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Johann Heinrich von Thünen-Institut

Development of a holistic methodology for implementing a REDD-Scheme at the example of Madagascar

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Institute for World Forestry

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by

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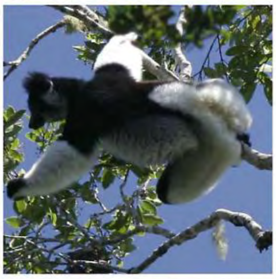


Development of a holistic methodology for implementing a REDD-Scheme

at the example of Madagascar

REDD–FORECA Final report

vTI, Institute for World Forestry, Institute of Forest Based Sector Economics

in cooperation with ESSA Forêts, University of Antananarivo

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1 Introduction

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The main anthropogenic cause of present climate change is greenhouse gas (GHG) emissions. The amount to which these emissions will be reduced will influence the magnitude of future climate change. CO_2 as one of the key relevant GHGs is of great importance regarding emission reduction strategies (Seppälä et al., 2009). Herein forests, especially when regarding their storage of CO_2, play a crucial role.

On global level, approximately 60% of carbon stocks in terrestrial ecosystems is stored in forest ecosystems (IPCC, 2000; Streck and Scholz, 2006). Deforestation accounts for more than 18% of the annual greenhouse gas emissions worldwide (Stern *et al.,* 2006). According to estimates by the International Panel on Climate Change (IPCC) 1.6 billion tons of carbon are released annually by land-use change activities, of which a major part results from deforestation and forest degradation (Denman et al., 2007). In recent past, developing countries showed high rates of deforestation. Reducing emissions from deforestation and degradation in developing countries (REDD) is thus an important element for reducing greenhouse gases in the atmosphere.

Economical incentives for reducing the emissions of greenhouse gases are given by the Kyoto protocol. In article 3.3 and 3.4 the benefit of forests as carbon sinks are considered (UNFCCC, 1998) and in the Clean Development Mechanism (CDM) measures for afforestation and reforestation can be accounted for generation of credits. Yet, the avoidance of deforestation and forest degradation (DD) is not integrated as an eligible action in the Kyoto Protocol. In 2005 the Rainforest Coalition initiated a process for considering a policy for REDD as a possible element in a post-Kyoto agreement at the Eleventh Session of the Conference of Parties (COP 11) to the United Framework Convention on Climate Change (UNFCCC). This integration into a new agreement is supposed to be implemented at COP 16 in Mexico in December 2010 (UNFCCC, 2009a).

As part of a future negotiated agreement REDD should support non-Annex-I countries to take additional actions that reduce emissions from DD by mobilization and distribution of financial resources. Such a functioning international REDD finance mechanism needs to be able to provide the appropriate revenue streams to the participating parties and further on via suitable incentives to the right people at the right time to make it worthwhile for them to change their forest resource use behaviour.

On behalf of the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV) of Germany the Johann Heinrich von Thünen-Institute (vTI) developed operational methods for the assessment of means of forest protection with regard to REDD. The development of methods was realized in cooperation with the "Schweizerische Stiftung für Entwicklung und internationale Zusammenarbeit (Intercooperation Suisse)" and the "Gesellschaft für Technische Zusammenarbeit (GTZ)" within the project REDD-FORECA in Madagascar. The cooperation partners in Madagascar were inter alia local and national forest authorities, like e.g. the MEFT (Ministère de l'environnement, des forêts et du tourisme), and as the local scientific partner the forest institute of the University of Antananarivo (ESSA Forêts).

It is widely accepted that reliable and operational methods for assessing and monitoring the status and change of carbon stocks are indispensable for any party to participate in a REDD regime and possible benefits (Köhl et al., 2009). In addition the main drivers of deforestation and forest degradation need to be identified in order to develop effective measures to exert influence on the maintenance of forest carbon stocks. Implementing a viable REDD regime involves several components (CPs): (i) initiating a system for the assessment of forest carbon stocks and their change over time and thereby quantifying the amount of reduced CO_2 emissions, which qualifies for accounting; (ii) identification and ranking of the relevant causes for human impact on forests in order to derive effective measures to combat forests destruction; (iii) definition of a reference emission level or a baseline, against which the changes of carbon stocks in forests are set off; and (iv) implementing a scheme for the transfer of benefits and incentives to local actors. A schematic illustrates the interdependencies of these components (see Figure 1).

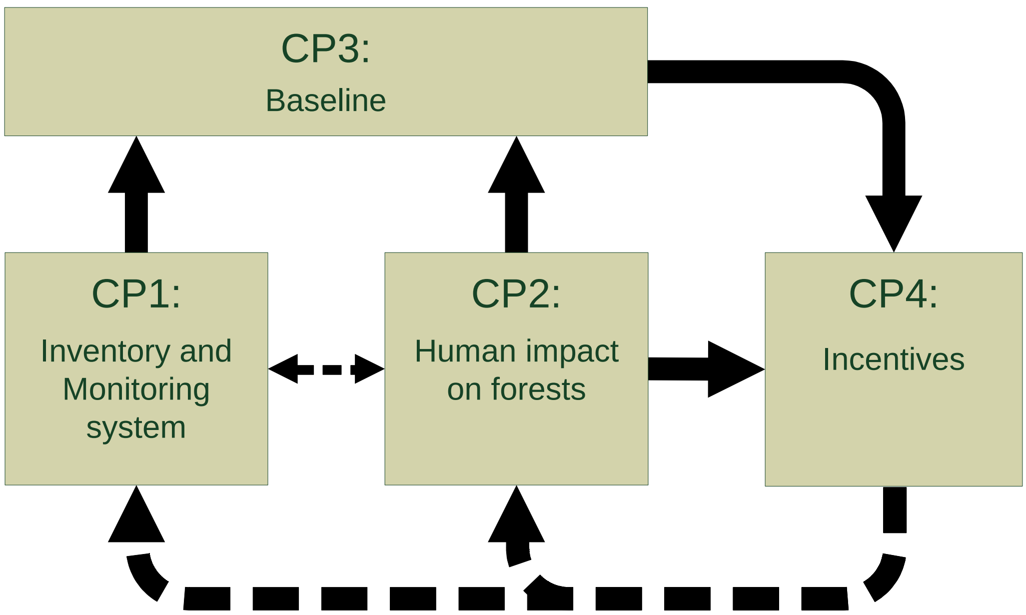

Figure 1: Schematic illustration of components and their interdependencies necessary for a REDD-methodology. The outcomes of the components "CP1: Inventory and Monitoring" and "CP2: Human impact on forests" form the basis for the development of "CP3: Baseline". The "CP4: Incentives" are designed based on the identified causes of DD (CP2) and the Baseline (CP3). The effectiveness of the implemented incentives can be tested by reiteration (dashed line) of the components CP1 and CP2. A cross validation can prove the outcomes of CP1 and CP2.

In the scope of the performed pilot study in Madagascar vTI mainly engaged in the two components "CP1: Inventory and Monitoring" and "CP2: Human impact on forests". Furthermore examinations of possible baseline methodologies and their potential implications have been realised (CP3). The main objectives of vTI were:

- Development of efficient methods for the quantitative determination of deforestation and forest degradation and its dynamics.
- Development of methods for determination and analysis of economic and socio-economic causes for deforestation and forest degradation
- Evaluation of potential baselines approaches

Within CP1 the Institute for World Forestry developed an efficient inventory method for the objective periodical determination of deforestation and forest degradation and its resulting release of carbon from a regional to national basis. The method is based on the use of satellite data in combination with terrestrial inventories. Furthermore, in CP2 contributions on the causes of DD in Madagascar and their potential of reduction were acquired on a regional level through interviews on the spot and the application of statistical analyses identifying the main drivers of DD, respectively through the analyses of national timber balances. Moreover, the Institute of Forest Based Sector Economics was concerned with approaches for the establishment of a baseline, which directly contributes to CP3.

In the following chapters the above described objectives of the work of vTI are elaborated and thereby contribute to the overall project as described in the REDD-FORECA project document (Radiharisoa et al., 2008).

2 Inventory and monitoring system

Authors:

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This chapter presents an approach for CP1, i.e. a sound, reliable and operational combined biomass inventory method at national-scale in the scope of future REDD regimes for measuring and monitoring the current state and changes over time of carbon stocks. The approach is furthermore intensively demonstrated and illustrated in an upcoming publication by ESSA Forêts and vTI, which is currently in the review process.

Objective:

In this component (CP1), the Institute for World Forestry elaborated an inventory methodology for the objective and periodical, quantitative determination of DD and its resulting release of carbon from a regional to national basis. The aim of this chapter is to show the methodology of the proposed cost-effective and robust monitoring system that is based on the use of satellite data in combination with terrestrial inventories.

Results:

An assessment of a country in a given time and cost frame requires a classification of the total area into separable classes (strata). Based on the IPCC-categories for the zone "(Sub-)Tropical Forests" a stratification in "wet", "intermediate" and "dry" was achieved and for each strata an assessment area was identified. Combined inventories, integrating both remote sensing and in-situ terrestrial data, were carried out on all three assessment areas. This combined inventory methodology permits the reliable estimation of the above ground biomass of the forests in the assessment areas.

Conclusion:

The results of the pilot study show, that the developed methodology is applicable for reliable conclusions on a country's forest biomass stock and its development. Thus, they cover one of the four components (CP1), and in the end successfully contribute to a possible national realisation of REDD.

2.1 Overview

In forests there are three major carbon pools: (1) living biomass, (2) dead organic matter (dead wood and litter), and (3) soil. By increasing at least one pool by maintaining the other pools forests become a carbon sink. In natural forests the carbon sequestration by the living biomass is in balance with the carbon offset by the decay of dead organic matter or carbon release from soils. For this reason natural forests are neither a carbon sink nor a carbon source on the long run. Thus the avoidance of deforestation and forest degradation aims at the maintenance of forest carbon stocks rather than increasing the sequestration potential of forests.

Currently there is a contradictory debate on the amount of carbon transferred by the decay of living biomass to the atmosphere and to soils. While some publications suggest an increase of organic soil components and thus an increase of carbon sequestered by soils (Freibauer et al., 2009), others report no significant changes in soil carbon or even a release of soil carbon to the atmosphere. Schlesinger and Lichter (2001) studied soil carbon in *Pinus taeda* stands and found high transfer rates of organic carbon in the litter layer but an absence of carbon accumulation in the mineral soil. They conclude that a significant, long-term net carbon sequestration in soils is an unlikely event. Bellamy et al. (2005) analysed data of the National Soil Inventory in England and Wales, which were assessed between 1978 and 2003. They report a mean annual release of 0,6 percent of the existing soil carbon stock, which compensates with high probability the carbon sequestration by soils. In accordance with the IPCC Good Practice Guidance (IPCC, 2006) we assume that carbon uptake and carbon release by soils is at equilibrium and exclude this pool from accounting.

The assessment of carbon stock and carbon stock changes is associated with uncertainties. The IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC, 2003) addresses this problem by offering parties to use three different levels tiers (i.e. levels of reliability) for their national greenhouse gas reporting. Where parties want to generate carbon credits by applying a REDD regime the reliable minimum estimate (RME) for carbon stock changes needs to be presented. A point estimate of the carbon stock or its change rate over time needs to be supplemented by a quantitative measure of its reliability. The point estimate is reduced by the reliability measure resulting in the RME; not the point estimate but the RME qualifies for accounting. Therefore parties are obliged to report on the errors associated with any carbon estimate and need to implement assessment methods that result in estimates with high reliability. The reliability of forest area changes is quantified via the accuracy of remote sensing classifications, while the reliability of biomass estimates results from the calculation of sampling error estimates. Errors associated with the assessment of individual tree biomass and its conversion into carbon contents are to be obtained by empirical studies. All different error sources can be combined via an error budget (Gertner and Köhl, 1992) and allow for a consistent and accepted quantification of the reliability of carbon stocks and carbon stock changes.

The assessment scheme proposed focuses on the quantification of aboveground living biomass, which is subsequently transformed into carbon content. As stated above, the stock of dead organic matter (i.e. dead wood and litter) over time can be seen in equilibrium and thus there is no need to estimate the carbon stock changes within these pools (Köhl et al., 2008). Changes of the carbon pools in living biomass are induced by either a total loss of the biomass due to deforestation and associated land use changes or by a reduction of the biomass stock due to associated forest degradation. Hence a survey scheme needs to assess changes of the forest area and changes of the living biomass.

The use of satellite imagery and remote sensing (RS) techniques has been widely described as an efficient tool to monitor forest area changes (Frayer et al., 1979, Goodale et al., 2001; Brown et al., 1999; UN-ECE/FAO, 2000; de Fries, 2007). Remote sensing provides spatially explicit data on forest areas and by multi-temporal approaches on forest area changes, but optical remote sensing sensors fall short when it comes to the assessment of sensitive changes in standing woody biomass (Köhl, 1994). Especially in natural forests stands in the tropics and subtropics, which are characterised by heterogenic vertical stand structures and contiguous canopy covers, degradation can only be detected, when the formerly closed canopy cover is dissolved (see Figure 2).

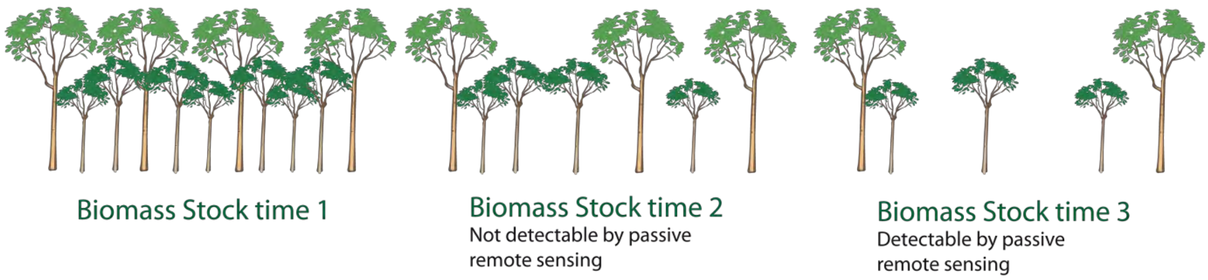


Figure 2: Different status of forest degradation and potential of detection by optical remote sensing techniques (Baldauf et al. 2009).

Stealthy degradation can be assessed by field surveys. As field surveys are especially time consuming and expensive in remote and difficult to assess areas, they are not conducted as full tallies but realised by statistical sampling approaches (Köhl et al., 2006). The proposed assessment method for monitoring current state and changes of forest carbon stock in a REDD regime utilizes the potential of remote sensing imagery to assess spatially explicit data on forest areas with the potential of sample based field surveys to capture sensitive changes in forest biomass stock by a combined remote sensing / in-situ assessment. A full coverage of the inventory area (wall-to-wall map) is obtained by remote sensing imagery. Within the wall-to-wall map thematic classes (e.g. non-forest and forest areas, explicit forest formations within the forest areas) are obtained by classifying the remote sensing data. The thematic classes are considered to be homogeneous groups or strata. Within each stratum sample based field surveys are conducted, which aim at the assessment of the growing woody biomass. The sampling design associated with this approach is stratified (random) sampling (Cochran, 1977, Köhl et al., 2006).

Stratification of a population of interest into sub-populations or strata has the objective to form homogenous sub-units. Stratification rules for separating a forest population in homogeneous sub-units can be any forest characteristic (e.g. species distribution, crown coverage, tree age, standing biomass volume) or – where remote sensing imagery is utilized - similarities in the spectral image space (Richards and Jia, 1999). The population variance within the strata is generally smaller than the variance between strata. From a statistical point of view stratification yields sampling estimates with lower sampling errors than simple random sampling. The combination of earth observation and field sample data by a stratified sampling approach has proofed as a cost-efficient and operational method in practical applications of forest surveys (Frayer et al., 1979; Scott and Köhl, 1994; Achard et al., 2002). IPCC (2003) presents stratification rules for forest formations related to aboveground biomass stocks.

Figure 1 shows a coarse schematic view of the applied methodology. On the left hand-side the top-down approach can be seen. It starts with a regionalisation process at national scale with remote sensing and NFI data, and ends with randomised branch sampling (RBS) at single tree level. On the right hand-side the bottom-up approach is displayed. This approach aggregates the results of the preceding processes to different levels.

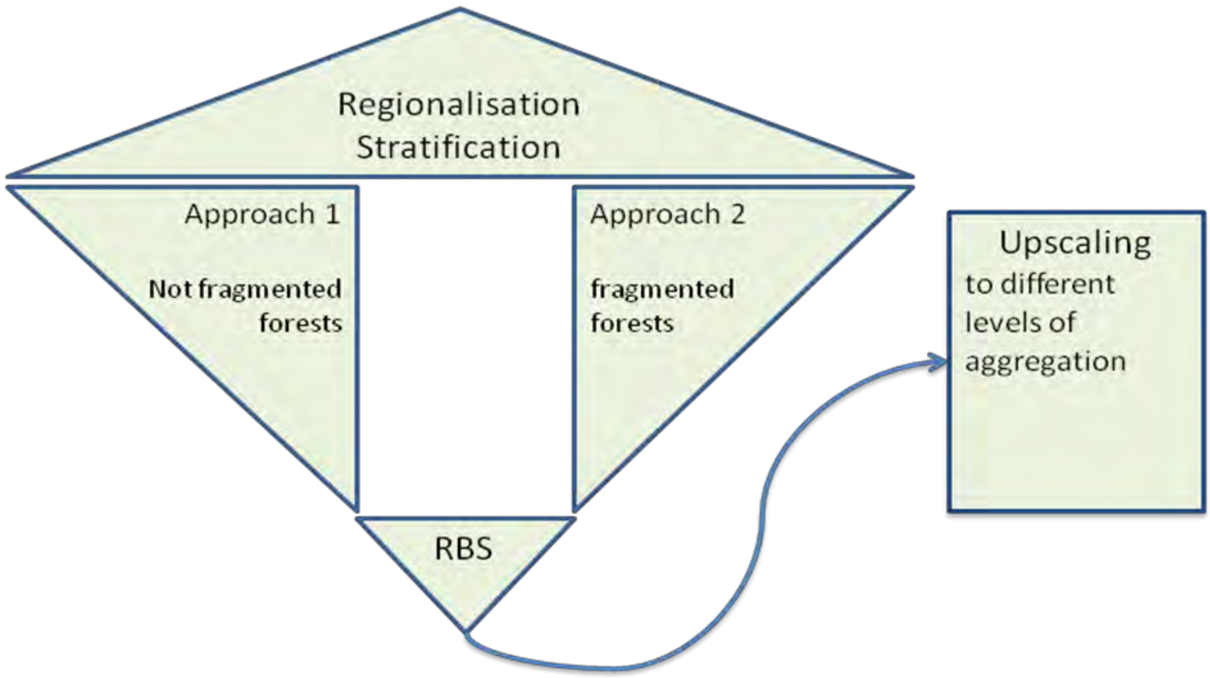


Figure 3: Overview of the combined inventory methodology (Baldauf et al. 2009).

A more detailed view on the inventory methodology is shown in the Annex (see Figure 35).

2.2 Top-Down

There are a number of factors influencing the amount of aboveground biomass (AB) stocks in forests, resulting in a broad range of AB stock in a single country. However, only some factors are feasible for breaking down the country's land area into regions, which allow assigning a specific part of the range of AB stock into one consistent compartment. The aim of this strategy within the REDD-project is to reduce cost for field assessments and/or to increase the accuracy.

2.2.1 Regionalisation of a country's land area

Within the "Good Practice Guidance for Land Use, Land-Use Change and Forestry" (IPCC, 2003) stratification rules for forest formations related to aboveground biomass stocks are presented, which can be applied worldwide. In the following table (Table 1) these rules are shown for tropical forests.

Table 1: Aboveground Biomass Stock in t/ha per Forest Formation for tropical forests (IPCC, 2003)

Tropical Forests						
	Wet	**Moist with Short Dry Season**	**Moist with Long Dry Season**	**Dry**	**Montane Moist**	**Montane Dry**
	R > 2000	2000 > R > 1000		R < 1000	R > 1000	R < 1000
Africa	310 (131-513)	260 (159-433)	123 (120-130)	72 (16-195)	191	40
Asia & Oceania:						
Continental	275 (123-683)	182 (10-562)	127 (100-155)	60	222 (81-310)	50
Insular	348 (280-520)	290	160	70	362 (330-505)	50
America	347 (118-860)	217 (212-278)	212 (202-406)	78 (45-90)	234 (48-348)	60
Note: Data are given in mean value and as range of possible values (in parentheses)						

A regionalisation can be performed using a supervised classification. This common technique uses remote sensing data with terrestrial reference data in order to assign discrete or continuous classes to areas (Lillesand et al., 2004).

With the purpose of using RS-data certain procedures have to be performed in advance. Such pre-processing includes geometric and atmospheric correction. These processes lower the estimated errors in the results. Especially in the tropics the use of passive sensors demands the masking of clouds and shadows in RS-data, as these areas can not be further processed.

In order to assign the IPCC categories (see Table 1) to a country we propose to use following input data (see Figure 4): (i) data of the sensor MODIS. This is a passive sensor with medium spatial, however, high temporal resolution. This RS-data can be acquired via the U.S. Geological Survey for no data costs. (ii) SRTM data. This active sensor provides data on topographic information. Data of this sensor is made available by U.S. Geological Survey at no data costs, as well. (iii) information on climate. Here the data sources are quite diverse and further quality management procedures (e.g. examination of metadata) have to be performed, in order to guarantee an adequate grade of quality. For Madagascar the climate zones by Cornet (1974) were used.

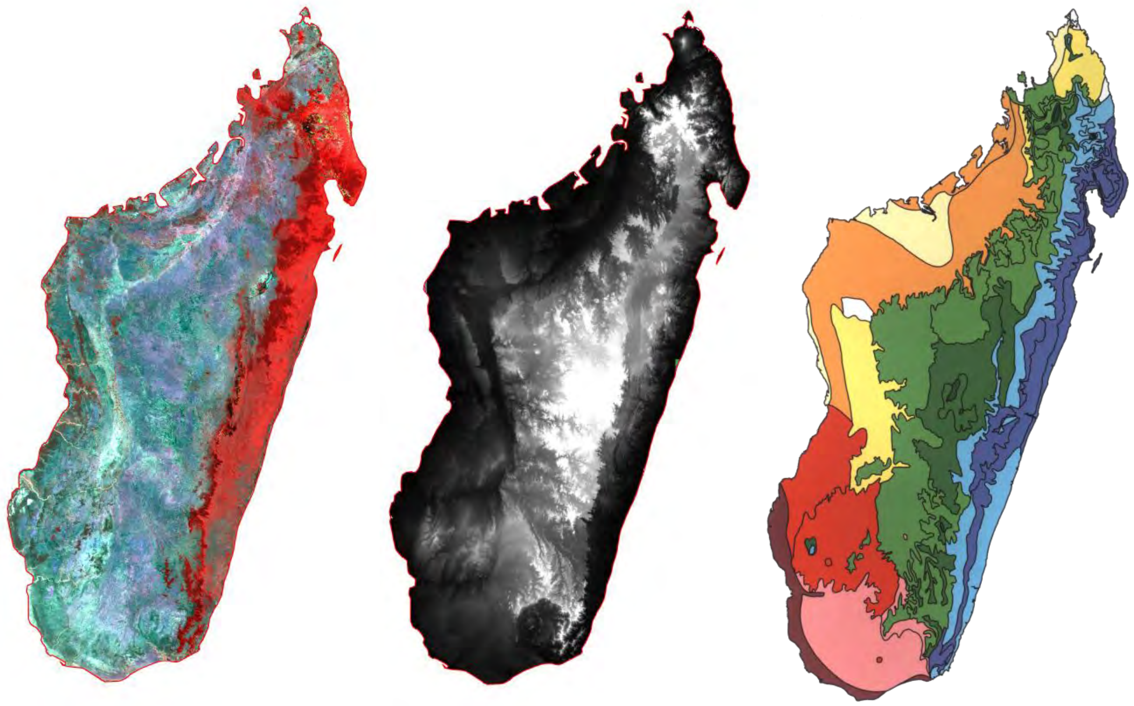


Figure 4: Input data for the supervised classification (from left to right): Layer stack of MODIS_13q1 (2-3-1) dated 2007-08-29, SRTM-data (darker spots represent lower areas), climate map based on Cornet (1974).

Within the classification, i.e. a maximum likelihood classification, statistical parameters are derived from the RS-data and resultant features. Specified these parameters, the statistical probability of a certain pixel value being a element of a particular class is calculated. After evaluating the probability in each class, this pixel is assigned to the most likely.

The implementation of these results in a geographic information system (GIS) provides the possibility to execute comprehensive spatial analyses. The development of a criteria list allows an identification of assessment areas, which ought to be representative for the above derived regions and where further assessment is conducted. Here, information on infrastructure and accessibility were included. Due to time restrictions a further aggregation of the categories proposed by IPCC to only three categories was realized (see Table 2).

Table 2: Adaptation of IPCC categories

IPCC categories		Adaptations	Aboveground biomass (t/ha)
Wet	=	Wet	310 (131 - 513)
Moist with short dry season		Intermediate (semi-dry/semi-wet)	123 - 260 (120 - 433)
Moist with long dry season			
Montane Moist			
Montane Dry		Dry	40 - 72 (16 - 195)
Dry			
Categories adapted from GPG for LULUCF, Table 3A.1.2. Aboveground biomass data is given in mean value(s) and as range of possible values (in parentheses) (IPCC, 2003).			

The integration of the above adapted categories into the regionalisation process resulted in the following parcelling of the country and identification of assessment areas (see Figure 5).

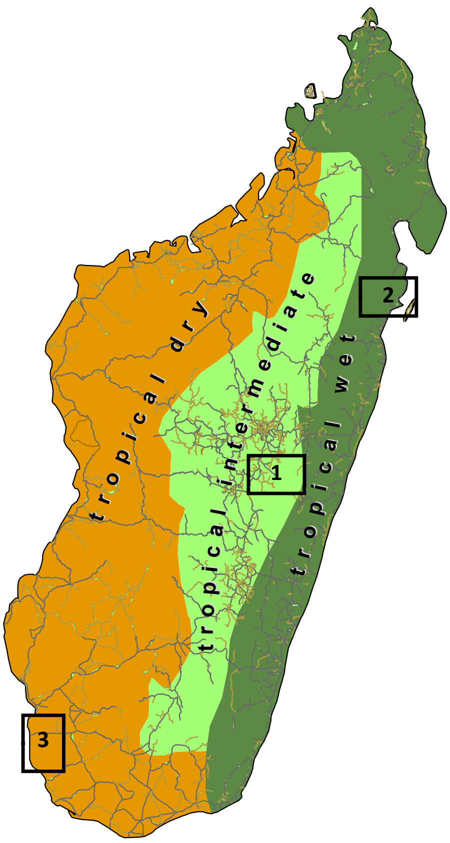


Figure 5: Regionalisation of Madagascar's land area based on aggregated IPCC categories; numbered black boxes show the identified assessment areas (1: Tsinjoarivo, 2: Manompana, 3: Tsimanampetsotsa) (Baldauf et al. 2009).

The indicated assessment areas (1-3) are briefly described in following:

1. Tsinjoarivo (TJV)

Tsinjoarivo, a commune 70 km south from the capital Antananarivo, represents the adapted IPCC category “intermediate (semi-dry / semi-wet)” (see Table 2). The area of the commune is 32.272 hectares but only the eastern part still shows coverage by forest or forest fragments. Due to the proximity to the capital and extensive agriculture the pressure on the forest remnants is very high. The terrestrial inventory took place from October to November 2007 (see also 3.2.3 and 3.3.4.1).

Photo 1: Photo of a small village in the commune of Tsinjoarivo showing a typical agricultural use and the pressure on the remnant forest areas (Photo: D. Plugge).

2. Manompana (MPA)

Manompana lies at the east coast of Madagascar adverse to the Ile Saint Marie (see Figure 7) and represents the IPCC category “wet” (see Table 2). The area is 46.095 hectares and the pressure on the forest mainly comes from the villages on the seaside moving upcountry as well as slash and burn activities (see also 3.2.3 and 3.3.4.2). The in-situ assessment was conducted in April and May 2008.

Photo 2: Photo of a view within the forest of Manompana. From this spot, the pressure on the forest is easy recognizable as the clearings on the left of the photo show (Photo: A. Rqibate).

3. Tsimanampetsotsa (TMP)

Tsimanampetsotsa is located in the southwest of Madagascar and typifies the adapted IPCC category “dry” (see Table 2). The area is 43.296 hectares and includes a national park as well as parts of the 3 circumjacent communes with different types of pressure on the forest (see also 3.2.3 and 3.3.4.3). The terrestrial inventory was accomplished from September to October 2008.

Photo 3: Photo of the plateau inside the national park Tsimanampetsotsa (Photo: D. Plugge).

Further information on the environmental and living conditions for the three assessment areas are provided in Table 12.

2.2.2 Stratification of regions and assessment areas

In a next step forest areas within the assessment areas have to be identified. Here, an unsupervised classification algorithm, where RS-data is classified into spectrally similar clusters, was applied. This classification is performed automatically, and in contrast to the above illustrated supervised classification, no reference data is used for the procedures. As a result, the RS-data is divided into a selected number of categories with similar characteristics, e.g. radiometric information. In order to determine this number of spectrally separable classes, scatter diagrams (see Figure 6) have been used, where the combination of applied spectral bands of the RS-data can be examined.

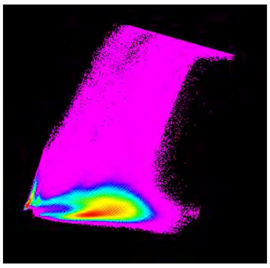


Figure 6: Exemplary scatter diagram of spectral band 1 and 2 of SPOT data.

This further classification based on the assessment areas has a high potential for error reduction as the classification results are used for stratification. This is reflected in the results of the bottom-up integration (see chapter Bottom-up).

One central point within a possible REDD-regime is the fact that statements on the development of forest areas will have to be made. This requires the assessment of data of at least two points in time. As data can not be measured retrospectively, archive data has to be used for the assessment of forest areas in the past. Using the same techniques for both the archive and the present data, permits to make statements on the development of these areas. Difficulties can arise, if there are different sensor systems used for the past and the present data, resulting in higher errors. Therefore we used for both points in time the passive, high resolution SPOT sensor, recording four spectral bands (red, green blue and infra-red light). Different time offsets between present and archive remote sensing data were tested, i.e. 3-5 years.

The identification of forest areas by the means of an unsupervised classification for each date primarily results in a number of intermediate classes, which in a second step have to be fused into the classes *forest* and *non-forest*. The fragments of forest correspond to the areas that are further being inventoried within the terrestrial concept (see chapter Terrestrial inventory).

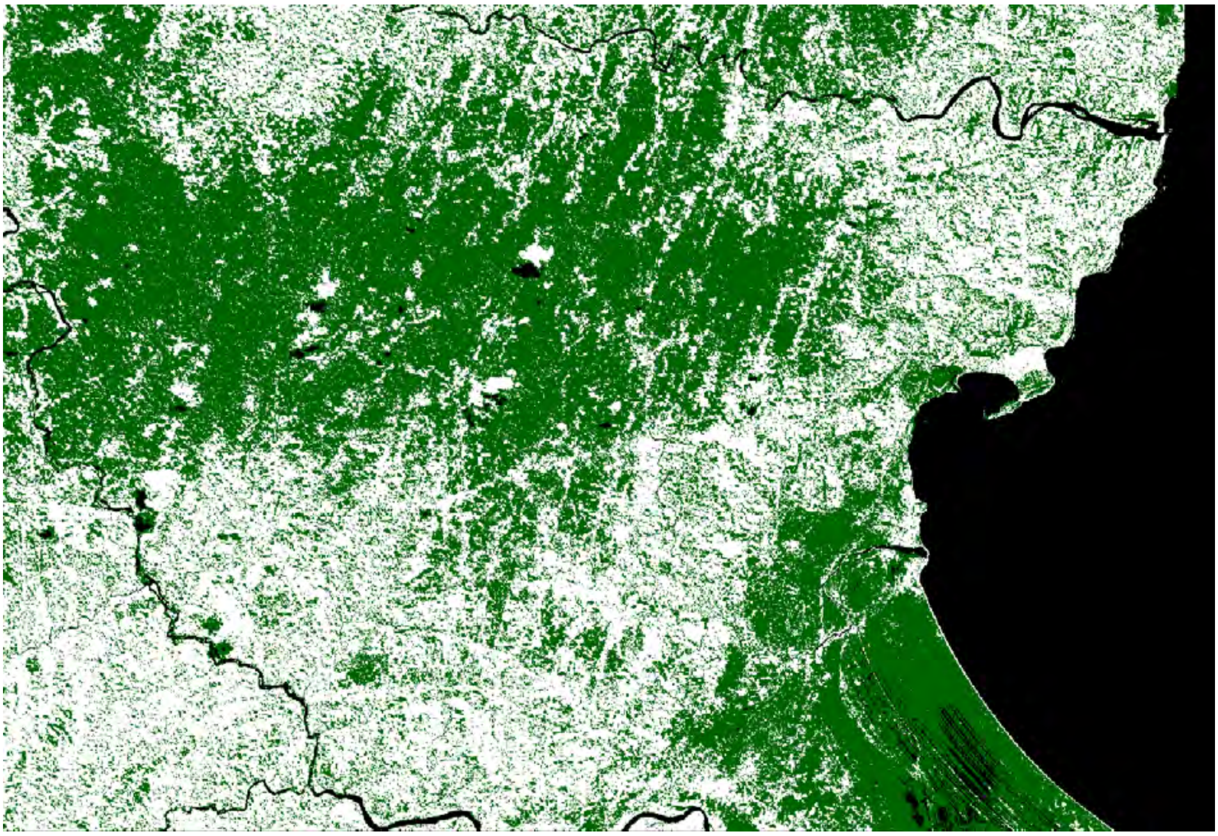


Figure 7: Forest fragments (green = forest, white = non forest), compiled through unsupervised classification of SPOT5-data of the year 2004. This figure shows the region of humid forests located near Manompana.

In Madagascar two diverse types of forests were detected. Firstly, contiguous or almost contiguous forest areas, i.e. nearly one forest fragment (see Figure 7), could be distinguished. Secondly, small, more fragmented forest areas were identified (see Photo 4).

Photo 4: Photos of fragmented forest with a high rate of non-forest areas on the left, and non fragmented forest on the right (left Photo: D. Plugge, right Photo: T. Baldauf).

These circumstances demand the need for a flexible methodology, in order to keep errors in the inventory low. The adaptability of the methodology is further illustrated within the terrestrial inventory chapter. Keeping errors in a reasonable scale requires more expenses for the field assessment. Figure 8 displays exemplary the typical relationship between the cost and the error of different methodological approaches for in-situ surveys.

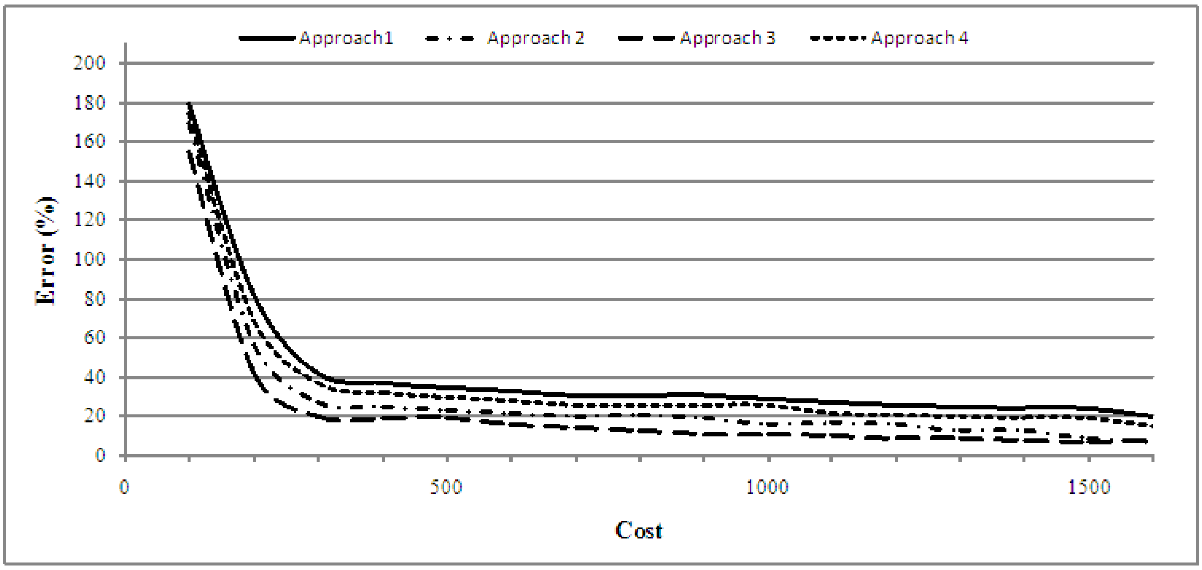


Figure 8: Exemplary relationship between cost and error for different field assessment approaches.

2.2.3 Terrestrial inventory

2.2.4 Sample grid on forest fragments

A grid of regular spaced lines (grid lines) is implemented for each assessment area. The coordinates of each intersection serve as a dot grid point (starting point) for the field survey by means of a systematic cluster sampling. Using the output described above the respective cluster can be either located in forested or non-forested areas. Only the forested areas are included in the survey for obtaining the AB stock. By combining existing data (e.g. NFI) or local expertise on land-cover and VHR RS data the spacing of the grid lines can be adapted to the conditions of the assessment area (i.e. topography, forest density, accessibility). As rule of thumb one can bear in mind that it should be possible to accomplish at least one cluster a day. Spacing that were used in Madagascar are: (i) Wet: 5 x 5 km; (ii) Intermediate (heavily degraded) 1 x 2 km; (iii) Dry 2 x 5 km. If further suitable data exists the forest fragments can be additionally stratified. Thus buffer-zones e.g. alongside forest boundaries, water bodies or roads which are likely to show a higher fragmentation can be assessed with a higher sampling intensity, while closed forest fragments may be assessed with a lower intensity (e.g. if the clusters are allocated within a 1 x 5 km grid, this will be used in the buffer zones, outside these one could opt for a 2 x 5 km spacing of the clusters). The increase of the sampling intensity will provide results with a higher precision / less variability for these buffer zones than with a lower sampling intensity. Especially for a possible REDD regime those exploited forest play an important role with their potential to reduce the human impact and by this the emissions. Thus information about the buffer zone is highly valuable. Before the actual survey starts the final planning for each assessment area can be performed in a geographical information system (GIS), resulting in the combination of high-scaled field maps and global positioning system (GPS) ready data.

2.2.5 Cluster sampling

A cluster can be described as a fixed allocation of sample plots in a regular geometrical shape. Cluster sampling is applied especially in remote and hard to access areas (like tropical forests) to facilitate the acquisition of field data on the one hand and to lower the cost of the field survey on the other hand. From the statistical point of view cluster sampling is justifiable in terms of overall precision as long as the variation within a cluster is large compared to the variation among the clusters (Köhl et al. 2006).

2.2.6 Cluster design

An efficient cluster sampling design offers an attractive balance between the cluster size and the number of sampling locations to visit (Köhl et al., 2006). There is a multitude of options regarding the cluster design (squared, rectangular, triangle), the spacing between each single sample plot (SP) of a cluster and the size, structure and form of each single SP. The spacing between the SPs in a cluster should not be too large to avoid time consuming travelling (locating an SP often takes more time than the data acquisition on the SP) and not too small to guarantee a gain of information on each sample plot. For the layout of the SP concentric circles are applied in many forest inventories resulting in a gain of time. In Madagascar we have chosen and tested a cluster design with six concentric SPs grouped in a rectangle of 100m length and 50m width resulting in 50m distance between each SP-centre (Figure 9). This design was used in those areas that did not show a high fragmentation (see Figure 7).

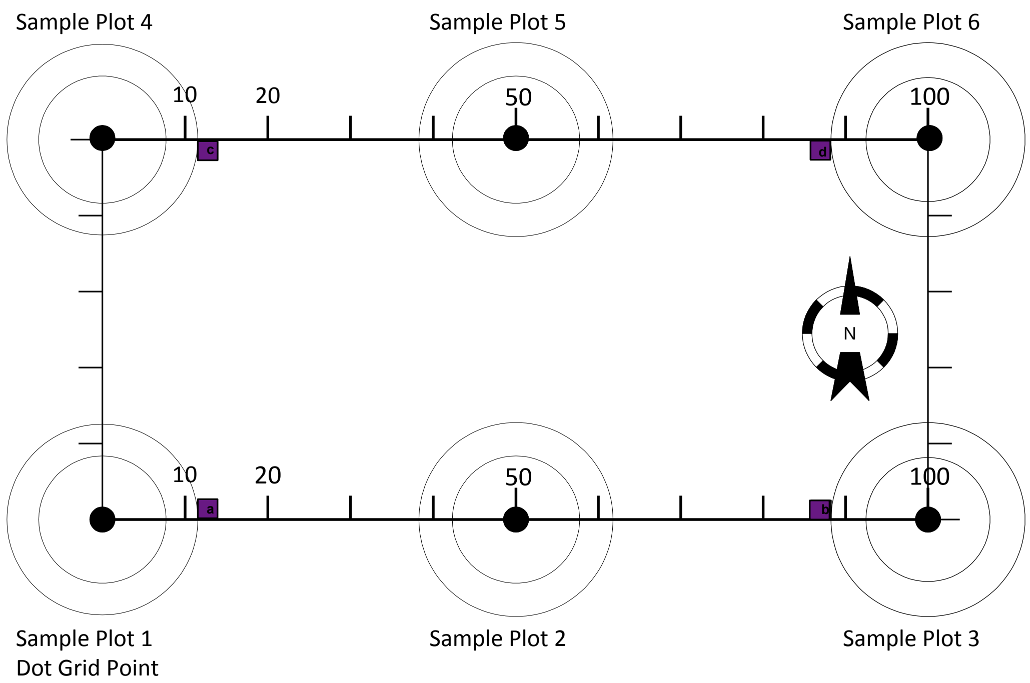


Figure 9: Cluster design for Madagascar (Plugge et al., 2010).

2.2.7 Adaptability to forest conditions

In assessment areas with a high fragmentation of the forest area (e.g. Photo 4) the cluster sampling design is flexible to avoid the risk of running out of the justification for cluster sampling as described above. The layout of the cluster is condensed with fewer SPs and probably shorter distances between the SPs. Thus the possibility of including many sample plots that include forest boundaries into the survey is minimized. Boundary plots or clusters including strata boundaries have to be treated with different and more complex statistical procedures. This gives a high flexibility to the proposed method and has been tested in Madagascar as well. However, it is important to apply only one cluster design per assessment area.

2.2.8 Acquisition of tree data

On each sample plot a multitude of data is assessed. Besides the specific tree data supplementary data is collected on the structure and status of the forest, the location and its topographic characteristics as well as on possible human induced impacts. For the young forest or regeneration there are special plots (small squares a, b, c, d in Figure 9). This supplementary data can be used in the data analysis for a post-stratification of the assessment area or results or a respective domain building.

The tree data includes information about the location of each tree, the species, the diameter at breast height (1,30m), several crown parameters (form, status), information on the status in the stand structure (social class, crown layer). On a sub-sample of trees the total height, the length and diameter of the crown and the diameter at 7m height are collected, to form the input for later regression analysis.

2.2.9 Biomass assessment

The direct assessment of woody biomass is not feasible for extensive inventories. Also a destructive sampling including the felling of trees and measuring all its assortments and of these the weight and volume is very laborious. Thus a sample based process called randomized branch sampling (RBS) is applied. The sampling procedure introduced into forestry by Valentine et al. (1984) consists of two steps: (1) employ RBS to construct a random path through the tree, and (2) a place along this random path is randomly determined at which a stem disc is extracted and weighted.

2.2.10 Randomized branch sampling of single trees

In RBS a tree is considered to be the entire stem system that develops from a single bud. A branch segment or segment is the part of a branch between two nodes. A path is the sequence of connected branch segments. At each node of branching a decision has to be made on which branch to follow in order to select the path through the entire tree. The continuation of the branch is selected with probability proportional to size (PPS), the "size" being equivalent to the estimated biomass of the possible path continuation. The size can be estimated by the product of the length of the branch, l, and its diameter squared, $d^{2,}$ as this quantity is highly related to biomass. In RBS there is no operational distinction made between branch, stem or twig.

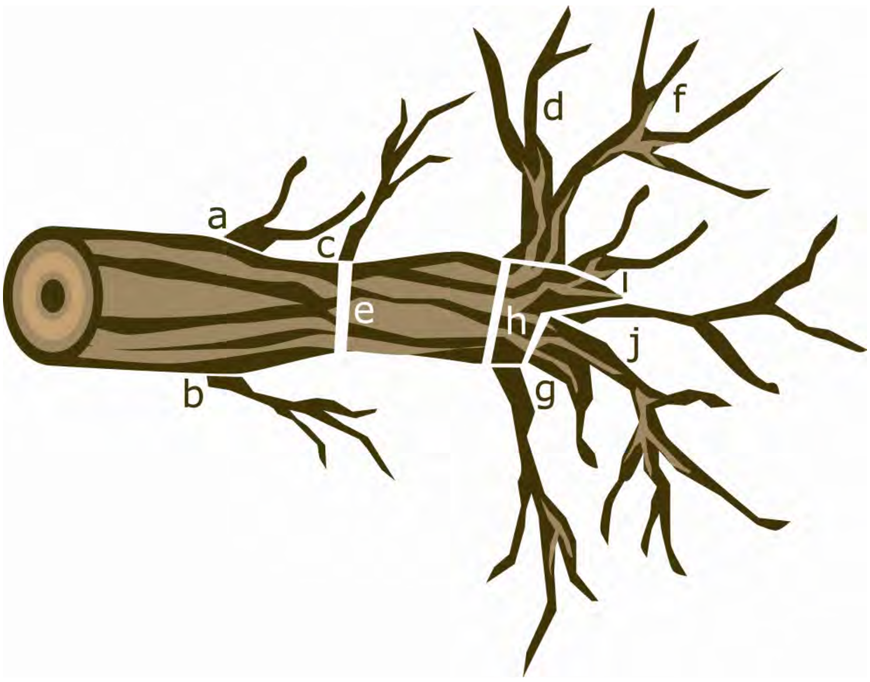


Figure 10: Segments for RBS.

By following this procedure each selected branch has a defined probability of being selected from among the other branches at the node. By multiplying the subsequent probabilities the conditional selection probability is calculated for each branch. The last segment has the lowest probability of selection.

2.2.11 Wood density samples

To collect information on the wood density a sample is extracted from the tree at a location chosen via importance sampling (IS) which can be seen as the continuous analogue of PPS. Along the path points are located wherever there is a change of taper, i.e. at the butt and before and after nodes. Diameter of each of these points as well as the distance to the butt is measured. Based on these measurements the volume of the path between any two successive points can be calculated by means of taper functions or more simple approximations. Using the volume of the last segment and a random number the position at which the sample has to be extracted can be derived. The sample has to be weighed and measured on the spot and can be used to calculate the biomass for the considered path of the sample tree afterwards.

2.3 Bottom-up

2.3.1 Post-stratification

Using the data gathered on the entity of sample plots (dendrometric and supplementary) a post-stratification may be applied to the population. The aims of stratification are described in the context. Thus it is intended to yield sampling estimates with a lower sampling error for each stratum. Nevertheless, a valid post-stratification is depending on the significance of the examined data and can not be forced. Hence, this step is not an indispensable prerequisite for the following.

2.3.2 Calculation of aboveground biomass of single tree

The calculation of the aboveground biomass for single trees via RBS is described above. RBS can also be used for other tree compartments (leaves, fruits). This would enhance the time needed for the field sampling. If this enhancement is not suitable IPCC (2003) provides default values for the calculation of the other compartments using the tree biomass as an input factor. The sum of the tree compartments shows the final AB of the sampled tree.

With the species and the dendrometric information as well as the biomass of the trees sampled via RBS it is possible to construct regression equations for every single tree on a specific sample plot and thus give information about the variance and sampling error of each single tree.

2.3.3 Calculation of aboveground biomass of sample plot and cluster

The sum of the ABs for all trees of one SP results in the AB for this SP. The variance and the sampling error do not require any extra calculations, i.e. they can be derived from the single tree values. The same applies to the sum of all SPs on one cluster. This holds as long as the cluster size is kept constant. Procedures to derive variances and sampling errors for unequal cluster sizes are described in Cochran (1977).

Upscaling procedures for the sample plot / cluster estimates can aggregate the respective values, variances and errors on different scales (e.g. forest fragments, strata, or country).

2.4 Results

Table 3 presents the results for the three assessment areas as identified by the processes described above and displayed in Figure 5. For each assessment area an apportionment was successfully applied employing the parameter crown cover. Thus three different domains could be identified, i.e.

'Closed Forest' (crown cover ≥ 20%), 'Open Forest' (crown cover ≥ 10% and < 20%) and 'Non Forest' (crown cover < 10%). The estimates for 'Forest total' are the combination of the two domains 'Closed Forest' and 'Open Forest'. As described above, only clusters within forest or forest fragments were included in the field survey. Hence, there is no further terrestrial information on the domain 'Non Forest' assuming that there is no considerable amount of biomass.

Table 3: Estimates for each of the three assessment areas.

Tsinjoarivo								
Domain	**n_SP**	**AF (ha)**	**SE of AF (%)**	**AB total (t)**	**SE of AB total (%)**	**Mean AB (t/ha)**	**SE of mean AB (%)**	**ICC**
Closed Forest	15	495	31,0	94.169	31,7	190,3	34,2	0,72
Open Forest	41	1.353	18,9	208.302	19,8	154,0	23,7	0,73
Forest total	56	1.848	19,0	302.471	20,0	163,7	23,9	0,78
Non Forest	922	30.424	1,2	0		0		1
Manompana								
Domain	**n_SP**	**AF (ha)**	**SE of AF (%)**	**AB total (t)**	**SE of AB total (%)**	**Mean AB (t/ha)**	**SE of mean AB (%)**	**ICC**
Closed Forest	47	28.136	12,4	8.250.251	13,1	293,2	29,5	0,27
Open Forest	11	6.585	32,4	1.211.540	32,0	184,0	43,0	0,18
Forest total	58	34.721	9,4	9.461.790	10,2	272,5	25,5	0,28
Non Forest	19	11.374	28,8	0		0		1
Tsimanampetsotsa								
Domain	**n_SP**	**AF (ha)**	**SE of AF (%)**	**AB total (t)**	**SE of AB total (%)**	**Mean AB (t/ha)**	**SE of mean AB (%)**	**ICC**
Closed Forest	21	6.448	23,8	877.889	27,5	136,1	34,7	0,22
Open Forest	70	21.494	9,1	1.885.991	9,5	87,7	23,0	0,15
Forest total	91	27.943	8,7	2.763.880	11,6	98,9	18,5	0,32
Non Forest	50	15.353	15,9	0		0		1
n_SP = number of sample plots; AF = area fraction; SE = standard error; AB = aboveground biomass; ICC = Intra-Cluster-Correlation-Coefficient; t = ton; ha = hectar								

2.4.1 Tsinjoarivo

The values for the mean aboveground biomass (AB) for 'Closed' and 'Open Forest' are not significantly different (190,3 to 154,0 t/ha) from each other showing that even the 'Closed Forest' is already heavily degraded. The resulting estimates do meet the estimates given by IPCC for the adapted category "intermediate (semi-dry / semi-wet)" forests (see Table 2). The high pressure on the forest in TJV is also underlined by the small number of sample plots that are located in 'Closed Forest' leading to a small area fraction (AF) of the assessment area that can be classified as such. The relatively high ICC shows that the high variance of each of the different sample plots in one cluster is similar due to the strong fragmentation.

The high amount of sample plots in the domain 'Non Forest' in Tsinjoarivo (TJV) is due to the fact that at the time of planning only earth observation data from the year 2000 (Landsat 7 ETM+) and maps from the national forest inventory (NFI) from 1996 were available. This resulted in a conservative layout of the sampling grid (1 x 2 km) over the whole project area to minimize the risk of leaving aside considerable areas of forest in this fast changing landscape (see 3.3.4.1).

2.4.2 Manompana

Manompana (MPA) represents an almost contiguous evergreen forest area (see Figure 7). The amount of sample plots in 'Closed Forest' is considerably higher than in 'Open Forest'. The differences between the mean AB of 'Closed Forest' (293,2 t/ha) and 'Open Forest' (184,0 t/ha) are significant. Compared to the estimates given by IPCC for the category "wet" (see Table 2) the resulting estimate for 'Forest total' is within the range of possible values (310 to 272,5 t/ha) . As this assessment area is under medium pressure from human impact, the 'Non Forest' area accounts for 25% of the total area. 'Non Forest' plots are either due to shifting cultivation (see 3.3.4.2) or to non-accessibility, which under the rule of conservativeness leads to the classification 'Non Forest'. The investigation of the remote sensing data of late 2004 for the area of Manompana resulted in a forest area of about 38.483 ha. This leads to a yearly deforestation rate of about 2,7% or a forest area loss of 1.254 ha/year respectively.

2.4.3 Tsimanampetsotsa

The dry forest of Tsimanampetsotsa holds a mean AB of 136,1 t/ha in the domain 'Closed Forest'. This results in a significant difference to the estimate for the domain 'Open Forest' with a mean AB of 87,7 t/ha. This difference is due to the protected forest area inside the national park representing the 'Closed Forest' and the 'Open Forest' buffer zone around the national park which is heavily affected by grazing and other forms of human impact (see 3.3.4.3). The resulting estimate for the total forest area ('Forest total') exceeds the one for the adapted IPCC category "dry" but still is well within the range of possible values (16-195 t/ha, see Table 2). More than one third of the sample plots had to be characterized as 'Non Forest' mainly because they did not meet the minimum crown coverage criteria of 10%. Nevertheless it appears feasible to apply the FAO definition of forest also to the southern dry forest of Madagascar as the derived estimates are reliable.

2.4.4 Madagascar

Table 4 shows the aggregation of the estimates for the three assessment areas as presented above. Consequently the apportionment into three domains ('Closed Forest',' Open Forest',' Non Forest') and the combination of 'Closed' and 'Open Forest' as 'Forest total' again is applied.

Table 4: Aggregation of estimates on country level.

Madagascar							
Domain	n_SP	AF (ha)	SE of AF (%)	AB total (t)	SE of AB total (%)	Mean AB (t/ha)	SE of mean AB (%)
Closed Forest	83	35.079	10,9	9.222.309	12,0	262,9	26,6
Open Forest	122	29.432	9,9	3.305.832	13,0	112,3	20,6
Forest total	205	64.512	6,4	12.528.141	8,2	194,2	20,1
Non Forest	991	57.151	7,2	0		0,0	
n_SP = number of sample plots; AF = area fraction; SE = standard error; AB = aboveground biomass; t = ton; ha = hectar							

The estimate for mean aboveground biomass for the combined domain 'Forest total' meets the value for the aboveground biomass content in forest in 2000 given by IPCC in table 3A.1.4 of the GPG-LULUCF as the default value for Madagascar (194,2 to 194 t/ha estimate of IPCC, 2003). This shows that the introduced combined inventory and the up-scaling methods applied (Köhl et al. 2008) are capable of producing reliable results on a national level. The overall sampling error (SE of mean AB, 20,1%) is justifiable in the scope of a pilot study. This error could be reduced significantly if the proposed method would be adjusted to a national scale inventory. This would among others imply an extension of the in-situ assessment to more than the three selected assessment areas, resulting in higher costs for the combined inventory (see Figure 8). The issue of cost efficiency is elucidated briefly in the following chapter.

2.5 Conclusion

The results of the pilot study show, that the developed methodology is applicable for reliable conclusions on a country's forest biomass stock and its development. Thus, they cover one of the four components (CP1), and in the end successfully contribute to a possible national realisation of REDD. Furthermore, the development of efficient methods for the quantitative determination of deforestation and forest degradation and its dynamics requires the reflection of particular crucial points, i.e. costs, change detection analysis and uncertainties.

2.5.1 Costs

The issue of cost efficiency was intensively regarded throughout this whole study. In general, several options for an inventory concept can be found for particular circumstances in a country, while finding the most cost-efficient alternative is a matter of optimization. There exist two objective subjects in the optimization process: (1) minimizing error for given cost or (2) minimizing cost for a desired error (Scott and Köhl, 1994). Firstly, the total cost of an inventory is a sum of fixed and variable costs. Fixed costs are not influenced by the area of the inventory, e.g. expenses for developing a survey design, or for computer equipment and software development. Secondly, variable costs are expenses that alter in proportion to the area to be monitored, e.g. expenses for remote sensing imagery and the number of field plots assessed (Köhl et al., 2009). However, there exist studies on inventory costs in the context of REDD, which in the end correspond to our findings. Hardcastle and Baird (2008) calculated the monitoring costs for 25 tropical countries for forests and reporting on REDD under the IPCC guidelines. They present the initial and recurrent cost separately for 4 alternatives: Tier 2A, Tier 2B, Tier 3, and Tier 3D.

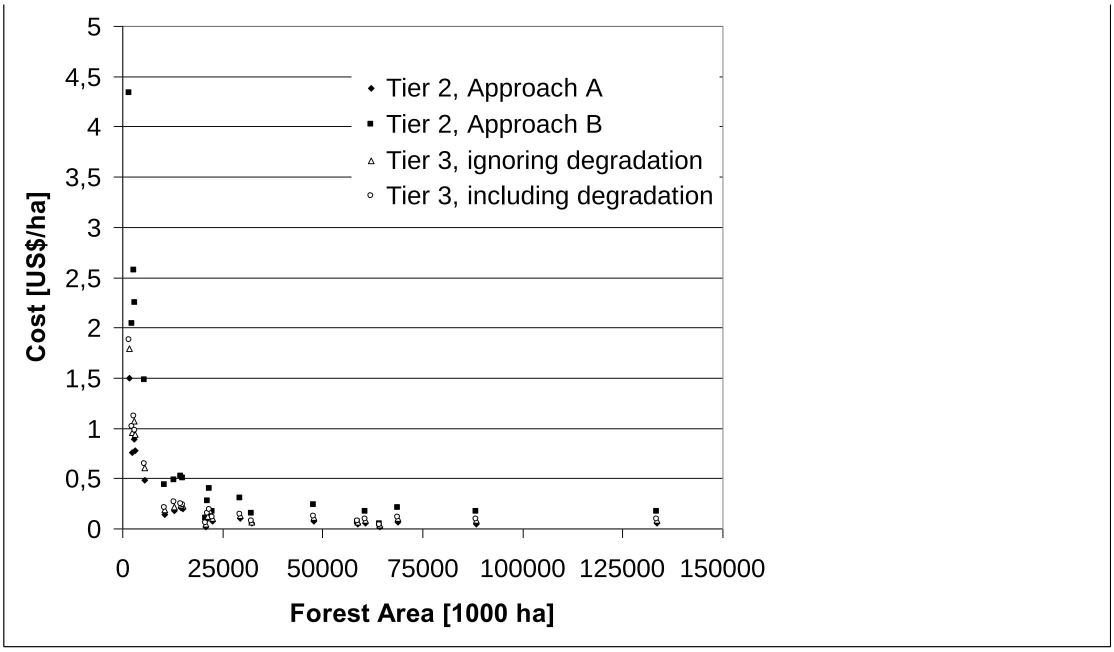


Figure 11: Cost estimates [US$/ha] in relation to forest area (source data: Hardcastle and Baird, 2008) for a 5-year Commitment Period.

2.5.2 Change detection analysis

Processes that lead to a possible emission of GHG in forests are deforestation and forest degradation. These processes are to be detected in RS-data through change in spectral and spatial patterns. Figure 12 illustrates these two processes.

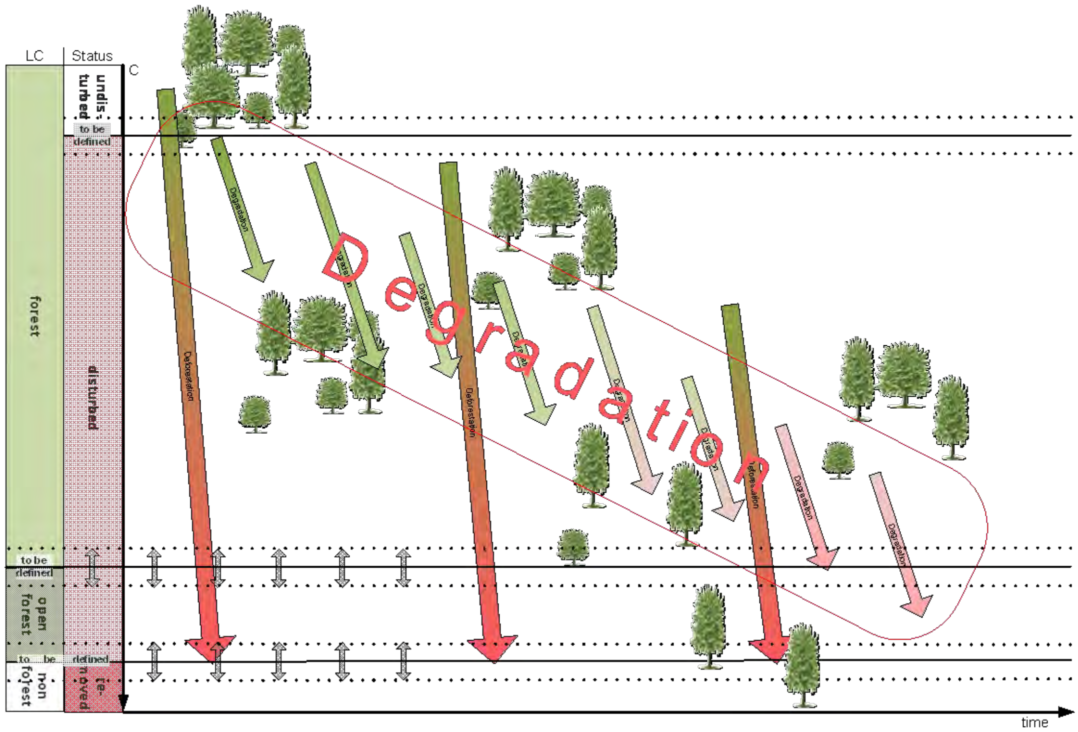


Figure 12: Differences between deforestation and forest degradation (Baldauf et al. 2009).

Deforestation expresses changes from the landcover class *forest* into *non forest*. Forest degradation describes diverse negative changes within the landcover classes *forest*/*open forest*. The definition of *open forest* and *non forest* varies in the international community, therefore the figure shows margins for these terms.

The detection of these two processes through the assessment of the RS-data of two dates can be described through (i) the delimitation through remote sensing of the exact, penetrated area and (ii) the quantification of the carbon released. This method works fine for the detection of deforestation, however, regarding degradation various difficulties arise:

The possibility of delimitating the exact, penetrated area is dependent on the degree of degradation. i.e. the higher an area is degraded, the more unproblematic is the detection through RS techniques. The option of quantifying the amount of carbon released needs a regression of remote sensing data and the degree of degradation. However, this is very low for passive sensors. Presently there are new active sensors with the appropriate spatial resolution emerging, e.g. TerraSAR-X that have to be further tested. This is currently under investigation by two PHD-students from the Institute for World Forestry of vTI (Baldauf and Köhl, 2009; Köhl and Plugge, 2008).

2.5.3 Uncertainties

2.5.3.1 Accuracy assessment of remote sensing results

The accuracy assessment of both the supervised and the unsupervised classification uses ground-truth data (GTD). The locations for the samples of these GTD-spots have to be equally arranged in the classes (e.g. forested and non forested), in order to satisfy statistical needs.

GTD can be derived of potentially existing national forest inventory (NFI) data, otherwise this data has to be determined on the spot. Typical accuracies can be expected to be in the range of 80%-90%. These accuracy figures are further processed in the up-scaling process in the next chapter.

2.5.3.2 Calculation of Mean Squared Errors (MSE) and Reliable Minimum Estimate (RME)

The assessment of carbon stock and carbon stock changes is associated with uncertainties. The IPCC Good Practice Guidance LULUCF (IPCC, 2003) addresses this problem by offering parties to use three different levels tiers (i.e. levels of reliability) for their national greenhouse gas reporting. Where parties want to generate carbon credits by applying a REDD regime the reliable minimum estimate (RME) for carbon stock changes needs to be presented. A point estimate of the carbon stock or its change rate over time needs to be supplemented by a quantitative measure of its reliability. The point estimate is reduced by the reliability measure resulting in the RME; not the point estimate but the RME qualifies for accounting. Therefore parties are obliged to report on the errors associated with any carbon estimate and need to implement assessment methods that result in estimates with high reliability. The reliability of forest area changes is quantified via the accuracy of remote sensing classifications, while the reliability of biomass estimates results from the calculation of sampling error estimates. Errors associated with the assessment of individual tree biomass and its conversion into carbon contents are to be obtained by empirical studies. All different error sources can be combined via an error budget (Gertner and Köhl, 1992) and allow for a consistent and accepted quantification of the reliability of carbon stocks and carbon stock changes.

In a recent publication, the Institute for World Forestry developed a framework for calculating carbon benefits by including assessment errors (Köhl et al., 2009). Sampling and non-sampling errors effect the reliability of estimated activity data and emission factors. This has a great influence on the potential to generate benefits from applying a REDD-regime. A simulation study for Madagascar including figures of FAO (FAO, 2005) show that even small assessment errors (5% and less) may outweigh successful efforts to reduce deforestation and degradation.

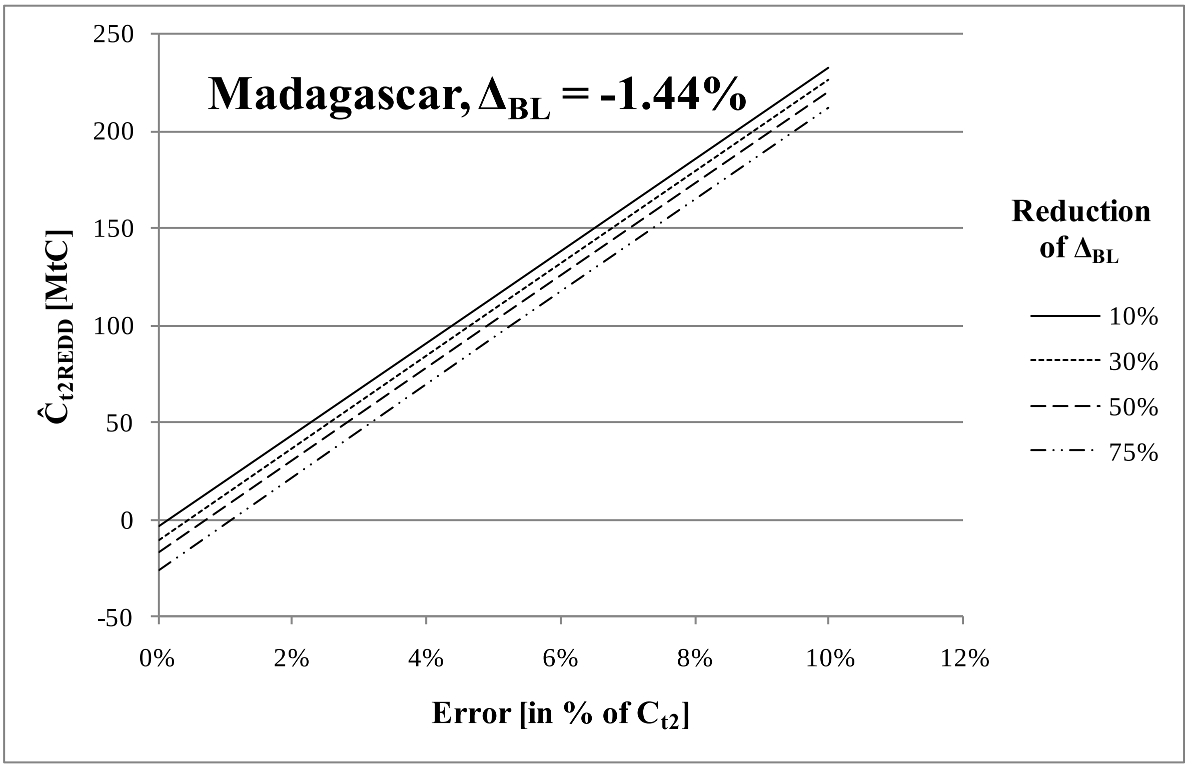


Figure 13: Graphs of resulting $\hat{C}_{t2REDD}$ (in tC*10^6) for Madagascar in relation to error at time 2, (E_{t2}) for different reduction scenarios for Δ_{BL} showing the effect of total error and deforestation and degradation rates on carbon credits; positive numbers display emissions, negative numbers removals $\hat{C}_{t2REDD}$ shows the amount of carbon stock qualifying for accounting, which incorporates uncertainties for the estimated carbon stocks at time 2. E_{t2} displays the error of the estimated carbon stock at time 2. Δ_{BL} is the proportional change between time 1 and time 2 according to the baseline (Köhl et al., 2009).

Figure 13 shows, that the generation of benefits from REDD for Madagascar is possible only in situations where assessment errors are carefully controlled.

3 Human impact on forests

Assessment of causes for deforestation and forest degradation, and options for their mitigation

Authors: Bettina Leischner, Aziza Rqibate, Matthias Dieter, Michael Köhl

A REDD regime as it is discussed today will give emission reductions from avoided deforestation and forest degradation an economic value. A reference emission level or baseline needs to be set, against which actual emissions are offset. In the previous chapter a method for the assessment of biomass and respective carbon stored in different forest formations was presented, by which the actual carbon stock and its changes over time, i.e. emissions from deforestation and forest degradation in a given period can be quantified. This chapter deals with options for setting a reference and thus value the emission reduction. It deals as well with human impact forests could be exposed to and which could affect the permanence of a reduction. It contributes to CP2 (see chapter 1) and complements the vTI-ESSA-Approach for REDD by analysis of causes for deforestation and forest degradation and options for their mitigation.

Countries participating in REDD need to establish a baseline or reference emission level, their emissions in the commitment period are offset against. Methodological approaches for setting such a reference and potential implications on national level are discussed in the first part of this subchapter (see chapter 3.1 p.29 ff). An intended reduction of deforestation or forest degradation in order to generate credits from deviation from this reference is supposed to take place in regions within the area of application of this baseline and thus may affect to certain extend people on sub-national level benefiting from forest resources. These impacts of the reduction of deforestation and forest degradation are treated in the second part of this subchapter in two studies. The studies were labelled "economic study" (see chapter 3.2.3) and "socio-economic study" (see chapter 3.3) and focussed on different key aspects and actors described in the following.

Forests represent resources for people in offering timber for material or energy use or in offering potential food supply. An important resource could also be the property concerning the option of land use change from forests in pasture or agricultural area. This range of importance of forest resources for people makes an addressing and mitigation of deforestation and forest degradation a challenging task. With an accounting of REDD in a future climate agreement efforts for reducing emissions from deforestation and forest degradation will need to tackle with its causes. In this context, benefits of local actors generated by forest use or the alternative land uses need special consideration.

Within the project REDD-FORECA in Madagascar two studies about causes for deforestation were conducted which cover the two aspects of human impact on the forest by commercial timber use and by land use for resident population. By commercial timber logging, more than the assessment area could be supplied with timber originating from the area and likewise affected by an attempted reduction of timber use while people's decision concerning their land use affects primarily forest cover changes within the assessment area.

Economic study

This study focuses on commercial timber use, i.e. the actors which are working with timber in different stages of processing, i.e. loggers, transformers (e.g. producers of charcoal, carpenters), timber traders or timber transporters. The focus is given to timber and its processing, i.e. the different stages of the timber from forest to the (product's) marketplaces. In the scope of the survey the assessment area was not left, i.e. the marketplaces were "inside" or "outside" of the assessment area. The study integrated an option of deducing potential leakage effects with regard to an implementation of policies concerning the reduction of timber removal.

Socio-economic study

The socio-economic study focuses on the Malagasy rural households and the land use changes implicated in their traditional way of life. They use forests both as source of income and as provider of material and energy, and in this way contribute to deforestation and forest degradation. The study identifies and ranks relevant causes for human impact on forests in each assessment area. The results show on the one hand the needs of the rural households and their dependency on DD, and on the other hand a tie-in link to the development of possible incentives.

The two studies complement one another with regard to timber use in the assessment areas for local people (household level and alternatives for timber use) and regional importance (commercial level and product distribution). Measures for reduction of human impact on forests could thus be investigated as direct implications for local livelihoods and – with regard to leakage effects – according to the effectiveness and efficiency of such policies in regional context.

Both studies were conducted in the three assessment areas Tsinjoarivo, Manompana, and Tsimanampetsotsa (see Figure 5) in Madagascar. In addition to the different forest formations in the areas, they represent regions of different circumstances concerning both land use respectively timber use, and ethnical and cultural backgrounds.

3.1 Baseline

Authors: Bettina Leischner, Matthias Dieter

The project part of the Institute of Forest Based Sector Economics (vTI-OEF) dealt with two major work packages. The first work package was the research about establishment of baselines and its methodological aspects. This work package was conducted in Hamburg as research about general aspects apart from field studies (see chapter 3.1.2). The second work package was the research about timber use, which was undertaken in the REDD-FORECA's host country Madagascar. This topic included the analysis of Malagasy national timber balances as well as the survey about economic causes for timber use in three selected assessment areas in Madagascar (see chapter 3.2.3). The analysis of economic causes for timber use was conducted with a homologue in cooperation with ESSA-Forêts.

The results displayed in this report are thus presented in two parts. First, the results from the analysis about baselines on national level are displayed. In the following chapter, the focus is given to the integration of country specific aspects in baseline approaches. It deals with national timber balances and the analysis of economic causes for timber use in the assessment areas in Madagascar, and deduced implications.

3.1.1 Objective

The objective of the following two chapters (both worked out by vTI-OEF) is the description of the approach to point out

- Which methodological requirements exist for baselines for REDD?
- Which approaches are discussed for establishing national baselines in REDD?
- Which implications can be deduced from those for potential participating countries?
    - On national level (at the example of Madagascar)
    - On sub-national level (at the example of three assessment areas in Madagascar)
- Which aspects could be considered in a more prominent manner in baseline discussion?
- Which conclusions can be drawn from the approach applied?

3.1.2 Overview

An accounting of REDD and rewarding of the resulting credits requires the identification of the amount of reduced emissions. For this purpose a reference needs to be set, the actual emissions from deforestation and forest degradation are offset against. Every country participating in a future REDD regime needs to commit itself to such a reference emission level or baseline. According to the theoretic approach of a baseline, credits would result for a country in case emission reduction is higher than the agreed. In case the actual emissions would exceed the agreed, the country would result in a debt.

The future REDD regime is most effective if as many countries as possible participate in the scheme. In order to secure a broad participation in REDD, the countries' points of view and the aspects necessary to include in the regime need to be considered as far as possible. Summarizing these aspects (UNFCCC not dated a), a method to determine a baseline need to be found that is applicable in any participating country, with passable effort and which is providing a reliable calculation. Furthermore it would have to reflect different national circumstances in an equitable manner and would need to consider all relevant aspects so that any participating country would face a potential for benefit and thus commitment. The major condition which needs to be fulfilled is to be effective, i.e. actually reducing deforestation on global level.

There are several approaches discussed to determine a baseline (see Parker *et al.* 2009; Angelsen 2008; Huettner *et al.* 2009). Those are brought by GO, NGO and different stakeholders to international scene (cf. webpage UNFCCC not dated a). The approaches use a continuation of historic trends concerning deforestation in a retrospective manner or prospective as dynamic land use modelling (cf. Huettner *et al.* 2009) or with differentiations according to the allocation of generated credits.

In this report some of those approaches are discussed and potential implications for a country's participation in REDD are deduced at the example of Madagascar.

3.1.3 Definitional aspects

For the reference emission level some definitional terms and aspects to be included are still unclear. In this introducing subchapter terms are explained how they are used in this paper.

According to the recent draft decision agreed in Copenhagen, the reference emission levels should be established "taking into account historic data, and adjust for national circumstances" (UNFCCC 2009a). A difference exists between the approaches of establishing a reference as the strict continuation of past trends of the emissions which is thus strictly orientated to past development. Taking into account national circumstances would consider potential future development and thus considers national circumstances concerning deforestation rates or emissions from deforestation and forest degradation. The first approach is labelled in this report "reference emission level" while the latter is referring to a "baseline".

The discussion about strictly historic trends vs. addressing national circumstances of a country faces the challenge to include early action, actions undertaken to reduce the emission reduction from deforestation and forest degradation without a REDD regime being established and thus no potential for being rewarded for the undertaken efforts. The question is whether if and in what scale those actions (in past periods) should be accounted or rewarded if a REDD regime is agreed. In this scope additionality of REDD measures is discussed as well. Only measures which are additional to developments which would happen anyway would be accountable. The criteria of additionality is not yet defined for REDD but it depends on the approach for reference emission level finally chosen. If a baseline is calculated according to past trends, the reductions of the deforestation rate (as the “plus” compared to the baseline) might be considered as additional. If the baseline is calculated by means of projections and political negotiations, measures might already be included in the baseline.

As forests are already accountable under the Kyoto-Protocol as carbon sinks, baselines and their establishment are already discussed in the Marrakesh Accords (see UNFCCC 2001). A key criterion for a baseline for CDM projects is the fact, that the project must provide additionality. As mentioned above, depending on the chosen baseline approach, additionality could already be integrated in a baseline. Further on, in REDD, the Parties seem to prefer baselines which are adaptable according to the countries’ development performance after a certain period (Sathaye and Andrasko 2007). Moreover, a baseline for CDM is not standardized yet (Sudha *et al.* 2008).

Some further aspects to be integrated in the accounting of the reference are still discussed. In the scope of international climate agreements, forests are considered as sinks and afforestation and reforestation are already accountable in CDM under the Kyoto Protocol (UNFCCC 1998b). If REDD focuses on carbon stocks only (emission reduction and / or changes in carbon stocks), changes of natural forest into plantations could be covered as only a changed carbon stock would be relevant in REDD (Friends of the Earth International 2008). Excluding enhancement of plantations for REDD, would shift the focus towards additional benefits of natural forest protection like conserving biodiversity and social benefits (Fearnside 2001).

A clear definition of the precise objective of REDD is still negotiated. In the scope of this report, the focus is given to carbon stock (as the implications of the discussed approaches are deduced by means of their change in forest area) but desirable additional effects like maintaining biodiversity are discussed as well.

3.1.4 Scale of baselines

Just as the methodological issues about what should be accounted a key question is the level of accounting. The discussed levels and key characteristics of accounting are listed in Table 5.[1]

[1] The focus in the table is given to “independent” levels; no mixtures of levels are mentioned (as for example the Nested Approach, cf. Angelsen et al., 2008)

Table 5: Level of accounting for the REDD Baseline with key characteristics

Level of accounting	Key characteristics
Project level / sub-national	– Development of a baseline for a project area – Accounting more reliable than on national level – Integration of indigenous people and other local stakeholders easier – Fast establishment could be possible
Regional / sub-national	– Development of a baseline for a region within a country – Possibility of calculating multiple projects within one single baseline Establishment could be more cost-effective
national	– Development of a baseline for one state – Integration and handling of leakage – Responsibility is taken by the states which ratify and decide about their goals.
supranational	– Development of a baseline with consideration of situation in neighbouring states – Possibility exists only if respective area is more or less uniform (e.g. Congo-Basin)

In the Parties' perception of how to account the baseline, the discussion about the level of accounting - national or sub-national – is a major topic. Though the national approach receives broad support recently, the sub-national approaches constitute important initial steps with a continuously adding on and extension towards a national approach (UNFCCC 2009a; UNFCCC 2008). Implications of non fulfilment on national level but succeeding on sub-national level still need to be clarified (UNFCCC 2007a). In any method of accounting, early actions in conserving forested areas should be considered (UNFCCC 2007a).

3.1.4.1 Sub-national level

A methodology for a reference emission level on sub-national level is proposed by Brown et al. (2007). This methodology focuses on the development of baselines as predicted future land-use change. The calculation uses the land-use models FAC, LUCS and GEOMOD, which may reference deforestation by impact-factors of land use. The research was undertaken in study areas in Belize, Bolivia and Mexico (Brown *et al.* 2007).

The results of this modelling show a broad range between supposed deforestation as the cumulative loss of forest cover accounted for 14% to 52% within a period of 20 years. Likewise depending on the model used, the results differentiated in the test-regions. The main differences were caused by alternative methods to calculate population growth. A major restriction is given by missing data availability in all of the test-regions. Thus not all factors were available for boundless use. The drivers of deforestation were modelled in several test-sites. As result Brown et al. (2007) conclude a different significance. In their studies the physical and biological factors are about twice as influential for the calculation of the baseline as social, demographic or economic and infrastructural factors.

The baseline methodology proposed by Brown et al. (2007) was tested in several project areas and showed to deliver robust findings. The authors also give valuable indications about the factors to be integrated for a potential REDD regime as well as their constraints. Regarding the local focus, some aspects still need further examination.

The models used may identify different drivers of deforestation as key indicators in the specific project sites. This might lead to significance of different factors in the test areas and significantly reduce the transferability to regions outside the test areas.

As the baseline has to show that the forest has to face the threat of deforestation to be integrated in the REDD scheme, inaccessible areas and protected areas are considered as not being suitable. The deduction might be a different valuation of existing forested areas.

Finally, significant indicators on local level are identified and considered in using this methodology, which might need different approaches for benefit transfer and incentives. Applied to local level, if these benefits don't show an alternative for local population, the menace of leakage is very high (considered that the forest has to be threatened of being deforested to be eligible). Actions to relieve the pressure and activities to minimize and integrate leakage should be borne in mind.

In case more projects for forest conservation are to be implemented in a region, the development of a common regional baseline might be possible. Potential project baselines and regional baselines are grouped on a sub-national level. As a precondition, the area in focus should be homogeneous as far as possible concerning carbon pools with relatively homogenous density. A broad setting of the borders of the area facilitates an inclusion of all relevant activities (Sathaye and Andrasko 2007).

If all relevant criteria are fulfilled, a regional baseline could provide several advantages compared to a local baseline. The methodology for establishment of a baseline could underlie a more objective point of view. Methods could be applied which are more standardized than approaches focussing on local level (Sathaye and Andrasko 2007). Moreover, the potentially higher costs, which could occur while establishing the baseline, could be shared amongst more projects. This could lead in lower costs for the individual project, which could finally let this choice look more reasonable.

Summarizing, regarding the development of a project-specific or sub-national baseline, elements of already developed and tested approaches (either CDM or its adaptation on REDD) deliver valuable aspects of lessons learnt. There are still uncertainties in accounting and integration of relevant aspects (such as the aspect of leakage effects, investigated e.g. by Boer *et al.* 2007; or Lasco *et al.* 2007) and thus in applying the sub-national based approaches in a future REDD regime.

Sub-national baselines could be set more adequate according to local conditions, as the drivers for deforestation and forest degradation could have different importance. Likewise it could be easier to find the best-possible incentives to address those drivers to reach a reduction of deforestation and forest degradation in this area. Attention needs to be paid on potential leakage effects, which could affect the outside of the boundaries of the area of intervention, and thus could reduce the effectiveness of incentives.

Finally, the countries which are in focus of REDD have to adopt the approach and implement the regime. Vice versa, the regime is implemented by a country, which ratifies and commits itself to REDD. So the final decision about the favoured approach, whether sub-national or national, is made on national level.

3.1.4.2 National level

A national baseline is established by a country committing itself to REDD. There are three major categories to establish such a reference (see Pirard and Karsenty 2009): a continuation of past trends, a modelling according to the causes for deforestation and an agreement according to political negotiations.

1. Continuation of historic development

   One possibility to set a reference for future deforestation rates is a continuation of historic development concerning emissions from deforestation and forest degradation. The countries are supposed to show the same deforestation rates in future like in past periods. Countries with high deforestation in the reference period would have a reference allowing high deforestation rates in the commitment period as well. Likewise, if high deforestation in the reference period is only for short term, credits might be created with little or no effort during the commitment period. Low deforestation in the past would lead to a reference in the commitment period which allows low deforestation rates in the commitment period. Countries which have extended forest cover and start using their forest resources during the commitment period could be disadvantaged due to low deforestation rates in the reference period (which is relevant for the accounting of historic development of deforestation rates).

2. Modelling according to the causes for deforestation

   A modelling of future deforestation according to the causes gives possibilities to include the major relevant aspects. Hitherto established models put emphasis on different points of view or emphasis of special aspects to be modelled. The indicators used in these models refer to the specific aim of previous models, e.g. in a model for identification of coherences and correlations of macroeconomic approaches indicators like total population or GDP per capita are used. In case local circumstances are more in focus, the more specific purpose of deforestation is in focus by microeconomic approaches (i.e. distance to roads, local market forces and alternatives or transportation costs).

Regardless the purpose of establishment, a modelling of future deforestation rates bases on the assumption that causes in the past will be relevant in the future as well. This could lead to a backwards perception and may cause reduced reliability of the baseline. On this account the countries which favour a baseline modelling according to the causes suggest to integrate an extra factor to consider national circumstances (UNFCCC 2008; Angelsen 2008) which better represents the countries actual condition and future prospects.

3. Agreement according to political negotiations
A baseline is considered to represent a future deforestation rate / carbon stock a country is committing itself to. The baseline is thus matter of a country's sovereignty and it is supposed that a country would commit itself to REDD in case it deems participation as beneficial, which means that the set baseline offers potential for rewarding. This manner of baseline establishment might be best adapted on a country's future development potential. Likewise it may base on inaccurate assumption of present or future carbon stocks because the political aspect comes in the fore. The environmental integrity of the approach might be (but not necessarily is) endangered.

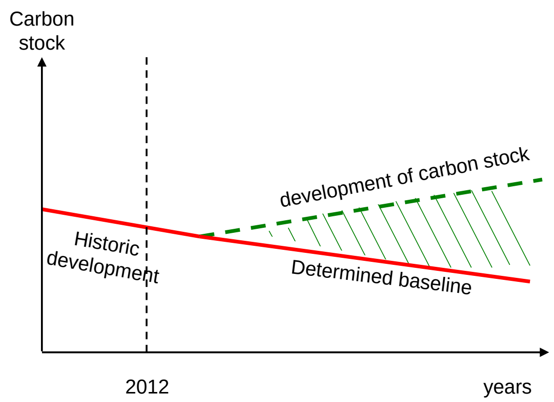
It might be possible that the reference emission level is finally set in a combination of those three approaches. As mentioned above, according to the negotiations and agreements in UNFCCC a reference should be set "taking into account historic data , and adjust for national circumstances" (UNFCCC 2009a). This would lead to a combination of both of the first above mentioned aspects. It might be probable that arguments of the "big players" concerning REDD could receive different importance (see Noordwijk *et al.* 2008, for the case of Indonesia), which would lead to an integration of the latter of the above mentioned aspects as well.

3.1.5 Approaches in discussion for national baseline

There are several approaches for setting a reference emission level in discussion (see Parker *et al.* 2009). Some of the approaches are displayed in this paper. Only those approaches, which are considered in the latter parts of the report, are described in detail. The choice was based on the actual calculating of a reference, which basically differs amongst the accounting instead of offering different advantage for the countries caused by alternative allocation schemes.

3.1.5.1 Compensated Reduction (CR)

The initial proposal of this approach was presented by Santilli et al (2005) and referred to a reference emission level as continuation of historic developments in the future. The deforestation rate in a reference period is used to set the historic development the actual deforestation in a commitment period is offset against. An example is illustrated in Figure 14 in a hypothetical development, in which the historic development of carbon stock reduces continuously. Given a development of carbon stock as described by the green line in Figure 14, the "plus" compared to the baseline (hatched area) can be considered as additional amount of carbon storage and thus compensable.



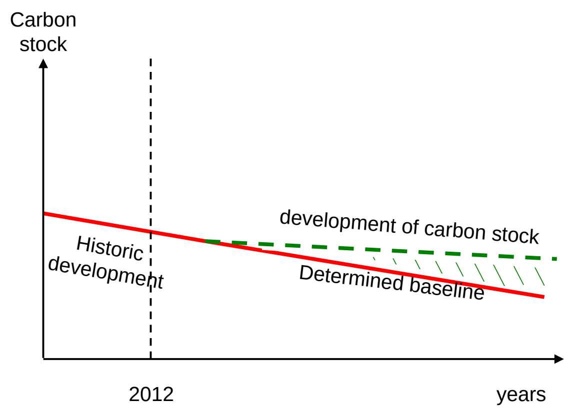


Figure 14: Compensated Reduction (CR): Hypothetical development of carbon stock over time (increase of carbon stock) and hypothetical development of reference emission level; left: reversion of carbon stock losses; right: continuation of carbon stock losses.

With a precondition that any plus in reference to the baseline might be compensable, negative change rates in forest cover might be profitable as well. Figure 14 (right) demonstrates such a hypothetical development. Even with a negative change rate of carbon stock there might be an amount for accreditation in case the baseline is determined adequately low.

The approach CR might be favoured and advocated by countries which have high deforestation rates at present. Historical development sets the course for a low reference emission level which might make it easier to gain even from little increases in carbon stock. This could lead to a rewarding already at smaller increases or smaller reductions of national carbon stock.

3.1.5.2 Compensated Conservation (CC)

This approach accounts for the country's carbon stock at a given year/time as the key factor. It was brought by India via submissions to UNFCCC to international scene (UNFCCC 2007b; UNFCCC 2007c).

The reference for the country’s carbon stock is set in a fixed year. In the reference period the increase/decrease of national carbon stock is offset against this fixed reference.

An accounting of extended areas of plantations or areas for conservation could be much easier in this approach. Methodological aspects like the accounting of plantations irrespective of the species composition of plantations (e.g. with exotic species or plantations for industrial purpose) or the integration of forest degradation need further discussion.

A reliable accreditation of the outcome with respect on effectiveness is possible in a national approach only. Accounted on sub-national level, this approach could cause leakage effects, which do not reflect actual emission reduction.

Figure 15 represents a hypothetical development of forest area in an approach of Compensated Conservation (CC). Historic development is only of inferior importance. The crucial factor is the forested area / carbon stock at a certain point of time. In Figure 15 this is shown to be a year before 2012, but it is not fixed. The beginning of accounting in a year prior to 2012 honours early actions undertaken by the countries to stabilize the forest cover. For future periods, any increase in forest area compared to the forest area at the fixed year is compensable. The increase might be reached by stricter regulations for environmental protection or extended reforestation. In case forest degradation is included in the accounting by CC, the increase could also refer to carbon stock, which means enhancement of existing forest areas.

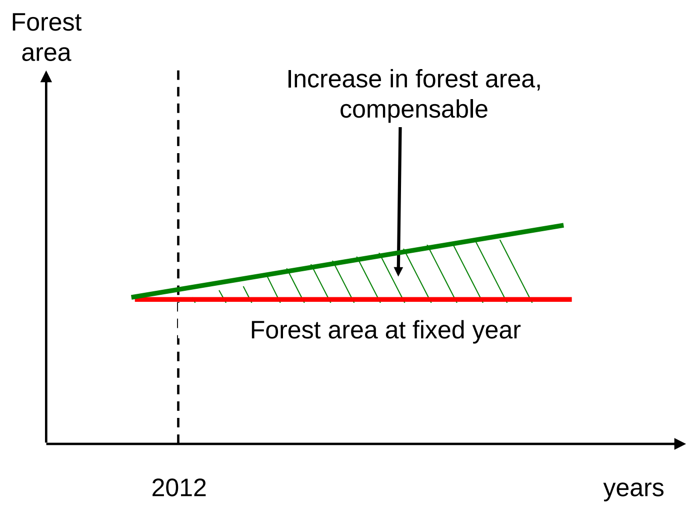


Figure 15: Compensated Conservation (CC): Hypothetical development of forest area over time and hypothetical baseline development.

The approach of Compensated Conservation is favoured and advocated by countries, which show strict environmental policies and which have already undertaken great efforts for forest conservation. Those countries benefit from an intensified integration of early action.

The approach CC is highly discussed in the “REDD-community” as REDD baseline approach as it focuses on increase in carbon stock. So discussed, this is no action for reducing anthropogenic emissions and removals and thus is not evidently in the focus targeted by REDD (UNFCCC 2009b).

An accounting by CC would give the most opposite method of accounting to CR and is favoured most prominently by India and China.

3.1.5.3 Corridor Approach (CA)

The third approach presented in this paper focuses on the question of permanence. Deforestation is not supposed to be stopped immediately; a major goal would be a long-term mitigation of deforestation and reduction of emissions. As people use the forest for their purpose and a certificate or credit will possibly offer alternatives for income at the most, forests' carbon stocks are supposed to show interannual variability which has to be included in the reference emission level's assessment.

In order to integrate such a variability, Joanneum Research, Union of Concerned Scientists, Woods Hole Research Centre and Instituto de Pesquisa Ambiental da Amazonia proposed a Corridor Approach (CA) in their joint submission (UNFCCC 2006a). To exclude interannual variability, a corridor between a high and a low level of emissions would be created. Theses emission levels could base on a past period of 5 up to 15 years, but could also be established by negotiation. The rewarding is proposed according to two variants:

1. The compensation requires an emission level below the lower bound of the corridor. Emissions, which are reduced within the corridor's upper and lower level, are accountable, but first accounted in a banking system. The actual year of rewarding is set by the year the emissions reach and fall below the lower level. Only then, at the end of the commitment period, all the generated credits gained in this period, could be compensated. Thus, the corridor is seen as buffer to sort out random emission reductions (which possibly could be caused by others than REDD measures) and concentrates on long term reductions. Early actions could be considered in a manner which is not necessarily at the expense of countries which had an early start in emission reduction.
2. In a second variant emission reductions within the corridor are accountable directly, but not in full account. A discount factor would be applied, which would vary according to the distance to the upper bound limit. Reductions which are located near the upper bound would thus be accounted by a discount factor near "zero" while reductions near the lower bound could reach a factor close to "one". The accounting by this variant would enhance a direct rewarding of the emissions – however to a lower rate. Likewise, the accounting of "hot air" (as accounting a cause that finally does not apply) is avoided as well as accounting of business as usual and interannual variations.

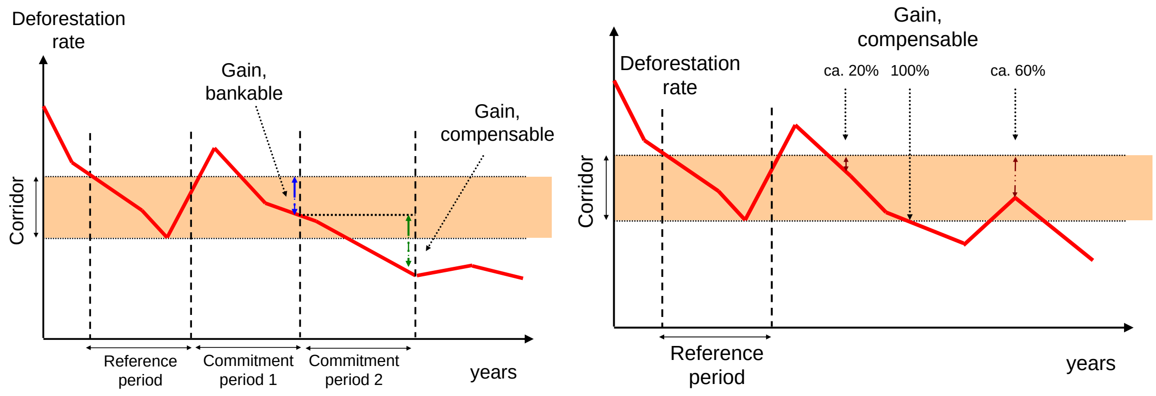


Figure 16: Schematical illustration of Corridor Approach (CA), (left: variant 1; right variant 2) Corridor based on political negotiation for one country, based on a reference period; (Illustration according to UNFCCC 2006b)

The Corridor Approach presented jointly by Joanneum Research and others (UNFCCC 2006a) combines the aspects of early actions, additionality and permanence in a promising approach. Still some aspects need further consideration. The exact position of the reference levels for example, the manner of their calculation or the aspects to be integrated in the calculation are not clearly defined yet. Likewise the determination of the corridors' amplitude (distance between the upper and lower bound) still needs to be discussed. It should be highlighted, that a low emission level (that means a low deforestation / degradation rate) in the past can result from a unique or random "accident". In this case, the low emission level cannot be used for baseline determination, since reaching the low emission level of the respective year again, will cause additional efforts and will be not a "hot air effect".

3.1.5.4 Incentive Accounting (IA)

The approach of Incentive Accounting (IA) bases on the principles of Compensated Reduction (CR). It is a refinement presented by the Institute for Environment and Sustainability for the European Commission Joint Research Centre. In this paper it is described according to Mollicone et al. (2007).

A country's deforestation rate is compared to a global reference. Mollicone et al. (2007) propose to use half of the global deforestation rate as this reference. For countries with higher deforestation rate the reference emission level is set using another calculation than countries with deforestation rates lower than this reference. In this approach, countries with high deforestation rates would be rewarded for reducing their deforestation rate while countries with low deforestation rates would be rewarded for maintaining lower deforestation rates (Parker *et al.* 2009). The rationale behind this approach is the argument, that countries with high deforestation rates may consider no chance of reaching a reasonable reduction and thus accounting of REDD. In case they "give up hope" they may import deforestation of the neighbouring countries. This could be in opposition to the aim of reducing global deforestation.

The approach aims to integrate deforestation as well as degradation and thus focuses on conversion rates. It addresses the following three categories of land-use change (Mollicone *et al.* 2007):

1. Intact forest to non-intact forest
2. Non-Intact forest to other land use and
3. Intact forest to other land use

The inclusion of forest degradation via conversion rates could face challenges for developing countries. The furnishing of GIS and remote sensing could be a challenge for some of the countries. Thus, countries with difficulties in technical equipment and / or capacity could be disadvantaged. This aspect stresses the importance of capacity building in the scope of REDD. Implementation and application of the methods will crucially depend of people's involvement, so the encouragement of capacity building was stressed in the decisions taken in Bali (UNFCCC 2008a).

Further on, the change in land use-types refers to a reduced forest area only. There seems no possibility considered to integrate non-intact forest or non-forest back to forest area. Hence, the increase of forest area or carbon stock is not considered in this approach.

Summarizing, there are approaches for reference emission levels discussed internationally, four of which were discussed in this chapter. They were chosen according to their clear difference in accounting method and according to their calculating of a real reference. The approaches focus on different aspects which are relevant for an integration in REDD. The magnitude of impact, resulting from these approaches for the countries could differ as well. These potential implications are treated in the following chapter.

3.1.6 Implications of the approaches applied to past periods (example Madagascar)

The approaches to establish a reference emission level presented in the previous chapter are supposed to have different magnitude of impact on participating countries, depending on past periods' country performance or specific situation in the country.

The potential implications of these approaches will be discussed in the following, applying them to a country's forest area in past performance. For this purpose, data about forest area change in past periods was used to display the implications of past period's development in case a REDD regime would already have been established. The implications of the approaches are displayed at the example of Madagascar. Used data concerning forest area originate from Forest Resource Assessment (FRA) of the FAO (FAO 2005), it thus refers to deforestation only. The reference emission level is set strictly on historic deforestation rates, using the approach presented in Leischner and Elsasser (2009, submitted).

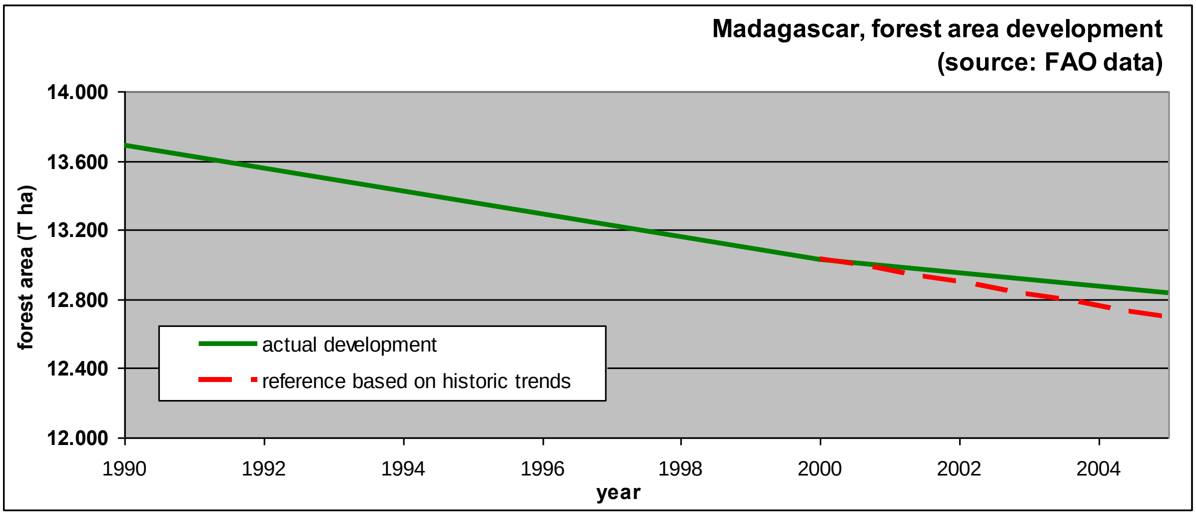


Figure 17: Forest area development in Madagascar (source: FAO, Forest Resource Assessment (FRA)).

According to FAO data the forest area in Madagascar was reducing between the years 1990 and 2000 (Figure 17). In the following period assessed by FAO there was a strict reduction of forest area as well, but with a reduced deforestation rate. Applying CR in this situation, credits would result as a better performance than the reference was achieved, irrespectively of still negative forest area change rates. The amount of the resulting credits could vary according to the approach applied for calculation, which is shown in Figure 18.

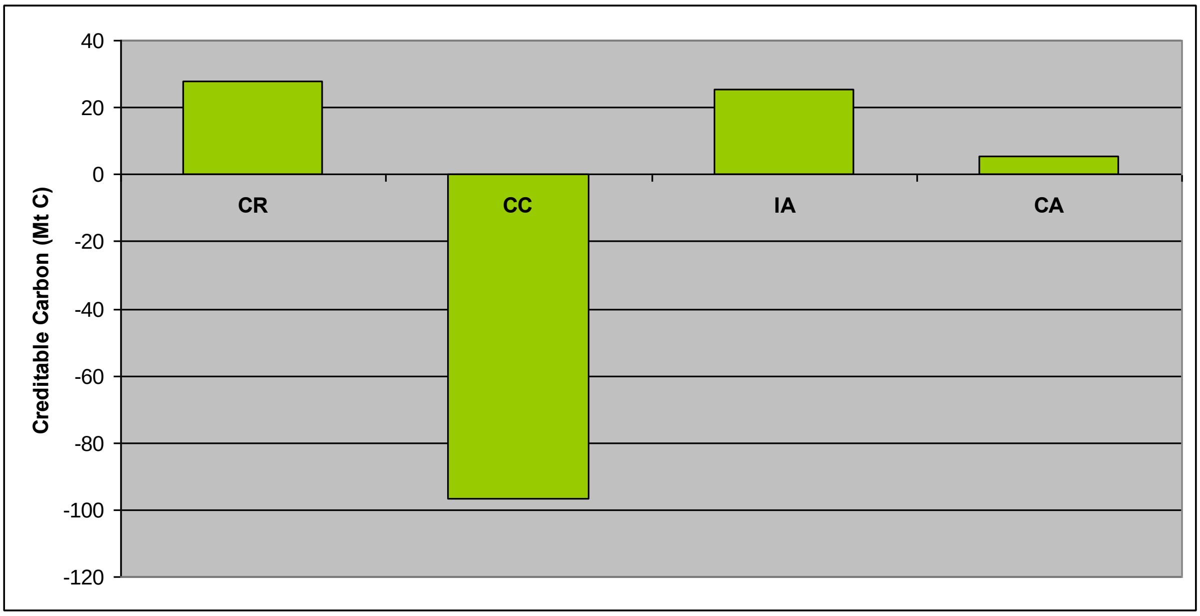


Figure 18: Hypothetical amount of creditable carbon (Mt C) in REDD which would have resulted for Madagascar in case a rewarding by REDD would already have been accountable in past periods. The amounts displayed result for the different approaches for reference emission levels Compensated Reduction (CR), Compensated Conservation (CC), Incentive Accounting (IA) and the Corridor Approach (CA), using the approach described in Leischner and Elsasser (2009).

Applying the approaches for setting the reference emission level discussed above to past forest area development in Madagascar, the approaches would seem to have offered different advantageousness for this country. By CR, IA and CA credits would have resulted while by applying CC a debit would have been generated. It needs to be taken into account that the numbers displayed refer to past periods and in which no incentive could have been given by a REDD regime. The countries did not have an opportunity to react during any of the periods, neither reference period nor the commitment period.

In addition to that, it is not likely that one approach is the most advantageous once and for all. In case forest area changes in future periods, advantageousness of the approaches could change as well. Furthermore these data refer to deforestation only. In case forest degradation is integrated in REDD, the focus on creditable carbon stock may shift the advantageousness of the approaches. Finally, the accounting of credits or debits in the scope of agreements in UNFCCC bases on data from national communications, instead of FAO data, whose quality is questioned and discussed (Matthews 2001). As only a few countries reported several times to UNFCCC (UNFCCC, not dated. b; Karousakis and Corfee-Morlot, 2007), FAO data was used for the presented overview of implications of the approaches. However, the methodology presented for CP1 (see Figure 1) could be used for this purpose.

3.1.7 Challenges

In the previous chapters several approaches for reference emission levels and their implementation were discussed. In this chapter two of the challenges concerning the establishment of reference emission levels REDD is facing at are mentioned.

Firstly, basing on historic trends, a clear identification of a historic trend is not always possible. A situation like in Figure 14 (description of CR; p. 36) might only be possible under ideal conditions. A historic development of carbon stock is not always constantly increasing / decreasing and may show a development as presented in Figure 19, which describes a country’s past deforestation which doesn’t offer an apparent trend for future reference.

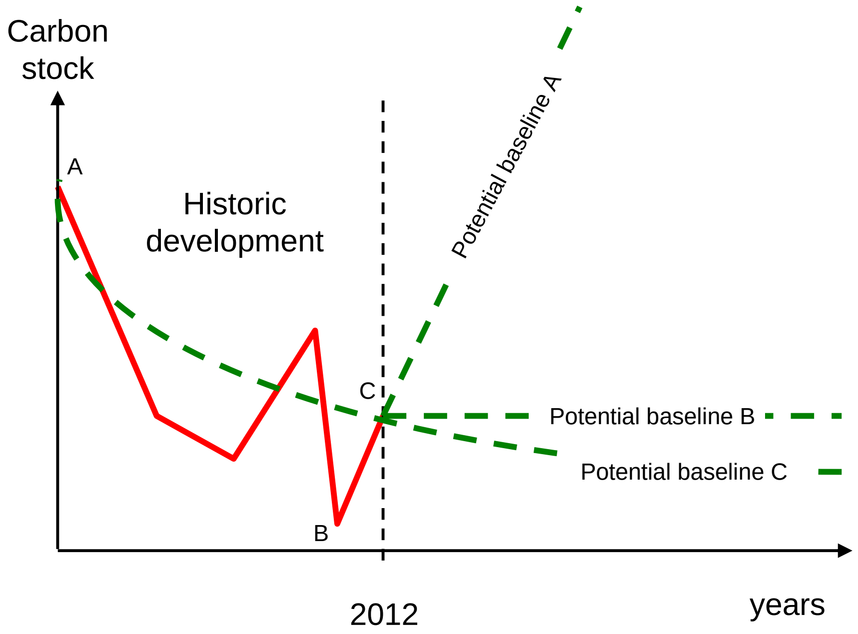


Figure 19: Hypothetic alternative historic development and potential options for baselines.

In the situation given in Figure 19, the deduction of a reference emission level according to past trends may be rather difficult. If only the latest development prior to a fixed moment is considered (e.g. 'BC', see Figure 19), there may result a reference according to the "potential baseline A", although there is a general trend in decreasing of carbon stock. In this case, the efforts to be undertaken by a country to store an additional amount of carbon stock would be enormously challenging and any country will try to avoid an increase of carbon stock at the fixed moment. Another option may be a fixation of carbon stock at a given moment. This would result in the potential baseline B. Given this situation, a country will work towards a low carbon stock at the fixed moment as reference. The establishment of a baseline according to this procedure will thus foster deforestation prior to the commitment and serve as perverse incentive with no honouring of early action. As another option, the reference emission level may be determined according to an x-years'-trend of past development, which might result hypothetically as the potential baseline C in Figure 19. Dependent on the past development of carbon stock this also may result in a development of a continuously increasing reference. The question about what causes this varying past development and implications for the future still remains.

Another challenge of setting reference emission levels could be given in case a historic development of forest area is clearly deducible and basing on strict historic trends it may cause perverse incentives and make countries acting strategically in order to get a better starting position once a REDD regime is settled. Perverse incentives could be given in a manner, which either encourages higher carbon loss prior to the reference or the commitment period or which sets the reduction goals too high, so that a country decides not to participate in the REDD regime.

The approach of CR may give such an incentive in case the baseline is set as a strict historic trend, for example. The more downwards a country's forest area develops in the reference period, the easier for the country to result credits in the commitment period. Likewise, countries which show an increase in forest area respectively carbon stock in the reference period, have disadvantages in case they do not reach the same performance in the commitment period.

Reaching the same performance like in the reference period is not only a matter of strategic behaviour but depends on the country's situation concerning the possibilities of increasing their forest area for example. An adaptation to national circumstances might thus be relevant to put more emphasis on the countries' specific situation. A forward looking baseline would be established which takes into account potential future drivers of deforestation and forest degradation as well as biological and ecological situation.

3.1.8 Conclusion

Several baseline approaches are presently discussed on international level. Those approaches vary in aspects like the manner of accounting e.g. continuation of historic developments or modelling future deforestation by assessment of the causes for deforestation in a country. The countries which are potential participants in REDD would profit in different manner by these approaches. This became apparent in applying the approaches to countries' past period's development.

Continuing strictly historic developments might not display expectable future trends concerning deforestation. Some countries could for example achieve a reduction of their deforestation rate because periods with high deforestation rates were preceding periods with lower deforestation rates just because there is not much forest left for a similar development. Assessing the causes for deforestation and their integration in REDD could offer results which display the countries' potential development according to national circumstances in a more prominent manner.

3.2 Integration of country specific aspects in baseline approaches

Authors: Bettina Leischner, Sitraka Rakotoson, Bruno Ramamonjisoa, Matthias Dieter

3.2.1 Overview

The baseline approaches shown in the precedent chapter refer to possibilities to integrate several aspects into a REDD regime. Concrete calculation or modelling was not provided. In case the reference is set by a strict continuation of historic development, it is calculable – data availability given as a precondition. This would mean a reference calculated according to 1. (p. 34), connected with challenges and risks which then occur for the countries. According to the negotiations on UNFCCC level baselines are to be established "taking into account historic data, and adjust for national circumstances" (UNFCCC, 2009a). This would mean a consideration of causes for deforestation in a more prominent manner.

Especially in the focus countries of REDD a lot of persons and people live in and with the forest and forest may be a basic for their livelihoods. A stop of timber use might deprive these people of the basics of their livelihoods and may increase poverty in these regions or areas. In case a reduction of timber use should be achieved, this reduction must be implemented in a rational manner, integrate local livelihoods and implemented effectively and efficiently. The costs for this reduction do not only refer to invested money of resulting credits in REDD, but also to people involved, considering possible evasion strategies.

Drivers of deforestation are assessed already in several studies (see for example Geist and Lambin, 2001; Angelsen and Kaimowitz, 1999; Lambin *et al.,* 2001). Some of the submissions by the Parties refer to existing literature (e.g. in UNFCCC 2006c) and mention the importance of addressing the causes for deforestation and human impact on forest (which might include degradation). The parties also mention different importance of the causes in different regions or continents. While in South America deforestation was considered with special regard to a conversion of forest in pasture land, in Africa an energetic use of wood is regarded as a major cause for human impact on forests. In Asia, in turn, a major cause is offered by use of timber, followed by clearing for agriculture (UNFCCC, 2006c).

In some of the submissions causes of deforestation are mentioned which are important in the respective country. An overview of important drivers of deforestation and their respective numbers of mentioning is given in Table 6.

Table 6: Causes of deforestation mentioned in submissions (Source: UNFCCC, 2006c; no mentioning of importance of causes, just number of mentions in submissions; no division in interrelation of causes).

Driver	Number of Parties
Forest conversion to agricultural uses	33
Harvesting for fuel wood and charcoal	25
Improper forest management, including selective logging and overexploitation	17
Fires and biomass burning	13
Population pressure	13
Development pressure, such as expanding urbanization, settlements and new infrastructure (e.g. electricity lines, roads)	11
Illegal logging	8
Policies and laws that drive land use conversions	7
Exploitation of mineral resources, mining	4

One of the causes for deforestation and forest degradation is the use of timber. In the vTI-REDD component about human impact on forests one focus was given to the economic causes of timber extraction (see chapter 3). These were approached by two perspectives: the national statistics concerning timber use and timber trade as well as timber use in three assessment areas and with concerned actors (“economic study”).

3.2.2 Timber use in Madagascar derived from timber balances

For the assessment of timber use on national level, the first step was the analysis of timber balances. During the first stay of the vTI-Team in the REDD-FORECA’s host country Madagascar existing literature and timber studies were analysed. Likewise, timber balances offered in FAO-databases were analysed and data about production and external trade were compared.

Production

The data presented in the following about timber production in Madagascar originate from existing studies e.g. a study published by USAID (Meyers *et al.* 2006, prepared for the project JariAla) and official statistics of the *Institut National de Statistique de Madagascar* (INSTAT) (INSTAT n.d.). Further on, data originating from FAOSTAT databases (FAO 2007) was used for preparation of timber balances.

The study published by USAID describes production and consumption of forest products in Madagascar basing on data of the year 2005. Production is defined as calculation of the maximum sustainable removal (in m^3/ha) in different forest formations. It is composed by annual increment in the forest formations and the area in use (without protected areas). The term *production* thus relates rather to potential removals than actual removals. The forest formations as classified in the study of Meyers et al. (2006) and shown in Table 7 were considered.

Table 7: Forest areas (in ha) and their classification of use (Source: Meyers *et al.* 2006).

Forest formation	Protected areas	Areas for priority (as potential protected areas)	Forest outside of protected areas and areas of priority	Total
Humid forest	778.679	2.388.564	1.389.521	**4.556.764**
Dry forest	316.506	657.652	1.356.674	**2.330.832**
Shrubland	47.480	1.245.470	660.265	**1.953.215**
Mangrove	4.849	78.376	143.735	**226.960**
Plantations (Pine)			115.469	**115.469**
Plantations (Eucalyptus)			150.397	**150.397**
Total	**1.147.514**	**4.370.062**	**3.816.061**	**9.333.637**

The annual increment supposed for the forest formations based on different purposes of the timber in use (see Figure 20). Relating to potential area for use (forests outside of protected areas, see Table 7), an average increment in the forest formations is deduced like presented in Table 8. If sustainable use is presupposed, increment of timber volume in Table 8 represents maximum volume for removals. These signify “production” in the study published by USAID.

In Figure 20 the aggregated increment is separated according to the potential uses of timber mentioned in the USAID study. Three main categories for use were distinguished: COS (*bois de construction, bois d’oeuvre, bois de service*: timber for use and construction), charcoal and fuel wood. The highest increments for timber classed in COS as well as for charcoal result in plantations. Humid forests serve as resource for all three categories. Caused by the high percentage of total area which is covered by this forest formation (see Table 8), humid forests offer about 1/3 of potential usable timber volume. Further on, a considerable share of usable volume is offered by removals outside of (closed) forests, which are an important resource for charcoal and fuel wood. The calculation of Meyers *et al.* (2006) result in a usable timber volume of 23.835.320 m³, aggregated for all forest formations.

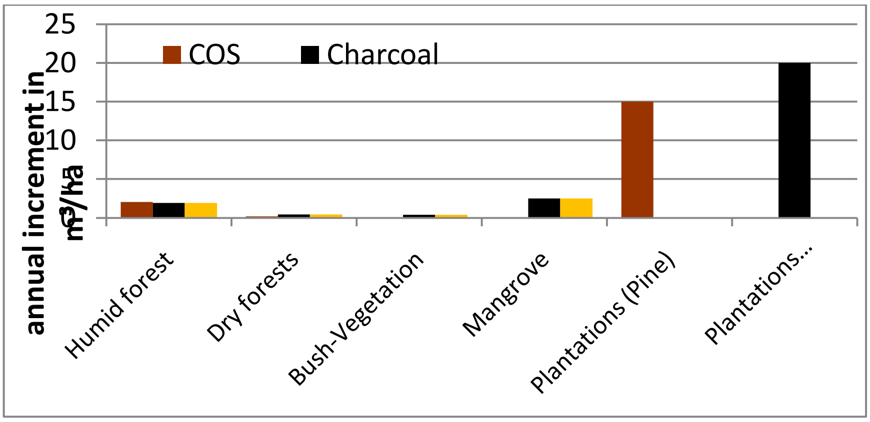


Figure 20: Mean annual increment in forest formations (Source: Meyers *et al.* 2006); COS (*bois de construction, bois d’oeuvre, bois de service*): timber for use and construction).

The official statistics base on an accounting of timber production in the cantons (administrative area). Timber removal is aggregated to province level and data collected about the registered volume of removals of round wood and saw logs (*bois non-débité*), sawn wood (*bois débité*), fuel wood, charcoal, timber for use (poles and posts) and by-products (*accessories*). In the year 2006 timber production result as shown in Figure 21. Original data for charcoal was delivered in tonnes and converted with the factor 6,0 into “*wood raw material equivalent”* in cubic meters. Values for fuel wood were provided in steres and converted with the factor 0,7 into cubic meters.

Table 8: Potentially usable timber volume in cubic meters per year (as annual increment) (Source: Meyers *et al.* 2006).

Forest formation	Timber for use and construction (COS)	charcoal	Fuel wood	Total
Humid forest	2.820.727	2.683.512	2.683.512	**8.187.751**
Dry forests	271.334	569.803	569.803	**1.410.940**
Shrubland	11.224	271.369	271.369	**553.962**
mangrove	-	359.338	359.338	**718.676**
Plantations (Pine)	1.732.035	-	-	**1.732.035**
Plantations (Eucalyptus)	-	3.007.940	-	**3.007.940**
Timber use outside of closed forests	-	1.972.473	5.917.418	**7.889.891**
Total	**4.835.320**	**8.864.435**	**9.801.440**	**23.501.195**

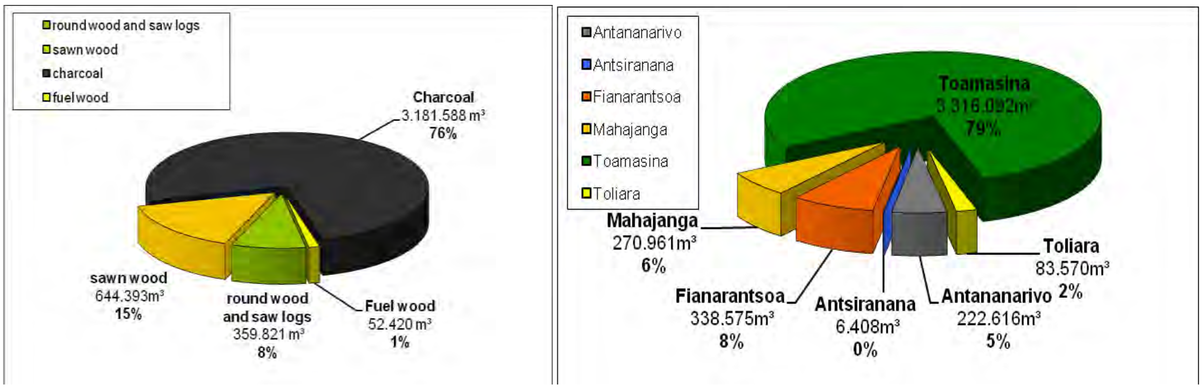


Figure 21: Production of timber and timber products in Madagascar, 2006; left: aggregated basing on products or groupings; right: aggregated basing on provinces.

Timber production amounts to 4.238.222 m³ in the year 2006 according to the official authorisations for exploitation and timber use. The major part of this originates from the province Toamasina. The provinces Toliara in the south of Madagascar and Antsiranana in the north held the smallest share of the production. Regarding the products, charcoal was the most produced product (76% of total production), while the production of fuel wood was remarkably low in 2006 (1% of production).

This surprisingly low production of fuel wood was compared with official statistics of proceeding years, shown in Figure 22. There are conspicuous variations in timber production in the course of the recorded year of about 8,5 Mio cubic meters in the year 1998 and about 1,3 Mio cubic meter in the year 2002. Likewise there is a conspicuous decline in production of fuel wood. In the year 1997 to 2002 the share of fuel wood to total production varied between 30% and 70%, in the following years this share was at about 15%. The share of charcoal to total production was in most of the years above 50% (apart from the year 2002). The share of round wood and sawn wood to total production reached higher values beginning with the year 2000 higher values.

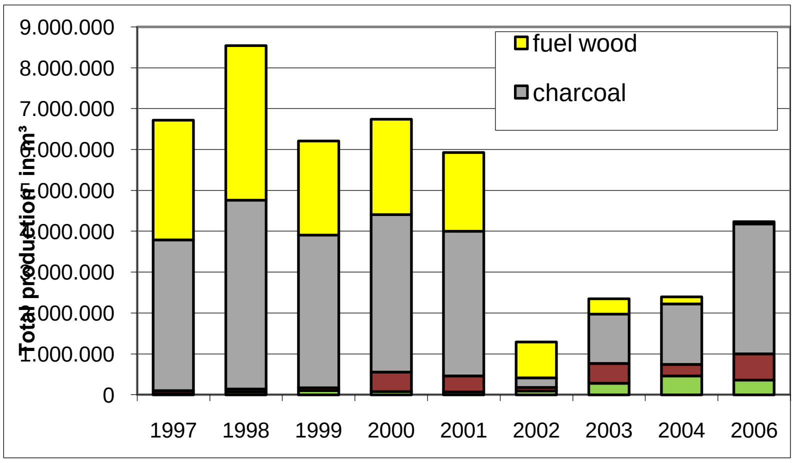


Figure 22: Timber production in Madagascar in the years 1997 to 2004 and 2006 (original data of fuel wood converted with factor 0,7 into cubic meter; original data of charcoal converted with factor 6,0 from tones into cubic meters); no data about the year 2005 available; until the year 2003 a category "round wood with bark" was assigned, beginning with 2004 there was a category "round wood"; this category was most probably renamed and data in the figure is thus just presented in one category "round wood" (Source: INSTAT n.d.).

A reform of procedure of issuing the official authorisation for timber extraction took place in Madagascar. As timber production is recorded on the basis of those authorisations, variation could occur which are caused by the change in this system and due to a potential rusty start in the new system. The recording of production of fuel wood is connected with high uncertainties. A large share of fuel wood production is collected by the consumers and in a non-commercial use, and thus it is not subject to registration. The allocation in official statistics might thus not be complete. In any case, production show an enormous range from about 3,8 Mio in the year 1998 and about 52,4 thousand cubic meters.

In order to assure a more uniformly data source (also for a potentially longer period), the FAO-statistics were used as additional data source. From this source, the importance of fuel wood and charcoal during the last decade became obvious (Figure 23). In contrast to the values in national statistics, there are constantly higher amounts of fuel wood than the other categories. Further on, in the absolute values a positive trend become apparent, i.e. in the past 10 years, the production of fuel wood has constantly increased – likewise the production of charcoal.

The production of round wood was decreasing, while the production of sawn wood increased. Both contribute only to a minor share to total production. Likewise the product groups of panels, pulp and paper have been of minor importance.

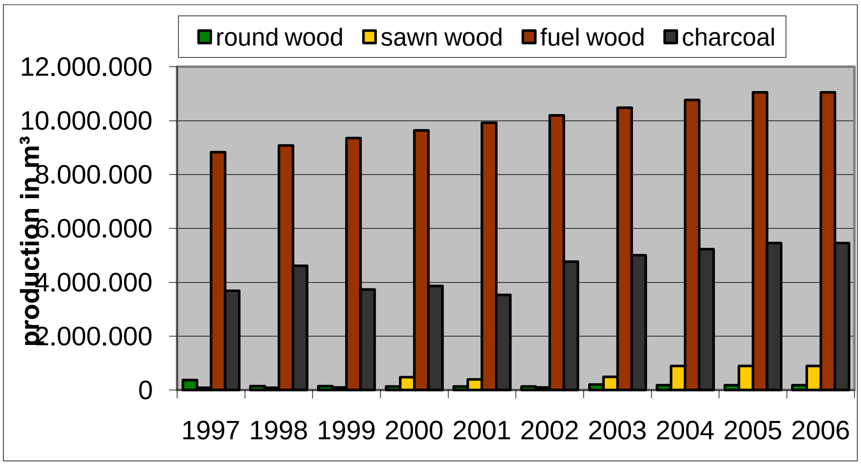


Figure 23: Timber production in Madagascar (displayed are the product groups round wood, sawn wood, fuel wood and charcoal (Source: FAO 2007).

Consumption

Consumption of timber and timber products can be calculated by means of production and external trade or by an extrapolation of per capita consumption of total population.

In the study published by USAID the second option was chosen and the volume of consumption per capita was distinguished between urban and rural population (Table 9). In urban areas the major timber product consumed is thus charcoal, while in rural areas the majority of timber is used in form of fuel wood. Timber for use and construction (COS) are about the same in urban and rural areas. Cross-product, a timber consumption of 21.728.000 m³ results for Madagascar in the year 2005. The study assumes a population number of 4,9 Mio in urban areas and 12,2 Mio in rural areas (Meyers *et al.* 2006).

Table 9: Timber consumption in the year 2005 (Meyers *et al.* 2006).

Product	Rural consumption (m³/capita)	Urban consumption (m³/capita)	Total consumption (m³)
Fuel wood	0,686	0,134	**9.026.000**
charcoal	0	1,75	**8.575.000**
COS[2]	0,24	0,22	**4.127.000**
Total	**0,93**	**1,97**	**21.728.000**

Timber Balance

By means of data about production, Import and Export, provided in the FAO database (FAO, 2007), timber balances can be established. Domestic timber use can be calculated by production plus import minus export. According to this database, the timber product groups listed in Table 10 were shown in Malagasy timber statistics in the year 2005. There are discrepancies of negative consumption in the volume of timber used. The highest amount of negative consumption occurred in the product group of other industrial round wood (NC).

The variations concerning timber quantities could have several potential explanations:

1. Inadequate allocation of quantities

   The timber use in the specific categories is not accounted comprehensively or the allocated groups (production, Export, Import) do not use a uniform classification. In this manner, the quantities could be classed in different categories and the allocated quantities show shortfalls.

[2] Timber for use and construction (*bois de construction, bois d'oeuvre, bois de service*)

2. Removals which are not subject to registration

   The removal of timber could be legal, but not mandatorily to be registered. In case these products occur in statistics concerning external trade, the results are again shortfall quantities.

3. Illegal loggings

   Shortfalls in timber quantities are often explained by illegal loggings in Madagascar. In recent years the controls were intensified in order to reduce these illegal loggings. Likewise, the new established system concerning authorisations of exploitation is expected to provide better options for control and surveillance.

The discrepancies in timber quantities used occur in major parts in the product groups of round wood and sawn wood. For timber exploitation classed in these groups, strict regulation is to be applied thus the second explanation of the above (removals not subject to registration) could be excluded. It is more probable that the shortfalls result as inadequate allocation of the timber volume or illegal loggings of timber with high value (which are still present according to personal communications and which are subject of discussions on regional and local level).

Concerning the use of fuel wood an allocation of the production is often hardly possible as dead wood is collected in community forests without authorisation or the wood is collected in forests on own territory. In case consumption is calculated by population number, it could exceed official production. According to forest law, removals of fuel wood would be subject to registration as well, but in reality it might be difficult to implement and removals are tolerated by local population.

Table 10: Malagasy timber balance in the year 2005 (Source: FAO, 2007)

groups	Product	Production	Import	consumption (calculated)	Exports
round wood	Pulpwood (round and split)	23.000		23.000	
	Chips and particles			-70	70
	Industrial round wood (coniferous)		0	-496	496
	Ind Rwd Wir (NC) Tropica			-197	197
	Wood residues	1.900	389	2.289	0
	Sawlogs+Veneer Logs (NC)	46.400		46.400	0
	Sawlogs+Veneer Logs (C)	113.700	0	113.700	
	Other Indust. Round wood (NC)	0	201	-42.512	42.713
Round wood (total)		**185.000**	**590**	**142.114**	**43.476**
Sawn wood	Sawn wood (NC)	885.500	512	872.692	13.320
	Sawn wood (C)	7.700	393	-6.360	14.453
Sawn wood (total)		**893.200**	**905**	**866.332**	**27.773**
Panels	Veneer Sheets		57	-29	86
	Hardboard	5.000	216	5.216	
	Insulating Board		1.699	1.699	
	MDF		518	518	
	Particle Board		1.468	1.416	52
	Fibreboard, Compressed	0		0	
	Plywood	0	577	577	0
Panels (total)		**5.000**	**4.535**	**9.397**	**138**
Wood fuel and charcoal	Wood Fuel(NC)	11.054.693		11.054.693	
	Wood Charcoal	5.462.370	0	5.290.770	171.600
Wood fuel and charcoal (total)		**16.517.063**	**0**	**16.345.463**	**171.600**
Paper and paperboard	Printing and Writing Paper	1.232	7.490	8.697	25
	Other Paper and Paperboard	7.607	7.486	14.892	201
	Newsprint	1.000	4.814	5.813	1
Paper and paperboard (total)		**9.839**	**19.790**	**29.402**	**227**
Pulp	Recovered Paper	2.200	1.827	4.027	
	Dissolving Wood Pulp		60	60	
	Chemical Wood Pulp		4	4	
	Semi-Chemical Wood Pulp	300	1	301	
	Mechanical Wood Pulp	400		400	
	Other Fibre Pulp	2.000	1	2.001	
Pulp (total)		**4.900**	**1.893**	**6.793**	

Concerning the production of charcoal, stricter regulations are in force. Charcoal is produced but rarely consumed in rural areas but transported to and consumed in the cities. By this commercial character official authorisations for removal and transport would be necessary, which are to be requested at an official place. Theoretically (!) production of charcoal would thus be accounted in correct volume. According to personal communications, is not assured, that total charcoal production is allocated. Small (illegal) production seems to be tolerated; aggregated, this could result in huge amounts of shortfall quantities.

Summarizing, the analysis of national timber balances showed uncertainties concerning available data about timber use on national level. Shortfall quantities occur, which could be caused by inadequate allocation of timber production, removals which are not subject to registration or illegal loggings. Different volumes could also result by applying different methods of allocation. National circumstances with regard to timber use could thus be represented imprecisely by available data.

3.2.3 Timber use in Madagascar derived from survey with actors in timber value chain

The statistics display used volume as a total but not the economic motivation for the individual actors using timber. For this purpose a study was conducted in Madagascar in order to assess the economic causes of timber use of the respective actors.

Timber use has different emphasis in Madagascar. Daily life cannot be imagined without wood as a source for energy. In regions with high deforestation economic reasons may play an important role for timber extraction. These and the economic value need to be assessed, in order to address the mayor causes in an adequate and effective manner as well as to choose the most efficient incentive or instrument for benefit transfer for measures to reduce deforestation and forest degradation.

The survey about timber use in Madagascar (labelled “economic study”) focussed on economic causes of timber extraction, i.e. commercial timber use in the assessment areas put in a regional scale. This implies the assessment of costs and revenues for involved actors, the used volume, the sales areas and trade partners. Likewise, the study investigates about implications of measures to reduce carbon losses and timber extractions. In order to achieve future reduction of timber extraction and carbon losses, the assessment about the implications of the reduction goal in the assessment areas can facilitate the choice of instruments for benefit transfer.

Methodological approach

The assessment of the economic causes for timber use was undertaken in three assessment areas in Madagascar. The methodological approach of personal interviews with actors working in the timber use chain was used, supplemented by interviews with representatives of forest administration on ministry level and forestry experts (in Antananarivo) and local key informants like public authorities or multipliers in the assessment areas. As timber use is a delicate issue, observations in daily life in the assessment areas offered in addition valuable potentials for data verification and additional information about timber use.

The study was conducted together with the scientific partner ESSA-Forets, the forestry department of the University of Antananarivo. The applied questionnaire was elaborated in Germany and in Antananarivo together with ESSA-Forêts, following the requirements of empirical social research (e.g. Mayer 2008; Atteslander 1995). The theoretical and methodological background of the study was presented and discussed in a training at ESSA-Forêts in April 2008. Participants of the training were students and the consultants who were in charge of the conduction of the surveys in REDD-FORECA's assessment areas, which were not covered by vTI and the training's material was distributed.

The final questionnaire was constructed as a combination of open and closed questions. The questionnaire was applicable to all actors in focus with some key questions set, which identified the sections within the questionnaire which were to be asked to the specific actor. The questionnaire covered i. a. the topics volume used, supply and demand, costs and revenues, trade partners and regions for delivery as well as expectations for the futures from the point of view of the actors.

The field trips and the conduction of the surveys was undertaken in two phases: in the first phase the contact to local key informants was established, general information about the test region was collected and the questionnaire was tested on local circumstances and adapted if necessary. During the following second phase the survey was conducted with 31 interviews in Tsinjoarivo (December 08), 44 interviews in Manompana (May 08) and 45 interviews in Tsimanampetsotsa (October 08), complemented by additional informal conversations and discussions, which rounded off the picture of timber use in the assessment areas.

Used volume by the respective actors was assessed by the questionnaire. This volume was extrapolated to the assessment area. On this basis, combined with the interviewees' trade partners the timber trade flows between the actors and in the region were deduced. The regions of delivery were distinguished by "within the assessment region" or "outside of the assessment region". Thus the volume leaving the assessment area could be deduced. Furthermore, by extrapolation to the assessment area the aggregated benefit of the specific actor group in the timber value chain was deduced.

The response to the survey and data situations was different in the three assessment areas. The most coherent picture was displayed in the assessment area of Manompana.

A country participating in a future REDD regime needs to commit itself to a reference emission level. The actual emissions from deforestation and forest degradation are then offset against this reference. In order to generate credits in REDD, the emissions from deforestation and forest degradation need to be reduced. This reduction, committed on national level, will take place in a certain area. A national strategy for reduction of 10% of the timber volume removed was supposed and economic implications deduced, which would result for the respective actor group. The reduction goal of 10% is used as example; other percentages could be conceivable as well. These implications are considered to be potential implications of a national baseline on sub-national level for income and benefit of resident population. The implications for the actors could also contribute to choose the most efficient incentive or instrument for benefit transfer. Such an approach could facilitate a country's choice of areas for intervention. This decision is finally done by the state itself. The assessed approach delivers aspects which could contribute to this decision.

Constraints of the study

Due to uncertainties concerning timber use which became obvious analysing Malagasy national timber balances (see chapter Timber Balance, page 52), the approach of questioning the actors about the volume they use was supposed to deliver information about economic motivation of the actors concerning all commercial timber removed. During the conduction of the survey and the followed analysis, other constraints became apparent.

Firstly, no official information was available about how many persons are working in the timber value chain, so no information about basic population was possible. Alternatively questioning on how many colleagues are working in the same occupation like the interviewees delivered some information. The extrapolation to the assessment area is thus connected with uncertainties. Secondly, timber use and removal was a delicate issue in the assessment areas. Not everybody was willing to participate in the survey. As a third aspect to mention, the results are based on the people's answers – as the case is in any survey. The information given by the interviewees was generally considered as reliable, the above mentioned aspects about the delicate topic of timber use and the potential "strategic answers" on the part of the interviewees cannot be excluded.

Results

Legal aspects concerning forest exploitation

In Madagascar, daily life can hardly be imagined without the use of timber. Wood or wood based products are used as energy source in most parts of the country and round wood, saw logs and sawn wood are exploited. In past periods, forest cover was reduced considerably in the country (Harper et al. 2007). In remaining forests commercial logging of tropical timber is still a major topic, and recently extended deforestation and devastation of Malagasy forests are still in media and subject to investigation (e.g. Global Witness and Environmental Investigation Agency Inc.(US) 2009). The forest sector contributed to 5% to national Gross Domestic Product (GDP) in the year 2000 (The World Bank 2003). The beneficiaries of timber products have been in major parts economic operators and the woodcutters and workers (Figure 24). The state receives benefits mainly from the product group medicinal plants and animals and - to a smaller share - from the product group wood. Benefits from eco-tourism contribute to about 1% to total benefits from forest sector. Local communities benefit to a negligible share from their forest resources.

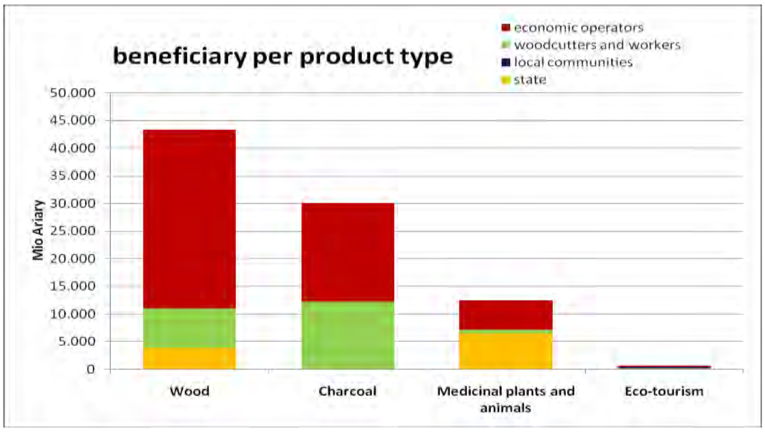


Figure 24: Incomes per product type and beneficiary type per forest product (Source: The World Bank (2003); data of the year 2000; original data in FMG).

Exploitable timber in Madagascar is classed in 5 categories (Table 11) according to its potential use. Official authorisations for logging are certificated according to the timbers' purpose and the classification of the species. All timber grouped in the 1st category is not allowed to log.

Table 11: Categories for timber species in use in Madagascar

Category	Description	Examples
1	Precious wood, highly valuable	Rose wood, Palisander
2	Timber for precious carpenter's work, cabinetmakers, violin making, precious parquet, sculptures, arts craft	Nato, Varongy, Lalona
3	Timber for common carpenter's work, roofs, shipbuilding, inner and outer panelling, furniture	Harofy, Hafotra, Kijy, Pin
4	Timber for boarding, slats, panelling, thermal and sound insulation, Model making	Kily, Voafotsy, Voantsilana
5	Round wood, (posts, poles, fences, energy wood, etc.) fuel wood, charcoal	Niaoli, Sangy, Talinala

Timber use for commercial purposes needs an authorisation which is delivered by the ministry after applying for an official announcement, detailed examination of technical capacity of the applicant and payment of a fee. In the logging authorisation (*permis d'exploitation*) the number of trees and the volume designated for logging in a specific area are listed. The regularly cut timber can only be transported with an official transportation permit (*Laissez-passer*).

Logging for non-commercial purposes can be undertaken by rural population on the basis of a customary right. The cutting of poles and posts needs a request at local forest service, but the volume is restricted to personal or municipal use. Timber use without authorisation or request is restricted to dead wood and fuel wood of species of 4th and 5th category.

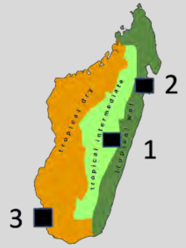
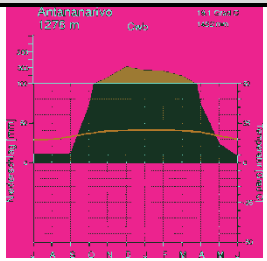
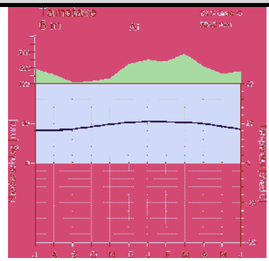
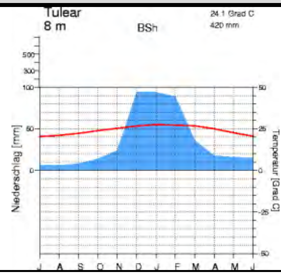
Exploiting timber requires a tax (*ristourne*) to be paid to municipal administration in the community where the logging takes place. This tax is about 1-3 % of the product's value. The benefices for local communities in the year 2000 amounted to 0,31% of total benefices in forest sector (Figure 24). This shows either that the value of forest products is not generated in the communities but in later processing stages or like in the national statistics (see above) unclear flows already occur in the sub-national timber statistics. Another option could be, that only parts of the logged timber pass the registration at municipal office, which would result in the conclusion that local population is receiving only limited benefits from their local resources (Leischner and Rakotoson *et al.* (in preparation).

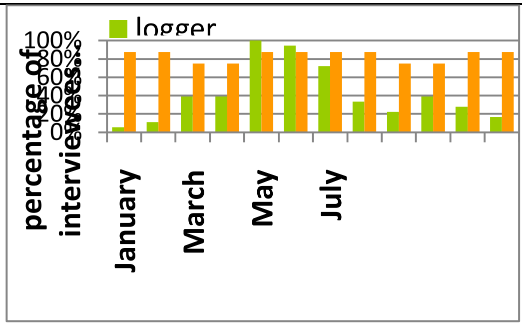
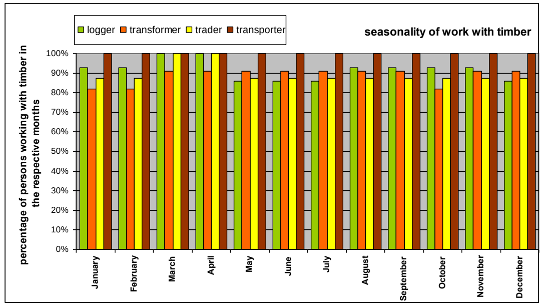
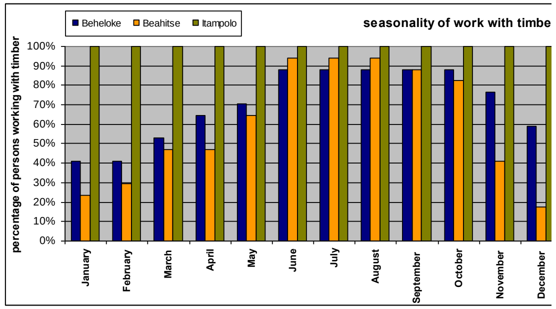
Timber use in the assessment areas

Economic motivation for timber use differed clearly in the three assessment areas Tsinjoarivo, Manompana and Tsimanampetsotsa. Most important differences concerning the forests, timber use and the commercial timber value chain are displayed in Table 12.

The timber value chain had different importance in the areas and the actors were distinguishable in different degree. The survey in Madagascar focused on actors in the assessment areas who commercially treat with timber. Four main actors were identified. The first actor was the logger, who actually removes timber in the forest and usually also does the first transformation of the timber into board or beam. The second actor was identified as a transformer, who uses timber to transform in products (e.g. carpenter, producer of charcoal, house construction, and chart construction). The third category was the trader who buys and sells the timber. As a fourth actor a transporter was identified who transports timber and usually is not the owner of the timber while transporting. As the most coherent picture was displayed by the assessment area Manompana, first, the results of this region area displayed.

Table 12: Overview of differences in timber use and the timber value chain in the three assessment areas (Sources: Leischner and Rakotoson *et al.*, *2009*, Leischner and Rakotoson *et al.* (in preparation) (Leischner *et al.* 2008; Leischner and Rakotoson 2008; climate charts: Mühr 2009); climate charts beginning with month of July

 Map in detail see Figure 5	 **1: Tsinjoarivo (TJV)**	 **2: Manompana (MPA)**	 **3: Tsimanampetsotsa (TMP)**
Climate conditions	 18,1 °C 1452 mm (Antananarivo)	 23,5 °C 3362 mm (Tamatave)	 24,1 °C 420 mm (Tulear)
Living conditions	- Life is dependent on seasonal variations (e.g. access by roads and season time schedule for land use activities) - In case of disposability of extra money to spend: investment in new clothes and tools	- Life is dependent on extreme climatic incidences (e.g. hurricanes, which could destroy villages and agricultural area) - In case of disposability of extra money to spend: investment in building and rebuilding of houses	- Life extremely dependent on climate (rain season is awaited and connected with intensive agriculture activities during a couple of month) - In case of disposability of extra money to spend: buying more zebus
Importance of forestry in livelihoods	- Difference in forestry between western and eastern part of the community: natural forests in the east, while in the western part, plantations were established - Actors in western part mainly loggers, while transformers are established in the western parts	- Forest and forestry have importance in livelihood (e.g. in "forestry season" people live in camps to lumber) - Villages are easy to resettle nearer to the forest - A considerable share of logged timber is leaving the region as saw logs, beams or boards	- Timber is a necessary resource for population, but due to the restrictions in the neighbouring National Park, it is connected with fear of the authorities

	TJV	MPA	TMP
Actors and work they are performing in the timber value chain	- Actors generally act globally (i.e. more production steps accomplished by a single actor) - Different main location of the majority of the actors (loggers mainly in eastern part; transformers in western part of the community) - Differences in timber use between the actors (and thus within the parts of the community)	- Specialized actors in the timber value chain (loggers, transformers, traders, transporters) - Differences in timber use between the actor groups, located in most parts of the assessment area	- One actor usually works globally in the work with timber (from cutting in forest to selling the product) - Differences in timber use in the three communities around the national park: <u>Beheloke:</u> national park entrance, and thus presence of authorities like MNP; <u>Beahitse:</u> inland borders of National Park (without entrance); <u>Itampolo:</u> Ocean-side southwards, timber use still allowed, but extension of National Park is planed
Accountability of the actors	- Actors work generally on own account; - groups (with a boss and hired workers) for felling in the forest	- Dominance of *patron* (work is commonly ordered by a *patron*, who sometimes also sets the price)	- Actors work on own account and usually alone (only for heavy work an assistant is hired for a couple of days)
Seasonality of work with timber	 - Working in the timber value chain is a seasonal activity mainly for loggers; - Transformers (in the western part of the community) work more frequently with timber	 - High percentages of actors work during the whole year with timber	 - Work in the timber value chain is a seasonal activity in two of the three communities around the National Park

	TJV	MPA	TMP
Importance of commercial timber use	- Commercial loggings were conducted in the area (with resident or non-resident workers); structure of transformers not well-established in the area - Timber was cut in the area, but transported outside of the area, so locals didn't receive much benefit from their resources	- Specified work and low seasonality suggest importance of commercial timber logging for local population	- Forestry has little importance as main source of income (seasonal activity in case of no alternative activities to generate income) - The timber product's sale could be a by-product on the market or the product is sold directly in the village of production/transformation
Environmental awareness	- High environmental awareness - Sensitization for awareness rising is common in schools to change the people's ways of using the resource - heated discussions about unclear land tenure	- Less awareness of environmental problems and unclear land tenure - In case of loss of forest and in this way loss of livelihood: removal nearer to the forest	- People have high environmental awareness because of scarcity of water and resulting implications to daily life - A high percentage of interviewees had ideas how to improve forest and timber situation in the region (but lack of financing)

Manompana (MPA)

The assessment area Manompana is located in the province Toamasina about 250 km north of the province's capital. Despite of location on the *route nationale* the access via the road is limited caused by missing bridges and ferry schedules dependent on tides. Nearby, the island St. Marie is a frequented tourist resort, which influences the economic prospects in the region via higher demand of natural goods and labour. Irrespective of difficult access via the roads, timber use is common in the region. At the northern and western boundaries of the assessment area, protected areas are located, where timber use is restricted. At the time of conduction of the survey (May 2008), the area was still highly affected by the cyclone Ivan, which passed Madagascar in January 2008 and caused severe devastations.

In Manompana the actors were clearly distinct in the work they are performing. The volume processed by the actors was calculated as the average of volume used by the specific actor group. Results are displayed in Table 13. The actors used different average timber volumes per year. The highest average volume (ca. 120m³ per year) was processed by the traders, who collect and sell timber. Every transporter transports on average about 40m³ per year, while the actor groups of loggers and transformers used about 20m³ per year per person. In Table 13 the average volume per actor is displayed, so the higher volume used by the traders is compensated by a higher number of persons in the actor group of loggers.

Table 13: Average volume used per actor per year (m³, Manompana)

Actor	Average volume used by actor per year (m³)
Logger	19,25
Transformer	23,40
Trader	122,68
Transporter	40,75

The economic use of timber offers different benefit for the actor groups (Table 14). The highest benefit was reached by the traders. Loggers and transformers receive about the same benefit per cubic meter. The lowest benefit per cubic meter is earned by the transporters.

Table 14: Average benefit per cubic meter for actor groups (rounded)

Actor	Average benefit per m³ for actor groups (rounded)
Logger	35.800
Transformer	36.200
Trader	57.800
Transporter	24.400

Using the average volume used per actor the timber volume used per actor group was extrapolated to the assessment area. Combining the resulting volumes aggregated for actor groups in the timber value chain and their sales regions a timber flow scheme as displayed in Figure 25 results. Here, the extrapolated volume used in this assessment area was distributed according to the actor's sales regions and trade partners. There were some ambiguous trade flows no information was given about, which are displayed as dashed lines in the figure (e.g. potential timber flows into the area). Comparing the flows within the assessment area and the volume which is leaving the area, in Manaompana about half of the timber volume logged in the area is leaving the assessment area.

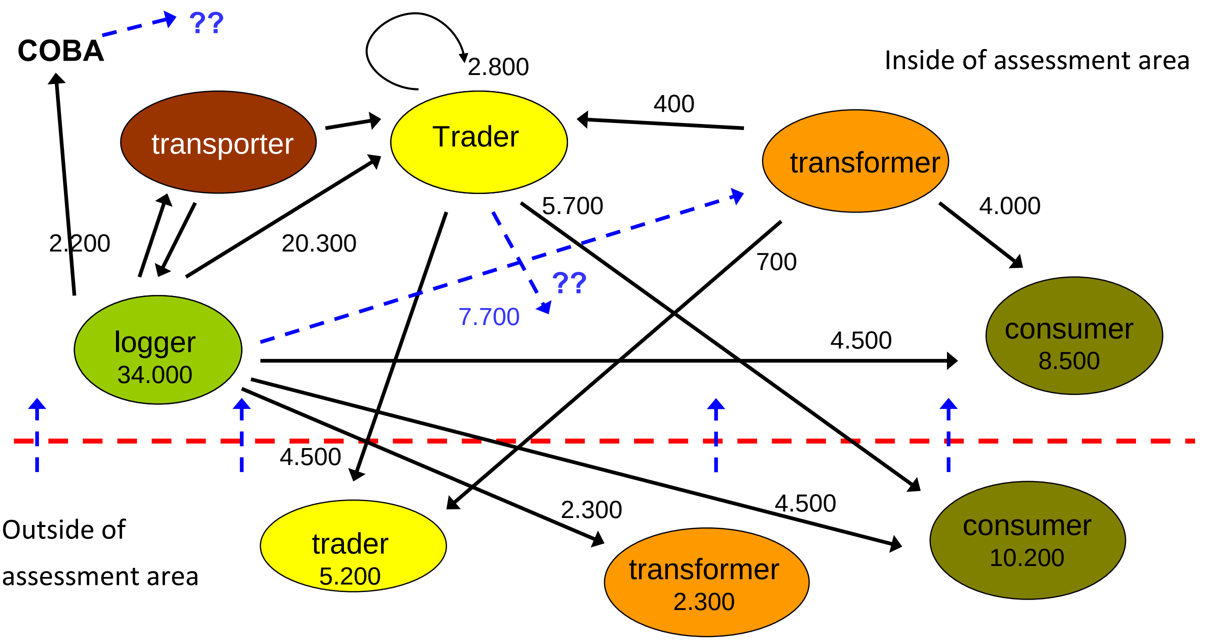


Figure 25: Timber flows in Manompana (volumes in m³). The dashed horizontal red line represents the limit of the test area: all actors displayed above are actors within the region, while the actors below this line are considered to be actors outside of the test region. Blue dashed lines represent potential flows without information, e.g. the leakage of 7.700m³ originating at the traders or potential flows into the test area. (COBA is an abbreviation of *Communauté de Base*, local forest management)

Summarizing, in the assessment area of Manompana timber use has importance during the whole year as timber is used by a high percentage of persons of every actor group during the whole year. The actors in the value chain are clearly distinct in the work they are performing. The most prominent actor in terms of volume processed and benefit per cubic meter is the trader, while loggers and transformers use the lowest volume of timber per person but earn medium benefit (compared to the other actors). The actor group earning the less per cubic meter are the transporters. From the actors' perception prospects for the future concerning timber use are still good as the forests still offer a lot of the timber resource.

According to the timber flow scheme basing on the interviewees' information about sales regions and sales actors, the volume about half of the timber logged in the region is leaving the assessment area. Thus, given similar demand, in case a reduction goal of removed volume is applied in the region, it could be possible, that this demand is served from other regions. This potential leakage effect needs to be considered when deducing the effectiveness of measures for reduction of timber removals.

Implications of a national baseline

The outcomes of the study about economic causes of timber use are used for scenarios concerning national reduction goals. These scenarios could base on different strategies concerning the removal of timber volume and thus carbon stock. These implications possibly show different magnitude for actors involved, as well as for the reduction of volume finally required (Figure 26).

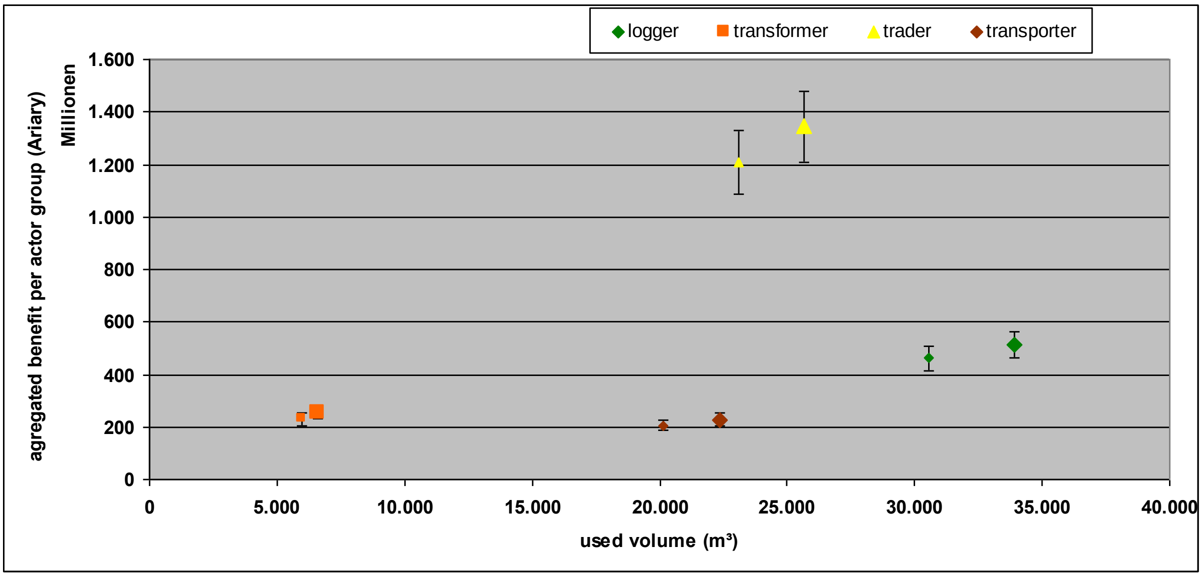


Figure 26: Used volume and aggregated benefit per actor group of the different types of actors (bigger symbols) and implications of a 10% reduction goal (smaller symbols) (extrapolated to assessment area Manompana); (Source: Leischner and Rakotoson et al. (2009).

The matter of uncertainties concerning the capture of timber production is a highly relevant topic for an integration of timber use into baselines on national level. In addition to considerable differences of timber volume produced between the years and between different methods applied, in the assessment areas uncertain timber flows occurred as well. These uncertainties, illustrated by the dashed lines in Figure 25, varied in magnitude between the assessment areas. In Tsinjoarivo for example, as will be shown, those uncertainties are much more present than in Manompana. An extrapolation of timber use to national level into REDD baselines would thus be subject to those uncertainties.

Tsinjoarivo (TJV)

In Tsinjoarivo, timber use is mainly an additional activity to other land uses. The predominant land use activity is agriculture (Commune Rurale de Tsinjoarivo *et al.* 2007) (cf. chapter 3.3.4.1). Nevertheless timber use is popular in the community and present in all parts of the community. The eastern part of the community is covered with natural forests, while in the western part plantations offer timber for use. Timber use is a seasonal activity between June and October in Tsinjoarivo caused by the rains season, which makes the roads inaccessible and thus no timber transport possible.

In Tsinjoarivo the actors of loggers, transformers and traders were identified (Leischner and Rakotoson *et al.* (2009)). At the time of the survey in the community two official authorisations for timber exploitation were issued but highly discussed within the community. The exploitations took place in the eastern part of the community in natural forests and the timber logged was brought via proper roads towards the north and not via the communities' capital outside of the area. Further on, the exploitation companies worked mainly with their (not resident) labour, so local residents expressed their resentments that they would not benefit in an adequate manner from their resources (Leischner and Rakotoson 2008). The matter of (insecure) land tenure is thus very important for resident population.

Environmental awareness is comparatively high as sensitisation is common in schools to reduce the former environmental deterioration on long term. This strategy already yields fruit as the number of bushfires decreased recently (Commune Rurale de Tsinjoarivo *et al.* 2007).

In Tsinjoarivo the timber flow between actors within and outside of the area generated in the approach described above occurred like presented in Figure 27. There are only few actors, mainly within the area. Nevertheless high uncertainties occur concerning the timber logged by the loggers. The reasons for the huge gaps are considered to be unregistered auto consumption or land use changes (or unregistered loggings) (Leischner and Rakotoson *et al.* (2009)). In case timber use is to be extrapolated to national level, this extrapolation has to deal with these uncertainties. This would reduce its reliability and is thus not recommendable.

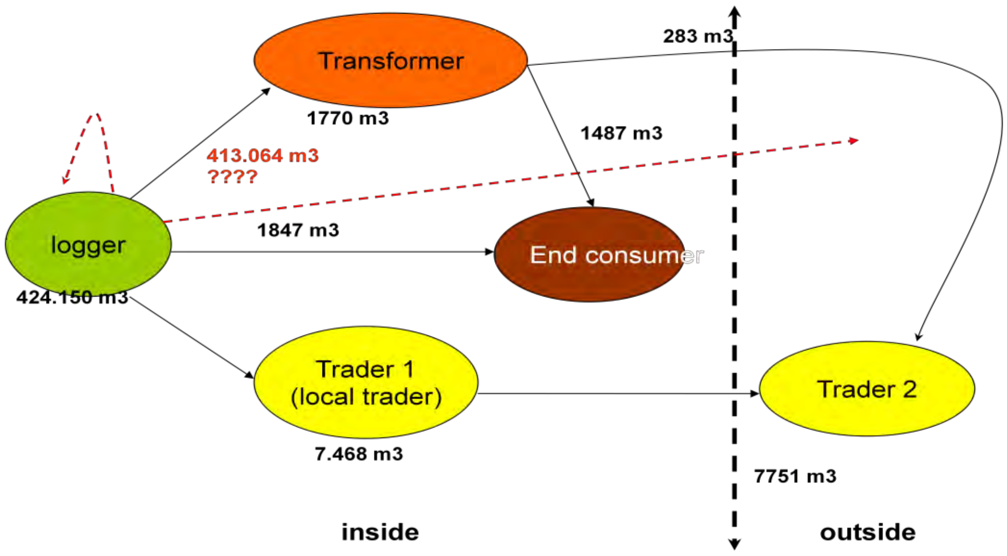


Figure 27: Timber flows in Tsinjoarivo; Loggers, transformers, local traders and end consumers are present within the assessment area; trader 2 (which are / is served by transformers and local traders are outside of the area); the horizontal black dashed line represents the border of the assessment area: actors on the left of the line are actors within Tsinjoarivo, actors on the right hand of the line are actors outside of the assessment area; dashed red lines represent uncertain timber flows; Source: Leischner and Rakotoson *et al.* (2009).

Tsimanampesotse (TMP)

The survey in the assessment area of Tsimanampesotse was dominated by the presence of the National Park with its restriction of timber use. By the presence of MNP (*Madagascar National Parks*, recently renamed from *Agence Nationale pour la Gestion des Aires protégées, ANGAP*) a strict eye is kept on the abidance by the law. The National Park in its present extension is neighbouring to the two communities Beheloke and Beahitse. Presently, a southbound extension of the National Park is planed, which would result in limited possibilities for timber use in the concerned community Itampolo. People’s livelihoods depend mainly on agriculture and cattle breeding. There are no major enterprises in search for labour.

Caused by the extended dry season in the south of Madagascar life and work depends on climatic conditions. Most of the annual precipitation is falling in the months of December and January, thus those are the months of intensive agricultural work. In months with limited workload for agriculture, there is time for work with timber.

The dependence on natural conditions results in a high awareness of environmental aspects. In discussions with population and key informants environmental problems and potential solutions were discussed, but the lack of financing for potential problems rendered these activities impossible (Leischner and Rakotoson 2008). In spite of the awareness of the problems connected with deforestation, the use of timber is still a frequent activity in the months without agricultural activity.

The actors in the timber value chain showed little specialisation. The majority of actors logged the timber themselves in the (degraded or natural) forest, transported it to their working place and sold the product either directly or at a marketplace. Most actors performed more than one activity in the timber value chain. The actor of trader seems not to exist in Tsimanampetsotsa (Leischner and Rakotoson *et al.* in preparation).

In Tsimanampetsotsa timber use (and questions about it) is a delicate issue. Thus the question about data validation is highly relevant. In this region uncertainties occurred according to the activities in the area. 75% of the interviewees reported cutting trees, while about 95% reported transforming timber. This would mean the (fewer) loggers sell some of their timber to the (more numerous) transformers. According to informal conversation and discussions it could be presumed that some transformers most probably docut timber (in the forest). A reason for this divergence could be the fear of admitting timber use in the region caused by the presence of authorities of the National Park in the region, even if the logging is undertaken in areas outside of the National Park, where it could be legally done.

Caused by the uncertainties in the actors' distinction, only one type of actor is displayed in this assessment area which is called "forest user". A distinction is made for Beheloke, Beahitse and Itampolo, the three communities surrounding the National Park.

Following the approach described above timber flows between the three communities in Tsimanampesotse as shown in Figure 28 could be deduced. In Itampolo in an area where timber use is allowed, the volume logged was reported to be much higher than in the other communities dominated by the National Park and its restriction of timber use.

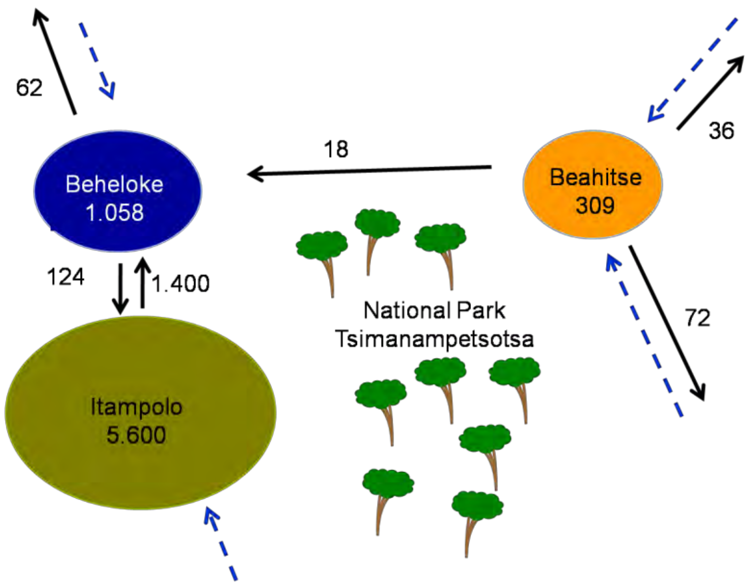


Figure 28: Timber flows in Tsimanampetsotsa; as just one actor ("timber user") was deduced, the timber flows were displayed between the three communities in the assessment area around the National Park according to their approximate geographical location. Dashed lines represent potential timber flows, no information was available about. In Beheloke and Beahitse timber use in the National Park's territory is restricted; the National Park is intended to be extended southwards to Itampolo, so if the extension is realized, timber use would be limited in this region as well (Source: Leischner and Rakotoson et al. (in preparation)).

Commercial timber use is much lower than in both of the other assessment areas, while timber use for subsistence was higher than the other areas (see 3.3.4.3).

One explanation could be the limited availability of timber in the region which does not offer potential for specialized timber value chain (like e.g. in Manompana, see Table 3). So timber use is limited to resident population's basic needs. Deduced from the timber flows in Figure 28, only about 2% of logged timber is leaving the area.

As timber use is a delicate issue and the uncertainties recognized in the actor's responses, it could be supposed, that real timber use in the communities near the National Park differed from the reported. If timber use is to be integrated into a binding baseline, this baseline needs to be based on reliable data. In this aspect, an extrapolation of timber use from this assessment area to national level is expected to reduce the reliability of the baseline.

Conclusion

Timber use is facing different challenges in the three assessment areas. The most coherent picture concerning timber use presents the area Manompana, where timber use is an important and frequent activity with a specialized timber value chain. Timber use for commercial purpose is frequent and about half of timber logged within the area is passing its boundaries. In Tsinjoarivo and Tsimanampetsotsa uncertainties occurred as questions about timber use could provoke suspicion. Reasons for this are related to people's incertitude concerning land tenure or restrictions of timber use.

Concerning the inclusion of timber use in the assessment areas into a binding reference emission level for REDD three main concluding remarks can be given:

1. Potential leakage effects could be relevant in case measures to reduce deforestation and forest degradation are to be implemented in an area. If much of the timber logged within its boundaries serves the demand outside, this extern demand would be served from other regions in case timber logging is restricted in the area. This needs to be considered when deducing the effectiveness and efficiency of such measures.
2. The assessment and extrapolation of timber volume used in the assessment areas are varying between the areas (and some highly uncertain timber flows). An extrapolation of these flows to regional or national level would be related to those uncertainties we well. An integration of timber use – based on the assessment in the regions – would thus affect the reliability of a national baseline.
3. In the analysis of timber balances variations between production and consumption between the years became obvious. Likewise, there were differences in timber production on national level if different methods for assessment of production were applied. In addition to those uncertainties, there are shortfalls in national statistics which could be caused by inadequate capture of volume, removals which are not subject to registration or illegal loggings. If timber

use is integrated into a binding national reference for REDD, this reference will be subject to those uncertainties.

3.2.4 Further aspects to be integrated into a national baseline

A modelling according to the causes of deforestation is not limited to the integration of timber use. In the submissions of participating countries in a potential REDD regime further causes were mentioned (see Table 6, p. 46), likewise in literature.

The investigation at the example of the country Madagascar has shown that the capture and extrapolation can be subject to uncertainties. An integration of country specific causes for deforestation into the calculation of a future deforestation rate (as desired in terms of an "(development) adjustment factor" (see UNFCCC 2009b), would thus be better achieved if based on national key figures, which are sufficiently reliable and which are available for a certain period in the past. Ideally the figures cover the economic, social and institutional situation of a country. Admittedly, extended key figures covering the sectors would probably not be available for Non-Annex-I countries which need to establish a baseline for REDD. Likewise, a comprehensive (and thus voluminous) set of key figures will increase the complexity and reduce the applicability. It will be a challenging task to choose a well-balanced path.

3.2.5 Conclusion

Several studies in literature assessed causes for deforestation. One of the causes for deforestation is timber use. In the study region of the project REDD FORECA economic causes for timber use were assessed in the "economic study" in the three areas covered by vTI (Manompana, Tsimanamptsotsa and Tsinjoarivo). The results of this study lead to the deduction that an extrapolation of the timber use assessed in the area to national level will cause high uncertainties. An integration of the extrapolation into a national baseline would reduce its reliability. Likewise in the analysis of national timber balances discrepancies in the national accounting occurred as well. Firstly, shortfalls occurred in the national statistics concerning timber use, and secondly, the amount of used volume differed depending on the method for the assessment applied. Thus, an integration of timber use in national baselines is a matter which could face uncertainties.

But the study about economic aspects of timber use in the scope of the project REDD-FORECA could be used to deduce implications of national reduction goals scaled down to sub-national level. Implications within a certain area could be deduced as well as effectiveness of such measures regarding potential leakage effects. The study thus offers good prospects to address the impact and efficiency of measures undertaken to reduce deforestation and forest degradation. Their implications in regional context (concerning leakage effects) could become more apparent and the actual effectiveness of the measures could be deduced more clearly. By this, a possibility could be provided to efficiently reduce deforestation and forest degradation by choice of the most convenient area of intervention. But this choice is eventually made by the participating country.

3.3 Socio-economic study about the causes of deforestation and forest degradation

Authors: Aziza Rqibate, Tahiry Rabefarihy, Zo Rabemananjara, Bruno Ramamonjisoa, Michael Köhl

3.3.1 Objective

The objective of this study was to develop a methodology that identifies drivers of deforestation and forest degradation. Furthermore, this common methodology was used in the three identified regions in Madagascar (see 2.2.1 and Table 12). The results provided a basis for the development of an incentive mechanism in order to reduce emissions of deforestation and forest degradation.

3.3.2 Overview of the direct and indirect causes of deforestation and forest degradation in Madagascar

3.3.2.1 Direct causes of DD

About 80% of Madagascar's working population is engaged in agriculture – primarily subsistence agriculture. Furthermore, 69% of the population lives below the poverty line (INSTAT, 2006). Agricultural activities are characterized by rudimentary and traditional approaches that are often harmful to the environment. In Madagascar fire is used to acquire land. This is often practiced as shifting cultivation by slash-and-burn ("Tavy") with different rotation cycles. An intensive agriculture is rarely applied, harvests per hectare are usually low and the used areas large. Intensive agriculture would yield higher gains but needed more resources like pesticides, fertilizers and labor forces that can not be afforded by Malagasy farmers. In Madagascar 33.000 ha/year of natural forest are lost due to slash-and-burn or uncontrolled fires (FAO 2005).

The demand of combustible material for private households is mainly covered by the use of fuel wood (81,6%, primarily in rural areas). Charcoal (17,4%, primarily in cities) and other combustibles like gas or oil (1%) only play a minor role (INSTAT, 2006). Moreover, the forest is a source of timber where the local population can obtain the materials needed for everyday's demands (construction of houses and tools etc.).

Cultivation, stock breeding and the use of wood (construction and fuel wood, production of charcoal) are identified as direct causes of deforestation and forest degradation (Kaimowitz and Angelsen, 1998).

3.3.2.2 Indirect causes of DD

Due to the direct causes mentioned above the forest takes an important role in covering the demands of the local population. Ongoing weakenings of the political, economical and social system affect the use of forest resources on the part of the population. Conflicts about land rights, poverty among the agricultural and forest sector as well as increasing migration of the population are counted among these weakenings. They are identified as indirect causes of deforestation and forest degradation (Kaimowitz and Angelsen, 1998).

3.3.2.3 "Community-based forest management" as a way to control the use of forest resources in a multi-ethnical country

Since 1996 Madagascar has pursued the GELOSE legislation (Gestion Locale Sécurisée). It implies that farmers are not obliged by a centralized, governmental land use plan. They are rather granted with a right of self-determination on a local scale that allows them to decide about the use of surrounding areas ("Transfert de Gestion" aux "Communautés de Base", COBA). This is implemented with the support of several initiatives in which farmers, NGOs and mayor/village heads take part. Therefore, the application of "Community-based forest management" takes regional and ethnical circumstances into account.

The resources of the forest are used differently by each of the eighteen ethnic groups in Madagascar because of their varying traditional backgrounds. For instance the people of "Bestileo" and "Merina" from the centre of the island are considered as experts in agriculture, whereas the "Betsimsaraka" from the east coast are known as woodcutters and the "Mahafaly" from the south of Madagascar are specialized in stock breeding.

3.3.3 Methodology

The following study deals with a specific kind of agent of deforestation and forest degradation – the smallholder farmers. In the scope of the project, socio-economic field studies were conducted on vTI assessment areas where also the inventory took place. The assessment areas - Tsinjoarivo, Manompana and Tsimanapetsotsa – differ significantly in the ethnic groups that constitute the local population as well as in the type and amount of available resources. Despite these differences, Malagasy smallholder farmers share their involvement in land use changes which endanger their environment and traditional way of life.

Functional analysis of smallholder farmer's needs for the purpose of identifying and quantifying the causes of deforestation and forest degradation

A requirement book (Rqibate and Rabefarihy et al., 2009) that contains the relevant fieldwork results and that is necessary for the incentive development and alternative development studies was distributed to the respective partners, i.e. Intercooperation and GTZ. These results were obtained through observation, individual and group interviews described in the following part, and finally through existing local expertise. Its design is based on a functional analysis of the deforestation and forest degradation. It describes which uses of the forest address the needs of the smallholder farmer through DD – to which extent, on which localization and during which period. It identifies and quantifies the direct and indirect causes of deforestation and forest degradation. Kanninen et al. (2007) recommended this distinction for analysing the causes in the scope of REDD.

Interviews for collecting social and economic data of rural households involved in land use change

Sampling and individual interviews of smallholder farmers, heads of the rural households

Within the scale of the commune (municipality) representative villages were visited. The statistical unit is the rural household. After a questionnaire was developed and tested that addresses four topics, 134 smallholder farmers were interviewed (34 in Tsinjoarivo, 50 in Manompana and 50 in Tsimanampetsotsa). These topics are the:

- Characteristics of the households and the exploitation (size of the households, migration, land acquisition, size converted to culture area, yield and quality of the production), the
- Farm and off-farm economic data of the households (input and output for calculating farm incomes and off-farm incomes), the
- The households use of the forest (localization of the fuelwood collection and log, species, forest activities, wood consume)

Furthermore, discussions with the population took place concerning social, economical, environmental and cultural aspects, i.e. demographic data, migration, economic exchanges with other villages, view about the agriculture activities and the deforestation.

Photo 5: Group interview with villagers in Tsimanampetsotsa (Photo: A. Rqibate)

3.3.4 Results of the functional analysis on the three assessment areas

⇒ The deforestation as a source of income, and a source of material and energy for the population

The socio-economic study (SES) identified “securing the income” as the most significant demand among the population in all three assessment areas. It is tried to be achieved by agriculture, logging or sale of forest products (e.g. wood, charcoal and honey). In addition, fuel wood and charcoal are used for subsistence. The population in the assessment areas is dependent on deforestation and forest degradation to subdue areas needed for the widespread subsistence agriculture. Furthermore, the clearing of the forest is a traditional way to claim land. The forest is also an important supplemental or compensating source of alimentation (e.g. fruits, honey and hunting) if the harvest is exhausted. Traditional constructions and activities (e.g. cart, houses or pirogues for fishing) demand forest resources as well.

3.3.4.1 Tsinjoarivo

Sources of income

- ***Forest clearing by the use of slash-and-burn (local name: tavy)***

Characteristics and quantification

After subduing new parcels of land in forest areas was prohibited in 1999 farmers illicitly tend to extend their old parcels. Logged wood is sold after clearing. Cleared areas are mainly used for cultivating tobacco, cane sugar or to plant manioc, maize, sweet potatoes and rice on sloped areas (tanety). 4% of respondents gained ownership of land by deforestation (Table 15).

Table 15: Results of the interviews in Tsinjoarivo pertaining to the access to property (Rqibate and Rabefahiry, 2007)

Level	Sources	Purchase	Heritage	Gift	Forest clearing	Other or No answer	Total
Local	SES in Tsinjoarivo	31 %	49%	12%	**4%**	4 %	100%
Region	*Vakinankaratra (INSTAT, 2006)*	*25 %*	*62 %*	*4 %*	*6 %*	*3 %*	*100%*
The ways of land acquisition follow the INSTAT classification.							

Farm incomes in Tsinjoarivo contribute 80% to the income of the respondents (37 % in Manompana and 10% Tsimanampetsotsa, see Figure 29). This can be explained with the sale facilities available during two weekly markets and with road connections to the nearest city and to the capital Antananarivo enabling distribution of the products. Off-farm activities are principally apiculture (37 %

of the off-farm activities), pisciculture (26%), services and offering their labour craft (24%), commerce (11%) and handcraft (2%).

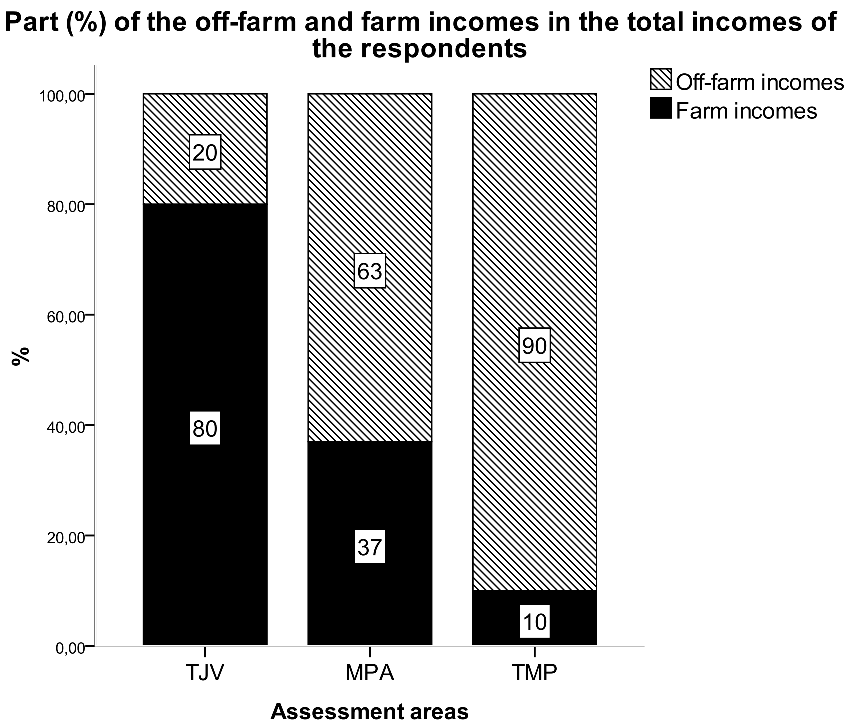


Figure 29: Percentage of the off-farm and farm incomes on the tree assessment areas.

Especially in this assessment area, incomes from agriculture are mainly invested in supplies for cultivation of rice, like e.g. fertilizers, labour forces, pesticides, seeds etc., which is completely different in the other assessment areas (71% of respondents, 0% in Manompana and Tsimanampetsotsa).

Causes: The forest is a source for new areas of cultivation and its remoteness inhibits effective surveillance by the authorities. Existing acreages are of very limited quantity and are becoming increasingly infertile due to aggradations (caused by deforestation of hills, Photo 6).

Photo 6: Rice field and cleared area on the Tanety (Photo: A. Rqibate)

- ***Logging and charcoal making***

Characteristics:

Non-local collectors visit the villages on the edge of the forest to obtain logged wood for the growing demand of larger cities. Craftsmen from Tsinjoarivo instruct people from eastern areas to supply them with wood. The wood supply chain in this area is managed. Eucalyptus and Pine plantations serve the production of timber and charcoal. Two organizations are responsible for 2000 ha of plantations. Trunks are sent to the cities whereas branches are used for charcoal making.

Causes: Wood provides a lucrative addition to the income of the rural population. As a road connects the assessment area with the nearest city, wood (and farm products) can be transported and distributed to an enlarge number of potential consumers.

Energy and material

- ***Charcoal and fuelwood***

Characteristics and quantification:

People in eastern areas of Tsinjoarivo use fuel wood from forests. In contrast, people from the deforested western areas can satisfy their needs through their own plantations and the use of charcoal. During the year, **11.890 m3** (**3.964 m3** from natural forest) of fuel wood and charcoal are consumed by the population (Rqibate and Rabefahiry, 2007 and USAID 2008).

Causes: Proximity to the resources plays a significant role for people’s choice to degrade.

- ***Construction wood***

Characteristics and quantification:

People in the western part of the commune rarely enter the natural forest. In most cases they can use the wood from their plantations. However, if a special kind of wood is needed they order it from people living in eastern forest areas who frequently get construction wood for their domestic need from the forest. Most commonly, Hazomena and Hazomby are stated as the used species of woods. Over the year, **3.698 m3** (**1.848 m3** from natural forest) of wood is consumed for domestic uses.

Causes: Again, proximity to the resources plays a significant role for people’s choice to degrade.

3.3.4.2 Manompana

Sources of income

- ***Forest clearing by slash-and-burn (Local Name: Tavy)***

Characteristics and quantification:

People from the western part of the assessment area and the migrants temporarily living in the forest in order to subdue acreages are the main actors of deforestation.

Regarding migration and its reasons, farmers were asked if they originally come from the village where they are working. If this was not the case, the reasons of their moving were examined. The most common reasons are finding fields for cultivation (33% of the given answers) or clearing the forest (33%of the given answers). Another reason concerns family issues (25% of the given answers) and the least common reason is finding work (8% of the given answers, 1% of no answer).

In Manompana, 24% of respondents gained ownership of land by deforestation.

Table 16: Results of the interviews in Manompana pertaining to the access to property (Rqibate and Rabefahiry, 2008a)

Level	Sources	Purchase	Heritage	Gift	Forest clearing	Other or No answer	Total
Local	SES in Manompana	17 %	47%	7 %	***24 %***	5 %	100%
Regional	*Analanjiroflo (INSTAT, 2006)*	*8 %*	*63%*	*2%*	*24 %*	*3 %*	*100%*
The ways of land acquisition follow the INSTAT classification.							

In addition to migrants subduing land, large-scale sugar cane plantations aggravate the situation. Forest clearing occurs during July and October. Logged wood is left unused. Deforestation is practised to allow extensive planting of rice, manioc, potatoes or sugar cane. Vanilla, coffee, cloves and lychees are cultivated for exportation. The other products are mainly self-consumed. Transportation is carried out by hand because there is no road available (Photo 7).

Photo 7: Traditional transport of goods in Manompana (Photo: A. Rqibate)

The amount of goods that can be delivered is therefore limited contrary to Tsinjoarivo. A major part of the production yielded by DD is consumed by the producer (subsistence farming). The following figure illustrates that the value of the products of deforestation is only marginally turned into incomes (20% in Manompana and only 9% in Tsimanampetsotsa). One reason for this can be found in missing opportunities to distribute the products. Furthermore, the decision to sale these products depends strongly on the quantity of the harvest, the existence of a market and the other available sources of income.

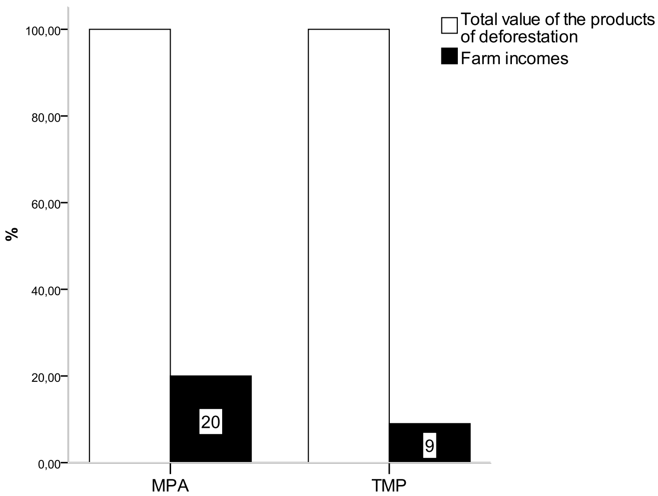


Figure 30: Value of the products of deforestation turned into incomes (Rqibate and Rabefahiry, 2009)

During a year, **1271 ha** of forest area converted into cultivated area (Rqibate and Rabefahiry 2008).

Causes: No teaching of sustainable cultivation techniques is offered. A lack of surveillance caused by the difficulty to access these areas further enlarges the problem.

- ***Logging***

Characteristics and causes:

80% of respondents use the forest as a source of income (including illegal activities). The main periods of logging are between September and November and between February and May. It is a welcome addition to people's income. Furthermore, wood related activities contribute 40% to off-farm activities.

Causes: The income from cash crops is not sufficient and uncertain, e.g. through cyclones (see Figure 31). There is also a high demand from cities outside the assessment area (Sainte Marie, Toamasina, Fénérive-Est, Soanierana-Ivongo). Furthermore, people don't fear government's law enforcement.

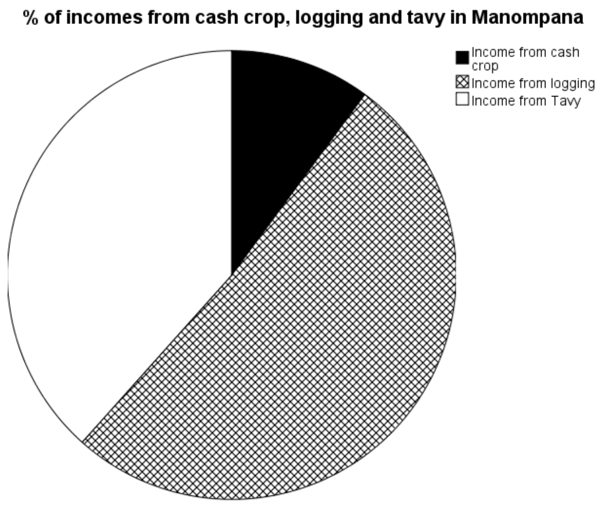


Figure 31: The three classes of income cash crops (10,2%), "tavy" (51,4%), i.e. "slash and burn", and logging (38,4%) could be quantified. The products gained by "slash and burn" are used in 90% of the cases for self consumption. The traditional practice of "tavy" is also a way to get access to the property. Thereby the farmer can assure the subsistence of the family and spread their cultivated area.

Energy and material

- ***Fuelwood***

Characteristics and quantification:

Especially small clove distilleries have a high demand of fuel wood. Dead wood (mostly Elampotsy) is collected in the forest or from small groves and solitary trees near the village. Over the year, **11.628 m3** of fuel wood are consumed by the population (Rqibate and Rabefahiry, 2008; USAID 2008).

Causes: No alternative source of energy supply is available. Wood can be found in close proximity to villages and is free of direct costs.

- ***Wood construction***

Characteristics and quantification:

Wood is principally used for constructing traditional houses, pirogues and tools. Some sorts of resin serve in rituals against ghosts. For construction purposes most respondents stated to use Tapiky, Nanto, Lalona, Vapaka and Hazombato. During a year, **16.722 m3** of wood is consumed for domestic uses (Rqibate and Rabefahiry 2008a and USAID 2008).

Photo 8: Wood transport in Manompana (A. Rqibate)

Causes: The high availability of wood in Manompana (see Table 3) and the use of no alternative material for building traditional homes play a major role. Additionally, there is corruption with handing out permits for logging and people are not aware of the ecological importance of the forest.

3.3.4.3 Tsimanampetsotsa

Sources of income

- ***Forest clearing for agriculture and stock breeding breeding by using slash-and-burn (local name: Hatsake)***

Characteristics and quantification

On the assessment area*,* 21% of the respondents gained ownership of land by deforestation (4% at the scale of the region of Atsimo Andrefana, this discrepancy can be explained by the difference of sampling methods or/and the level of mistrust of the respondent to the interviewer). In the assessment area, 21% of respondents acquired land by using delimitation e.g wood enclose or plants.

Table 17: Results of the interviews in Tsimanampetsotsa pertaining to the access to property (Rqibate and Rabefahiry, 2008b)

Level	Sources	Purchase	Heritage	Gift	Forest clearing	Other or No answer	Total
Local	SES in Tsimanampetsotsa	4 %	51 %	2 %	***21%***	**21%**	100%
Regional	*Atsimo Andrefana (INSTAT, 2006)*	*4%*	*82 %*	*7 %*	*4 %*	*3 %*	*100%*
The ways of land acquisition follow the INSTAT classification.							

Despite existing prohibitions 13% of respondents claim to continue forest clearing. Farmers change acreages every two or three years (0,6 ha per household, Rqibate and Rabefahiry, 2008b) as soon as the soil is depleted. Before the interdiction of forest clearing farmers used to own up to 10 ha of land. Most slash-and-burn areas are near the planned national park's extension or on the plateau calcaire (areas of transhumance). Between April and August parts of the forest is cleared to extensively cultivate maize and manioc which is mainly bought by traders from Toliara and Antananarivo. During the year, **990 ha** of dry forest are converted into culture/pasture area (Rqibate and Rabefahiry 2008b).

Photo 9: Fire in the National Park of Tsimanampetsotsa (Photo: A. Rqibate).

In Itampolo and Behatse (see Table 12) almost all products are self consumed. In this assessment area, the production is the least diversified (5 ±2 kinds of products per farmer, see Figure 32). The dryness of the region regularly causes starvation periods and doesn't allow the cultivation of numerous vegetables and fruit trees as in Tsinjoarivo (10 ±2 kinds of products per respondent).

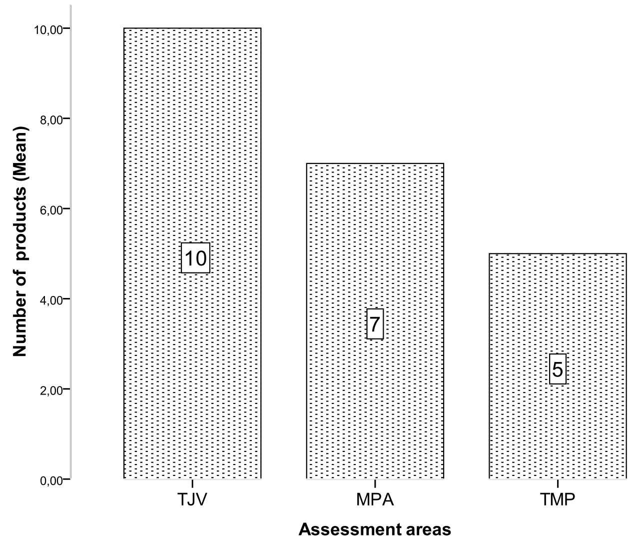


Figure 32: Diversification of farm products on the three assessments area (Rqibate and Rabefahiry, 2008b)

On this assessment area labor force generally originates from within the family. Indeed only 8% of the respondents pay additional labor force (21% in Tsinjoarivo and 28% in Manompana) to maximize their yearly yield (see Figure 33). The interviewed farmers and stockbreeders, i.e. ethnic group Mahafaly, preferably locate both off-farm and farm incomes in cattle activities.

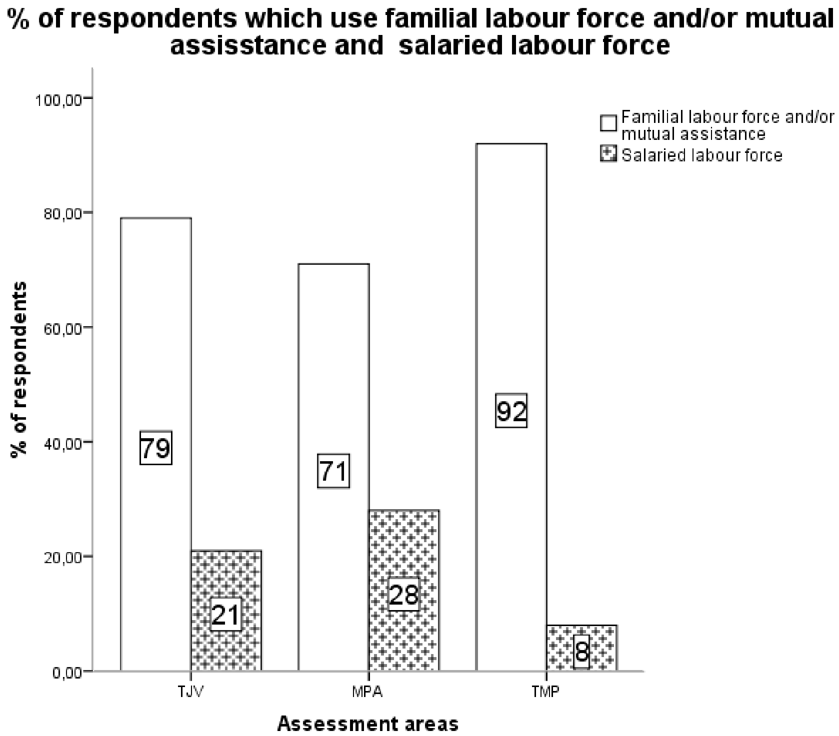


Figure 33: Percentage of respondents employing labour forces on the three assessment areas (Rqibate and Rabefahiry, 2009).

Causes: The proximity of a big city and many decent roads provide easy access to the area. Farmers aim for high yields by extensive farming in short periods of time in order to lower the effects of unforeseeable circumstances (e.g. locust, dryness). Agricultural incomes are used to accumulate stock breeding which is a symbol of respectability. Furthermore, pastoral farmers subsist on resources from the forest during transhumance. After all, farmers lack in knowledge of modern agricultural techniques.

- ***Fuelwood and charcoal making***

Characteristics and quantification

Especially the production of smoked fish shows a significant demand of fuel wood. Dead wood is collected in the dry forest or around the villages. Charcoal (mainly Katrafay, Kily or Azomena) is sold to traders in the village or at the road that leads to the city. Since fuel wood (Katrafay, Kily, Kapaipoty) becomes increasingly rare near the villages it is logged in the forest to be sold. Over the year, **51.458 m3** of fuel wood and charcoal are consumed by the population (Rqibate and Rabefahiry, 2008b and USAID 2008).

Material

- ***Wood construction***

Characteristics and quantification

People from far away areas enter the forest to find materials for constructions.Wood may be logged in parks with a special authorization and in “zones d'utilisation durable” (sustainable managed area) allocated by ANGAP. Permits for logging are predominantly handed out for construction of houses, bullock carts and aloala (wooden ornaments for tombs). Residents that need a larger amount of wood are supposed to order it in Tuléar. Some literate COBA employees may abuse their position and make money with permits attribution.

During the year, **18.000 m3** of wood are consumed for domestic uses (Rqibate and Rabefahiry, 2008b and USAID 2008).

Causes: There is a high demand of wood for entombments. It is also needed by the residents as means of work and subsistence: e.g. fishermen (Vezo ethnic group) need wood for constructing pirogues (see Photo 10).

Photo 10: The construction of a pirogue requires five species of wood which are becoming more and more difficult to obtain, i.e. presence of a National Park and rareness of the necessary species; (Photo: A Rqibate)

3.3.5 Conclusion

The results of the socio-economic study, i.e. causes of deforestation and forest degradation, enter in the development of possible incentives. Therefore it is necessary to prioritize these causes.

Prioritization of the causes

The quantification of uses shows that slash-and-burn is the primary reason of deforestation and degradation in the assessment areas Manompana and Tsimanampetsotsa (1.271 ha/year in Manompana and 990 ha/year Tsimanampetsotsa).

In Tsimanampetsotsa slash-and-burn is mainly practised at the edge of the local national park. Thus, surveillance is more intense than in Manompana and farmers are better informed about the dangers of slash-and-burn. In the assessment area of Tsinjoarivo the quantification of the transformation of forest areas into acreages could not be conducted because the people were unwilling to comment on this issue. Any publications including these data could not be found either.

In Tsinjoarivo plantations are an important source of energy for the individual households (75% energy from plantations) and of construction materials (66% from plantations). Construction and fuel wood come from private Eucalyptus and Pine plantations that also help to prevent erosions. Illegal logging has been practised by non-locals (Rqibate and Rabefahiry, 2007). In Manompana the main reasons for the local population to work as woodcutters and pursue slash-and-burn are the easy access to forest resources and generally low farm and other off-farm incomes. 82% of respondents consider their subsistence as dependent on the forest (in contrast to 75% in Tsimanampetsotsa and 64% in Tsinjoarivo). The traditional wooden buildings in Tsimanampetsotsa demand more material than in Tsinjoarivo, where houses are mainly built out of clay. In the region of Tsinjoarivo the amount of wood used for houses and fixings is two times lower than in Manompana (INSTAT, 2006). This difference can explain the higher demand of construction wood in Manompana compared to the more populated Tsinjoarivo (5.546m^3/year).

Indirect causes

Poverty, lack of education and deficient healthcare on national scale have influence on the local scale.

Income of households

The richest households are least dependent on acquiring wood as a source of income. However, they benefit most from deforestation and forest degradation by subduing acreages. Off-farm activities and the diversity of crops further ensure other sources of income and alimentation. In contrast, the incomes of the poorest households are primarily dependent on wood products. The distance to roads and markets puts an additional limitation to the possibility of selling their products. The bad condition of the infrastructure and unorganized selling-chains slow the local economic growth down (Rqibate and Rabefahiry, 2007; Rqibate and Rabefahiry, 2008a; Rqibate and Rabefahiry, 2008b).

Lack of financial resources in the forest and agricultural sector

On account of a lack of financial resources the forest and agricultural sectors are not able to effectively approach problems like slash-and-burn and logging. Corruption on a local scale (e.g. foresters, COBA members) impairs the working conditions in this domain (Rqibate and Rabefahiry, 2007; Rqibate and Rabefahiry, 2008a; Rqibate and Rabefahiry, 2008b).

Health and education of the local population

Diseases (primarily malaria) weaken the workforce. This leads to suboptimal treating of soil and a low yield. Thus, off-farm activities (i.e. other sources of income) are unfeasible for the farmer as well (Rqibate and Rabefahiry, 2007; Rqibate and Rabefahiry, 2008a; Rqibate and Rabefahiry, 2008b).

Knowledge of better and more sustainable agricultural techniques could not be found in any assessment area except Tsimanampetsotsa. Fertilizers and pesticides were indeed used in Tsinjoarivo but they were poisonous and wrongly applied. Furthermore, the lack of education among some of the rural population makes them unaware of their rights in managing resources (Rqibate and Rabefahiry, 2007; Rqibate and Rabefahiry, 2008a; Rqibate and Rabefahiry, 2008b).

3.3.6 Recommendations

The “community-based forest management” allows considering these local social-cultural aspects in the land use planning. However, a problem of this approach arises due to an unweighted treatment of households from different income groups within a commune. The poorest households (“poorest of the poor”) are not supported sufficiently when possible economic surpluses are distributed. This may lead to conflicts inside the community (Rqibate and Rabefahiry, 2007; Rqibate and Rabefahiry, 2008a; Rqibate and Rabefahiry, 2008b).

All agents should be viewed independently of their status, in order to develop adapted and viable incentives (CP4). This regards especially to the “poorest of the poor” which often belong to the least educated groups (Rqibate and Rabefahiry, 2007; Rqibate and Rabefahiry, 2008a; Rqibate and Rabefahiry, 2008b). An equalized view is particularly indispensable when it comes to the decisions of the resource management that are supposed to change the economic and social conditions in the future.

Access to credits should be easier for farmers (Rqibate and Rabefahiry, 2007; Rqibate and Rabefahiry, 2008; Rqibate and Rabefahiry, 2008b). It should also be considered that most farmers work under unstable and insecure conditions (e.g. cyclones, calamities, malaria, prices). Minimum prices should be guaranteed for their products and the influence of wholesaler should be diminished.

The basic needs of the agents must not be ignored in the course of establishing alternative land uses. That is to say, securing life has to remain possible beside further diversifications of the land use.

The same methodology, which allowed assessing the causes of deforestation and forest degradation on assessment areas differing in forest formations and ethnic groups, showed that, even the needs of the population are the same, the type and quantity of forest uses depends strongly on local and regional conditions. These have to be considered for the development of efficient incentives. In order to reduce the emissions of deforestation and forest degradation at national scale through the implementation of local and regional adapted incentives, the proposed methodology has to be conducted in additional relevant areas in total Madagascar.

4 Interfaces and conclusion

Authors: Thomas Baldauf, Daniel Plugge, Aziza Rqibate, Bettina Leischner, Matthias Dieter, Michael Köhl

4.1 Interfaces

Main aspects of the components (CP1, CP2 and CP3) and their interrelation were already referred to within the relevant sections of this report. In this chapter, additional interfaces are presented.

4.1.1 Interfaces between the inventory and the study about timber use

The subject of investigation of both analyses was timber (either in form of biomass or in form of board or beam in the timber value chain).

As timber for the value chain is mainly logged selectively, a further cross validation of assessment of degradation could be possible. This validation is limited on the one hand caused by uncertainties about removed biomass mentioned in the study about timber use (see chapter 3.2.2). On the other hand it would require a re-inventory of the assessment areas, i.e. continuous forest inventory (CFI), in order to identify the change of biomass between two points in time. A thorough modelling of degradation in tropical forests, e.g. through selective logging (see Köhl and Plugge, 2008) encounters severe difficulties.

Likewise this aspect would occur, if regional baselines were established. Then a scenario of business as usual could be established in form of changes in (carbon) stock, which could include both increment and removals. As above, a reliable modelling of the development of tropical forests is very difficult (see Vanclay, 1995), which sets limitations to this approach. Default values, e.g. by IPCC (2003), could be used for the development of baselines. However, this would be connected with severe uncertainties.

4.1.2 Interfaces between the study about timber use and the study about causes of DD

An important interface is given by the combination of the study about timber use (“economic study”) and the socio-economic study about the causes of DD. In the former potential leakage effects are considered. It contributes to the effectiveness of measures against deforestation and forest degradation and thus the question about where to act. The socio-economic study focuses on a contribution to the setting of incentives in the areas. It contributes to choose incentives with highest impact and thus to the question of how to act.

4.1.3 Interfaces between the inventory and the socio-economic study about causes of DD

An example, how interfaces can be used for cross-validation, can be shown based on the results for the assessment area Manompana of the inventory (CP1) and of the socio-economic study about the causes of DD. On the one hand, the inventory finds a yearly deforestation of about 1.254 ha/year expressed in forest area loss (see 2.4.2). Figure 34 shows an image emphasising the differences of forest area between 2004 and 2008 in the assessment area Manompana. On the other hand, the socio-economic study identified that 1.271 ha of forest area converted into cultivated area every year (see 3.3.4.2, or Rqibate and Rabefahiry 2009). Regarding the difference of only 17 ha or 1,3%, the results of these completely different approaches, i.e. combined forest inventory and interviews, match very well. This fact supports the validity of the approaches' results within this assessment area.

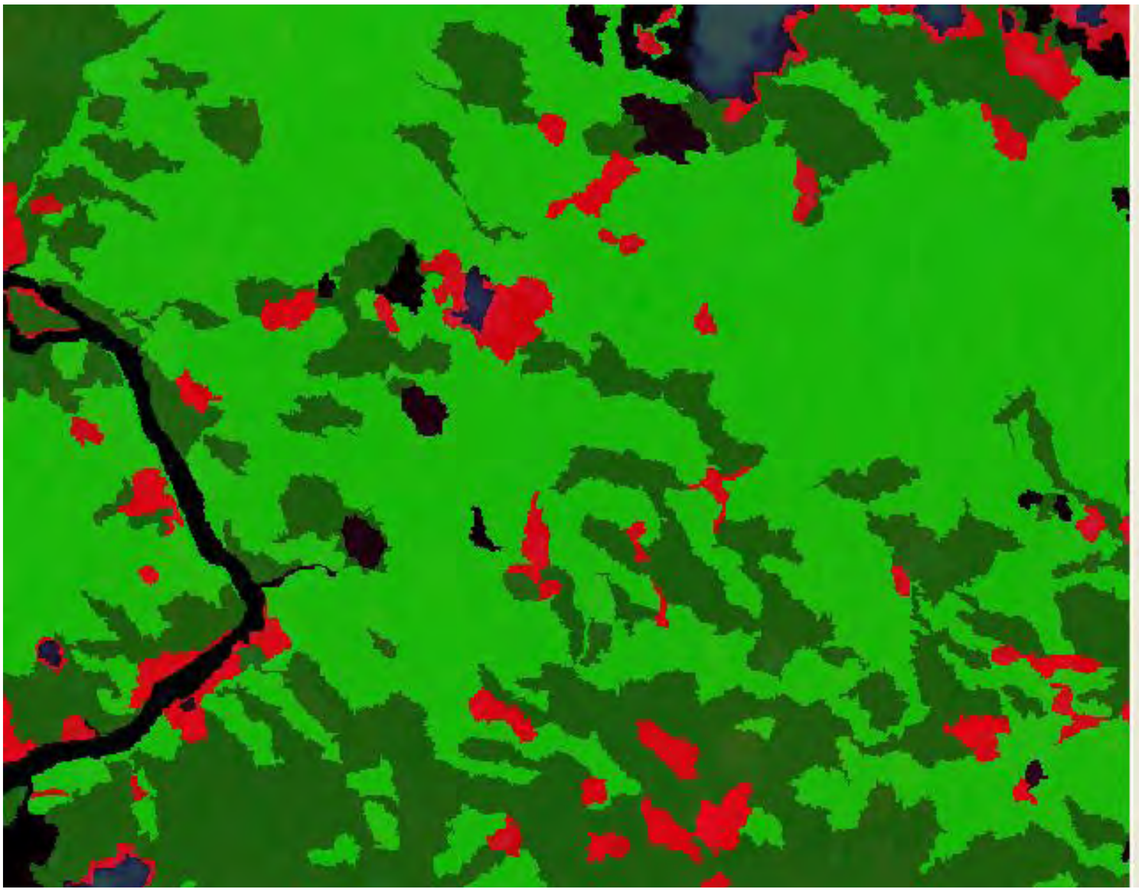


Figure 34: This figure shows a classification of remote sensing data. The classification was based on a SPOT4 image dated 2004 and a SPOT5 image dated 2008. Here the differences of forest area between the two points in time are emphasized. Forest area loss is shown in red, different forest status in green (light green and dark green). Black areas refer to areas that could not be classified, i.e. clouds and shadows of clouds.

4.2 Conclusion

The methodology developed and conducted by vTI covers several components that are relevant for a holistic consideration of REDD. In this regard, these components identified in the REDD-FORECA project are shown in Figure 1. Within this report, vTI shows efficient methods for the quantitative

determination of deforestation and forest degradation and its dynamics, and methods for determination and analysis of economic and socio-economic causes for deforestation and forest degradation and evaluations of potential baselines approaches. Each of the methods was tested in the three assessment areas, i.e. Tsinjoarivo, Manompana and Tsimanampetsotsa, in Madagascar, while the evaluation focused on possible baselines and their potential implications. The respective results are shown in the chapters 2.4 (Inventory and Monitoring), 3.1.5 (Evaluation of potential baseline approaches), 3.2.3 (Economic Study) and 3.3.4 (Socio-Economic Study). The conclusions are presented in the chapters 2.5, 3.2.5, 3.3.5, respectively.
On the whole, the methods deliver sound and reliable information for the fulfilment of each of the components' requirements (see Figure 1), thus proving their operability.

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7 Appendices:

7.1 Illustration of the combined inventory methodology:

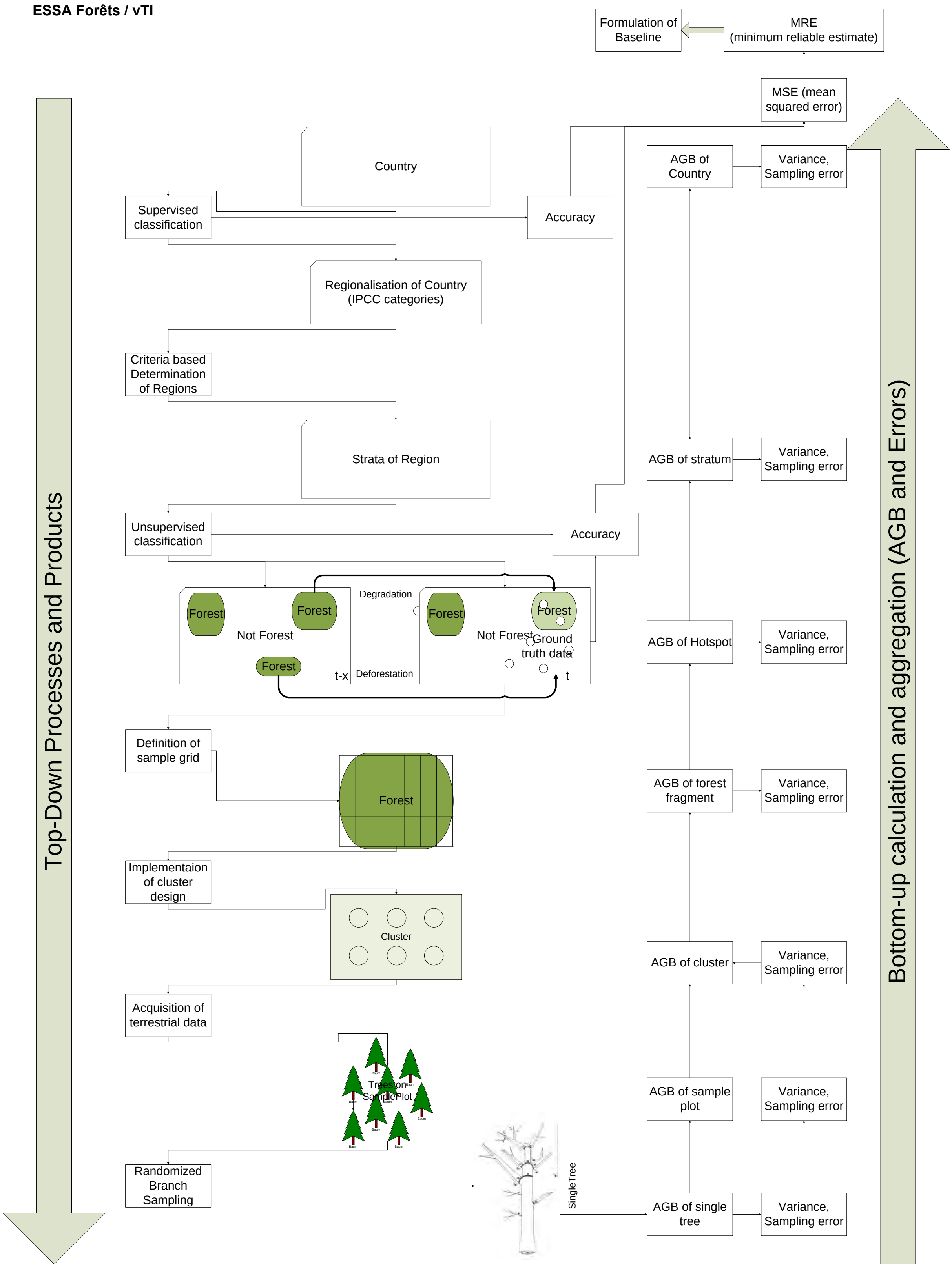

Figure 35: Detailed illustration of the applied combined inventory methodology showing the top-down and bottom-up approaches (adapted from Plugge et al., 2010)