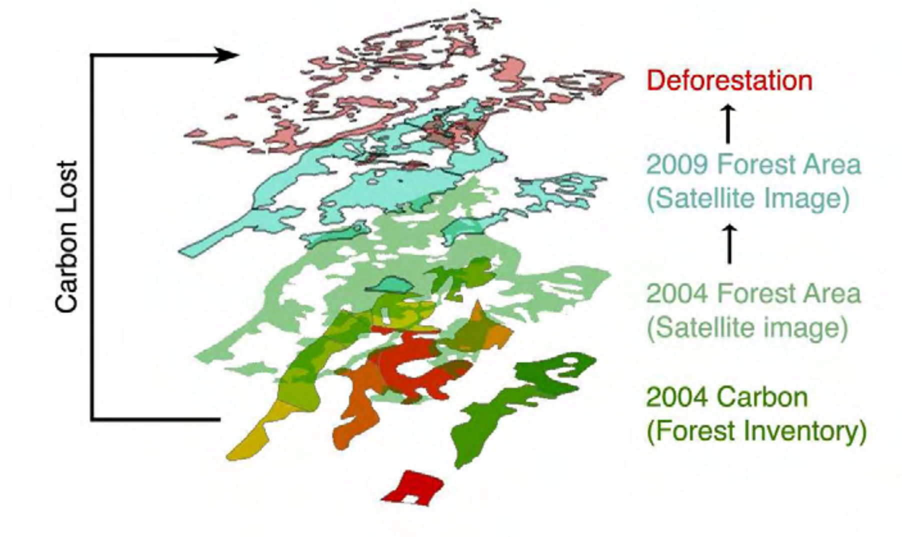
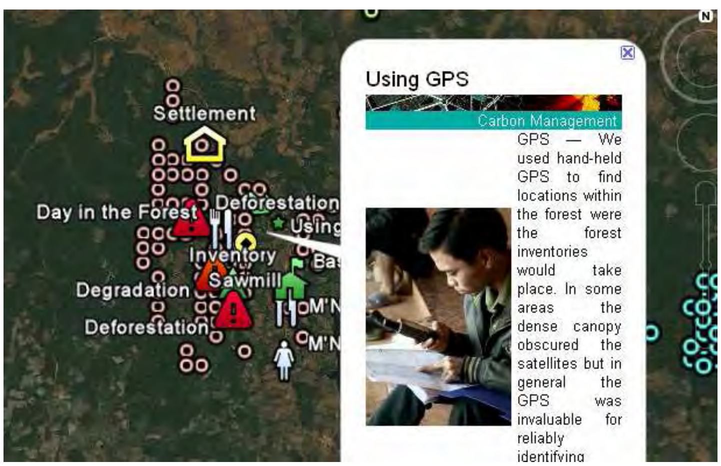


REDD Pilot Report



Supported by Google.org, GTZ, Planet Action, Spot Image, GIS Corps, CartONG

CartONG and GTZ | Tuesday, 31 August 2010

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Summary

The aim of this project is to support Vietnam in finding a REDD mechanism, which integrates the local forest owners and thus should contribute to livelihood improvement and sustainable management of natural resources. In doing so a number of individual objectives were achieved. The project areas are community liable forests in the Central Highland region of Vietnam. We used participatory carbon stock assessment (PCSA) to determine the current carbon quality of the forest and lay the empirical grounds for a sustainable forest management plan (SFM).

The past and the future conditions of the pilot forests were addressed. Satellite imaging and analysis was used to determine the rate of deforestation and subsequently also to make some estimate of degradation of the forest. The future condition of the forest has been estimated using a carbon projection model. Both the satellite image processing and the model required the detailed forest inventory data to calibrate their formulae.

A number of key findings were made in the process. The experience has shown the PCSA can be very successful and that local people in this area of Vietnam have the capacity for being trained in and executing the guidelines. The output from the model shows that SFM in conjunction with payment for carbon protection would result in greater income to the local people and a sustainable carbon sink.

Of course the predictive aspect of these results is speculative not least because the exact arrangement of UN-REDD is yet to be determined. How, for example, the benefit of protecting forests is shared within a country will influence the amount of money that the people in our pilot areas would receive. Nonetheless the project has shown that protecting carbon using SFM works.

This is a joint project between the GTZ and CartONG. The project was supported by a grant from Google.org and in-kind donations like satellite images and image classification software from the Planet Action Group. Additionally, GISCorps was assisting with the image interpretation through identifying a volunteer ready to work on this particular aspect.

Background

Forests, Climate and Global Finance

Deforestation and forest degradation of natural forests continue despite more and more efforts are made to implement Sustainable Forest Management (SFM). SFM is a dynamic and evolving concept that aims to maintain and enhance the economic, social and environmental value of all types of forests for the benefit of present and future generations. (Non-legally binding instrument (NLBI) of the United Nations Forum for Forests, 2007). In a stricter sense "maintain" the forest can be interpreted as an extraction of timber volumes as well as other sources limited to the yearly increment increase in forest volume. SFM is mostly undervalued due to the lack of markets or other compensation mechanisms for most non-timber forest goods and environmental services. Thus, sustainable managed forests often fail to compete with other land-use opportunities such as agriculture. Stopping forest degradation and deforestation — and enhancing the contribution of forests to development — requires an increase in the revenue from sustainable forests.

Payments for storage and binding of carbon in forests can close this gap, while they play an important role in providing alternative sources of energy and mitigating climate change. The concept of Reducing Emissions from Deforestation and Forest Degradation (REDD) recognizes forests' role in climate-change mitigation. By attributing financial value to carbon, REDD increases the economic value of natural forested land irrespective of timber quality or accessibility, and thus, could lead public and private sectors to invest in forests previously not commercially viable. REDD contributes to SFM by increasing forests' financial value and hence decreasing the conversion into agricultural lands.

Early experiences with the REDD approach revealed some major shortcomings: (i) countries with a high forest cover but low deforestation rates cannot participate, those being Panama, Colombia, Democratic Republic of Congo, Peru, Belize, Gabon, Guyana, Suriname, Bhutan and Zambia, and with French Guiana. These countries contain 20 percent of Earth's remaining tropical forest and 18 percent of tropical forest carbon. (ii) Poor countries with already diminished forest resources cannot participate, even if they want to replant forest to sequester carbon and (ii) the highest carbon benefits can be generated from areas where the forests are not used. This third point means that people living in the forest may be forced to leave their forest areas, the justification being that the government needs to develop the country as a whole. As a consequence governments together with NGOs demand further development of the REDD approach, which resulted in the adding of a "+".

REDD+ (REDD "plus") expands the scope of REDD beyond avoiding deforestation and degradation to include forest restoration, rehabilitation, sustainable management and/or afforestation or reforestation. This concept was introduced during the Climate talks in Ghana 2008. Thus, throughout this report the term REDD always include REDD "plus". However, it is not yet decided which specific activities will be included in REDD+ and the last conference of Parties in Copenhagen (COP 15) did not result in a clear roadmap to carry out REDD 'plus'.

The combination of benefits from REDD with sustainable forest management is a relatively new and challenging issue. The consensus opinion of this project is that without the integration of local people into forest and carbon management, REDD(+)'s aims will not be achieved. Ideally the local forest owners would be directly integrated as beneficiaries of the upcoming REDD scheme. However the Government of Vietnam tends to favour another option. In Vietnam local people are contracted to patrol and protect *state owned* forest areas. Currently, the Ministry of Agriculture and Rural Development increased the payment up to 200,000 VND/ha/year (government programme 661). These payments can be insufficient, and additional money from REDD could, theoretically, improve the situation given the right parameters and benefit-sharing structure. Provincial Forest Protection and Development Funds will be established to manage these future funds.

UN-REDD Program

Financing instruments have been developed for climate change adaptation and mitigation, including projects on forest management, under the Climate Change Convention and Kyoto Protocol. The evolving policy discussions within UNFCCC[1] to establish a financing mechanism for REDD[2] have created high expectations for its role in SFM. The UN-REDD programme will support a selection of countries with tropical forests as part of an international strategy to include REDD in a new and more comprehensive UN climate change arrangement for 2012 onwards. It aims to shift the economic balance in favor of SFM so that forest benefits go to communities and forest users while also reducing greenhouse gas emissions.

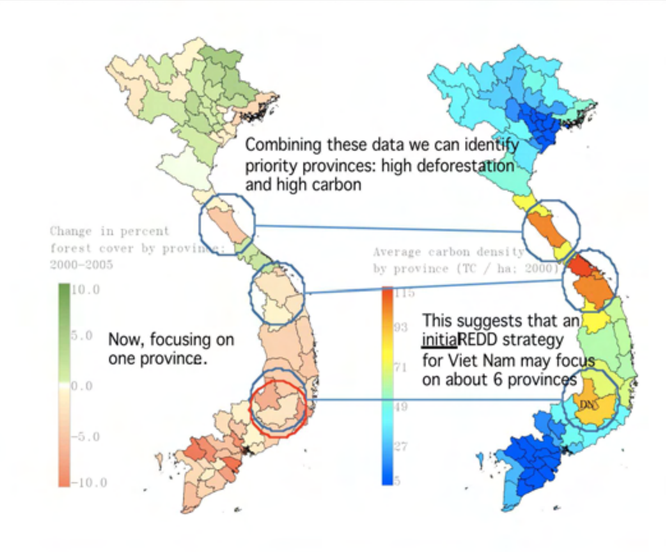


Fig. 1 This figure shows the rational behind the selection of Dak Nong for this project. The map on the left shows that the province has comparatively high deforestation. The map on the right shows that the Central Highlands have some of the highest carbon density in the country.

Vietnam is among the 14 countries which were selected for the UN-REDD Program and has already received the approval for an R-Pin (Readiness Plan Idea Note) by the World Bank's Forest Carbon Partnership Facility (FCPF). The Government of Vietnam, the UN-REDD program and the WB FCPF have agreed that these two initiatives should be aligned where possible. Lam Dong province was selected as a pilot area for the UN-REDD program. Experiences in Payment of Environmental Services (PES) schemes (gained by the GTZ in Son La provinces) would also be considered. The steps envisioned included establishing a national coordination mechanism, setting-up a national reference scenario, building a resilient national REDD framework, establishing robust systems for monitoring, assessment, reporting and verification of forest cover and carbon stocks, increasing awareness of approaches for reducing regional displacement of emissions and, building necessary capabilities with support for others who wish to follow in due course.

This program seeks to address deforestation and forest degradation through capacity building at national and local level. It consists of three main components: (i) Improved institutional and technical capacity on national level, (ii) Improved capacity to manage REDD on local level (province, district, and commune) and (iii) Improved knowledge of approaches to reduce regional displacement of emissions.

The outputs of Outcome II were formulated as follows:

Output 2.1: REDD potential **mainstreamed** in provincial and district-level forest land-use plan

Output 2.2: **Participatory** "C-stock" (volumes of carbon in different forest stocks) monitoring system

1 United Nations Framework Convention on Climate Change (UNFCCC)

2 The term "REDD" is used for both "traditional" REDD and REDD+ within this document.

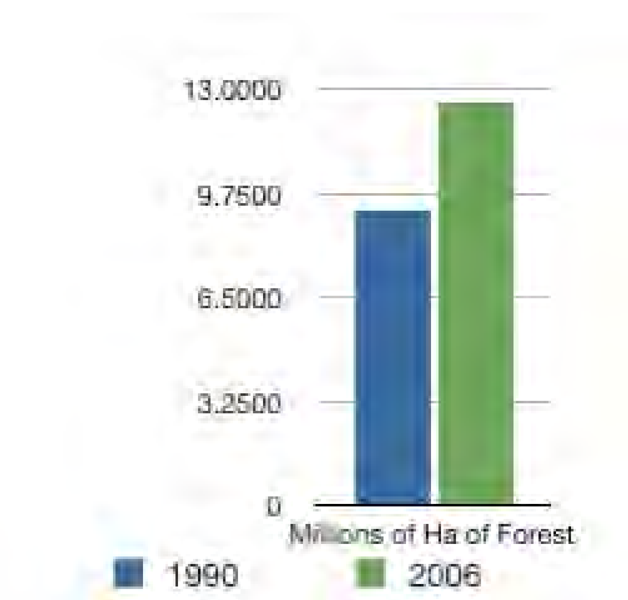
Output 2.3: Equitable transparent **benefit sharing** payment systems

Output 2.4: **Awareness-raising** at provincial, district and local levels

Vietnam's Lam Dong province was designated as pilot province for the UN-REDD program. Nevertheless, lessons learned by donors and government agencies outside of Lam Dong have been incorporated into the UN-REDD effort. Other provinces have been encouraged to participate, with six shortlisted for UN-REDD on the basis of high deforestation and degradation rates and sufficient standing forest to warrant protection. The province to which this report pertains, Dak Nong, is considered to have the great potential (see Fig. 1 on the previous page).

In order to facilitate this process, the UN-REDD program established the UN-REDD Working group. This working group was divided into 4 sub-groups: (i) REDD governance, (ii) REDD carbon accounting (carbon inventories, data management), (iii) REDD financing and benefit sharing and, (iv) local implementation of REDD in rough accordance with the outputs of Output II (see previous page).

In 1993 GTZ launched the Social Forestry Development Program in the North of Vietnam. This resulted in several projects engaged in natural resource management, forestry and rural development. A comprehensive study on the state of the art of community forestry in Vietnam (Wode, Bao Huy, June 2009) summarized experiences of Community Forestry in the country (including CFM projects of various donors). Experiences from the field suggested a promising benefit sharing payment system for REDD[3]. This was presented at the Conference of Parities (COP) 15 in Copenhagen. This study has been embedded in the UN-REDD program and contributes to Output: 2.3 ("Equitable transparent benefit sharing payment systems").



This project in context of REDD

This Google financed REDD readiness project directly contributes to Output 2.2 of the UN-REDD program:

"Participatory "C-stock" (volumes of carbon in different forest stocks) monitoring system"

The project is embedded in the Environmental Protection and Natural Resource Management Project (EPMNR) in Gia Ngia, Dak Nong. It is the strategy of the EPMNR to seek innovative forest financing mechanisms in order to increase the benefits from forests, which should also enhance the protection of the forests by a more involved model of ownership.

This is a joint project between the GTZ and CartONG. The project was supported by a grant from Google.org and in-kind donations like satellite images and image classification software from the Planet Action Group. Additionally, GISCorps assisted with the image interpretation through identifying a volunteer ready to work on this particular aspect.

[3] http://www.un-redd.org/UNREDDProgramme/CountryActions/Vietnam

Vietnam's Forests

The state of Vietnam's forests has been inextricably linked to the country's history: once ravaged by war and now threatened by a modernizing world. In recent years, however, Vietnam's forest area has increased; expanding from 9.18 Mill ha (27.2%) in 1990 to 12.61 Mill ha (37%) in 2006. This is a laudable achievement, but the forest gains are by plantation establishment, while exploitation and degradation of natural forest areas continues. However, Vietnam is making progress in slowing the rate of natural forest degradation by reforming the forestry sectors and transferring forests from big state forest farms to households (HH) or communes. Forest management plans and training were provided for the communes/HH.

The government is interested in finding ways to protect the forest in an economically responsible way. They have been testing and analyzing the potential of different methods, for example Payment for Environmental Services, REDD or FSC Certification.

The aim of this project is to support Vietnam in finding a mechanism to improve the livelihood of the poor by increasing the value of their forests by setting up a REDD pilot.

Integration of partners, distribution of results and shortcomings

Provincial level

One of the key issues, for all development activities, is the involvement of relevant partners and stakeholders in the process. Thus, the project elaborated a very clear strategy defining responsibilities and task for every stakeholder (Annex 2: Objectives and Tasks of involved stakeholders).

Objectives and challenges were discussed at the inception workshop held on the 22nd September 2009. Colleagues participated from the Ministry of Agriculture and Rural Development (assigned by the Government of Vietnam to be in charge for REDD issues). The national level delegates explained the importance of REDD, and the current status, to the provincial participants. Tay Nguyen University described their scientific work on the issue and at the end of the workshop presented detailed practical steps including budget issues. The workshop was a success and resulted in an approved Memorandum of Understanding and provincial approval of the project.

Provincial partners were trained how to implement the new guideline and they participated during the forest inventories. Unfortunately detailed discussions of the REDD approach were not feasible and the governmental departments did not follow up on the tasks that they agreed to at the inception workshop. Some aspects of the project, such as economic development, have been handled diligently but others, such as land-use change, have been less than satisfactory.

In the modeling of the carbon projection the project applied the "gain-loss" approach, which simulated carbon stock developments based on statistical calculations and actual field measurements. The technique is very involved and therefore it was impractical to integrate provincial partners into the elaboration of the model itself.

Currently the UN-REDD program in Vietnam has focused on political discussions and passed on the provincial level piloting to international consultants. Increasingly the Vietnamese government is being involved in this activity but the exchange of knowledge about the technical specifications of the processes is still limited. In addition, decisions have not been made on an international level such that procedures can be standardized. It was hoped that some of this would have been decided at Copenhagen and had

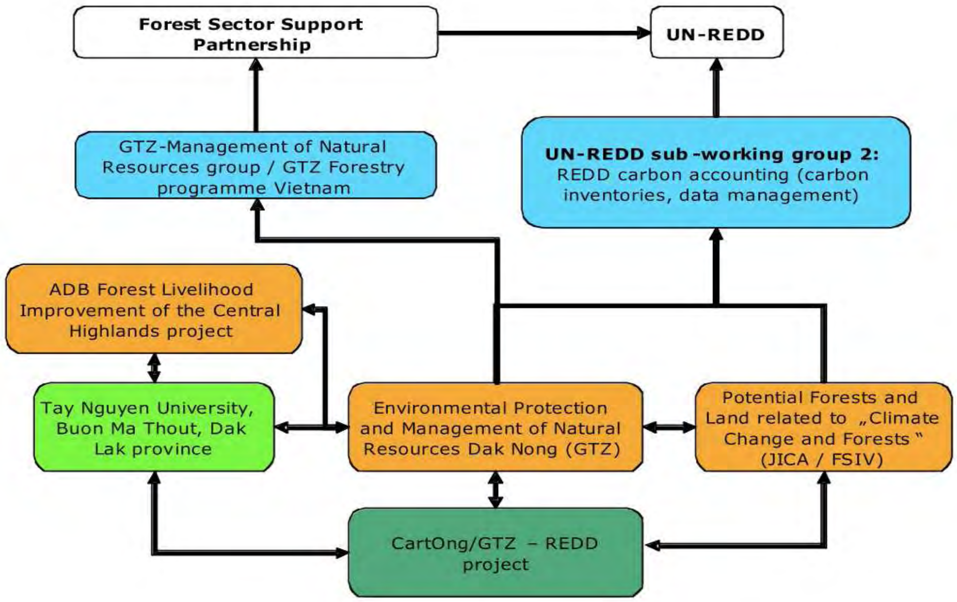


Fig. 3 This figure shows the project in the context of other actors in the region concerned with REDD on a provincial and national level.

this happened then the projects around the world would have a better basis for increasing the capacity of the local counterparts. In March 2010 a UN-REDD consultant proposed possible ways that the carbon reference emission level could be measured but there was no decision made on which of those would be used going forward. The EPMNR project will integrate lessons learnt into the UN-REDD discussion process (see: National Level). If the Vietnamese government decided to use the "gain-loss" modeling technique then our model could be used as a well developed starting point. It should be clear, that the model in its current state is reliable but in order to publish it officially a scientific revision process must be initiated. If the Government of Vietnam decides to do so, the Tay Nguyen University, FSIV and FIPI will be integrated in the revision process and, thus, should enhance their capacity.

The forestry department will establish permanent sample plots which would allow a permanent monitoring of forest changes, the locations of which have not yet been determined. By doing so, the Government of Vietnam will enable the "stock-based approach" to carbon projection modeling which compares two points in time and extrapolates from the trend. Technically, this approach is simpler than gain-loss but more time is needed and in many countries reliable data is not available at two or more points in time.

The GTZ project supported the establishment of a provincial forest consultative group. This group should serve as a "thinktank" for the province as well as enhance the cooperation between different departments. The group is made up of 15 members, 10 department leaders, one GTZ and one ADB FLITCH staff and three technical advisors. All results of this project will be presented to this group. At the moment, Vietnam is still not "REDD ready" and there is a concern that this project will languish at the provincial level. Thus, results and lessons learnt must be integrated in the national level as soon as possible.

National and International level

The UN-REDD program coordinates its activity with the Forest Sector Support Partnership (FSSP). This network was established 2001 and aims to create an effective partnership among international and national forest stakeholders. The FSSP is co-chaired by the GTZ.

Another important multiplier will be the Tay Nguyen University who were continuously informed of the project's progress. Knowledge gained here will enhance the capacity of students and lecturers as well as provides the basis for further scientific work.

During the project implementation preliminary results were shared with the ADB Forest for Livelihood Improvement in the Central Highlands (FLITCH). This project is working in all five highland provinces and Phu Yen province on provincial forest management plans based on forest inventories and satellite images from December 2009 (SPOT 5). The project is already delayed due to complications in the implementation procedure. Since the ADB project is steered from the national level it is unlikely that our findings will be incorporated even if the Provincial Project Management Unit is very cooperative. Hopefully, because ADB FLITCH is working in the same target district as the GTZ project, Dak R'tih, follow-up activities or monitoring will take our results into account.

The Japanese International Cooperation Agency (JICA) started a study on "Potential Forests and Land related to Climate Change and Forests" (October 2009). One of the study objectives is the potential of Community Forestry and REDD. JICA decided to carry out further in-depth studies within our pilot areas. JICA contracted the Forest Science Institute of Vietnam (FSIV) to implement the field work in Dak Nong. All activities will be closely coordinated with the GTZ EPMNR project.

In conclusion it can be stated that all effort will be made to integrate the experiences gained from this project into the national REDD discussion. Regarding the institutionalization of REDD procedures in the province there will be no follow-up without project support. If the national level enables the environment for REDD, it will provide clear guidance (regulations, implementation procedures, guidelines) to the province, which will establish a provincial "REDD working group" and all relevant departments: this is the nature of a centralized government system.

Methods

Summary Diagram

The diagram right (fig. 2) summarizes the steps taken and data sources used in the process of this project.

The primary data sources were **satellite images**, forest inventories and maps available in the archives.

Satellite images were used to guide the locations of the data collection points in the **forest inventory** and to determine the amount of deforested land between 2004 and 2009.

The forest inventory data itself was in basal-area per Ha and this was **converted to carbon per Ha** using a formula developed at the Tay Nguyen University.

The carbon per Ha values at each measurement point were **interpolated** into a surface that extended to the edges of the 2009 forest boundary using kriging, a geo-statistical interpolation method.

The interpolated carbon map from 2009 was then compared to the results for the 2004 inventories to determine the change in carbon content that had occurred within the forest that remains. The carbon content in 2004 was used alongside the forest area change maps to estimate the amount of carbon that was lost when those areas were cleared.

Increment data, the rate of tree growth, the baseline carbon content and the planned community forest management scheme were used to calibrate **carbon projection model**.

Finally, **Google Earth's KML** format was used to present the results online on an interactive platform that allowed the data to be explored by anyone with access to the internet. The KML data was also made available for download so that it could be inspected in more general contexts.

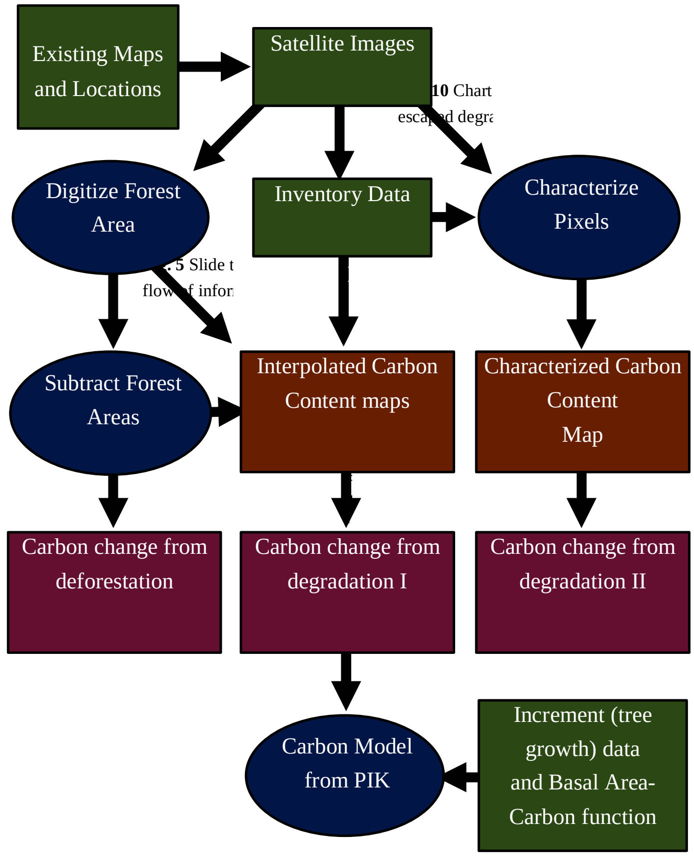


Fig. 4 This figure outlines the processing methods used in this project. The arrows indicate that the output of the process feeds into the following stage.

Data Sources and Processing

Summary of Sources

Type	Source	Description
Satellite Images	SPOT Images: 5 277-326 09/03/15 03:05:32 2 J Level 1A SAT 0	
Satellite Images	SPOT Images: 5 277-326 04/01/03 03:15:451 J Level 1A SAT 0	
Satellite Images	**SPOT Images:** **S5_277-326 15/03/2009 J** **Level 1A SAT 0**	

Type	Source	Description
Forest Inventory	2004	Forest Management Plan was elaborated for Thon 6 with support of the Tay Nguyen University and the HELVETAS supported Extension and Training Support Project for Forestry and Agriculture in the Uplands (ETSP) Forest plot description are incorporated in the plans, which allows a rough calculation of forest structure and forest volumes. No GPS coordinates were recorded.
Forest Inventory	2009	Each area (Thon 4, 5, 6) required a separate inventory lasting 6-8 days in the field. Inventories were performed by the local stakeholder villagers with advice from Vietnamese technicians from government, GTZ or educational institutions.
Carbon stock – Biomass relation	2009	This regression formula was elaborated by the Tay Nguyen University. This relation is an important parameter of the computed model and allows to calibrate the model to local conditions

Satellite Images

The satellite images were used in three principle ways: 1. to determine the areas of forests for the inventories; 2. to determine the deforestation from 2004 to 2009 and; 3. to verify the carbon estimates using image analysis.

Areas for Forest Inventory

The areas for the forest inventory were determined by a combination of visual inspection of the 2009 satellite image and rough ground measurements with a hand-held GPS device. This iterative process of digitizing the forest, checking and adjusting was necessary because the satellite images were more than six months old. Unfortunately, six months is sufficient time for significant deforestation to have taken place. The result was good quality maps of the perimeter of the forest areas which would then be populated with locations at which the inventory measurements would take place. There was some attempt to use the Google images from Google Earth which can be freely accessed online. However the images were too old, perhaps only 6 months, to be used for delimiting the forest boundaries because the rate of deforestation is so rapid.

Forest Cover Change

Deforestation was determined by comparing the 2004 forest cover map with 2009. Of course the 2004 forest perimeter could not be verified by *in situ* measurements. The measurements for the 2009 map were made to guide the inventories and not to alleviate doubt about the perimeter determined from the SPOT image therefore satellite alone was sufficient for 2004. As a result, the 2004 forest perimeter is from March and the 2009 from October. The two forest shapes were subtracted from one another leaving the forest change: deforestation and afforestation. The carbon content of the deforested areas could be estimated in the case of Thon 6 since there had been a reliable forest inventory in 2004. The values were taken from the 2004 map and superimposed upon the shapes of the areas that have been deforested.

Satellite Classification

After the fieldwork started and was completed in one of the villages; it was found that whereas the newly collected data would give a good overview and provide a good base for the Carbon stocks model projecting future carbon contents under different forest management scenarios; the data on carbon content which could be obtained through past forest inventories was fragmented and verification needed. Especially the range on carbon content was reported to be much higher in 2004 than 2009. Whereas this was to be expected, the differences were striking and raised questions.

Therefore, it was decided to find a specialist who would be able to work on extracting carbon content values based on the fieldwork conducted in 2009 and compare it to 2004. Satellite images for both periods were available; donated through the Planet Action Initiative by SPOT image as well as SNV (Image references: S5_277-326_15032009, SCENE 5 277-326/0 04/01/03 03:15:45 1 J). For 2004, only the interpolated Carbon Content in forms of shapes was available and therefore could not be taking into consideration as the coordinates of the original plots were unknown.

Fortunately Jason San Souci (GISCorps Volunteer initiative), who had many years experience of working with satellite images and questions of carbon content classified the images according to the inventory data. He used the following process to complete the classification:

Converting the Digital Number (DN) values to planetary unitless reflectances; some input was given by the SPOT technical team

Overlaying the plot coordinates of 2009; extracting the DN values

Computing the average Carbon content based on the extracted DN values

Applying the average Carbon content on Thon 4 and 6 as well as on the full images

Forest Inventory

Participatory Carbon stock Assessment

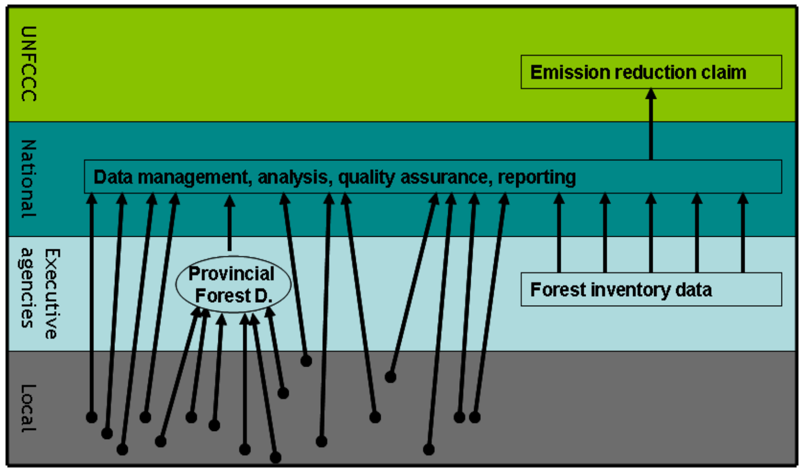


Fig. 5 Slide taken from Patrick van Laake, Presentation at the inception Workshop 3. Shows schematically he flow of information about the forests.

Satellite images and interpretation algorithms are sufficient to define deforestation rates but the analysis of *degradation* dynamics needs measurement on the ground. From the satellite-view of the forest - the canopy - it is impossible to be accurate about the integrity of the forest without at least calibrating satellite analysis with on-the-ground measurements of the trees and vegetation in a systematic way. There are two possibilities when it comes to finding someone to perform this measurement task. Either local people / local forest owners collect the data or independent consultant bodies are contracted. The Government of Vietnam tends to choose the latter because at present only 1% of forest land is under the jurisdiction of communities.

Nevertheless, in order to protect a forest it is important to integrate local people in any forest management plan. Basic forest inventory measures such as identifying tree species and measuring diameters are effective means to integrate local people in the process. Furthermore, assigning local people to monitor forest areas is by far the cheapest solution and can cover large areas. Conceptually, all major national forest programs try to involve local people into forest protection efforts by provision of financial compensation due to above mentioned reasons. In order to make use of this resource, private forest consultancies, which are needed to control and monitor large forest areas of State Forest Enterprises, could (partly) consist of local forest owners.

The next steps for community owned forests is to involve local people to an even greater extent and prepare the way for REDD. Experiences derived from several forest projects in Vietnam show that without the participation of local people, forest protection is not feasible. Thus, the GTZ in Vietnam promote the integration of local people in any REDD related activity right from the beginning. The fig. 5 above displays a potential system to gather relevant data for REDD.

Even if the methodology of Participatory Carbon Stock Assessment (PCSA) is well known, piloting of this approach has not been taken place in Vietnam until now. Pioneering PCSA in practice in Dak Nong is sensible: Dak Nong has good REDD potential and Tay Nguyen University has carried out scientific work on carbon contents in the area. Students led by faculty staff conducted numerous field measurements. On that basis the University elaborated a mathematic regression, which allows the conversion of measured forest inventory data into carbon values.

The objectives of the participatory forest inventory can be summarized as follows:

Elaboration of a Participatory Carbon Stock Assessment (PCSA) guideline, Piloting of this guideline and improvement,

Ongoing capacity development of local forest owners and provincial staff,

Integration of lessons learnt into ongoing national programs and projects, e.g. UN-REDD program: Output 2.2.

Inventory in Practice

As a first step, a detailed guideline was prepared by Prof. Bao Huy who lectures at the Tay Nguyen University in Buon Ma Thout (Annex 4: PCSA guideline), which was commented on by the GTZ EPMNR project. In summary, the guideline encompasses the following *participatory* steps:

Discuss the forest status and management goals of every forest block together with the forest owners / community

Identify where the sample plots are to be measured: A map should be prepared in advance so that participants can identify the coordinates of the sample plots (grid net distance was defined as 225x225m displaying a sample plot intensity of 1% of the forest area).

Forest Inventory

Participatory summarization of collected data and discussion of outcomes

Participatory carbon calculation (carbon contents per diameter class are provided by the Tay Nguyen University)

Two days of training were conducted and with the field work directly afterwards. The use of the GPS receivers in the field required a steep learning curve but otherwise there were no difficulties. The inventory teams consisted of three to four farmers and one technician. At least two group members could write while the others measured the tress. It was ensured that at least one farmer of each group possesses sufficient knowledge to identify tree species.

The forms that were used to record data in the field can be found in Annex 4: The PCSA guideline and all tally sheets have been retained. Data collection was completed at the end of January with sorting and interpretation finished at the end of February. The GTZ EPMNR project will conduct a wrap-up meeting (discussion of the forest inventory results and participatory carbon calculations) with the villagers and present and discuss the outputs by end of May.

Interpolation of Inventory Data

To move from the points created by the forest inventory to areal data requires interpolation. The interpolation method known as kriging was chosen to interpolate the data since, when inspected, it appeared to accommodate the expected spatial dynamics of a forest most appropriately. For comparison the Inverse Distance Weighted (IDW) method which is much simpler than kriging would have predicted sharp peaks in carbon density and much higher variability in space than is expected of forests.

Ordinary kriging, which is the variety used here, has three components First, the mean value is estimated. Secondly, a correlation matrix that describes how deviations from that mean vary together in space, is generated. Finally, a krig function is generated in terms of that mean value and the covariance matrix describing the relationship between the deviations from the mean value.

2004 Forest Inventory Data

In Thon 4 forest inventory data was available from 2004 having been elaborated by the Tay Nguyen University with the support of the ETSP project. This data is in a much reduced form from the point data that was gathered in 2009. All that could be salvaged from the inventory was a map of the named sub-forests and a table of their respective basal density values. The values were used for the entirely of their corresponding sub-forests and as a result there is a high degree of uncertainty in that data. However, it is the only available inventory data that is available prior to 2009.

Carbon Projection Model

Introduction

Carbon accounting aims at setting the base for calculations on the offset of carbon emissions in difference harvest and management approaches. Two conceptual approaches are proposed in the literature to calculate carbon emissions (GOFC-GOLD 2008). The **stock-based** approach estimates the difference in carbon stocks in a particular pool at two points in time and is often applied in setting national-wide baseline degradation rates based on national forest inventories (GOFC-GOLD 2008). In contrast, the **gain-loss** approach estimates the net balance of additions to and removals from a carbon pool for different carbon pools (GOFC-GOLD 2008). We opted for implementing a gain-loss approach for two reasons. First, cross-sectional data sets on diameter increments and diameter distributions were measured as part of the participatory forest inventory. These data are required for the gain-loss approach but are not sufficient for the stock-based method. Second, it is possible to compare sustainable forest management schemes and business-as-usual degradation in terms of income for local people and carbon stocks but altering the rate of forest loss.

The model is inspired by CO2FIX (Schelhaas et al. 2004, Masera et al. 2003) in terms of structure, modules and simplicity but deviates in how it treats tree mortality, timber harvest and financial feasibility calculations. The projection of carbon stocks is not as comprehensive as a process-based vegetation model (e.g. LPJmL, Sitch et al. 2003). This is because the model uses simplified mechanisms of forest regeneration, growth, mortality and harvest in line with the limited data available in tropical and subtropical countries (Schelhaas et al. 2004, Masera et al. 2003). The model must be prepared to simulate the impact of demand for forest products (fuelwood, timber in different diameter-classes etc.) on the development of the total carbon stock. A major prerequisite in REDD studies is to precisely define forest degradation and deforestation. We use the definition of forest degradation based on IPCC (2003), extended by Griscom et al. (2009: 7) as the

> “direct, human-induced reduction in the forest carbon stocks from the natural carbon carrying capacity of natural forest ecosystems which persists for a specified performance period and does not qualify as deforestation”.

Therefore, the objectives are to estimate the natural carbon carrying capacity and the historical forest degradation of natural forest ecosystems based on calculating the carbon stock and flows in different carbon pools by means of a simulation model with feedback mechanisms of forest growth and forest degradation. The carbon stock in different carbon pools are projected according to different policy scenarios: business-as-usual degradation and sustainable forest management.

Simulation model and scenario setup

The simulation model consists of six modules – regeneration, growth, mortality, harvest, carbon budgeting and dynamic investment calculation. We loop the model over N number of years, with forest regeneration, growth and natural mortality taking place in each year.

Forest regeneration is a function of the change in number of trees per hectare due to mortality and harvest events

Forest growth is based on mean annual diameter increment from observed current annual increment data over different diameter classes from the forest inventory

Mortality due to senescence is approximated by a fixed maximum diameter which can be translated to the ratio of current biomass to potential maximum biomass per tree

Tree mortality prior to mortality due to senescence is implemented as function of forest density in three diameter cohorts

The business-as-usual scenario harvests trees above a threshold growing stock per hectare without a predefined harvest interval

Sustainable forest management-based scenarios give priority to restoring the natural carbon carrying capacity with harvesting taking place at predefined harvest intervals

The carbon budgeting module compiles the carbon emissions due to harvesting and carbon stored in each of five pools: aboveground biomass, belowground biomass, soil, litter (aboveground, belowground and foliage dead organic matter).

Dynamic investment calculations estimates the net income under different harvesting conditions for a predefined REDD project lengths. This is done with carbon costed at different dollar prices.

A spin-up phase of 200 years is needed to bring forest regeneration, growth and natural mortality into equilibrium, where the change in volume increment per hectare is close to zero. Without sample plots in undisturbed natural forest, the potential maximum biomass stock has been estimated from sample plots in village 6 in 2004. This is an estimate of the forest capacity without human intervention. Placing a 'harvest shock' on undisturbed growth causes the forest to try and restore the equilibrium condition. We shock the model in equilibrium with the observed forest degradation between 2004 and 2009. Thus, all harvest scenarios start from the degraded forest status in 2009 while forest use continues according to business-as-usual or under sustainable forest management scenarios.

Baseline scenario

The business-as-usual practice of wood harvest follows governmental regulations on the quantity of harvestable biomass. There is a prescribed minimum threshold of biomass volume of 130 m3 per hectare to be maintained on the stock. In addition, the critical minimum threshold of timber harvest is 50 m3 to warrant cost-efficient harvest and transport to saw mills. Thus the volume of aboveground biomass is used as criterion to define sustainably-managed forests, but leaves diameter distribution out of considerations. There are two major arguments against this simple harvesting protocol. First, harvesting diameter classes from 30 cm to 40 cm of major marketable tree species disturbs the natural diameter distribution, changing the species composition and disrupting income from timber sales. Second, the business-as-usual scenario alters the canopy layers and post-harvest mortality leading to changes in the ecosystem such as surface runoff and soil stabilization.

Sustainable forest management (SFM) scenario

Sustainable forest management takes harvesting and ecosystem services into account by selective logging over a range of diameter classes. This limits the impact of changing the diameter distribution and canopy layers. To evaluate the feasibility of these scenarios the revenue lost in reduced timber sales must be compared to the revenues gained from carbon credits for carbon sequestered.

In contrast to the baseline scenario there is no prescription on the minimum threshold of harvestable timber. Harvest is prescribed to be the arithmetic mean of gross annual volume increment in fixed periodic harvest intervals. Only trees with a diameter of 25 cm and above qualify for being harvested.

Increment and Forest Growth

Biomass growth is determined by tree diameter increment in each year of simulation. The mean annual increment (MAI) has been calculated as arithmetic mean from trunk discs of randomly selected cut trees gathered during the forest inventory in Village 6. The last five years were ignored since harvesting will have affected stand density and in turn MAI. According to these measurements an MAI of 0.5 cm*y^-1 for the time period before 2004 is estimated. This value is assumed to apply to the entire forest area.

Carbon budgeting

The aboveground biomass of each tree in kg dry matter was estimated with diameter-based biomass expansion factors in line with FAO methodology. Observed values for aboveground mass in kg CO_2 per diameter class were used to fit biomass expansion functions which were the same for all of the villages. The harvest residues, i.e. tree crown wood, foliage and stumps, remain in the area and enter the litter pool. The total carbon pool is the sum of all components of the aboveground biomass, the belowground biomass, the soil carbon and the litter carbon due to harvest and senescence.

The dynamic soil carbon model Yasso (Liski et al. 2005) is used to get a rough estimation for the carbon pool in the soil. The model describes decomposition and dynamics of soil carbon in well-drained soils. The current version is calibrated to describe the total stock of soil carbon without distinction between soil layers. The model can be applied for both coniferous and deciduous forests. It has been tested to describe in a wide range of ecosystems from arctic tundra to tropical rainforest. There is no interaction between the Yasso soil model with the biomass growth model.

Financial feasibility calculation

The financial analysis compares costs and revenues based on the total carbon accumulated in different scenarios over time. The question pertains to the given price of CO_2/tonne to make a REDD project financially feasible. The REDD project is treated as any other capital investment. The opportunity costs of foregone timber extraction are considered the minimum payable to the resource owner to agree to reduce harvest activity. There is no reason however why the payment for sequestering carbon should not exceed this minimum. Since there is reason to expect uncertainty in the carbon price we analyze with carbon prices of 10USD, 25USD and 50USD throughout the duration of the project.

Different cost types, i.e. setup costs (forest management planning) treated as fixed costs, operating costs (monitoring costs, cutting and hauling costs) and natural resource tax on harvested timber volume are defined from local data and expert estimates. However, several other setup costs types, i.e. feasibility study, preparing communities for participation, setting up payment scheme and operating costs, i.e. administration costs have not been included.

Outputs

The output is thematically divided into biological and economic outputs. Biological outputs comprise, inter alia, carbon pools for each 5-year time step for the number of time steps simulated. Financial feasibility results are produced in separate files.

Output is summarized in separate files for every management scenarios in csv-format for the ease of further processing.

Limitations of the model

A model is always a simplification of reality. The quality of results depends strongly on the availability of reliable input data and the functional relationships implemented. It is reflected by the ability to reproduce selected observation data by output data which is termed validation.

Our model is based on reliable forest inventory data from one point in time and yearly increment measurement of trees. Nevertheless, some parameters need to be estimated (e.g. potential biomass stock) due to the lack of reliable historical data and some fixed ratio between tree parameters were used due to the sake of simplicity (e.g. share of crown wood to tree wood based on yield tables of Pinus sp. monocultures).

At the current stage, the model provides reliable data but in order to validate the model a scientific discussion needs to be initiated. It is a common procedure in the scientific work that any elaborated model is officially announced and discussed to gain pros and cons. Recommendations should be integrated in the current model. A second forest inventory after a certain time period is needed as well to validate that simulated carbon development matches carbon changes in reality.

Results

The multifaceted nature of this project means that there are a number of different results to discuss. First is the completion of the PCSA. This is in itself a result since PCSA has not been practically implemented in before in Vietnam. Second are the numerical results from the forest inventory and satellite image analysis done to determine the current and past conditions of the forest. These show that the current state of the forest is much worse than in recent years and suggest that if past trends continue then the forest will be in danger. Third is the model and its projections into the future. The model has results of two forms: carbon stocks and financial gains. There is a lot of data in the output but it is clear that according to the model SFM and payment for carbon at a reasonable level would offer greater income to local people while preserving carbon stocks for the world.

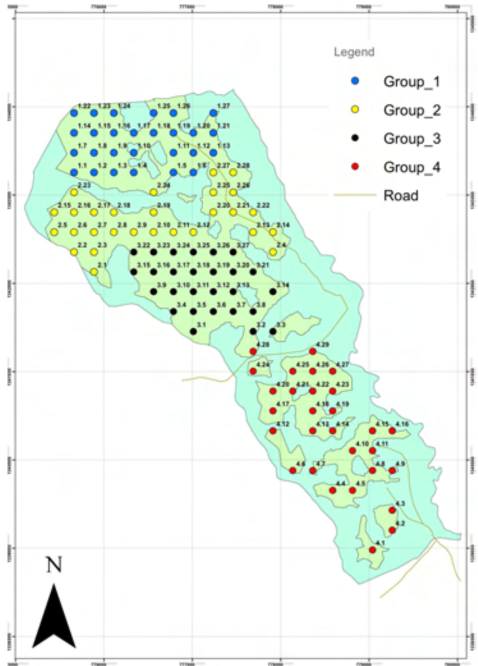


Fig. 6 Locations of measured points for Thon 4 (Village 4). The points are clearly snapped to a grid overlaying the forest area. This map was used in the field, the different groups refer to the inventory groups performing the measurements.

PCSA

The inventory teams measured 56 sample plots in Thon 6, 108 in Thon 5 and 134 in Thon 4. Each sample plot has an area of 500 m2 (20 x 25 m). The total investigated area comprises about 1,500 ha or 1% of the total forest area. Approximately 150 different tree species were recorded, underlining the high biodiversity value of these forests. Tree names were recorded in M'Nong as well as in Vietnamese language but classification by scientific nomenclature require the support of a botanical specialist.

Total costs for training and implementation were 5,190 US$, which means 17 US$ per sample plot and 3US$ per ha respectively. These costs are relatively small compared with forest inventories carried out by governmental staff only, which are about three times higher.

The trained methodology could be applied in the field without any restrictions. Technical staff supported the villagers by using GPS receivers to identify the sample plots. Villagers established the sample plot, measured and recorded all needed data self-handed. Training and implementation enhanced the capacity of local and provincial staff.

Historical Carbon

Afforestation and Deforestation

The preliminary satellite image analysis, perimeter assessment and forest inventory allowed for accurate measures of afforestation and deforestation to be ascertained. In the cases of Thons 4 and 5, where no previous forest inventory data was available, changes in the size of the forests were the entirely of the historical description. Degradation, which will be dealt with in the following section, was the remit of Thon 6 alone.

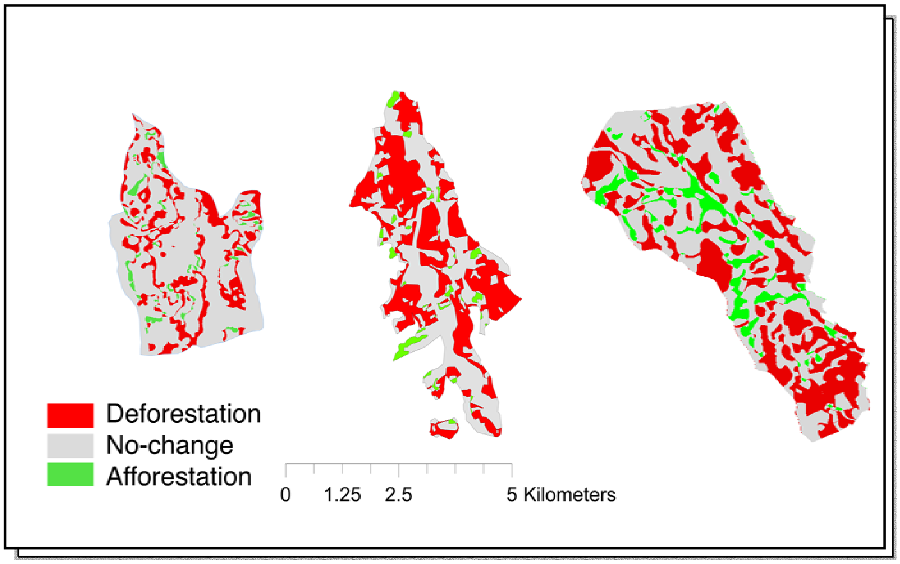


Fig. 7 Map showing the areas of deforestation and afforestation for Thons 4, 5 and 6 in the five year period between 2004 and 2009. This map view of the historical situation makes the impact of deforestation very clear.

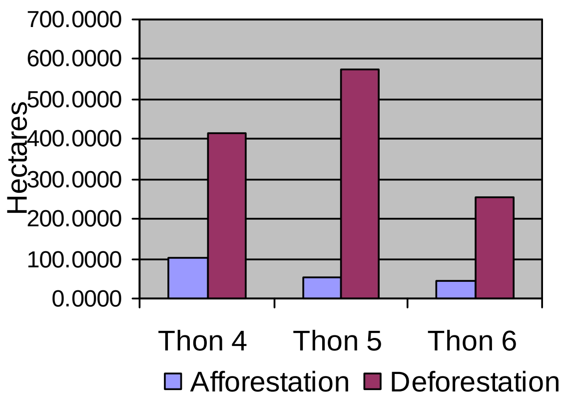


Fig. 8 Chart showing the absolute afforestation and deforestation figures for Thons 4, 5 and 6.

To the left Fig. 8 shows the absolute amounts of deforestation and degradation that took place in the five years between 2004 and 2009. Starkly, the deforestation rate has far exceeded the afforestation rate. It is important to be reminded at this point that in terms of carbon contribution newly planted trees, often of a fast growing tree like pine, cannot match long standing natural forest, to say nothing of the biodiversity impact of replacing natural forest stands. Although it is not possible to estimate for all the Thons the carbon content loss in the deforestation a reliable heuristic is at least that afforested areas are far below a one-to-one replacement for natural stands.

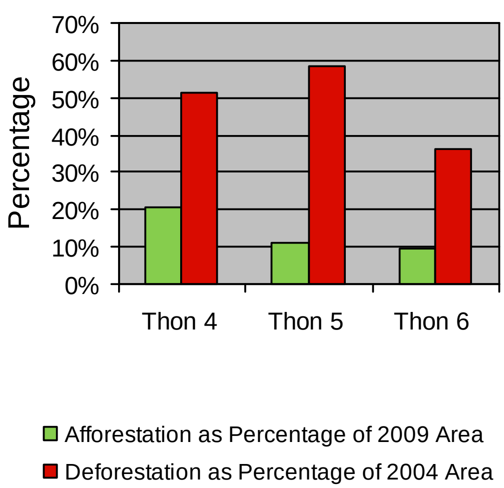


Fig. 9 Chart showing the relative areas of afforestation and deforestation. It should be noted here that if the comparison for proportionality were reversed, e.g. comparing deforested area with current (2009) area then the figures would be much worse.

The absolute numbers are better understood in the context of the forest sizes. The map in Fig. 7 shows the deforested and afforested areas with respect to the sizes of the Thons and the areas of no change. The chart in Fig. 9 illustrates this relationship. The figures are for deforestation as a percentage of the total area in 2004 while the afforestation is as a proportion of the area in 2009.

The charts and map in Fig. 7, 9 and 9 show that there has been a large amount of deforestation and degradation in the five year period in all of the Thons.

Degradation

Estimation of the degradation in an area is simplest when comparing the results from two different forest inventories. This method was only possible in the case of Thon 6 where the inventory data from 2004 was made available.

The forest inventory data from 2004 was not of the best quality and had to be read off of of a map where average tree density was drawn on areally. In the next section we will see that independent satellite analysis of the region has confirmed the estimates of forest density recorded in this 2004 inventory but as with any data acquired second-hand it was always treated with a dose of caution.

Degradation was calculated as percentage density loss to give a clear indication of the level of degradation that was accomplished in just five years. Most areas experienced degradation and the majority of those were degraded by more than 50%. The most concerning statistic is a large proportion where more than 80% of the basal height density has been lost.

The absolute *carbon content* values of degradation can be inspected in the maps of Fig. 10. The carbon content was calculated using the formula devised by the Tuy Nguyen University. The map boundaries are from 2009 and ignore areas lost to deforestation. These maps do not have comparable symbology because the scale of degradation is such that the ranges of carbon contents barely overlap. The maps do, however, give a good overview of the data collected for Thon 6 and the degree of degradation of the area.

The deforestation and degradation results for Thon 6 are summarized in Fig. 11 in terms of carbon content. Here it is possible to inspect the impacts of deforestation and degradation on the change in carbon content from 2004 to 2009. The 2004 and 2009 boundary values are shown for the 2004 carbon content to make it easier to see from the data how degradation has affected the carbon content. Clearly from this chart degradation has had a bigger effect on the change in carbon content of the forest: more than twice as big an impact. The areas that were deforested tended to have smaller carbon contents n 2004 and therefore the impact of the lost area was not so large (data not shown). While the amount of deforestation as a percentage of forest area was larger in the other two Thons there is no reason to believe the degradation effect will not at least match the deforestation effect, or even surpass it as here in Thon 6.

Comparison between Field work and Satellite Analysis

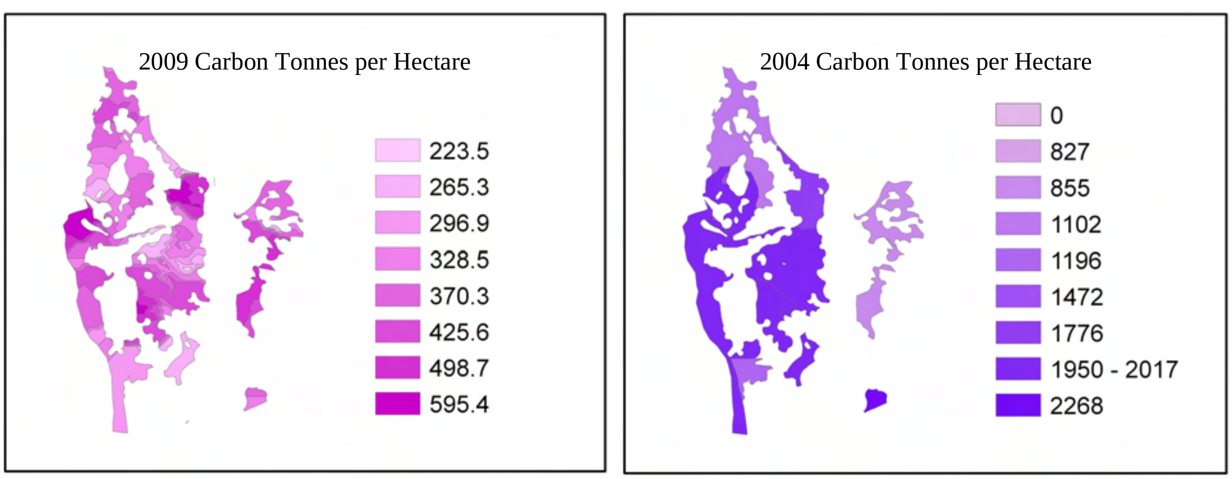


Fig. 10 Chart showing the degree of degradation of the areas of Thon 6 forest in 2009. Clearly only a very small amount escaped degradation and much larger proportion was degraded by more than 50%.

When comparing the overall computed results it becomes evident that the trend identified during the fieldwork with a strong deforestation and degradation since 2004 can be confirmed through the Satellite Image Analysis.

The Carbon range in the satellite images is slightly below the carbon range determined through fieldwork in 2004 and 2009. This can be explained through the fact that trees with a bigger diameter will store more Carbon which the mixed-pixel analysis cannot determine to the same extent.

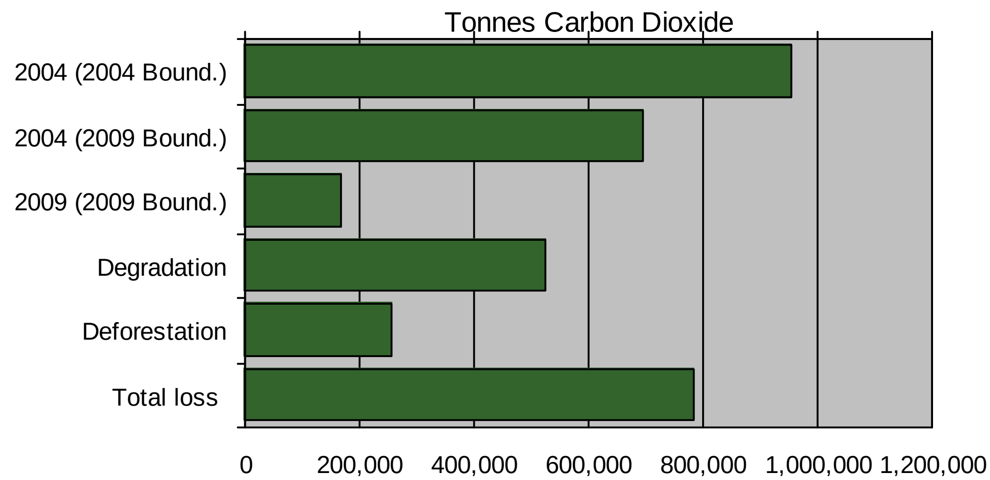


Fig. 11 Chart showing the total carbon content in Thon 6 and how is has been changed between 2004 and 2009.

The degradation trend is reflected in the results of the satellite image analysis shown in the table overleaf. In 2004, the lowest carbon value is ranging between 501 – 750 Tonnes/Ha; in 2009 the highest value is not exceeding 500 Tonnes/Ha.

Year	Carbon per Ha / Fieldwork	Carbon per Ha / Satellite Image Analysis
2004	827 - 2268	626 - 1347
2009	202 - 1166	195 - 405

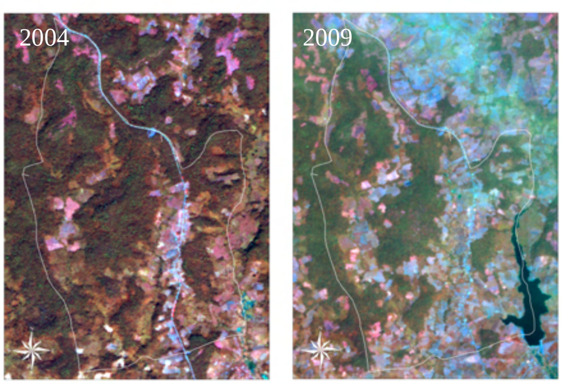


Fig. 12 SPOT 5 satellite images of the region in false colour. The outline of Thon 6 has been superimposed in white.

More detailed analysis than is required of this overview would be necessary to determine the exactitude of the similarity between the fieldwork and the satellite image analysis. However, for the purposes of this report, it is gratifying to find that the results loosely concur. The satellite analysis was extended to the whole region.

Model Projections

The simulation model consists of six modules – regeneration, growth, mortality, harvest, carbon budgeting and dynamic investment calculation. It loops over N number of years, with forest regeneration, growth and natural mortality taking place in each year.

A spin-up phase of 200 years is allowed to bring forest regeneration, growth and natural mortality into equilibrium, i.e. close to the prescribed asymptote of carbon carrying capacity of the forest ecosystem where the change of volume increment per hectare is close to zero. Now the model was forced to display the change in the forest structure, which was observed between 2004 and 2009 and allows two plausible scenarios of human-induced interventions. Thus, it should be clear, that both of the harvest scenarios start from the degraded forest status in 2009: forest use can continue as 'business-as-usual' or under sustainable forest management.

The model allows simulation of carbon stock development under the baseline scenario and a management scenario. Following parameters can be adjusted: (i) management/harvest scenario, (ii) harvest intervals (ranging from 1 to 10 years), (iii) REDD project duration (20 to 50 years, 5 year steps), (iv) carbon price scenario (10, 30 or 50 US$), timber price (60 US$/m3) and, (v) discount rate (set to 8%). Costs for project establishment, monitoring as well as costs of forest management activities were assumed and incorporated in the model.

Beside the displaying of development of carbon stocks in the different pools, a simple financial feasibilty calculation was added, with the results shown in Fig. 13. The dynamic investment calculation concept of the net present value of monetary flows per time unit, i.e. costs and revenues are employed. The results are displayed on the Webpage, where 3,5,7, and 10 years were defined as harvest intervals with a discount rate of 8% and a REDD project duration of 20 years. Possible price scenarios might be 10, 30 and 50 US$/ton CO2.

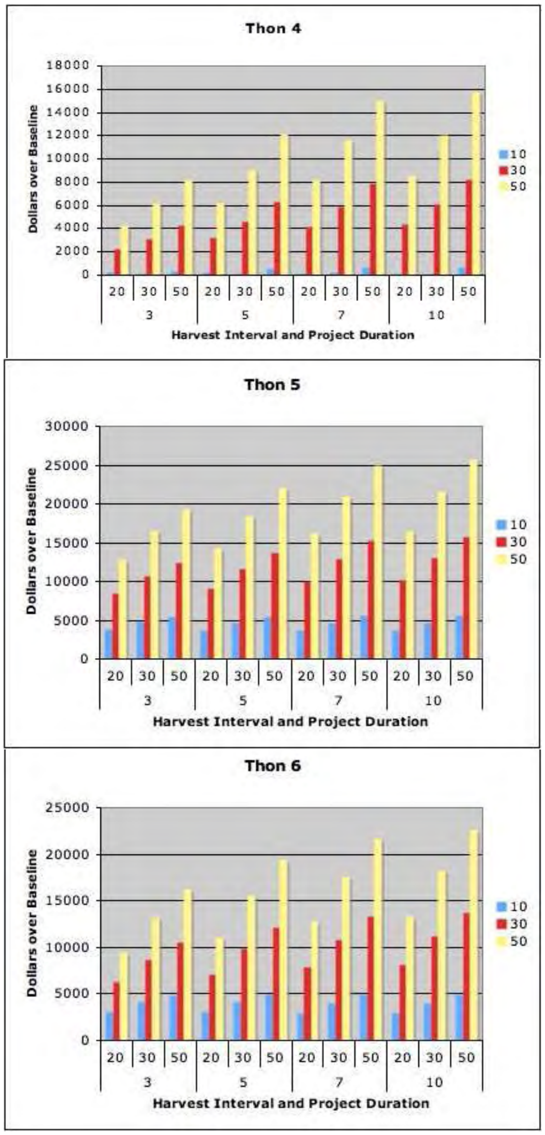


Fig. 13 Charts summarize the monitory output from the model. The three main parameters are the cost of carbon (shown in the key in dollars), the harvest interval and the duration of the project. The numbers are dollar values above the baseline expected value from the forests.

Visualization

The results of the field measurements, the satellite image analysis and the model projections were presented online using Google Earth. The visualization, therefore, was largely in the form of maps that lay over the correct locations on the Google Earth globe. Data are turned on and off using a JavaScript file explorer built using open source Dojo tools.

Creating the online visualization tool and importing the data in their various forms required the following steps:

- Creating the JavaScript setting for the Google Earth application programming interface (API)
- Organizing the data in ArcGIS and other GIS software such that the most pertinent information is displayed
- Building a few simple components to draw together the data from the model into displayable formats
- Importing and symbolizing the data in Google Earth pro and KMZ format
- Clarifying the data with legends and pop-up
- Launching the data online

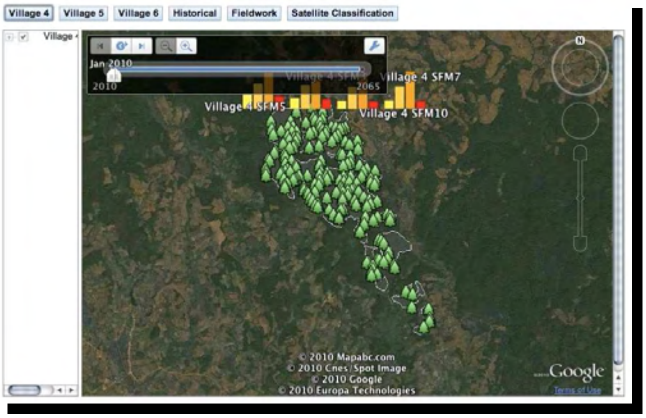


Fig. 14 This figure shows the data viewer being used to inspect the output of the carbon projection model. The figure shows that on the left hand side there is an expandable folder-tree that can be used to turn on and off different layers and 'fly-to' selected data items. The main panel shows that the data is presented spatially but that charts are also included where appropriate. The sub-panel at center-top shows the playback controls that play the data through time. The buttons above both of the panels load data sets into the viewer.

The visualization of the data online allows users to interact with the results and get a spatial sensation for the figures. Although there were some limitations in the API implementation of the data, the online presentation is very similar to exploring with Google Earth on a desktop and should therefore be familiar to a large number of interested parties. The data was also made available for download onto users' computers.

Creating a website that functions as an online report offers a lot of flexibility over and above that available to an orthodox written format. The data is better integrated with information about the background and technicalities of the project. There is better scope for in-line referencing across sections and to other sources on the internet. It is hoped that the online presentation of the results will allow them to reach a far greater audience around the world. The format is considered to be more approachable and engaging and by writing the site in simple HTML the bandwidth required is much less than to download a large PDF report. Subjective but important it is hoped that the professional and attractive presentation will underline the importance of the project's aims and findings.

Lessons learned and Recommendations

The lessons learned in this report refer exclusively to conducting a project like the one discussed and its sustainability; they do not go into any details about REDD or REDD+ policy decisions or implementation in general. There are two sub-working areas within the project, firstly the direct implementation in the field (communication of the project objectives to the partners, data collection in the field, discussion with the partners/training measures) and secondly the project implementation/coordination among the different international stakeholders.

Field implementation

During the field data collection, no critical difficulties occurred. Regarding capacity development and sustainability of the

project the following difficulties should be mentioned: (i) limited understanding by governmental partners about the project objectives due to the complexity of the REDD(+) approach and translation problems, (ii) lack of reliable data on provincial level (e.g. dynamics of land-use changes over the last years), (iii) difficulties to integrate governmental staff into field activities and, (iv) low visibility and acceptance of the project by provincial agencies.

The project tried to actively solve aforementioned problems by e.g. a conducting a provincial inception workshop (including key speaker from the national Ministry of Forestry) and defining the of tasks for each involved department and a provincial approval of the project. Later on, all field data were be collected but integration of governmental staff was hampered by the lack of a facilitation body on the provincial level. GTZ has recently introduced a provincial forest consultative group, which could provide the function that was lacking during the Google REDD readiness project implementation.

Lessons learned (if sustainability is envisaged):

- Establish a provincial facilitation body (including budgeting),
- Establish a project management body on district level (including budgeting),
- Continuously develop capacity. This can only take place, if above mentioned two points are in place, otherwise the departments will not allow their staff to join any capacity development activity,
- Continuous information flow. This can only take place, if the provincial facilitation body advise provincial departments t do so.

It was expected that the GTZ management structure (which looks similar to that what was missing) can also be used for the Google REDD readiness project but it turned out that the partners did not accept this procedure since GTZ project indicators are different from the project's. It is common procedure in Vietnam that a new project needs to have an individual management structure, which hampers the cooperation between different projects. There might be the chance that other projects follow up these activities but that will likely fail due to the different interests and priorities of these projects.

An international partner is needed for any project implementation in Vietnam but expectations regarding project sustainability and capacity development should be low. Handing over final data and reports to the partners are not enough to ensure that there is any follow up activity.

Further lessons learned can be grouped into the overall project management from an outside perspective and the technical details of the project's execution.

Project Runtime

Whereas time delays are to be expected when fieldwork is involved due to weather or any other unforeseen events; it is recommendable to involve every authority from an early point onwards to obtain necessary permissions for fieldwork and staffing the soonest possible.

Every model needs a validation process, which could not be carried out in the given timeframe. Assumptions and relations used for the model need to be discussed with scientific bodies in Vietnam, furthermore the outputs of the model need to be monitored to prove that the model works correctly. The UN-REDD program is the right body for that but such a scientific work needs to be endorsed in the work of international projects.

The component of using Satellite images for verification of the 2004 data had not been planned in and budgeted for and therefore was only made possible through Planet Action and GIS Corps. It was assumed that the historical data was de-tailed and reliable enough. It is recommended to leave room for verification in a follow up project as well.

Technical

When piloting the kml viewer on the webpage, it was found that some major functions (like viewing the balloons or invoking radio buttons) do perform differently in the viewer than in a general kml/kmz viewed on Google Earth

Every care should be taken to ensure that projections are used consistently. This general point is especially relevant when working with technicians and departments with predisposed protocols,

Conversion from SHP to KML format is most simply done using Google Earth Pro although there are third party alternatives.

Resources

General resources used in the background and completion of this project:

- UN-REDD programme: http://www.un-redd.org/
- REDD Monitor: Independent views on the REDD process: http://www.redd-monitor.org/redd-an-introduction/
- Interview with GTZ Head of Divsion Dr. Stephan Paulus on forest conservation and climate protection http://www.gtz.de/en/themen/laendliche-entwicklung/natuerliche-ressourcen/22939.htm
- UN-REDD programme newsletter about launch in Vietnam http://www.un-redd.org/NewsCentre/Newsletterhome/US438millionUNREDDVietNamProgrammelaunche/tabid/1469/language/en-US/Default.aspx
- GTZ Vietnam page http://www.gtz.de/en/weltweit/asien-pazifik/vietnam/24188.htm
- Asian Development Bank report on forests for livelihood improvement in the Central Highlands of Vietnam http://pid.adb.org/pid/LoanView.htm?projNo=34341&seqNo=04&typeCd=2&projType=GRNT
- Information about the Mekong Delta: http://www.mekonginfo.org/mrc_en/Contact.nsf/e3b1f73debcd2275802565d50057124a/7260396129339f0dc72566010070fb8c?OpenDocument
- http://www.fao.org/docrep/005/ac778e/AC778E22.htm
- UNEP report on conservation and poverty in Vietnam

http://ekh.unep.org/?q=node/1732

Google + Other soft:

http://code.google.com/apis/maps/ (For reference)
http://www.youtube.com/watch?v=6BlecrkM7w4 (For reference)
http://code.google.com/apis/kml/documentation/kmlreference.html (For reference)
http://www.dojotoolkit.org/ (For reference)

Final Data, link hosting:

CartONG: http://g-redd.cartong.org/
http://cartong.org/gredd/

Annexes

Annex 1: Agreement on Implementation of a REDD pilot

1) Objective

The overall goal of the project is to support the Vietnamese government within this REDD development process. The project should provide one cornerstone by monitoring and displaying deforestation rates within ***three pilot communes in the Central Highlands (Quảng Tâm and Đăk R'tih)***. Satellite or aerial maps provide exact area measurements, but forest ecosystems are quite different and calculation of Carbon stocks varies among different forest types. Thus, the project will carry out forest inventories and based on this findings Carbon stocks will be calculated. Based on this pilot measures, models can be elaborated (*forest type + soil type + area gaining/reduction = Future Carbon Emission Certificates*). Area changes can be recorded easily by using aerial or satellite images.

Thus the overall objective was formulated as follows:

> *"Displaying of forest gains or losses within two pilot communes within the Central Highlands of Vietnam combined with a detailed calculation of CO2 emissions contributes directly to the efforts of the international community to set-up reliable CO2 emission calculation.*
>
> *(A resilient Carbon reduction calculation constitutes the basis for future CO2 Certificates. If the REDD mechanism is establishes, such payments should lead to poverty reduction and enhanced forest management).*

Three main interventions were formulated to achieve overall objective :

I. *Displaying of forest gains and losses*
Methodology: **On the ground mapping / Aerial maps**

II. *Calculation of Carbon stock*
Methodology: **Forest Inventory**

III. *Provincial staff is enabled to monitor and follow up REDD pilot*
Methodology: **Training** and **monitored** by other projects working in this area

2) Concrete project deliveries

We will provide training measures, collect forest inventory data, elaborate Carbon stock calculations and display all data on Google Earth and on a website. Further datasets should be updated by the trained staff of the province. Since it is always critical to ensure continuation after an only six months project duration, we identified projects that will monitor the process after the grant is finished.

3) What are the benefits for Đăk Nông province?

Vietnam was selected as one of the countries for the UN-REDD programme. This programme seeks to address deforestation and forest degradation through capacity building at national and local level.The programme consists of three main components: (i) Improved institutional and technical capacity on national level, **(ii) Improved capacity to manage REDD on local level (province, district, commune)** and (iii) Improved knowledge of approaches to reduce regional displacement of emissions.

The outputs of Outcome II were formulated as follows:

Output 2.1: REDD potential mainstreamed in provincial and district-level forest land-use plan

Output 2.2: **Participatory C-stock (volumes of carbon in different forest stocks) monitoring system**

Output 2.3: **Equitable transparent benefit sharing payment systems**

Output 2.4: Awareness-raising at provincial, district and local levels

a) Thus, immediate benefits for Dak Nong province are:

(i) Emphasis the integration of Community forest management within the future REDD approach and provision of needed knowledge about CFM-REDD interactions to the central government,

a. Analysis of current weaknesses/problems of forest management and elaboration of strategies to cope that issues,
b. In-depth forest knowledge including **database establishment**,
c. Contribution to the establishment of an equal benefit-sharing systems to significantly alleviate poverty of local forest owners (communities),
d. Proven participation of local forest owners within the REDD scheme

(ii) Enhancement of knowledge of all forest resources (including district-level forest land-use plans) and forest management of Đăk Nông province,

(iii) Direct contribution to the development of the national methodology and ensure that local communities are considered as importance as they are,

(iv) and finally, underlines and prove its strong interests to slow down deforestation in Dak Nong to the central government.

b) Future benefits for the province:

(v) Database knowledge enhance the forest management capacities of local communities and related provincial and district departments

(vi) Elaboration of improved CFM plans and strategies to enable access to REDD benefits based on conducted analysis.

(vii) Established database and methodology provide the basis for future application of REDD projects and should directly contribute to poverty reduction.

(viii) Enable the environment for private investors to buy CO2 Certificates from Dak Nong province

Annex 2: Tasks and responsibilities of involved stakeholders:

Stakeholder	Responsibilities / Overall task	Concrete Questions / tasks / datasets / deliveries
EPMNR	Project coordinator / advisor	Administration of the project, Monitoring of project progress, Constant technical input
Communities (Thôn 4,5,6)	Participatory Carbon Stock measurements / Forest Inventory	Field data collection under supervision of EPMNR and TNU
PPC Đăk Nông	Vietnamese project director	Ensure that the project is align with provincial needs, Advise involved departments to support the project, Submit gained experiences to the national level, Support collaboration with other provinces *(e.g. PPC Lam Đong – UN-REDD pilot province)* Administrative support of the project (permissions),
DARD Đăk Nông	Provision of **data on land-use change** (<u>timeline</u>) and **agricultural production** to en-able the project to calculate costs and benefits of alternative land uses	How has the land-use changed over the last 5 years? What are the main drivers for deforestation? What are the costs and benefits of agricultural production (focusing on the main drivers for deforestation)?
FD / FPD Đăk	Provision of provincial / district	How has the forest area changed over the last 5 years?

Nông	forestry data	What were the measures on provincial level to reduce deforestation? Support of data collection in the field, Support in data compiling and preparation of reports to be submitted to DARD and PPC
MARD / FIPI	Technical input and Application / dissemination of results	Support provision of forest inventory data and satellite images, Support the integration of gained experiences and knowledge into REDD discussion on national level
Tây Nguyên University	Technical Input and supervision of the data collection process	Collaborative elaboration of an appropriate forest inventory design (EPMNR and PIK), Support data collection of more advanced questions (including discussion with other departments, e.g. FIPI) like: **Potential growth on the area as baseline** (Amount of carbon stocks at the area without human interventions ("stabile CO2 system") **Yearly increment** (according to ecological forest type)? **Share of deadwood in the forest** (according to ecological forest type)?
PIK (Institute for Climate Research)	Carbon and scenario calculations	Model, which provides future carbon stock development under consideration of different forest management regimes (Changes of the carbon stocks plus dynamic carbon changes)

Participatory Carbon Stock Assessment Guideline for Community Forest Management Areas in Vietnam

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PART I: Introduction

The approach "**R**educing **E**missions from **D**eforestation and Forest **D**egradation – REDD" has been elaborated to diminish the release of CO_2 in the athmosphere. Additonal, further negative impacts caused by deforestation and forest degradation, like depletion of biodiversity and reduction of the protective function of the forest, should be addressed as well. The basis for any REDD payment will be the remaining CO_2 in the forest area , due to improved (sustainable) forest management and the amount of CO_2 absorbed by the forest due to increase of biomass over its lifespan.

The main reasons for integrating communities in any REDD-scheme are the following:

- **Stable and long-term user rights** (Land Certificate, so called "Red Book" provides land use rights for 50 years). This is the precondition for long term planning and sustainable forest management,
- **Communities** are the **actual owners** of the forest and the CO_2 stored, consequently they can benefit directly from any certificate traded,
- **Forest inventories** and **monitoring** of forest changes can **be carried out by communities in a very cost-effective way**. Furthermore, communities living adjacent to state forests could be an important player to protect the forest. Gained REDD benefits will be channeled through the Vietnamese tax system and money will be used to improve the livelihood of the poor.
- **Active involvement** will enhance the awareness of local people (also them, who are no forest owners) towards the value of the forest and the need to protect them.

In order to claim for REDD credits, it is necessary to have knowledge on forest resources (Forest inventory data base), biomass relations and the amount of CO_2 absorbed by the forest; therefore, it is necessary to have a simple method to support communities to assess their forest resources and analyze the absorbed CO_2 stored in the forest over the time. The method should be as simple as possible, to enable the community to do it by themselves with the support of forestry staff. On the other hand a certain degree of reliability needs to be maintained in order to claim for REDD credits, which can be accepted by the market or governmental bodies.

Objectives:

- Provide methods and skills for local forestry staff to support community in their self-assessment of current forest resources.
- Provide forms to convert measured field data into CO_2 values according to each forest status block of the community. Different forest blocks have different management objectives which consequently results in different amount of CO_2 stored in the area.

Users:

Users should be governmental departments involved in forest management and those staffs who facilitate the process of community-based forest management, in particular:

- Provincial Forest protection and forest department staff, who has on the one hand to ensure that state forest enterprises manage their forest resources sustainably and might in the future claim for REDD credits and on the other hand staff, who has to support community based forest management.
- District staff (sub-department of agriculture and rural development, forest protection station, agro-forestry extension) and technical staff of state forestry enterprises.

The Guideline can be used as training document on procedure of community forest management and REDD implementation in universities and colleges on forestry; or to train technical staffs to promote the procedures at the localities.

Part II: Principles of Participatory Carbon Stock Assessment (PCSA)

2.1 Role and responsibilities of each stakeholder

2.1.1 Cooperation among stakeholders

The integration of local communites in the process of **Participatory Carbon Stock Assessment (PCSA)** right from the beginning will help them to self-organize their forest resource assessment and enhance the awareness of forest values in the context of climate change.

The participation of local people means that every person is allowed to attend in all activities, while it does not mean that they have to do everthing by themselves. Within the **Community Forest Management(CFM)** and REDD projects, local people will not be able to formulate and implement forest management plans as well as determine their carbon credits without the assistance of technical staff. On the other hand, the technical staff by themselves cannot manage to establish a plan - they need to not know the actual timber stocks existing in the area, the preferred management objectives for each forest management block and certain needs of the local population. Thus, both (communities and technical staffs) need to have a close cooperation and understanding of each other in order to come up with a practicable and adjusted forest management plan, which is the prerequisite for any sustainable forest management. Finally, these are the preconditions for any REDD claim in the future.

2.1.2 Role of technical staff

The role of technical staff is to facilitate and support the community during the PCSA process and monitoring of forest resource changes. They also provide the community with new policies and regulations, and instruction on necessary silviculture techniques and market information on CO_2 trade.

The responsible of technical staffs is to establish a communication method to create mutual trust, to enhance information sharing, to learn and share experiences and to cooperate with the community members and with outsiders. Thus, facilitators need to be equipped with regulations for training elder people, participatory approaches as well as facilitating skills.

2.1.3 Role of community members

Community should be considered as people, who have an active role in the CFM decision making process and REDD project implementation, in particular:

- The **community forest management board (CFMB)** is responsible to organize and carry out the PCSA in each forest management block. It is in charge for any further CO_2 monitoring in order to maintain the validity of the CO_2 claims.
- **Representatives of the households** and other community members participate in the assessment of forest resources, forest management planning as well as carbon valuation of their forest plots.

2.2 Principles of PCSA in community forest

2.2.1 Methods and simple tools

In the context of community forestry development and implementation of REDD in Vietnam, methods of assessment and analysis of forest resources, and of estimation of carbon storage have to be adopted to the local circumstances in order to ensure that local communities can understand and implement them properly.

Technical staffs have to develop beforehand the models for estimating volume, biomass and absorption of CO_2 using complex methods but they need to turn the models into tools simple and easy to understand like tables and charts. When collecting data, do not use those methods of surveying which are too complex for local people to understand. If forest users do not fully participate in the assessment and analysis of forest resources, they will not bear responsibility for the result and not be so willing to follow a management plan based on that data.

2.2.2 Relevance and suitability

The process of community forest management and of REDD should rely on management capacity of rural people. It should be as simple as possible, while fulfilling minimum requirements for administrative (governmental) needs. Besides simplicity, it should focus on the collection and analyzing of absolute necessary information and data.

2.2.3 Effectiveness and cost

Reducing cost and time and human resources of community and relevant stakeholders is an important principle in community forest management and in implementation of REDD. With such a requirement, the activity can last long and can be implemented regularly even by poor communities, who usually lack implementation resources (especially time availabity).

In addition, activities related to forest surveys often take more resources because forests are often located in remote areas having complicated terrain thus, forest carbon inventory, and outdoor work in the forest should be well prepared and a realistic time schedule should be agreed upon. Yearly monitoring of changes in carbon stock, due to forest management plan implementation, needs to be discussed as well. This is not explicit part of this guideline but this further workload must be discussed with the forest owners and agreed upon.

Part III: PCSA and monitoring of CO_2 dynamics

Objectives:

- Assess current carbon stocks according to each forest block
- Establish a system of long-term positioning sample plots to track biomass, and the CO_2 absorption
- Provide information on forest resources for community forest management planning
- Provide information on the amount of CO_2 absorbed over time to participate in REDD
- Monitor periodically changes in forest condition and status, and the situation of forest loss

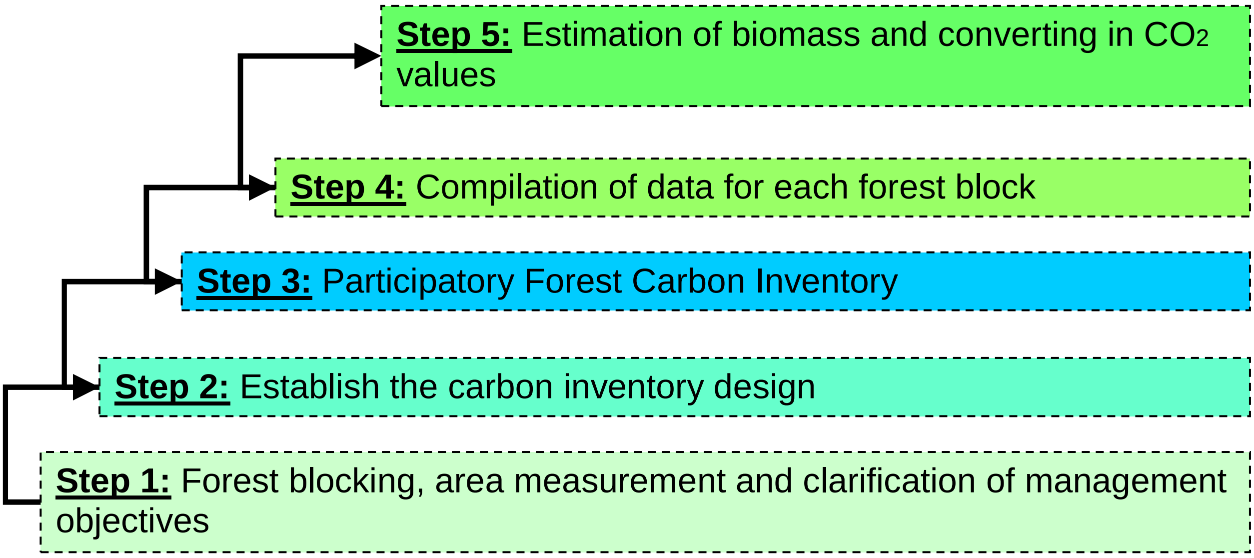


Figure 1: Procedure of Participatory Carbon stock Assessment

3.1 Forest blocking, area measurement and clarification of management objectives

Objectives:

- Assess the current situation of forest degradation and loss.
- Divide forest into blocks of homogeneous forest status that are actually easy to be recognized by local people in order to organize the survey to assess forest resources, to protect forest, to elaborate forest management plan and to sell forest carbon credits

Results:

- Village forests are divided into separate blocks based on forest status and on management goals of the community.
- Forest plots are named after local names, are identified with forest status (technically and locally), are calculated for plot area and agreed with forest management goals for each plot.

Preparation:

- Forest status and topographic map with rate of 1:10.000 analyzed from SPOT 5 satellite image with resolution of 10x10m depicting CFM area boundaries,
- Forest plot description sheets,
- GPS receivers to check the boundary of the forest blocks,
- Transparent paper (big enough to cover the map) with pins,
- Marker pen to write on transparent paper and oil colour pen to draw on map; alcohol and cotton-wool to erase wrongly-drawn lines,
- Compass to identify map direction,
- Transparent paper with grid net of 1 x 1 cm to calculate area.

Location and time:

- Location: At community house of the village or at the house of the head of the community forest management board
- Time: 2 hours

Implementation

- Establish a group of core farmers together with the community forest management board, about 7-10 members,
- Introduce maps depicting current situation/status of forest and simple specifications of topographic maps, locations and boundaries of community forests to the people.
- Ask people to orient maps northwards,
- Put the transparency over the map and use clips to temporarily hold it in place. Using a whiteboard marker show how to draw roads, rivers and streams and boundaries of forest blocks. Encourage local people to draw and show them that if they draw incorrectly, they still can erase easily and draw again.
- Criteria for division of forest blocks: In the same area, plots of forest have the same forest status, same management purposes, and locate in a small area of 0.5 – 100 ha. Should utilize natural boundaries such as rivers, streams, bridges, hills, etc. to be boundaries of the forest plots.
- Upon completion of drawing lines and boundaries of the forest blocks on the map; ask people to discuss and name each block on the map. Encourage the use of place names being familiar to people like rivers, streams, mountains, hills, or commonly known local names.
- Write the name of forest blocks to the map with the forest status (technical and local names),
- In case of doubt, it is necessary to verify the boundaries of forest blocks in the field with local people: Use a compass to navigate in the forest. Use GPS to identify the exact boundary points on the field.
- Measure the area of each forest block: Explain to people that they need to know the exact area to be able to check and monitor forest status and to calculate the number of forest trees on each forest block in order to calculate amount of CO_2 absorbtion.
- Instruct people how to estimate the area by drawing squares on the transparency paper. If the map is with the rate of 1:10.000, a 1 x 1 cm squares corresponding to 1ha (*compare figure 2: Forest status map of Bun Bo Nor Commune*). Write the area of each plot on the map. In addition, if conditions are available, the boundaries identified with GPS receivers will be transmitted into computer using map management softwares such as MapInfo or ArcGIS to digitalize the block-division map and to calculate area of each block.

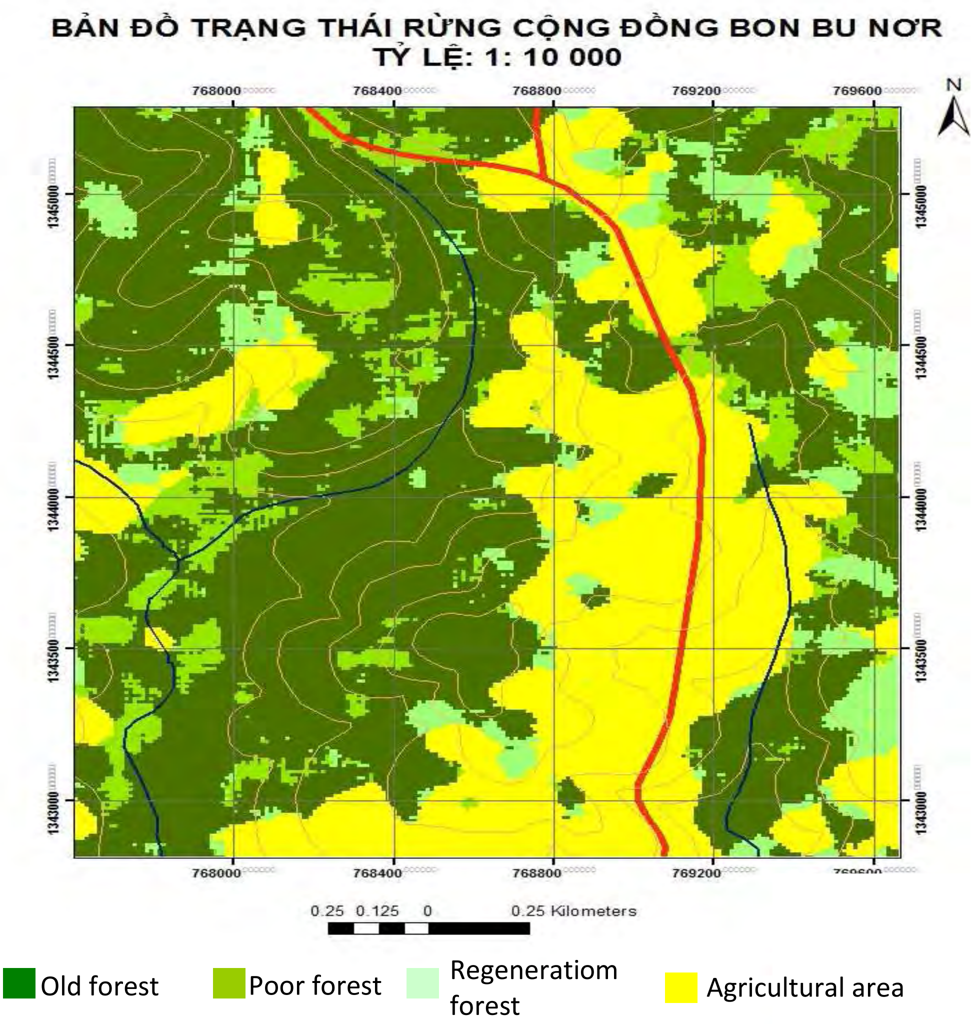


Figure 2: Forest status (analyzed from SPOT 5 satellite images in 2009, resolution 10x10m)

- Finally draw up all the curvature of the terrain, rivers, roads, forest plot with the permanent marker pen.
- On the basis of each plot having its name, status, area, location on the map; discuss with the group of core farmers to describe and define forest management objectives for their forest blocks for example, timber production, firewood, NTFPs, bamboo production, watershed protection, sacred forest.
- Define management difficulties and challenges, elaborate opportunities to improve the situation and finally write down solutions to overcome these challenges in order to manage the forest area properly.

→ Use Table 1

- After analysation of every forest block a summary table should be filled out together with the villagers at a community meeting.

→ **Use Table 2**

Table 1: Identification of management goals for each forest block

Forest Block Name / Forest Block Number		
Management goal		
Difficulties / Challenges		
Strengths / Opportunities		
Solutions to enable proper forest management		

Table 2: Summary of forest blocks of the community

No.	**Unit**	**Compartment**	**Name of block**		**Forest status**		**Area (ha)**	**Management goals of community**
			Technical	Local	Technical	Local		
Total	**No. of unit**	**No. of compartment**	**No. of block**				**Area**	

3.2 Establish the carbon inventory design

Objective:
Establish a sample plot design on the map and on the field for carbon measurements, evaluation and monitoring of forest resources.

Results

- Sample plots are identified on the map and locations are GPS coordinates recorded
- Identified sample plots are "permanent" and will be used for further monitoring

Preparation:

- Forest status map, topography and division of forest blocks with rate of 1:10.000,
- Transparent paper (big enough to cover for the whole map) with pins,
- Marker pens to write on transparent paper and oil colour pens to draw on map; alcohol and cotton-wool to erase wrongly-drawn lines,
- 50 cm ruler to draw grid net for positioning sample plot,
- Compass to identify map direction,
- GPS hand-held machine to identify location of sample plots.

Location and time:

- Location: At community house of the village or at the house of the head of the village community forest management board.
- Time: 0.5 hour

Implementation

- Establish a group of core farmers together with the community forest management board, about 7-10 members and one technical staff
- Calculate amount of sample plots to be measured:
    - The sample plot density (percentage of the total forest area to be measured) needs to be clarified in advance based on the forest structure and political regulations. **Sample density for CFM should be between 0,75 to 2,5%** but can be less for state forest enterprises.

- The following calculation should be applied:

$$\text{Sample area} = \frac{\textit{Forest block in square meter } \mathbf{x} \textit{ sample intensity}}{100}$$

$$\text{Number of sample plots} = \frac{\textit{Sample area}}{\textit{Plot size}}$$

$$\text{Grid net distance} = \sqrt[2]{\frac{Forest\_block\_in\_square\_meters}{Number\_of\_sample\_plots}}$$

- Following these fomula, a **sample plot intensity of 1,25 %** would result in a **grid net of 2x2cm** (200x200m in the field). This calculation should be done by technical staff before the field implementation starts. Beside the adaptation of the sample plot intensity based on forest homogenity a "drawable" grid net should be applied
- Lay the transparent paper over the map and use pins to temporarily hold on a flat surface and draw a grid net of 2x2 cm (200x200m in the field) on transparent paper, with map rate of 1:10,000
- Identify the GPS UTM co-ordinates and record them for each sample plot *Note: only record location of those plots that are really inside the forest area to be investigated.*
- Location of sample plots is demarcated with permanent landmarks when the survey is implemented

3.3 *Participatory Forest Carbon Inventory*

Objective:
Collect information on forest resources in sample plots to estimate number of trees, volume, biomass and amount of CO_2 absorbtion

Results: Complete datasets of all relevant forest data.

Preparation:

- Establish group of core farmers (especially those who have indepth knowledge about the forest). Each group has five people, four farmers and one technician.
- Forest inventory set for each group must consist of:
    - 2 adjusted color tapes to measure DBH at 1.3m (centimer scale as well as colour scale division),
    - 3 twenty meter ropes with a knod in the middle,
    - 1 thirty meter measurement tape,
    - 1 improvised slope measurement tool (refer to Annex 1)
    - 1 compass,
    - 1 GPS receivers,
    - Chalk to mark the tree,
    - Survey sheets for each sample plot.
- Form inventory groups and agree on the minimum amount of sample plots to be investigated for one day.

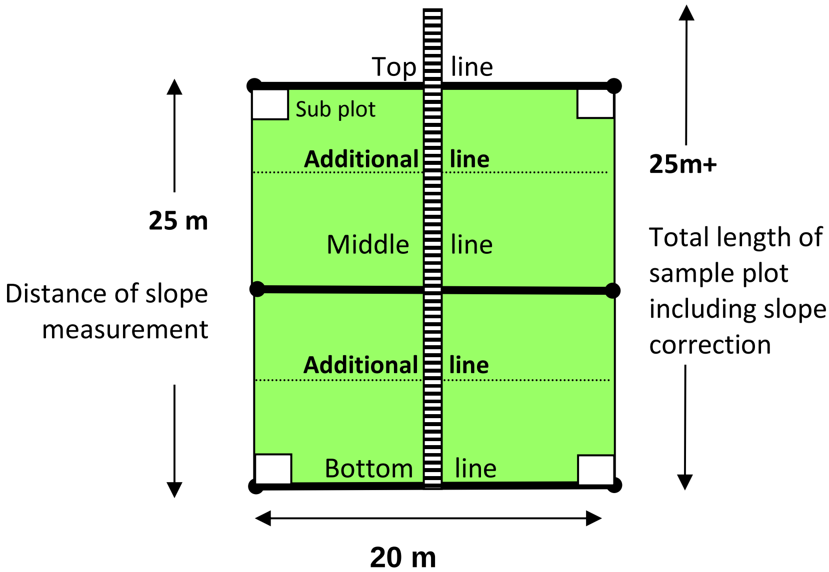
Location and time

- Location: Identified sample plots in the forest area
- Time: Depending on the amount of groups available and the terrain.

Implementation

- Use compass and GPS machine to identify location of the sample plots in the field based on the pre-identified coordinates of the sample plot system (recommend to use the routine-guiding function of GPS machine),
- Identify the slope and correct the sample plot accordingly

Figure 3: Sample plot design (20x25m+slope correction)



- Establish permanent landmarks at the location of the sample plots and record the UTM coordinates,
- Measurements to be conducted in the sample plots:
    - Measurement of all trees of H≥1m and a diameter larger than 5 cm

Table 3: Diameter measurement tape

Diameter class	Class width	Min. Girth [cm]	Colour
05–9,9	5cm	15,71	white
10-14,9	5cm	25,13	yellow
15-19,9	5cm	47,12	black
20-24,9	5cm	62,83	stripes
25-29,9	5cm	78,54	blue
30-34,9	5cm	94,25	dots
35-44,9	10cm	109,96	saw
45 – 54,9	10cm	141,37	red
> 55	open	172,78	

→ Use Table 4: Tally sheet

Table 4: Tally sheet

Province		District		Commune			
Village		Date		Reporter			
Forest plot		Plot number		Slope			
Coordinates UTM X		Coordinate UTM Y		Canopy layer*	1	2	3
Forest type		Forest status		Canopy coverage			

#	**Tree name**	**Girth**	**Color**	**Quality****			**Social class *****	**Remarks**
1	**2**	**3**	**4**	**5**			**6**	**7**
				A	**B**	**C**		
				A	**B**	**C**		
				A	**B**	**C**		
				A	**B**	**C**		

* **Layer:** Divide the forest into 5 layers, the highest layer is marked with 1, the lowest 5.
** **Quality:** A,B,C (A: Good, B: Average, C: Poor)
*****Social class:** **1 -5** (1 = dominant tree in the canopy layer, 2 = restrained tree in the canopy layer, 3 = good tree in the subjacent layer, 4 = restrained tree in the subjacent layer, 5 = dead tree)

- Set 4 sub-plots of 2x2m at 4 corners to identify species and number of trees of H<1m (*remark: all trees are recorded with names, while only trees with a height<1m are counted*)

→ Use Table 5: Survey sheet for subplots

Table 5: Survey sheet for subplots

Number of sub-plot 2x2m	**Species**	**Amount of trees with height <1m**

3.4 *Compile data for each forest block*

Objective:
On the basis of the forest inventory survey, compile data on forest resources in a simple way to have all basic information for forest resources. Basically, there are two steps: firstly the mean values of each forest blocks based on the measured values of each sample plot must be calculated and, secondly all this data need to be summarized in one flip chart representing the mean values of each forest block. During the inventory precise diameter values are measured but in order to allow the calculation in a participatory way without computers, the defined diameter classes must be used.

Results:

Compile the following basic criteria for each forest plot: plot name, area, status, management goals, dominant three species (name the three most often ones), number of trees per hectare and per forest block, number of trees by diameter class of the forest plot

Preparation:

- Set up groups of core farmers:
  2-3 people/group
- Summary sheet for the forest plots
- Calculators

Location and time:

- Location: At community house
- Time: 4 working groups (1 day)

Implementation:

-
- Calculate number of trees per diameter class and per forest block. Participants count the amount of trees according to the respective diameter class and record them on a A0 summary sheet. At the end of the table the mean values are calculated.

→ Use Table 6: Compiled forestry data of one forest block

Table 6: Compiled information on forest resources of one forest block

Sample Plot	Dominant species	Total number of tree per plot	Number of trees per diameter class (color)									
			H <1m	White H≥1m, D = 5-9.9 cm	Yellow 10 – 14.9 cm	Black 15 – 19.9 cm	Stripes 20 – 24.9 cm	Blue 25 – 29.9 cm	Dotts 30 – 34.9 cm	Saw 35 – 44,9 cm	Red 45 – 54,9 cm	≥55cm
Sum												
Average*												

* This values are calculated by dividing the **"Sum"** values through the amount of sample plots investigated

- Calculated averages values (sample plots) need to be converted into ha-values, the following calculation should be applied:
- Number of tree with height <1m per ha:
  - o $N_1/ha = n_{plot1} \times 625$, with n_{plot1}: average number of trees with H<1m in 4 2x2m sub-plots.
- Number of tree with height ≥1m and with diameter <5cm:
  - o $N_2/ha = n_{plot2} \times 20$, with n_{plot2}: average number of trees with H≥1m and with diameter <10cm in 01 plot.
- Calculated ha-values need to be multiplied with the current size of the forest block and must be recoreded in the following table

→ Use Table 7: Compiled forest data

Table 7: Compiled information on forest resources of each forest block

Forest Block (Local and technical name)	Forest status		Dominant species	Number of trees per ha	Number of tree per block	Number of trees per forest block according to each diameter class									
	Local name	Class				H< 1m	White H≥1m & D = 5-9.9 cm	Yellow 10 – 14.9 cm	Black 15 – 19.9 cm	Stripes 20 – 24.9 cm	Blue 25 – 29.9 cm	Dotts 30 – 34.9 cm	Saw 35 – 44,9 cm	Red 45 – 54,9 cm	≥55cm
Total															

3.5 Estimation of biomass and converting in CO2 values

Objectives:
Calculation of the CO_2 amount stored in the community forestry area.

Results:

Total amounts of CO_2 stored according to forest blocks

Preparation

- Establish groups of core farmers (2-3 people/group).
- Print out of a summary table presenting the relations between diameter class and CO_2 amount stored *(Remark: This table must be prepared by a technicans and is based on a local biomass – diameter regression, which has to be elaborated by a scientific body)*
- Calculators

Location and time:

- Location: At community house
- Time: 1 day with 4 working groups

Implementation

- The amount of trees per diameter class (as recorded in Table 7) are multiplied with the values given in Table 8 (*local biomass regression*),

Table 8: Amount of CO2 in an average tree based on DBH class

DBH class (cm)	Colour	Average D1.3 (cm)	CO_2 (kg)
<5		2.5	1.4
5 – 9.9	White	7.5	21.3
10 – 14.9	Yellow	12.5	75.8
15 – 19.9	Black	17.5	174.8
20 – 24.9	Stripes	22.5	326.1
25 – 29.9	Blue	27.5	536.7
30 – 34.9	Dots	32.5	812.5
35 – 44.9	Saw	40	1360.2
45 - 54.9	Red	50	2366.4
>55		*70**	5454.3

This value is estimated since very few, but large trees occur in that diameter class. The regression formula who are the basis for the relation between average diameter and CO_2 content are the following:

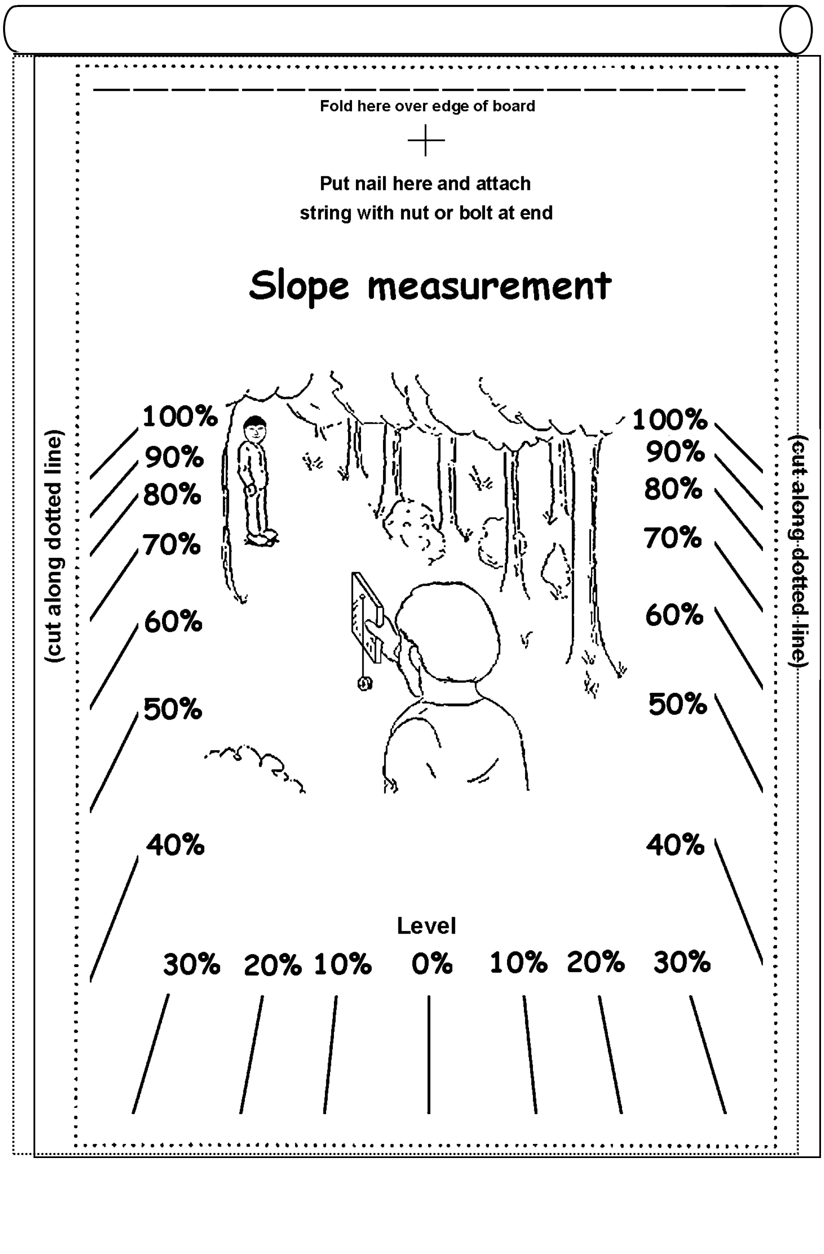
CO_2 = 0.1438*(Average breast high diameter)^$^{2.4817}$

→ Use Table 9: Summary table carbon contents

Table 9: Estimated CO_2 stored in the forest area according to forest blocks

Forest Block (Local and technical name)	**CO_2 content per diameter class**										**Total CO2 value / forest block**
	H< 1m	**White** H≥1m & D = 5-9.9 cm	**Yellow** 10 – 14.9 cm	**Black** 15 – 19.9 cm	**Stripes** 20 – 24.9 cm	**Blue** 25 – 29.9 cm	**Dotts** 30 – 34.9 cm	**Saw** 35 – 44.9 cm	**Red** 45 – 54,9 cm	≥55cm	

Appendix 1: Slope Measurement Tool



Instruction for preparing the slope measurement tool:

- Print out the slope measure tool and glue the page on a piece of carton or veneer board and cut it along the dotted line.
- The top has to be cut precisely along the bold dotted line.
- Print out the slope correction table and glue it on the other side of the measurement tool.
- Fix a plastic straw on the top line of the tool
- Drill a hole through the "+" at the top of the tool and attach a fine string with a nut or bolt at the end exceeding the size of the measurement tool.

Table 10: Slope correction table

Slope	Plot length	Slope	Plot length
%	25 m	%	25 m
15	25,25	70	30,50
20	25,50	80	32,00
25	25,75	90	33,75
30	26,00	100	35,25
35	26,50	110	37,25
40	27,00	120	39
45	27,50	130	41
50	28,00	140	43
60	29,25	150	45

Note: The table provides corrected distances for 25m horizontal distances, as function of the slope, e.g. the distance correction for a horizontal distance of 25 meters, with a slope of 40% is 27 m.