្ត REDD+។

សមាសភាព និងសកម្មភាពកម្មវិធី UN-REDD កម្ពុជា

- **សមាសភាគ ១៖** រៀបចំរចនាសម្ព័ន្ធគ្រប់គ្រងជាតិដើម្បីត្រៀមរៀបចំជាស្រេចក្នុងការអនុវត្ត REDD+ និងការចូលរួមរបស់អ្នកពាក់ព័ន្ធ
  - **សកម្មភាព ១.១៖** បង្កើតយន្តការសម្របសម្រួលថ្នាក់ជាតិសម្រាប់ការងារត្រៀមរៀបចំ REDD+
  - **សកម្មភាព១.២៖** គាំទ្រដំណើរការត្រៀមរៀបចំ REDD+ នៅថ្នាក់ជាតិ
  - **សកម្មភាព១.៣៖** ចាត់ចែងអ្នកពាក់ព័ន្ធអោយចូលរួមក្នុងដំណើរការត្រៀមរៀបចំ REDD+
  - **សកម្មភាព១.៤៖** ចែករំលែក-ផ្តល់ព័ត៌មានពី REDD+ និងដំណើរការត្រៀមរៀបចំ REDD+ នៅថ្នាក់ជាតិ ជូនដល់អ្នកពាក់ពន្ធ័។

(បន្ត)

សមាសភាគ ២៖ ការកសាងក្របខណ្ឌយុទ្ធសាស្ត្រ និងគោលការណ៍អនុវត្ត REDD+
  - **សកម្មភាព ២.១៖** ការបង្កើតយុទ្ធសាស្ត្រ និងទម្រង់ផ្សេងៗសម្រាប់អនុវត្ត REDD+ នៅតាមស្ថាប័ននីមួយៗ
  - **សកម្មភាព២.២៖** ការវាយតម្លៃផលប្រយោជន៍រួមគ្នា (Evaluation of co-benefit) ។
  - **សកម្មភាព២.៣៖** យន្តការផ្តល់មូលនិធិ និងការចែករំលែកផលប្រយោជន៍
  - **សកម្មភាព២.៤៖** ការបង្កើតគោលនយោបាយ ច្បាប់ ក្នុងក្របខណ្ឌជាតិ ដើម្បីអនុវត្ត REDD+
  - **សកម្មភាព២.៥៖** ប្រពន្ធ័សុវត្ថិភាព និងការតាមដានអំពីផលប្រយោជន៍រួមគ្នា។

(បន្ត)

- **សមាសភាព៣៖**ការកសាងសមត្ថភាពនៅថ្នាក់ក្រោមជាតិ និងការសាកល្បងអនុវត្តគម្រោង REDD+
  - **សកម្មភាព ៣.១៖** ការបង្កើតវិធីសាស្ត្រសម្រាប់អនុវត្ត REDD+នៅថ្នាក់ក្រោមជាតិ
  - **សកម្មភាព៣.២៖** សកម្មភាពអនុវត្តគម្រោងសាកល្បង។

(បន្ត)

- **សមាសភាព៤៖**ការបង្កើតប្រពន្ធ័តាមដាន REDD+
  - **សកម្មភាព៤.១៖** បង្កើតក្រុមបច្ចេកទេស វាស់វែង រាយការណ៍ និងផ្ទៀងផ្ទាត់ (MRV/ REL) និងបង្កើនសមត្ថភាពថ្នាក់ជាតិអោយបានសមស្រប
  - **សកម្មភាព៤.២៖** បង្កើតប្រព័ន្ធតាមដាន និងត្រួតពិនិត្យសម្រាប់ប្រទេសកម្ពុជា
  - **សកម្មភាព៤.៣៖** ពិនិត្យឡើងវិញលើលទ្ធផលនៃការប៉ាន់ប្រមាណគម្របព្រៃឈើ ដើម្បីផ្តល់ទិន្នន័យពីសកម្មភាព REDD+ និងបង្កើតប្រព័ន្ធតាមដាន ត្រួតពិនិត្យព្រៃឈើតាមផ្កាយរណប (satellite)
  - **សកម្មភាព ៤.៤៖** ធ្វើសារពើភ័ណ្ឌព្រៃឈើជាតិ ដើម្បីបង្កើតវិធីសាស្ត្រក្នុងការគណនាការបំភាយ និងស្រូបឧស្ម័នសម្រាប់សកម្មភាពពាក់ព័ន្ធនឹង REDD+
  - **សកម្មភាព៤.៥៖** គាំទ្រការបង្កើតប្រព័ន្ធរាយការណ៍ពីឧស្ម័នផ្ទះកញ្ចក់ ដែលទាក់ទងនឹងការងារ REDD+
  - **សកម្មភាព៤.៦៖** គាំទ្រការបង្កើតក្របខ័ណ្ឌការងារសម្រាប់កម្ពុជា ក្នុងការវាស់កម្រិតការបំភាយចូលទៅក្នុងបរិយាកាស(RL/REL)។

វឌ្ឍនភាពនៃការអនុវត្តកម្មវិធី UN-REDD កម្ពុជា

សមាសភាគទី១	• សិក្ខាសាលាចាប់ផ្តើមស្តីពីការអនុវត្តកម្មវិធី UN-REDD កម្ពុជា(វិច្ឆិកា ២០១១) • បង្កើត**ក្រុមការងាររេដ+កម្ពុជា** ដែលមានសមាជិកចំនួន០៩រូប តំណាងមកពីក្រសួង ស្ថាប័នពាក់ពន្ធ័ និងកិច្ចប្រជុំប្រចាំខែរបស់ក្រុមការងារ **(២៨ ខែកញ្ញា និង ២៥ ខែតុលា ឆ្នាំ២០១២**
	បង្កើត**លេខាធិការដ្ឋានក្រុមការងាររេដ+កម្ពុជា** និងការអនុវត្តការងារជាប្រចាំ • មន្ត្រីចំនួន៧រូប មកពីស្ថាប័នអនុវត្តកម្មវិធី(GDANCP, FA, FiA) • មន្ត្រីកិច្ចសន្យាកម្មវិធី UN-REDD ចំនួន៤រូប បានបំពេញការងារនៅក្នុងលេខាធិការដ្ឋានក្រុមការងាររេដ+កម្ពុជា(UNDP) **ក្រុមប្រឹក្សាប្រតិបត្តិកម្មវិធី** (PEB)និងការប្រជុំជាប្រចាំ(ចំនួន២លើក: ០៧ ខែមិថុនា និង ០៣ ខែតុលា ឆ្នាំ២០១២)។ កិច្ចប្រជុំលើកទី៣ គ្រោងរៀបចំនៅថ្ងៃទី ១៣ ខែធ្នូ ឆ្នាំ២០១២ **ទស្សនៈកិច្ចសិក្សា**ស្វែងយល់ពីការអនុវត្តកម្មវិធី UN-REDD នៅប្រទេស វៀតណាម និងហ្វីលីពីន

	• រៀបចំ និងកែសម្រួលពង្រាងគោលគំនិតសំខាន់នៃការបង្កើតបណ្តាញតំបន់ការពារធម្មជាតិ (CPA Concept Note) • ជ្រើសរើសតំណាងសង្គមស៊ីវិល(១រូប) និងជនជាតិដើមភាគតិច(១រូប) ចូលរួមជាសមាជិកក្រុមប្រឹក្សាប្រតិបត្តិកម្មវិធី។
	• រៀបចំគោលគំនិតសំខាន់សម្រាប់សកម្មភាពបង្កើតវែបសាយស្តីពី REDD+ នៅកម្ពុជា • រៀបចំផែនការប្រឹក្សាយោបល់ និងការចូលរួម • រៀបចំគោលគំនិតសំខាន់សម្រាប់សកម្មភាពបណ្តុះបណ្តាល និងបង្កើនការយល់ដឹងពី REDD+។
សមាសភាគទី២	រៀបចំគោលគំនិតសំខាន់សម្រាប់សកម្មភាពរៀបចំផែនការយុទ្ធសាស្ត្រគ្រប់គ្រងតំបន់ការពារធម្មជាតិ
សមាសភាគទី៣	រៀបចំលក្ខខណ្ឌការងារ (ToR)សម្រាប់ក្រុមការងារបច្ចេកទេស
សមាសភាគទី៤	• វគ្គបណ្តុះបណ្តាលដល់មន្ត្រីរដ្ឋាភិបាល និងអ្នកពាក់ពន្ធ័ (ការត្រួតពិនិត្យព្រៃឈើតាមផ្កាយរណប នៅប្រទេសប្រេស៊ីល។ល។ • សិក្ខាសាលាចាប់ផ្តើមសម្រាប់ការរៀបចំការធ្វើសារពើភណ្ឌព្រៃឈើជាតិ • ពិនិត្យឡើងវិញពីនិយមន័យព្រៃឈើ ការប្រើប្រាស់ដី • ប្រមូលព័ត៌មាន ទិន្នន័យសម្រាប់ការធ្វើសារពើភណ្ឌព្រៃឈើ និងគម្របព្រៃ និងទិន្នន័យនៃការប្រើប្រាស់ដី

សកម្មភាពអនុវត្តបន្ត

- កិច្ចប្រជុំរបស់ក្រុមការងារREDD+កម្ពុជា និងក្រុមប្រឹក្សាប្រតិបត្តិរបស់កម្មវិធី
- វគ្គបណ្តុះបណ្តាលក្រុមការងារREDD+កម្ពុជា
- វគ្គបណ្តុះបណ្តាលក្រុមការងារលេខាធិការដ្ឋាន ស្តីពីគោលការណ៍ណែនាំសម្រាប់ អនុវត្តន៍ថ្នាក់ជាតិ និងរបាយការណ៍លទ្ធផលត្រួតពិនិត្យលើប្រព័ន្ធហិរញ្ញវត្ថុ
- ការជ្រើសរើសឡើងវិញនូវតំណាងសង្គមស៊ីវិល និងជនជាតិដើមភាគតិច និងការលើកកម្ពស់ចំណេះដឹងអំពីគម្រោងកម្មវិធី REDD+កម្ពុជា
- ធ្វើការត្រួតពិនិត្យទៅលើគម្រោងសំណើនៃការគាំទ្រទៅបណ្តាញ CF និង CPA
- បន្តដំណើរការបង្កើតគេហទំព័រ
- ចាប់ផ្តើមដំណើរការជ្រើសរើសក្រុមការងារប្រឹក្សាយោបល់ និងកិច្ចប្រជុំក្រុមការងារ

- ផលិតឯកសារអប់រំ សម្រាប់ចែកចាយជូនសហគមន៍ និងអ្នកពាក់ព័ន្ធអំពីកម្មវិធី REDD+
- ធ្វើការប្រកាសជ្រើសរើសអង្គការមានសមត្ថភាពក្នុងការអនុវត្តសកម្មភាពការកសាងសមត្ថភាព និងដំណើរការលើកកម្ពស់ចំណេះដឹង
- បន្តពិនិត្យទៅលើគម្រោងសាកល្បងដែលបានកំពុងអនុវត្តន៍
- រៀបចំបង្កើតក្រុមការងារបច្ចេកទេស
- សិក្សា និងវាយតម្លៃពីសក្តានុពលភាពព្រៃលិចទឹក និងព្រៃកោងកាងក្នុងការអនុវត្ត REDD
- បន្តប្រមូលព័ត៌មាន ទិន្នន័យសម្រាប់ការធ្វើសារពើភណ្ឌព្រៃឈើ និងគម្របព្រៃ និងទិន្នន័យនៃការប្រើប្រាស់ដី
- វគ្គបណ្តុះបណ្តាល Image Interpretation។ល។

សូមអរគុណ