4. Setting Interim RELs/RLs for REDD+ in the National Level of Vietnam

The definition and clear methodology for how to develop RELs/RLs have not been provided. On the other hand, the importance of understanding historical trends and the effectiveness of understanding forest dynamics by combining satellite data and ground-based surveys are widely recognized. It is important to reduce uncertainty as much as possible and methods with robustness and transparency should be used when submitting reports to UNFCCC.

It is possible to select technical options for developing RELs/RLs by taking into consideration these basic principles (the options are shown below).

Table 4.1.1 Options for Developing Interim RELs/RLs

Item to be considered	Option 1	Option 2
Method for calculating Interim RELs/RLs	Integrating RELs/RLs	Separating RELs and RLs
Unit for developing Interim RELs/RLs	The projections are made at the national level.	The projections are made at the regional level and the results are aggregated to obtain national results.
Number of sets of past satellite data to be used	Three points in time	Five points in time
Stratification classification for developing EF	Agro-ecological zones	Bio-ecological zones
The model to be used to make the projections	Calculation of the average	Regression model

For the stratification classification for developing EF, it was concluded that Bio-Eco regions should be used in order to reduce uncertainty in Chapter 3. The following explains the results of considering each technical option.

Note: In the Study, RELs (Reference Emission Levels) and RLs (Reference Levels) are defined as follows.
RELs; the change of emission levels of CO2 resulted from the deforestation and forest degradation.
RLs; the change of removal levels of CO2 resulted from forest enhancement, rehabilitation and reforestation.

4.1 Stock Change Method and Forest Change Matrix Method

Two kinds of method are considered to estimate the amount of carbon stock change in the past: integrating RELs/RLs; and separating RELs and RLs. The former method is called Stock Change Method (SCM), based on the calculation method for GHGs provided by IPCC. However, SCM cannot observe each historical trends of the amount of emission and removal respectively because SCM calculates them together. This indicates that even SCM is the method recommended by IPCC, it cannot separate RELs and RLs to be calculated.

On the contrarily, if RELs and RLs are developed separately, it is possible to understand more detailed forest dynamics between two points in time using Forest Change Matrix Method (FCMM): it is possible to observe how the amount of removal and the amount of emissions changed in the past. This method makes it possible to observe forest dynamics by linking it with factors which contributed to deforestation in the past, socio-economic factors and the effects of policies. This is very important in order to be able to make projections using a model which takes into consideration the relationships between forest dynamics and other factors. In addition, this method makes it easier to clarify the trends of past forest dynamics because the amount of removal and the amount of emissions are estimated separately. However, note that FCMM is not the method approved by IPCC and requires its characteristics to be understood.

4.1.1 The Methodology

(1) Stock Change Method

Based on the calculation method for GHGs provided by IPCC, the amount of removal/emissions can be estimated by calculating the total carbon stock change between two points in time (Stock Change Method: SCM). Therefore, by using forest distribution maps for two points in time and the EF for respective forest types (multiplying the area of land by the respective Emission Factor), carbon stock levels at the two points in time can be estimated.

$\Delta t_2\text{-}t_1 = (ADt_2 * EFt_2 - ADt_1 * EFt_1)$

ADt_1: The forest distribution situation at the beginning of the period

ADt_2: The forest distribution situation at the end of the period

EFt_1: The Emission Factor at the beginning of the period

EFt_2: The Emission Factor at the end of the period

The calculation of SCM is relatively easy, but the results offset some of the forest decrease and some of the forest increase between the two points in time. Therefore, the amounts of increase and decrease cannot be estimated separately. If RELs are defined as levels based on activities for controlling deforestation and forest degradation and RLs are defined as the levels based on forest increase, SCM cannot evaluate these levels separately.

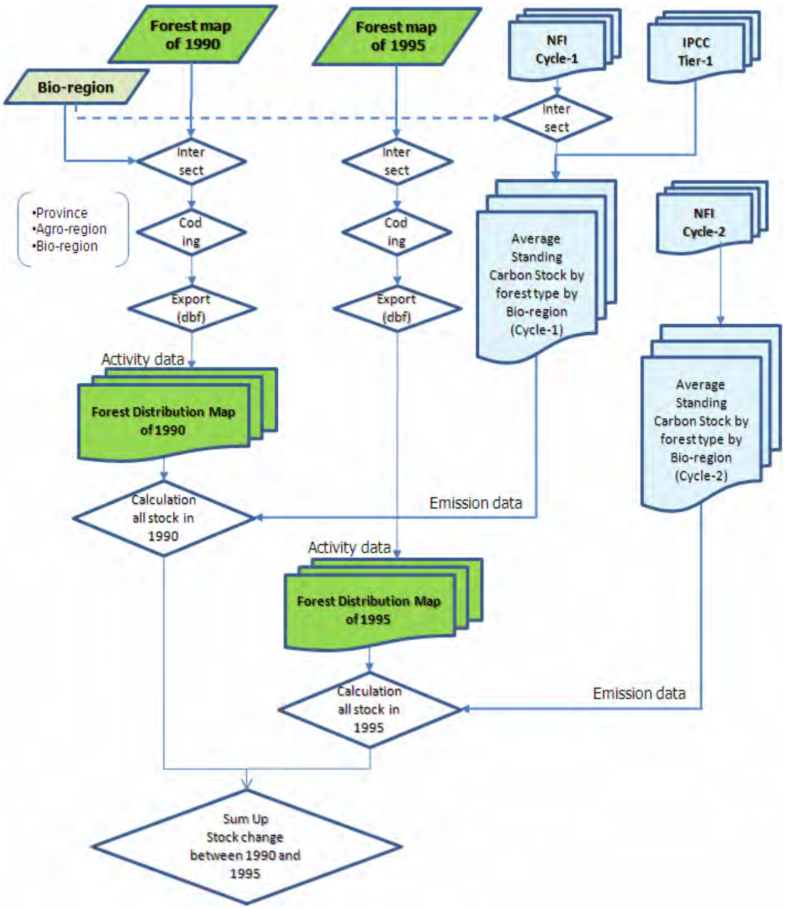


Figure 4.1.1 Estimation of Carbon Stock Change by Stock Change Method

(2) Forest Change Matrix Method

If the Forest Change Matrix Method (FCMM) is used, the forest decrease and the forest increase between two points in time can be estimated separately, although such estimation is time consuming.

$\Delta t_2\text{-}t_{1=}\sum (F_{a/a}*(EF_{a2}- EF_{a1})) + (F_{a/b}*((EF_{b2}- EF_{a1})) + (F_{a/c}*((EF_{c2}- EF_{a1})) + ... (F_{q/q}*((EF_{q2}- EF_{q1}))$

a/a: The area of land which changed from “forest type a” to “forest type a” in the period between t_1 and t_2

a/b: The area of land which changed from “forest type a” to “forest type b” in the period between t_1 and t_2

EF_{a2}: EF for “forest type a” in t_1

EF_{a2}: EF for “forest type a” in t_2

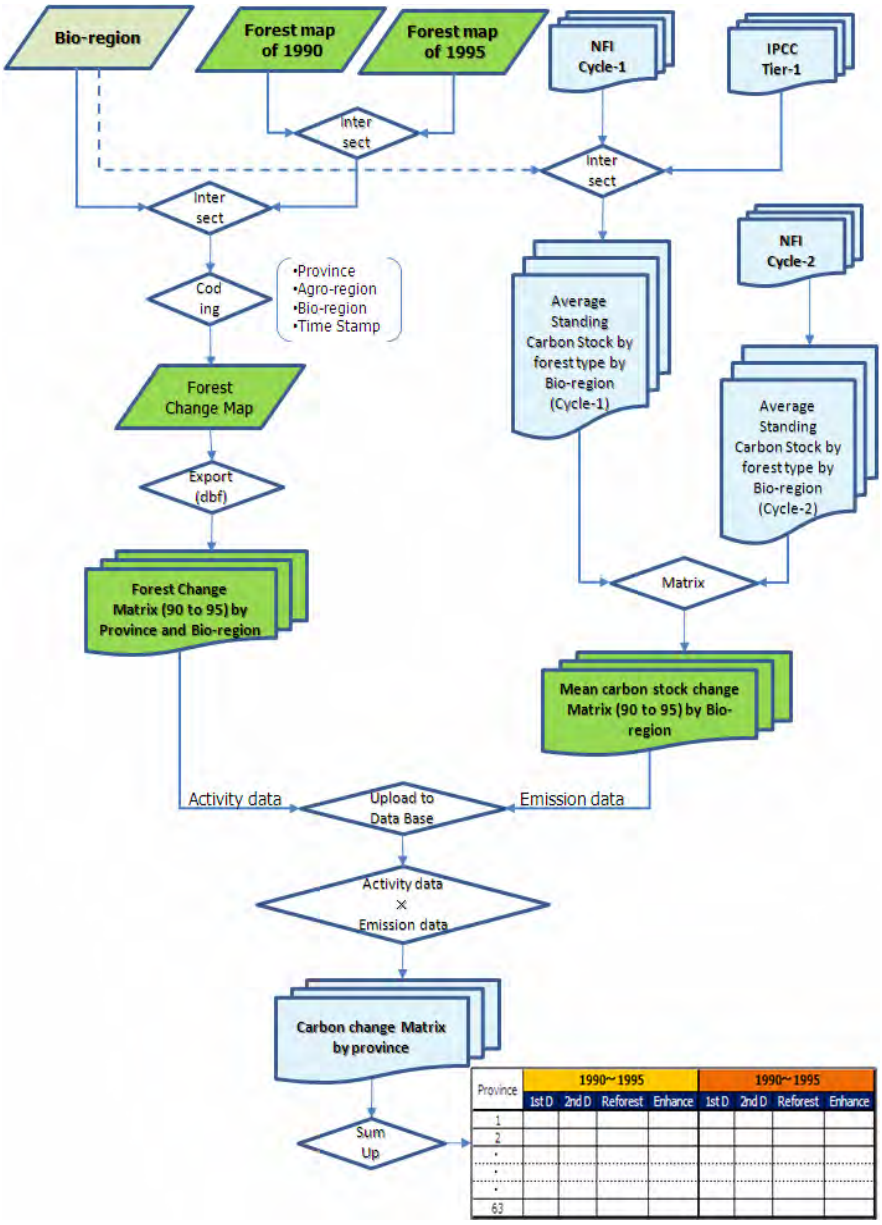


Figure 4.1.2 Estimation of Carbon Stock Change by Forest Change Matrix Method

4.1.2 The Results

The following explains forest area dynamics and forest dynamics in Vietnam which were estimated using SCM. The AD for five points in time since 1990 (five-year interval) has been compiled and EFs for four points in time (from Cycle-1 to Cycle-4) have been developed. Therefore, the EF developed for Cycle-1 was used for the 1990 AD and the 1995 AD. For the other points in time are also the same: EF developed for Cycle-2 was used for the 2000 AD; EF of Cycle 3 for the 2005 AD; and EF of Cycle 4 for the 2010 AD. This matching of the EF of every Cycle with the AD of every point in time is taking account of estimation of RELs/RLs throughout in the Study.

When looking at the changes in the total carbon stock using SCM, the Forest Sector was an emission source up to 2000, but it changed to a carbon sink after this point (Figure4.1.3). If RELs/RLs are integrated instead of being separated, this forest dynamic will be used for projections. The value R^2 = 0.5689 was obtained when using a linear equation.

On the other hand, when estimating changes in the amount of removal and the amount of emissions separately using FCMM, the amount of removal has increased since 2000 and the amount of emissions has decreased slowly (Figure4.1.4). When approximate equations were used to obtain the future projection, the best correlation coefficient was obtained using a linear equation for the amount of removal, and the best correlation coefficient was obtained using a quadratic polynomial for the amount of emissions.

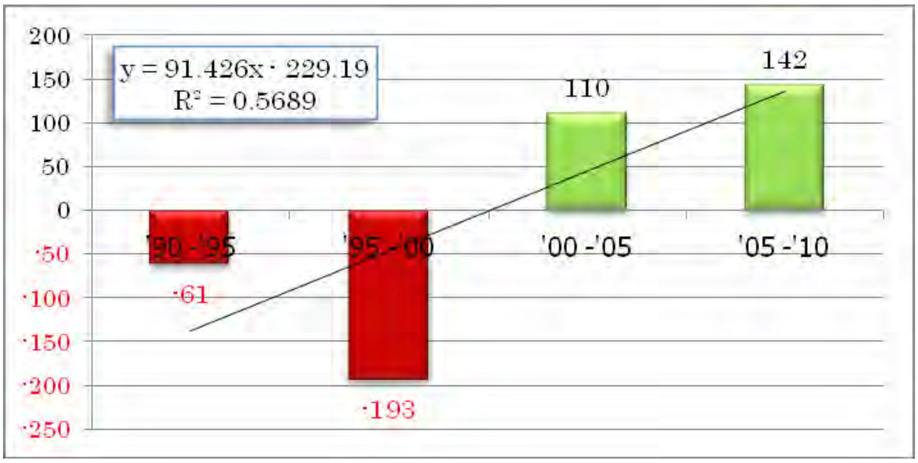


Figure 4.1.3 Stock Change in the Forest Sector since 1990 Using SCM

(National unit)

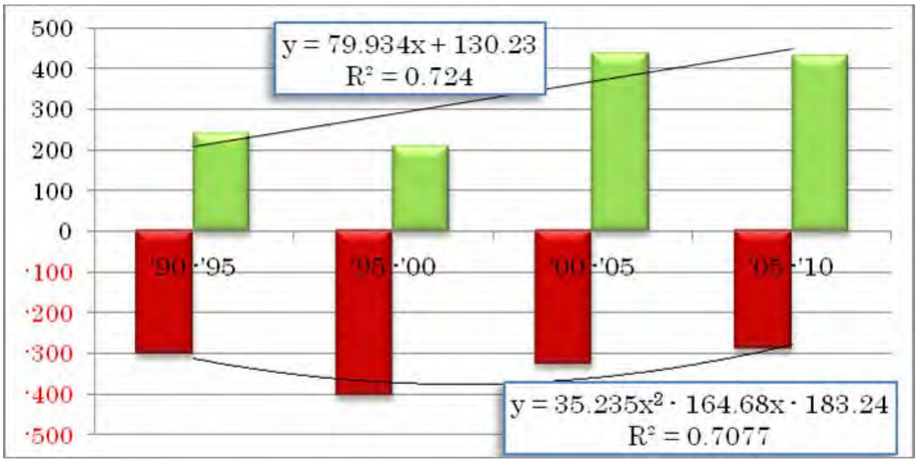


Figure 4.1.4 The Amount of Removal/Emissions in the Forest Sector since 1990 Using FCMM **(National unit)**

4.2 Aggregation Units for RELs/RLs

There are some options for deciding which units should be used to decide the geographical boundaries when developing RELs/RLs. More specifically, there are three options: the national unit, Agro-Eco regions units, and province units. From the discussion below, it is concluded that if the national unit is chosen as the geographical unit, the macro trends can be observed while regional trends are lost. If Agro-Eco regions are chosen as the geographical unit, the result shows the trends of activities influenced by policy as well as the trends of bio-ecological characteristics in each of the northern, central, and southern regions. If province is chosen as the geographical unit, the trends of activities related to the policy are clearly observed in large-scale forest distribution maps. However, it is necessary to take note that there is a limitation of the accuracy of interpretation for forest distribution maps if the scale becomes larger and larger. The observations of each unit are described below.

4.2.1 The Methodology

The dynamics of the amount of carbon emissions/removal calculated for each province using GIS were aggregated for Vietnam and for each Agro-Eco region.

4.2.2 The Results

This section explains about the result of the estimation comparing the national unit, Agro-Eco regions unit and province unit using FCMM, separating RELs and RLs.

(1) National Unit

As a result of estimating RELs /RLs for national unit is shown in Figure4.1.4 of last section. It does not indicate the trends of regional characteristics like in Agro-Eco region units, as a matter of course. Moreover, if regression model is decided to use for future extrapolation, the data of future benchmark would be different between the future extrapolation of using national unit; and using sub-national (Agro-Eco region and province) to be integrated into national level. Then, the necessity of taking account of regional characteristics would increase. As a result, this would be the demerit of the national unit for estimating RELs and RLs separately (see 4.4 for further discussion).

On the contrarily, if the average model is used for the future extrapolation as described in 4.4 later, mean value would be the same as by Agro-Eco region units as well as province units. However, if RELs/RLs is used for not only as the benchmark of gaining the credit, but also as the indicator of monitoring the results of PaMs and MRV; and being implicated as the historical trends itself; national unit is not suitable to indicate those historical trends.

(2) Agro-Eco region units

RELs/RLs nationwide are as shown in Figure 4.2.1 to 4.2.3. Figures for representative Agro-Eco regions from the northern part, central part and southern part of Vietnam are shown below.

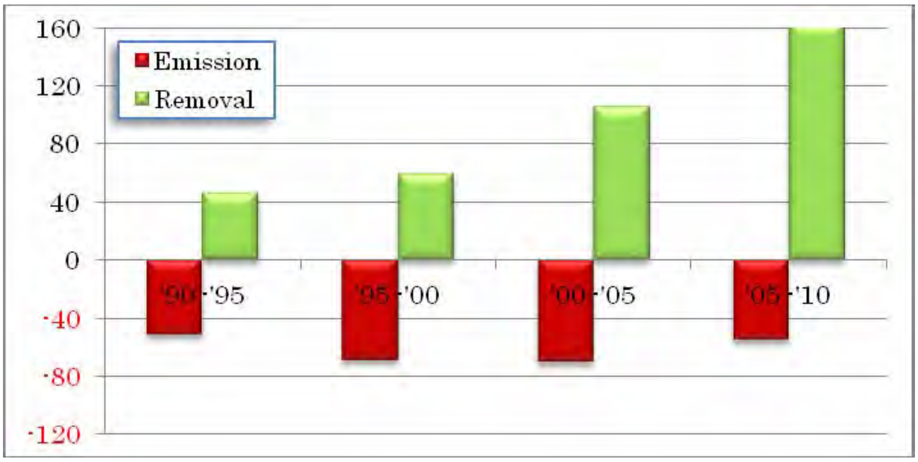


Figure 4.2.1 Forest Dynamics since 1990 (North East Region)

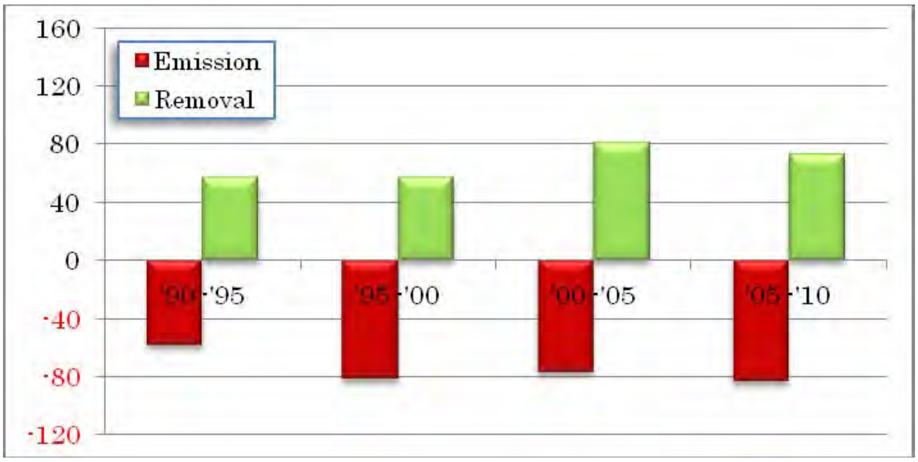


Figure 4.2.2 Forest Dynamics since 1990 (North Central Region)

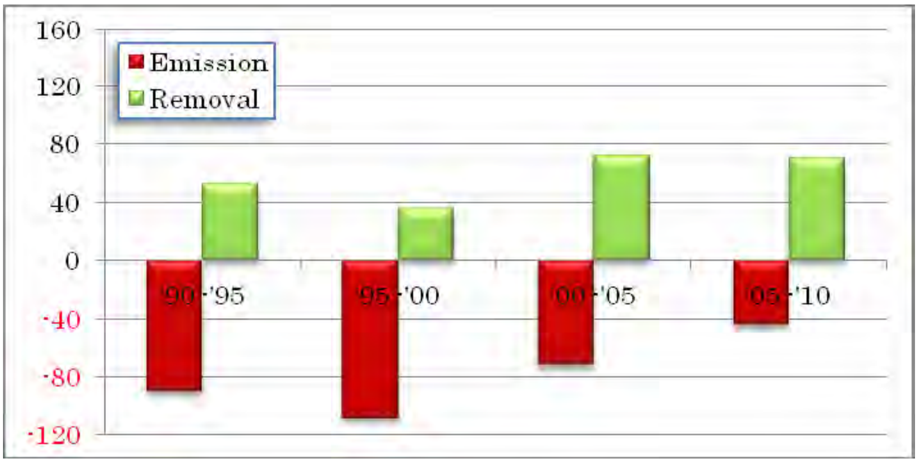


Figure 4.2.3 Forest Dynamics since 1990 (Central High Land Region)

As a result of estimating the past forest dynamics for each region, the characteristics of each region were discovered. For example, the amount of emissions showed a slightly decreasing trend in the northern part of Vietnam and a surge in the amount of removal was observed after 2000. In the central region, there have been no major changes in the amount of removal since 1990 and the amount of emissions has slightly increased. In the central highlands, the amount of emissions has shown a decreasing trend since 2000.

Possible factors which contributed to the increase in carbon stock are the effects of policies such as the five million ha afforestation plan and an improvement in livelihoods which decreased the level of dependency on forests. It can be interpreted that the outcome of implementing these policies in accordance with regional characteristics manifests itself in RELs/RLs. There are various possible factors which contributed to the decrease in carbon stock through deforestation and forest degradation. These factors include turning forests into traditional types of farmland, the expansion of slash-and-burn agricultural land, the development of large-scale dams and regional development. These activities are taking place in accordance with regional characteristics and they are relevant to the interpretation of RELs/RLs. For example, the central highland region had high quality forest carbon stock. However, due to the pressure of turning forests into farmland since 1990, deforestation occurred over a large area. This was followed by the intensive efforts of the Vietnamese government to control deforestation. As a result, the amount of emissions has become lower than in other regions in recent years.

Therefore, by estimating past amounts of removal/emissions for each Agro-Eco region, it is possible to clarify regional characteristics.

(3) Province units

Estimations were made by calculating RELs/RLs for each province. Examples from three regions (using Bio-regions) are shown below because it would be too complex to discuss all 63 provinces.

1) Trends of Tow provinces in the North Eastern Region

In the North East Region, carbon stock levels have rapidly increased since 2000, but slightly different trends can be seen when looking at the detailed results for each province. For example, in Lao Cai Province, the carbon stock level has increased steadily, but in Lang Son Province, the carbon stock suddenly increased from 2000 onwards although virtually no increase was observed until 2000 (Figure 4.2.4 and 4.2.5). This suggests that the effects of the intensive forest restoration program may have contributed to the increase in the carbon stock level. In the North East Region, although deforestation has progressed at a constant speed since 1990, virtually no carbon emissions have been observed in Lang Son Province, for example.

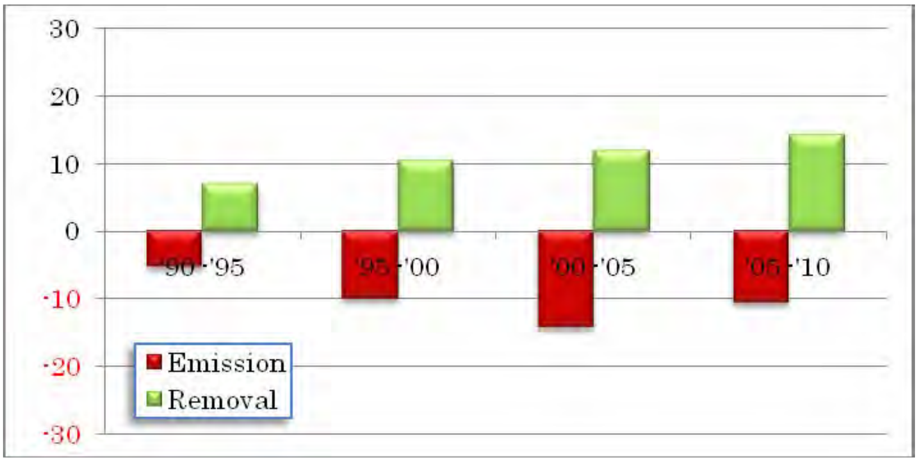


Figure 4.2.4 Forest Dynamics since 1990 (Lao Cai Province in the North East Region)

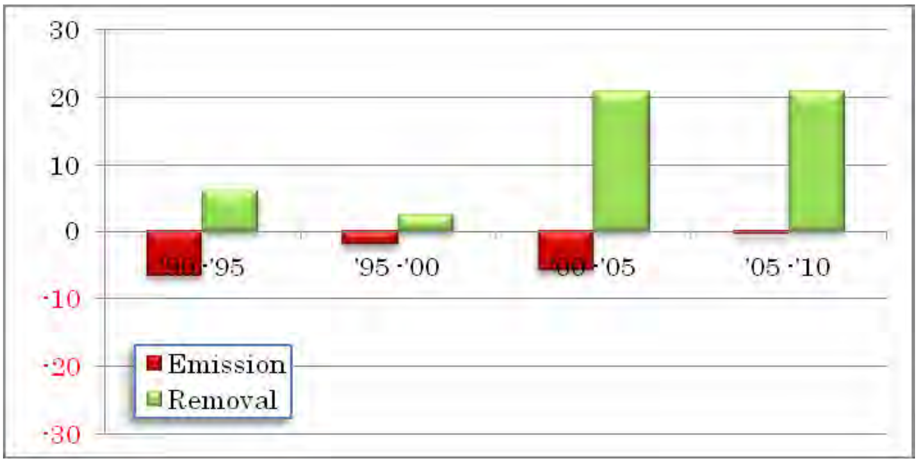


Figure 4.2.5 Forest Dynamics since 1990 (Lang Son Province in the North East Region)

2) Trends of Tow Provinces in the North Central Region

In the North Central Region, the amount of carbon removal and the amount of carbon emissions have been observed at similar levels since 1990. When looking at each province, in the case of Thanh Hoa Province, the amount of carbon removal suddenly increased at one point (Figure 4.2.6). In Nghe An Province, the amount of carbon removal decreased in recent years (Figure 4.2.7). On the other hand, the amount of carbon emissions has increased in both provinces in recent years.

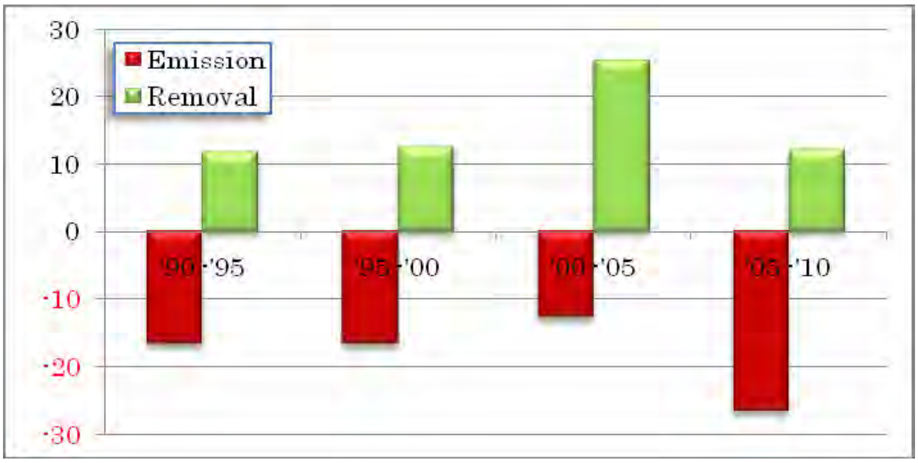


Figure 4.2.6 Forest Dynamics since 1990 (Thanh Hoa Province in the North Central Region)

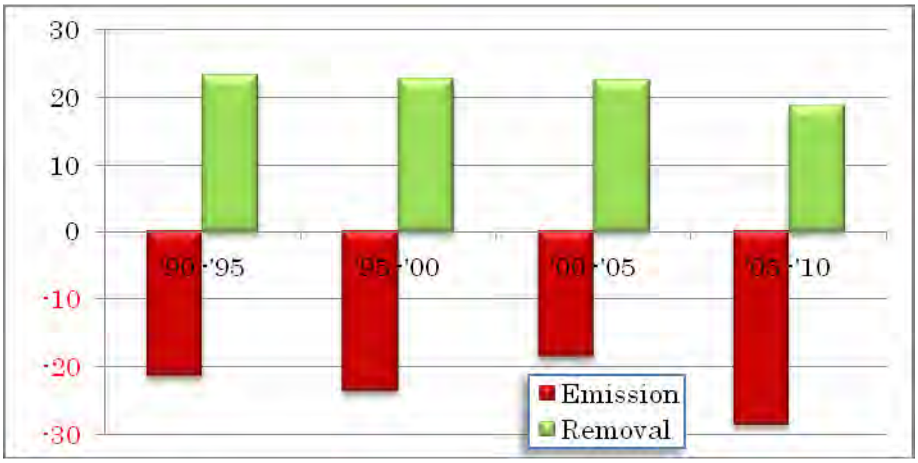


Figure 4.2.7 Forest Dynamics since 1990 (Nghe An Province in the North Central Region)

3) Trends of Two Provinces in the Central Highland Region

Regarding the results for the Central High Land Region, activities to control deforestation have been vigorously implemented since 2000. When comparing Lam Dong Province and Kon Tum Province, deforestation increased for a while and then suddenly decreased in Lam Dong Province (Figure 4.2.8 and 4.2.9). In Kon Tum Province, deforestation was gradually controlled and very little carbon emissions derived from deforestation have been observed in recent years. Although the forest carbon stock has steadily increased in Lam Dong Province, no obvious trend was observed in Kon Tum Province.

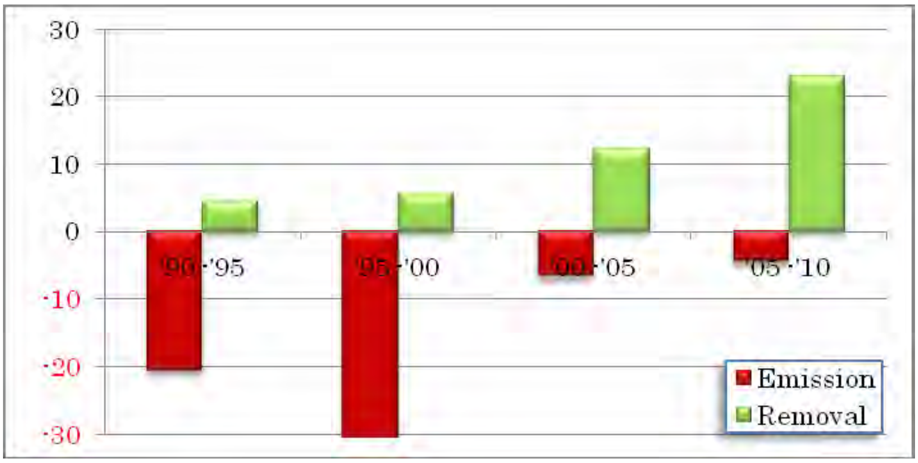


Figure 4.2.8 Forest Dynamics since 1990 (Lam Dong Province in the Central High Land Region)

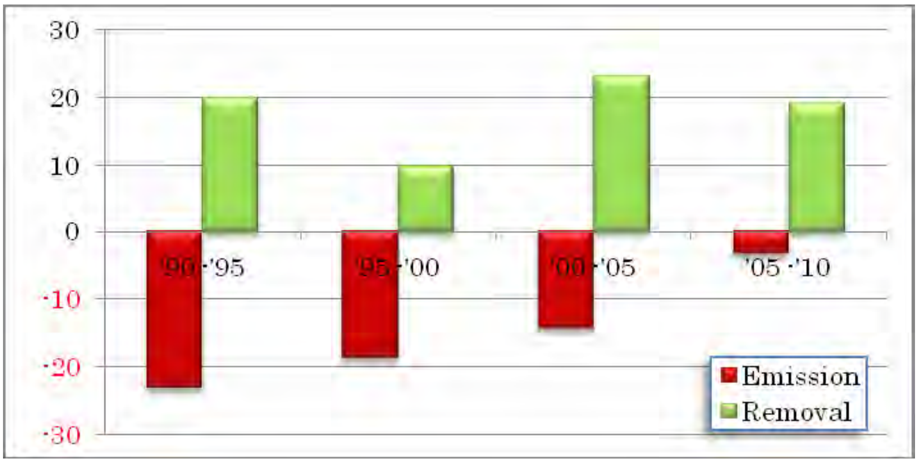


Figure 4.2.9 Forest Dynamics since 1990 (Kon Tum Province in the Central High Land Region)

From the above described discussion results, the following conclusions can be made regarding the geographical boundaries for developing RELs/RLs.

- When looking at the forest dynamics for each Agro-Eco region, different trends were observed for the northern region, the central region and the southern region.
- It is surmised that the trends in each region are linked to factors contributing to deforestation and factors contributing to forest restoration in each region. This is important information when taking into consideration the socio-economic factors needed for making projections.
- When looking at the forest dynamics of each province in different Agro-Eco regions, some provinces showed slightly different trends from the trends in the Agro-Eco region as a whole. It is surmised that this reflects the policy and the current forest dynamics situation in each province.
- When looking at the forest dynamics for each province, there were cases where a clear trend was observed and where various changes were observed. This suggests that deforestation and forest increases are occurring in a mosaic pattern and in a complex manner. It is important to fully pay attention to this point when making projections.

4.3 Time points of historical data

Basic principles which need to be followed when developing RELs/RLs are: certainty and transparency in the methodology; and conservative estimates. It is also commonly recognized that obtaining past forest dynamics data is essential because it is important basic data for developing RELs/RLs. However, there are no internationally agreed guidelines on specific numbers regarding how many points in time should be used to understand past forest dynamics. In this section, different numbers of points in time are used to understand forest dynamics and the uncertainty generated in the process is discussed. Through the discussion, the appropriate number of points in time to be used when developing RELs/RLs is clarified. The results of the discussion are described below.

4.3.1 The Methodology

In order to calculate changes during two or more different periods, a method which uses data from three points in time (the minimum necessary points in time) and a method which uses data from five points in time since 1990 were compared. The results were then examined from the standpoint of robustness.

4.3.2 The Results

The appropriate number of points in time was considered by looking at reforestation in Kon Tum province as an example. When using data from five points in time, a specific trend could not be observed (Figure4.3.1). Therefore, although a linear equation was selected as a regression model, only a very low correlation coefficient was obtained. This means that the levels of carbon increases derived from reforestation have repeatedly fluctuated.

On the other hand, when using data from three points in time, only a linear equation can be used (Figure4.3.2). The resulting observed trend was a simple increase. However, it was clear from the results obtained using five points in time that the carbon stock derived from rehabilitation did not simply increase in Kon Tum Province. Therefore, it can be concluded that the results obtained from the data from three points in time have high levels of uncertainty.

On the other hand, with regard to deforestation, it was observed that the levels of deforestation have decreased when using data from five points in time (Figure4.3.1). When using a linear equation as a regression model to express this trend, a high correlation coefficient was obtained. A very similar linear equation was obtained when using the data from three points in time (Figure4.3.2). Therefore, it can be concluded that, if the forest dynamic has a constant increasing or decreasing trend, a method using the data from three points in time and a method using the data from five points in time can both produce similar future projections. However, as was mentioned in the discussion about forest dynamics for each province, the amount of carbon removal and the amount of carbon emissions have shown complex trends in the past due to various deforestation factors and forest restoration policies. Therefore, it is not appropriate to use data from only three points in time to understand the past forest dynamics for all 63 provinces from the standpoint of ensuring robustness.

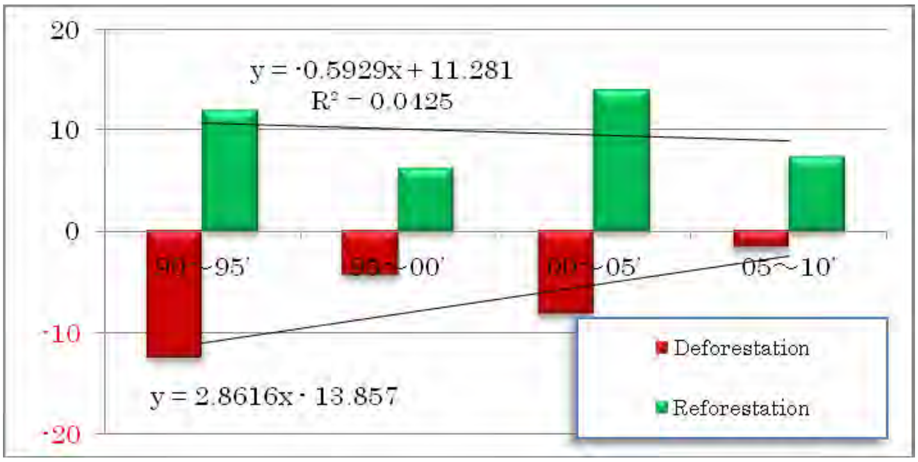


Figure 4.3.1 Carbon Stock Change using data from Five Points in Time (Kon Tum Province)

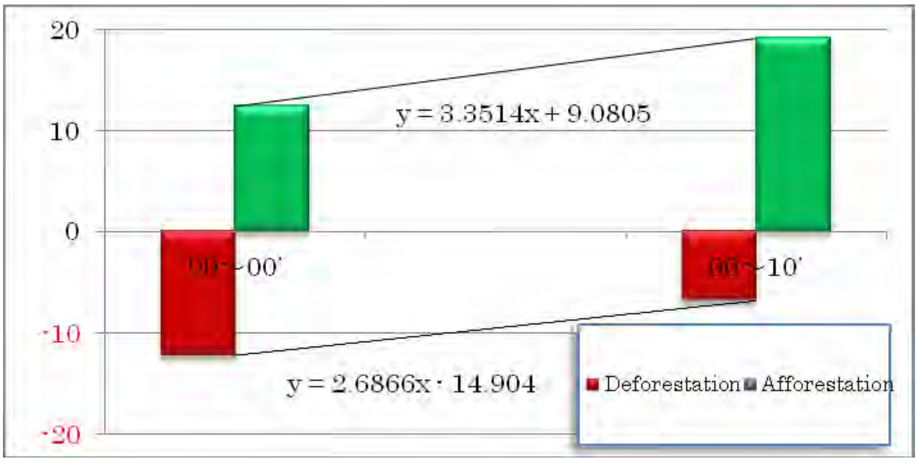


Figure 4.3.2 Carbon Stock Change using data from Three Points in Time (Kon Tum Province)

4.4 Projection model

When estimating the future amounts of removal/emissions based on past forest dynamics, it is necessary to examine what kind of extrapolation model should be used. The RELs/RLs being considered in the Study only use information about past forest dynamics in order to obtain projections. Socio-economic factors and the country-specific situation are not taken into account. Therefore, it is expected that the projection model will be decided upon after examining the level of appropriateness for applying the regression model developed based on past forest dynamics.

4.4.1 The Methodology

Based on changes during the four periods calculated from the forest situation data from five points in time, various models were applied to examine which model would provide a high level of robustness, using their correlation coefficients as the criteria. The considered models include: the average, the linear regression model, the exponential function model, the logarithmic function model and the polynomial model.

4.4.2 The Results

(1) Projection Model on Deforestation and Forest Degradation

Figure4.4.1 shows the changes in the amount of emissions in Kon Tum Province. The amount of emissions has steadily decreased since 1990. Three models can be applied to express this trend. Both the linear model and the quadratic regression model show very high correlation coefficients. The linear model has the highest correlation coefficient. According to this model, carbon emissions derived from deforestation will reach zero in the near future. However, in reality, it is unlikely that any province will have zero deforestation. Therefore, an asymptote where deforestation reaches close to zero is thought to be the most appropriate projection model.

On the other hand when using the average, past emissions is directly included in the mean value and therefore a higher estimation of future emissions will be made. This means that a higher benchmark will be set for deforestation control.

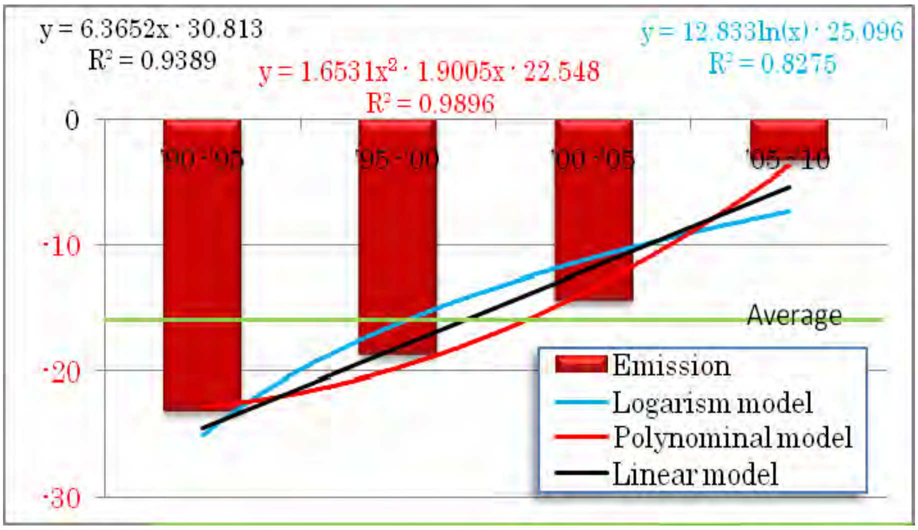


Figure 4.4.1 Trends of Carbon Emission in Kon Tum Province

Figure4.4.2 shows a case where carbon emissions derived from deforestation have an increasing trend. In this case, the quadratic regression equation has the highest correlation coefficient. If this model is used, the future projection would be that the emissions will increase dramatically from 2015 onwards. This is because the latest emissions (during the period between 2005 and 2010) were higher than emissions in other periods. Therefore, in this case, the linear regression equation is thought to be more appropriate for the emissions projection, although its correlation coefficient is low.

If the average is used, the future projection for the amount of emissions will be estimated at a lower level than it should be, because of the lower emissions in the past although the emissions in the latest period were high. This may result in a lower benchmark for deforestation control and therefore this model is disadvantageous for calculating the benefits of emissions reduction.

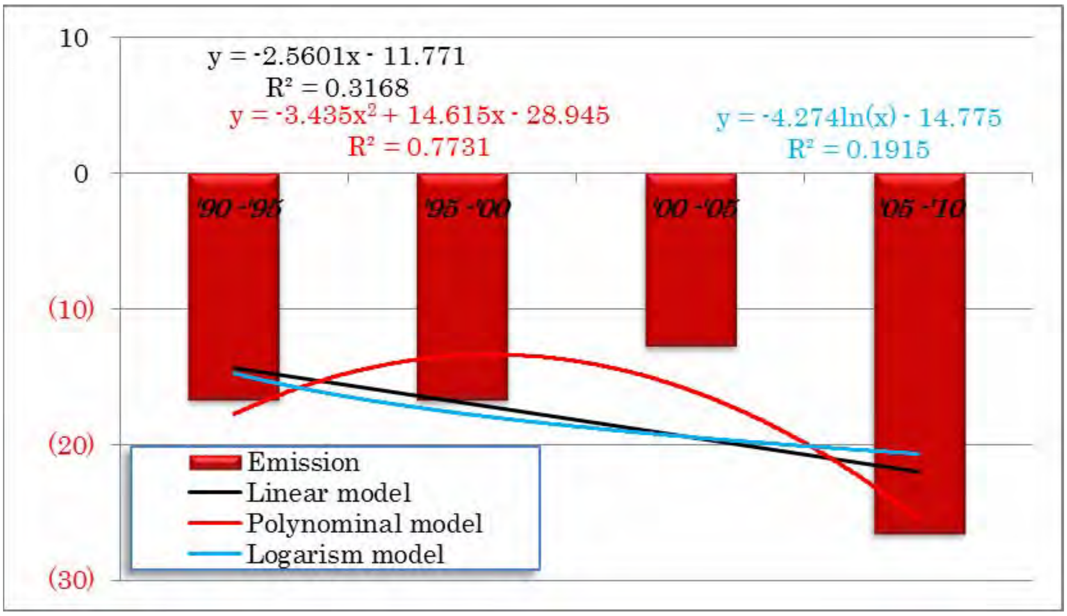


Figure 4.4.2 Trends of Carbon Emission in Than Hoa Province

(2) Projection Model of Regrowth and Rehabilitation

Figure 4.4.3 shows the trend of the carbon removal in Lam Dong Province. It shows the simple increase from 1990, and both the linear model and the exponential function model have higher correlation coefficients. In the case of the exponential function model, the model of higher projection is applied in accordance with the dramatic increase of the removal after 2005. In this case, since the future removal is projected to be higher, this model is disadvantageous for calculating the benefits of removal. However, when looking at only the correlation coefficient, the exponential function model is thought to be more appropriate.

When the average was used, the future projection for the amount of removal is estimated at 11 MCO_2t, which is a lower level than the results projected by the regression model. Therefore, this model is advantageous for calculating the benefits of removal projection due to the lowest amount.

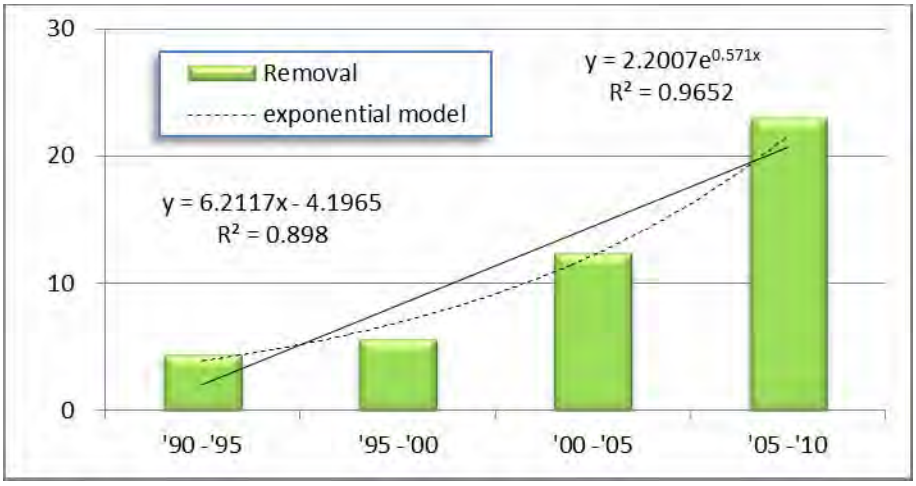


Figure 4.4.3 Trends of Carbon Removal in Lam Dong Province

Figure 4.4.4 shows the case of Dien Bien Province, where carbon removal has a decreasing trend. The carbon removal increases until 2005 and decreases afterwards. In this case, the linear regression model has a slightly low correlation coefficient while the quadratic regression equation has a higher correlation coefficient. When the average is used, the future projection for the amount of removal is estimated at 9 MCO_2t. Therefore the linear regression model is disadvantageous for calculating the benefits of removal projection due to the higher carbon removal.

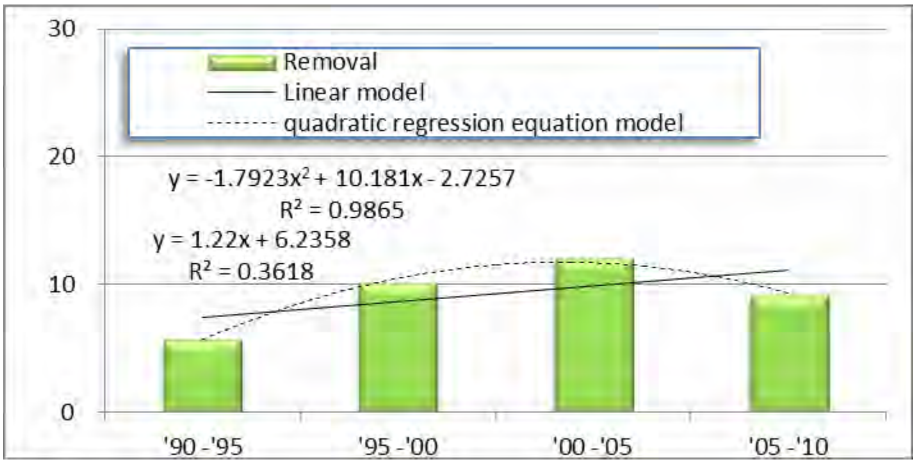


Figure 4.4.4 Trends of Carbon Removal in Dien Bien Province

(3) Projection of Past Historical Trends in no Particular Trend

The next case is the projection model where carbon emissions and removal do not show any particular trends. Figure 4.4.5 shows the carbon removal trend in Kon Tum Province. The carbon removal after 1990 alternates between increasing and decreasing trends. In this case, the linear regression model and the quadratic equation have only low correlation relations. This may result from there being no particular trend in the past history. In such case, the average amount of carbon emissions/removal (18 MCO_2t) is considered to be applied to the projection model.

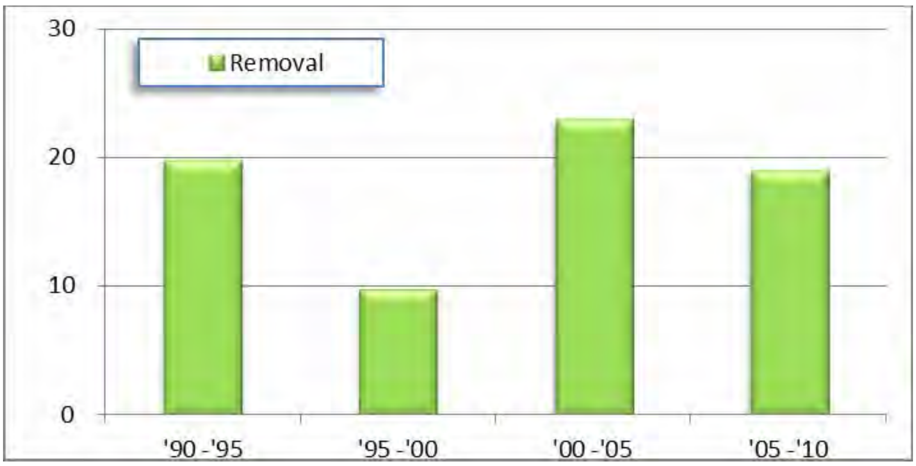


Figure 4.4.5 Trends of Carbon Removal in Kon Tum Province (Average at 18 MCO2t)

To summarize the discussion above, the projection model has several characteristics as in Table 4.4.1.

Table 4.4.1 Characteristics of the Projection Model of Emission and Removal

	Latest trends of forest change	Projection used Average model	Projection used Regression model
Removal	Increasing	low level	high level
	Decreasing	high level	low level
Emission	Increasing	low level	high level
	Decreasing	high level	low level

- From calculating the benefit point of view, the projection model is more advantageous for estimation when removal is at low level and emissions are at high level.
- Regarding carbon removal, when the latest trend is increasing, the average model estimates a lower level while the regression model estimates a higher level.
- Regarding carbon emissions, when the latest trend is increasing, the average model estimates a lower level while the regression model estimates a higher level.
- When the latest trend is decreasing, the result is the opposite of the above.
- In the case when there is no particular trend in the past forest change, use of the average model should be considered.

4.5 Recommended Method for Setting an Interim RELs/RLs

Considering the consistency between the factors of increase and decrease of forest, a method that separates RELs and RLS for their calculation is appropriate, in order to explain historical trends. However, take note that no method using separating RELs/RLs has been approved by IPCC. In addition, in order to observe regional characteristics of forest increase/decrease, stratification classification is defined as the effective geographical unit for calculating RELs/RLs. This will influence the robustness of the results when observing the model of future projection.

Regarding the number of sets of past satellite data to be used, the options have no differences when they have simple increase trends. However, the results of options may be different between using three points in time and five points in time. Moreover, Bio-Eco region, stratification classification to develop EF, has less uncertainty.

Regarding the model for future projection, applying a higher polynomial regression model requires careful consideration, since it sometimes estimates extreme levels because of fluctuation caused by the latest trend. The influence of future projection by respective models would be different depending on whether the historical trends of carbon emissions/removal are positive or negative.

Table 4.1 shows a summary of the results of discussion of the options above.

Table 4.5.1 Characteristics of the options to develop RELs/RLs

Item to be considered	Option 1	Option 2
Method of Calculating Interim RELs/RLs	Integrating RELs/RLs • The historical trends of emissions/removal are unknown. • The method is approved by IPCC	Separating RELs と RLs • The historical trends of emissions/removals are known. • The trends of emissions/removals are clearly defined by the influence from the policies and deforestation. • The method is unique and not approved by IPCC.
Unit for developing Interim RELs/RLs	The projection are made at the national scale • It is suitable to grasp the macro change. • It does not indicate regional character of forest change and policies.	The projections are made at Sub-national scale and aggregated to obtain national results • It is suitable to grasp the trends of forest change as well as the factors of forest increase/decrease. • The results are indicating regional uniqueness of the policies.
Number of sets of past satellite data to be used	Three points in time • If forest change has the certain trends, the model ensures low uncertainty. • Cost performance is low.	Five points in time • The model ensures robustness rather than the one used three points in time. • Cost performance is high.
Stratification classification for developing EF	Agro-ecological zones • Uncertainty may be high if Agro-Eco regions are applied to calculate EF.	Bio-ecological zones • Low uncertainty may be ensured if Bio-Eco regions are applied to calculate EF.
The model to be used to make the projections	Calculation of the average • If the removal has a simple increase trend, the future projection would be at low level. • If the removal has a simple decrease, the future projection would be at high level. • If the emissions have a simple increase trend, the future projection would be at low level. • If the emissions have a simple decrease trend, the future projection would be at high level.	Regression Model • If the removal has a simple increase trend, the future projection would be at high level. • If the removal has a simple decrease, the future projection would be at low level. • If the emissions have a simple increase trend, the future projection would be at high level. • If the emissions have a simple decrease trend, the future projection would be at low level.

Taking into account the diversity of forest change trends among provinces in Vietnam, application of the average model seems to be suitable. However, further discussion is necessary, because application of the models mentioned above must be decided through analysis of the past forest change trends; particularly, the factor of deforestation; and the policy implementation for reforestation.

Appendix 14 shows the future projections of the emission and removal from 2010 to 2015 using the average of emissions and removal in each province.

5. Examining Other Data for REDD+ Development

5.1 Possibility of Use of MODIS data for REDD+ Development

5.1.1 Development of the MODIS Data

Moderate Resolution Imaging Spectroradiometer (MODIS) is an instrument abroad Terra and Aqua satellite and viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands, or groups of wavelengths. Since MODIS data is free to download, global dynamics of the forest can be obtained without any additional cost. However, the potential of measuring deforestation and degradation by MODIS is unknown in order to meet the requirement of REDD+ due to its low resolution (250m ground-resolution). The following explains the procedure for identifying forest dynamics using the MODIS data.

(1) Collection of the MODIS Data

The MODIS data was downloaded from NASA's website called LP DAAC (Land Processes Distributed Active Archive Center, https://lpdaac.usgs.gov/lpdaac/products/modis_products_table).

The data used was MOD09Q1 (8-day composite, 250 m resolution, band 1 and 2 data) and MOD13A1 (16-day composite, 500 m resolution, EVI data) in order to calculate NDVI (Normalized Difference Vegetation Index). The numbers of satellite data scenes used were 2,360 scenes from the MOD09Q1 data and 1,210 scenes from the MOD13A1 data.

(2) Conversion of the Coordinates

The entire surface of the earth was covered with a tiled grid and each scene was projected in accordance with the MODIS Sinusoidal Tiling System (Figure 5.1.1).

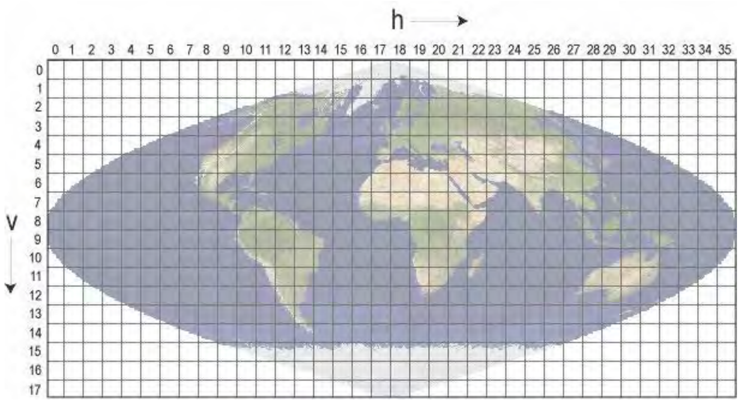


Figure 5.1.1 MODIS Sinusoidal Tiling System[4]

The coordinates for the collected MODIS data were converted to UTM coordinates using MRT (MODIS Reprojection Tool) provided by NASA (Figure5.1.2).

[4] https://lpdaac.usgs.gov/lpdaac/products/

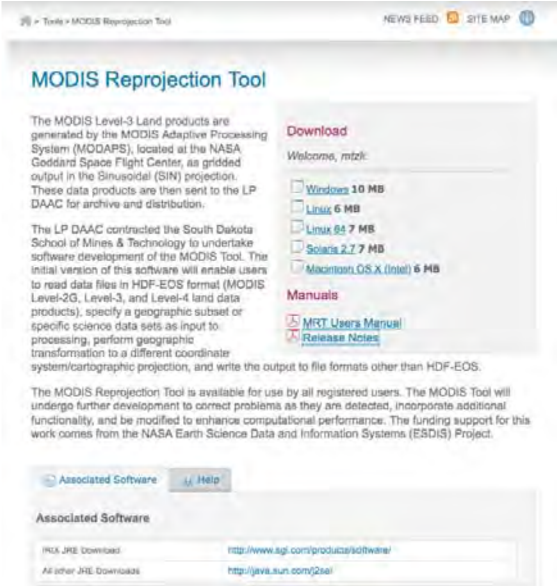


Figure 5.1.2 NASA's MRT Download Website

(3) Calculation of NDVI

NDVI is the ratio of the difference between visible (red) and near infrared (NIR) wavebands to the sum of those bands in order to provide an indication of the amount and vigor of vegetated surface. NDVI was calculated from the MOD09Q1 data with the equation: NDVI = NIR-red / NIR + red.

(4) LMF (Local Maximum Fitting) Processing

LMF processing was conducted for the NDVI and EVI (Enhanced Vegetation Index) data through time-series modeling in order to remove the noise. The LMF program is available for download on the website of JST (Japan Science and Technology Agency) (http://act.jst.go.jp/content/h10/ter_cosm/T04/PageMain.html).

The program is also available on the website of AIT (Asian Institute of Technology) (http://www.rsgis.ait.ac.th/~honda/lmf/lmf.html,http://www.rsgis.ait.ac.th/~honda/lmf/lmf_linux.zip,http://www.rsgis.ait.ac.th/~honda/lmf/lmf_windows.zip).

(5) Identification of Forest Changes

Regarding the NDVI 8-day composite data, data for 46 points in time per year can be obtained. Out of the data observed at the 46 points in time, the number of times where a high NDVI value exceeding 0.7 was observed for each pixel was examined. In this document, the point in time when the NDVI value exceeded 0.7 is called the Green Leaf Period (GLP) (Figure 5.1.3 and Figure 5.1.4).

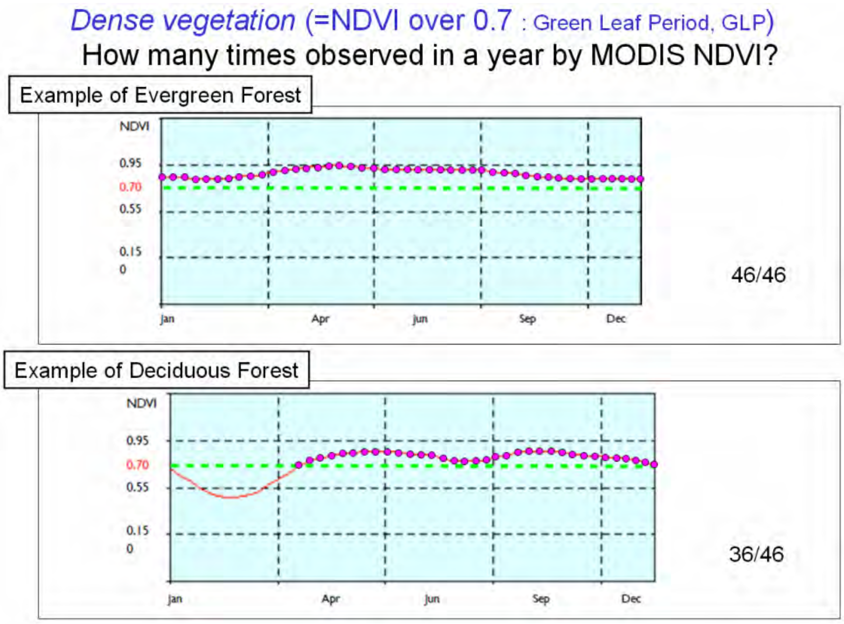


Figure 5.1.3 Example of Changes in the NDVI Value for Evergreen Forest and Deciduous Forest

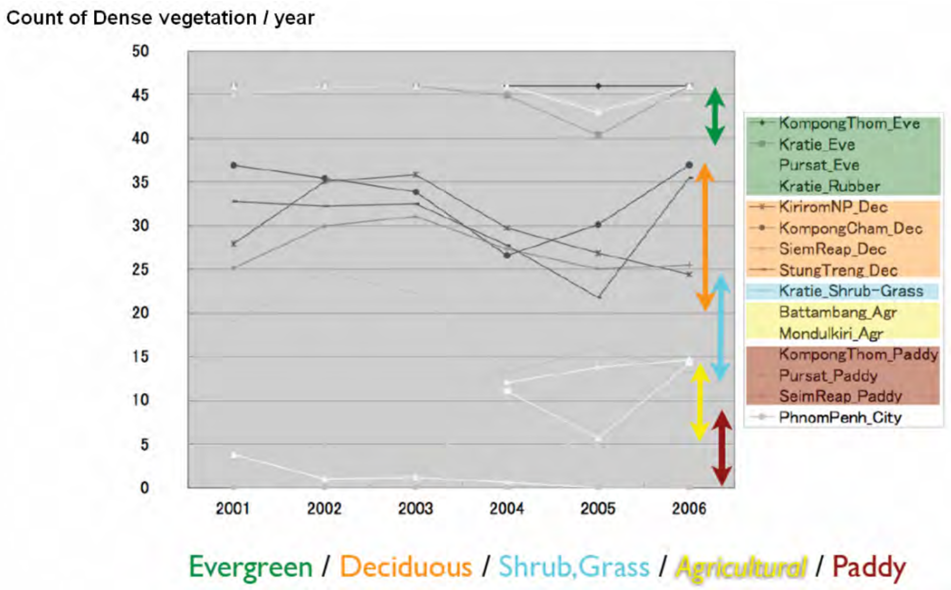


Figure 5.1.4 Trends in GLP for Each Vegetation Category

Forest changes were identified by comparing the forest situation in two different years in accordance with the following criteria in order to determine if there were changes (decreases) in the forest cover. Figure5.1.5 shows the criteria visualized.

1) The number of GLP observed in the earlier year was over 26.
2) The number of GLP observed in the later year was under 26.
3) The difference between the number of GLP in the earlier year and the number of GLP in the later year was more than 26.

When 3) happens, we expect that a large vegetation change has occurred (a similar level of change as from low-density deciduous forest to bare land).

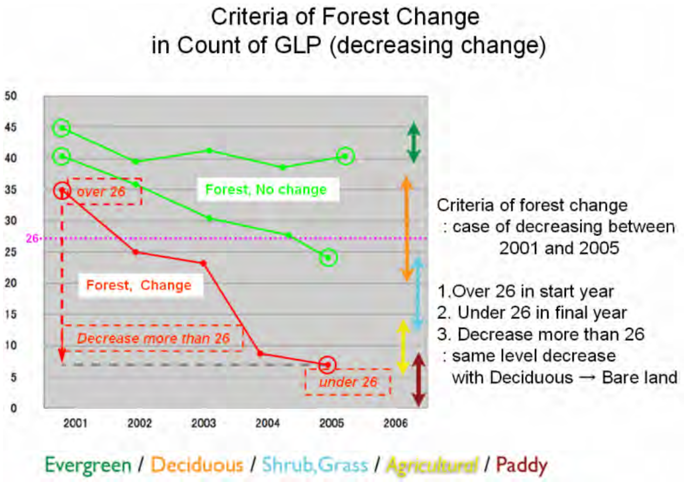


Figure 5.1.5 Criteria for Determining Forest Changes (Decrease)

The MODIS NDVI data for 2001 through to 2010 was prepared. Using the above-mentioned method, data which suggests deforestation was obtained by comparing the 2001 data and the 2002 data. Data on deforestation for nine periods (for each year, starting from 2001-2002, 2002-2003, and so on) was obtained in this way.

(6) Calculation of the Forest Distribution Data

A rough forest distribution data set was created from the EVI and NDVI data. Firstly, the average and the standard deviation were calculated for the EVI data (2001-2009, 23 points in time per year, a total of 207 points in time).

Examples of EVI profiles at sampling points for different vegetation categories are shown below. Figure5.1.6 shows the EVI value for every 16 days in time-series, for each sample site pixel.

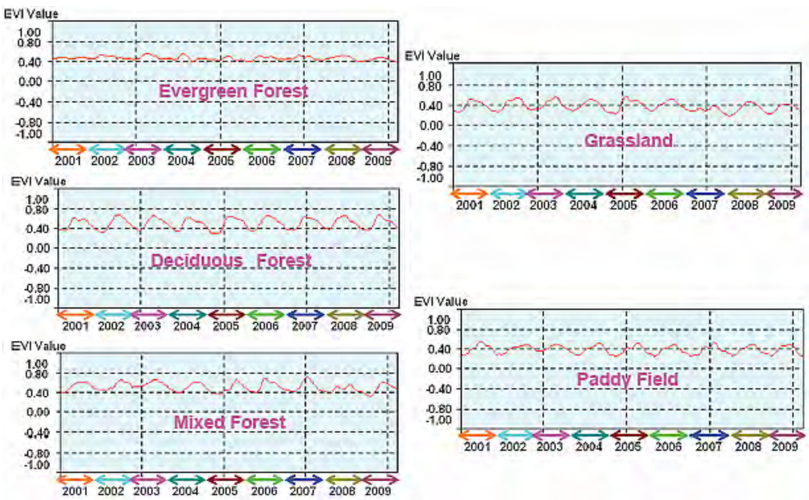
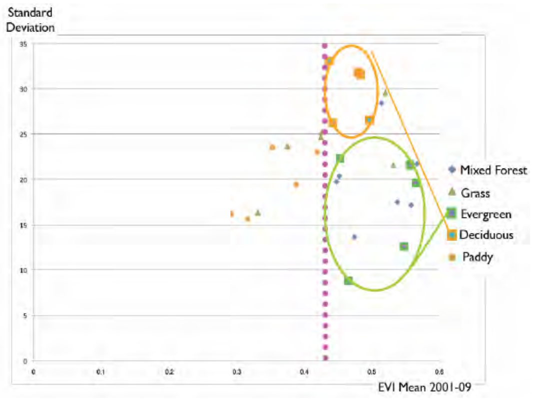


Figure 5.1.6 Examples of the EVI Profiles for Each Category at Each Sample Site

Each vegetation category has different characteristics in the patterns of chronological changes and the range of changes in the MODIS EVI value. The average and the standard deviation for these EVI values were calculated, for the period over 2001- 2009.

The following explains about a plot diagram for the means and the standard deviations, and the trends in the distribution of rough vegetation categories (Figure 5.1.7 and Figure 5.1.8).



X-axis: EVI mean Y-axis: Standard deviation

Figure 5.1.7 Distribution of Rough Vegetation Categories

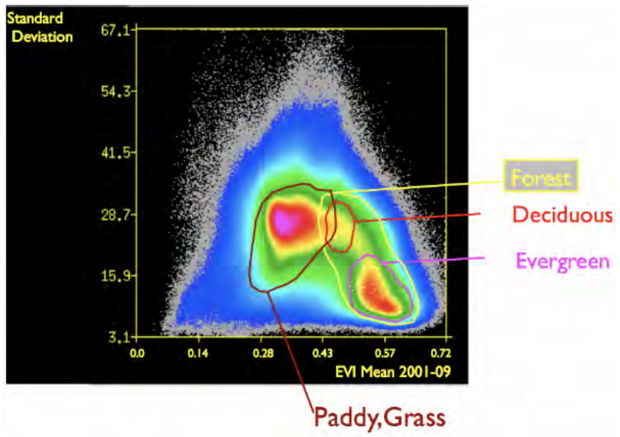


Figure 5.1.8 Plot Diagram for All the Raster Pixels

Figure 5.1.7 shows the distribution by plotting data for each sample site on the graph with the Y-axis being EVI standard deviations and the X-axis being EVI means. For Evergreen Forest, Deciduous Forest and Mixed Forest, all the EVI means were more than 0.43. Figure5.1.8 has plotted data for all the pixels subject to the study on the graph with the X-axis and the Y-axis as of the diagram on the top left. Blue indicates larger numbers of pixels and Red indicates smaller numbers of pixels, with light blue, green and yellow in between. When checking the vegetation categories, the areas on the graph where Forest is distributed and the areas where Paddy/Grass is distributed are mostly separated from each other. Similar distribution patterns for vegetation categories shown in Figure5.1.7 were observed in Figure5.1.8 of all the pixels. Based on the observations above, it was decided that forested land would be identified based on the following conditions: the EVI mean (2001-2009) is 0.43 or higher; and the EVI standard deviation (2001-2009) is 33.0 or lower.

The lowest EVI value for the latest five years was identified and the pixel for which the lowest EVI value is less than 0.31 and the above-mentioned standard deviation is less than 0.25 was identified as paddy, grass or non-vegetated area (therefore identified as non-forested land) and excluded from the forest distribution data. This is how a rough forest distribution data set was created from the EVI data.

The data was then overlaid with the data for sites where forest changes were identified (i.e. sites which became non-forested land), the data for the two-crop system farmland and the data for the double cropping system farmland (where one type of crop is grown twice in a year), in order to exclude the non-forest data from the forest distribution data. The data for the sites where forest changes occurred was identified using the method explained in “(5) Identification of Forest Changes.” The two-crop system farmland and the double cropping system farmland were identified through waveform analysis.

The Harmonic Series function of TNTmips (commercially sold remote sensing software) was used for the waveform analysis.

The throughout procedure of making forest information using MODIS from above (1) to (6) is shown in Figure 5.1.9. Each method follows the procedure for preparing forest data using MODIS for the Indochina Peninsula which was developed by the “Project for the Promotion of Forestry and Forest Management for Preparing for Natural Disasters such as Tsunami” supported by the Forestry Agency (conducted by the Japan Forest Technology Association (JAFTA), ended in FY 2010).

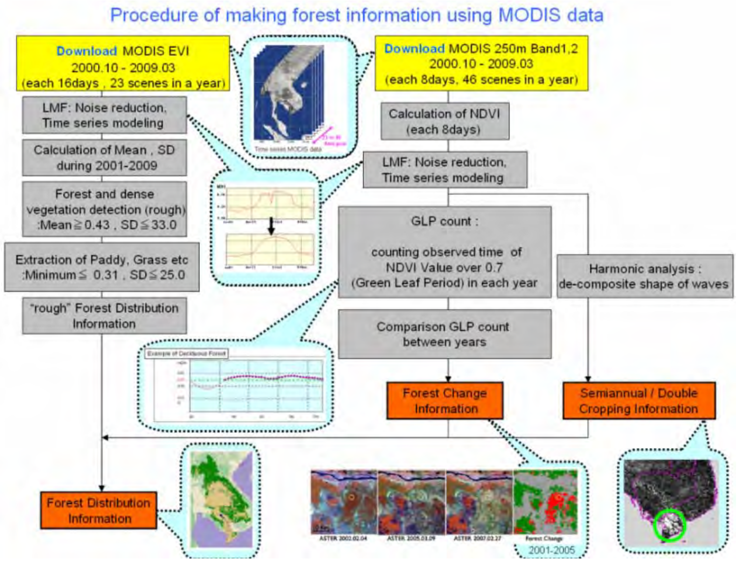


Figure 5.1.9 Outline of the Procedure for Creating and Processing Forest Data Using MODIS

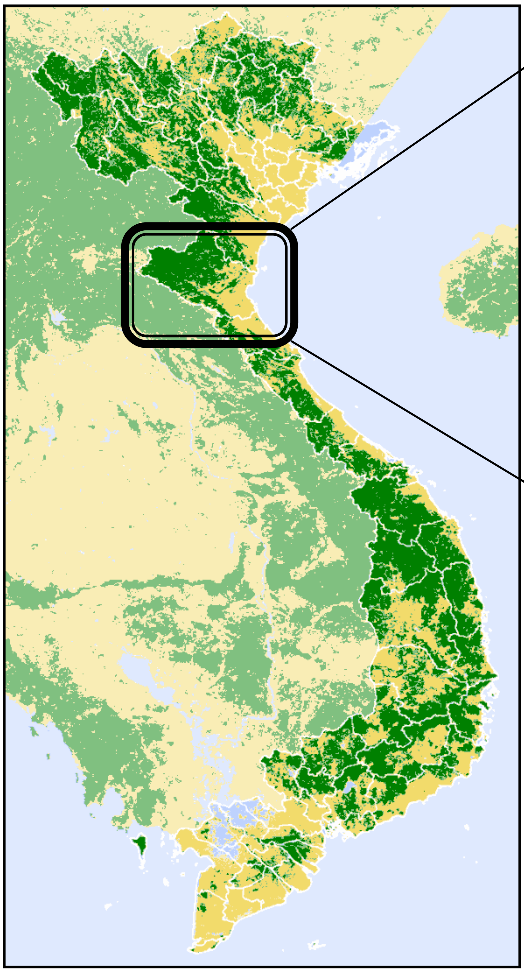
5.1.2 Quantitative Evaluation of Forest

The advantages of utilizing an observation satellite which frequently images a large area such as MODIS are: that data for many points in time can be collected; that clouds can be removed using data for many points in time; and that data can be obtained with a very small budget. Large forest area and trends of the forest change can be observed as shown in Figure5.1.10 and Figure5.1.11.

5.1.3 Qualitative Evaluation of Forest

After the qualitative evaluation, a carbon distribution map for Vietnam was tried to be created based on the direct estimation method for biomass which was used by the WoodsHole Institute for Africa. As a result, a clear correlation could not be found between the MODIS pixel value and the average carbon amount per unit area calculated based on the ground-based survey.

This is because a pixel covers a large area of land (250 m square, for example) and therefore a mixture of elements is contained in each pixel.



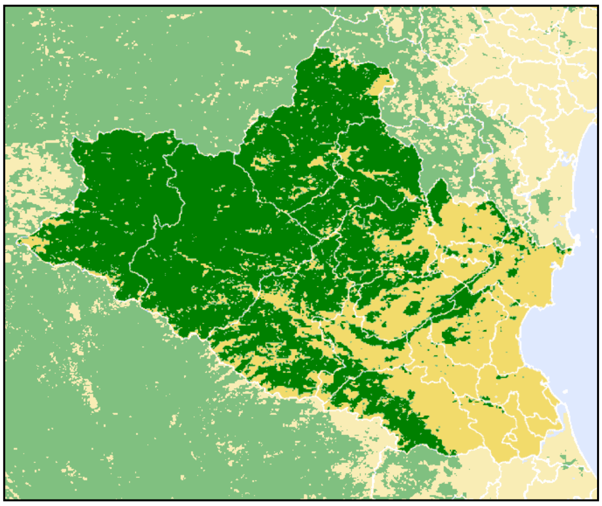


Figure 5.1.11 Forest distribution map of Nghe An province measured by MODIS

Figure 5.1.10 Forest distribution map of Vietnam measured by MODIS

5.1.4 Evaluation of the Area of Forested Land

Figure 5.1.12 and Figure 5.1.13 show the comparison of the forest area obtained by different way from different satellite: interpretation of LANDSAT and SPOT; and digitized MODIS. According to the result of comparing standard deviation between each province in the Vietnam as a whole and each district in Nghe An province became the same (0.9), the reasonable accuracy in order to estimate forest area using MODIS was determined. However, it is expected that the error contained in the forest area estimation would exceed the deforestation area in the relevant area. This means that it is possible to use the estimation of the forest area using MODIS for understanding general trends in changes over long periods of time (several dozens of years) or at the global level, but MODIS is not suitable for calculating small changes within several years or at the regional level.

With regard to the estimation for each forest type, it is relatively suitable to use MODIS for determining some types of stands including Evergreen Forest. However, it is difficult to differentiate evergreen and deciduous mixed stands and non-dense deciduous forests from non-forest vegetation which have a dense vegetation cover all year round such as two crop system farmland. Therefore, time-series data like the MODIS data is more suitable for monitoring changes in each pixel, but the MODIS data is of limited use when creating a distribution map.

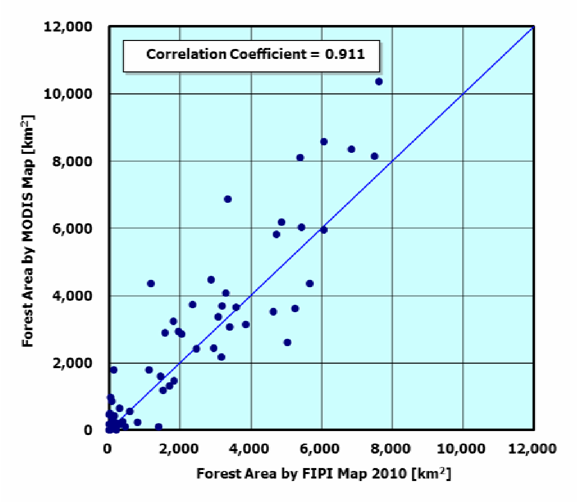


Figure 5.1.12 Comparison of the forest area obtained by the interpretation of LANDSAT and APOT, and digitized MODIS (Each Province)

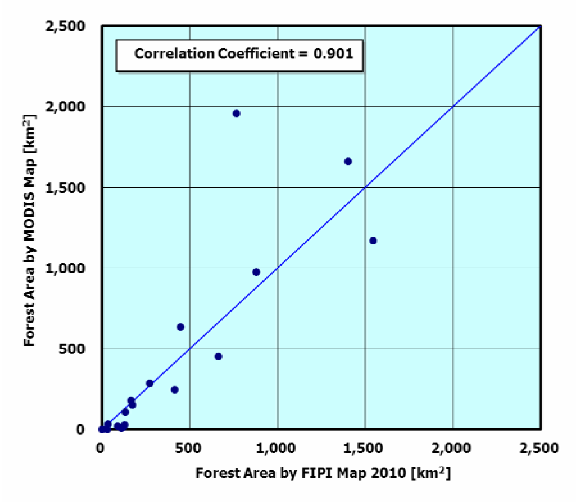


Figure 5.1.13 Comparison of the forest area obtained by the interpretation of LANDSAT and APOT, and digitized MODIS (Each Districts in Nghe An

5.1.5 Utilization of Forest Change Data

Utilizing monitoring per pixel for the analysis on the difference of forest change for each region was taken place. Figure5.1.14 shows that if vegetation is shown by the time series per pixel using MODIS EVI and NDVI, the analysis may results in the vegetation cover has changed or not. Each steps of the analysis is explained below.

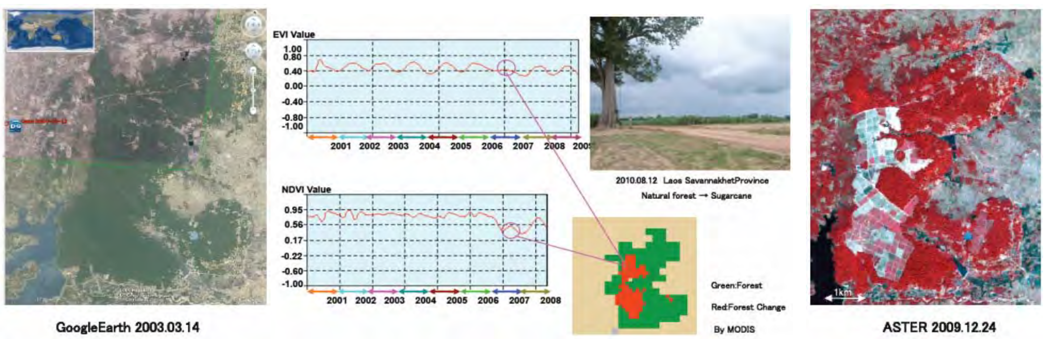


Figure 5.1.14 Example of Forest Changes: The area was changed from natural forests to sugar cane plantations in 2007

Step1: Forest change extraction processing was conducted for each period (one year each) using the method explained above. As a result, the deforestation data was created for nine periods (deforestation in 2001-2002, deforestation in 2002-2003 and so on up to 2009-2010).

Step2: Three zones were set up. The first zone is from the border to 10 km inside Vietnam, the second zone is from 10 km inside Vietnam to 20 km and the third zone is from 20 km to 30 km. In order to examine whether regional characteristics can be observed, the zones were further divided into three at latitude 15˚ N and at latitude

20˚ N. The zones north of latitude 20˚ N was divided into two at longitude 110.5˚. In this document, these zones which were divided in accordance with the latitudes and longitudes were named Zones 1, 2, 3 and 4 as shown Figure5.1.15 and the trends in each zone were studied in order to find regional trends.

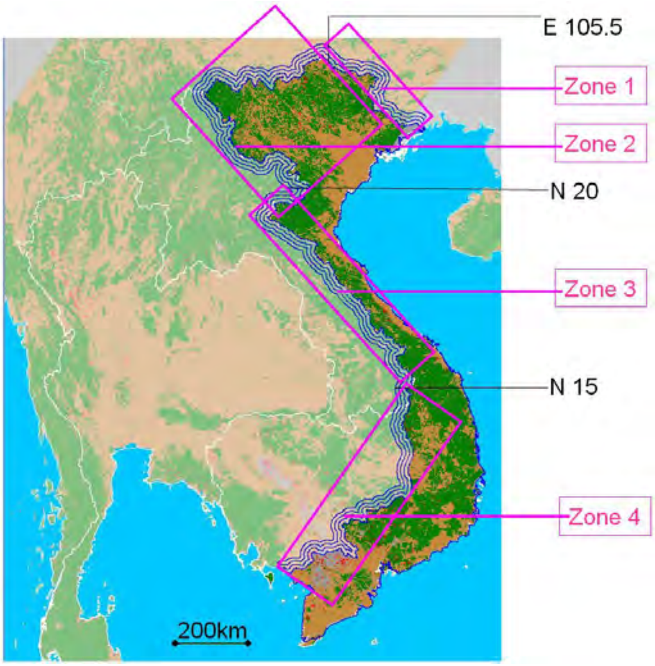


Figure 5.1.15 Zoning for Evaluation

Step 3: The number of MODIS pixels (250 m square) where deforestation occurred was counted for the 0-10 km zone, the 10-20 km zone and the 20-30 km zone in Zones 1, 2, 3 and 4.

Step4: The percentage of pixels where deforestation occurred in each zone and in Vietnam as a whole is shown in Figure5.1.16 in order to compare the zones which land sizes are different.

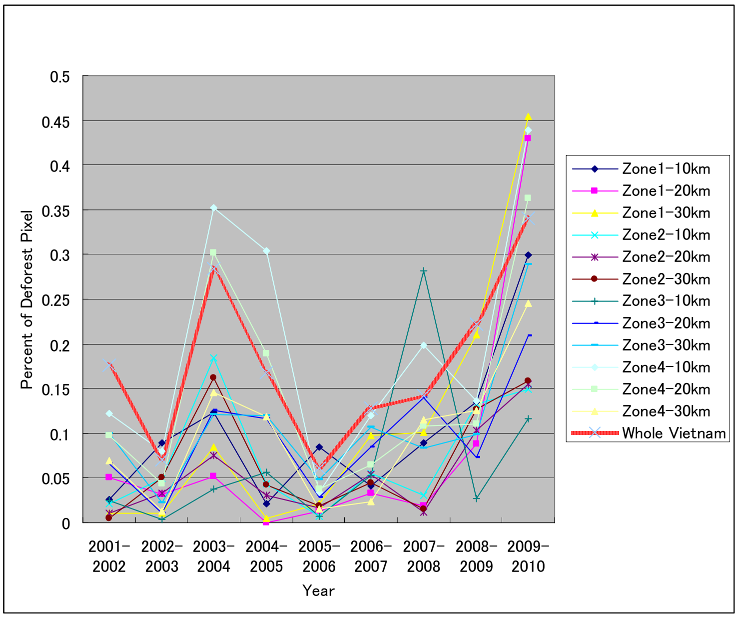


Figure 5.1.16 Deforestation Trends for Evaluation

Figure 5.1.16 indicates that percentage deforestation of each zone is almost synchronized with that of Vietnam as a whole. Zone 4 shows that the percentage of deforestation rapidly increased over 2003-2004, 2004-2005, and 2009-2010. This result indicates that the land close to the borders of Vietnam has experienced higher deforestation.

Figure 5.1.17 shows a part of zone 4 located near the border observed by MODIS, showing the result of analysis on the deforested land. Zone 4 includes the border of three countries; Vietnam, Laos, and Cambodia. The real situation of the site of zone 4 in year 2010 was determined by the survey conducted by JAFTA on 17 Aug, 2010; specifically, that a large amount of timber had been transported from Laos to Vietnam. It seems that such timber transportation was the cause of the data analyzed by the satellite imagery. This example shows that information given by MODIS data can determine potential sites for conducting socio-economic and field surveys.

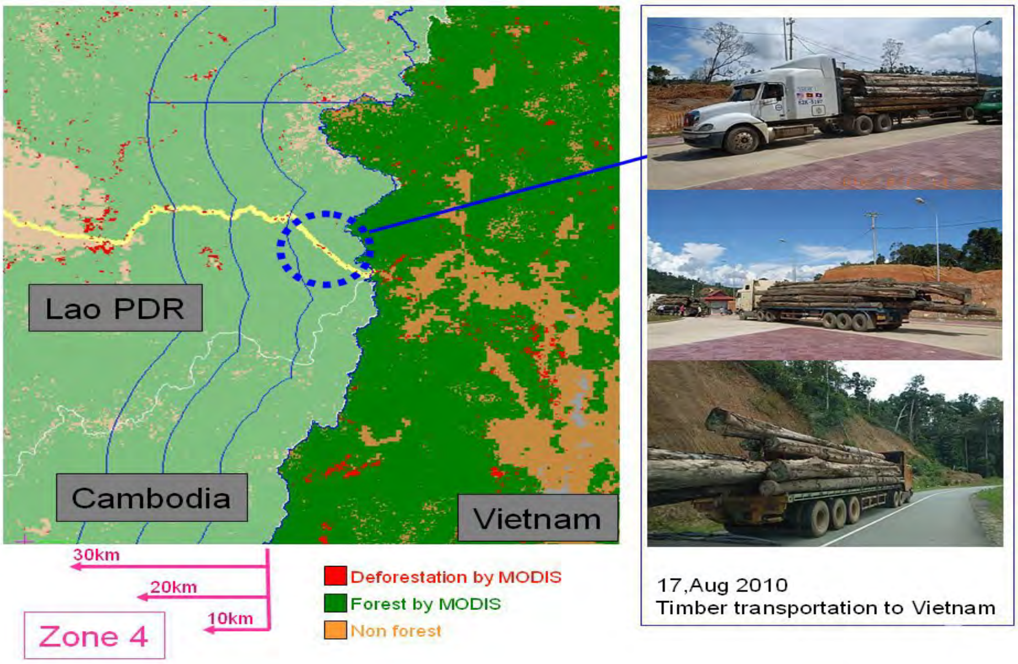


Figure 5.1.17 Example of the analysis on the deforested land near by the border observed by MODIS

5.1.6 Leakage Across National Borders

In order to proceed with the REDD+ mechanism, UNFCCC has been recommending the national approach as a key to avoid leakage within a country, considering the border as the boundary. However, when thinking about several countries connected by land, the problem of leakage from proceeding with the REDD+ mechanism may occur. For example, ethnic people living in a mountain area near a border may move from one country to another country in order to continue shifting cultivation, escaping the pressure of the policy regarding reducing deforestation and degradation.

In order to determine the leakage, the Study has investigated the chronological and geographical trends of deforested land near borders as the basic information of leakage. As a result, it is determined that the closer forest is located to a border, the greater the percentage of deforestation. However, this deforestation does not necessarily mean leakage; the cause of deforestation cannot be specified by interpreting satellite imagery, such as deforestation by the pressure from Vietnam or deforestation by activities by other countries themselves. When discussing leakage, it is necessary to understand the areas or regions of deforestation based on facts like those found in the Study, and to conduct field investigation of deforestation as well. As a matter of fact, only this kind of sensitive investigation across national borders can determine whether governments of multiple nations facing the same issues cooperate together.

5.2 Possibility of Use of Statistical Data Combined with NFI Data as Activity Data

5.2.1 Methodology of the Use of Statistical Data Combined with NFI Data

Rather than creating forest maps (GIS) from satellite data, which is burdensome in terms of cost and technology, this method attempts to make use of existing statistical data and other information to obtain the forest area by forest type as activity data for each forest stratified classification (Agro-Eco-Region and Bio-Eco-Region) in a simple way.

The estimation was conducted by the following procedure: (1) ascertain (or estimate, for times when there are no statistical figures) the forest area for artificial and natural forests for each province from statistical reports, (2) derive the ratio of sub-plot data points by forest type for each province at the time of each NFI survey from Cycle data, (3) multiply (2) by the total natural forest area by province in (1), and (4) tabulate the area by forest type for each eco-region.

(1) Artificial and Natural Forest Area Estimates by Province

The area of artificial and natural forest by province at five points in time (1990, 1995, 2000, 2005, and 2010) was obtained from statistical reports issued by the Vietnamese government. The statistical reports used were, as a general rule, those published in the nearest year to the year in question (some regular statistical figures are slightly changed due to error correction in subsequent years). However, since statistical reports covering the figures for 1990 and 1995 could not be found, the Study Team were forced in the estimations to use reports with reference to statistical figures for the nearest year to the year in question (documents released on the Internet and elsewhere), forest inventory reports by the FAO, and other documents. The details of the estimation methodology are as given in Interim Report 2: 4.1.3.1 (137P).

(2) Forest Area Estimation by Forest Type for Bio-Eco-Region, and Province

The areas by forest type for each province at each point in time were estimated by totaling the number of sub-plots[5] of each NFI survey plot (composed of 40 sub-plots each) in the forest inventory conducted by FIPI by forest type (17 classifications) for each Bio-Eco-Region and province, and then apportioning the statistical area of natural forest in each province by that component ratio. The procedure used in performing the work is as follows.

[5] In Interim 2, the data provided by FIPI indicates the average timber volume by forest type for each survey plot, and only in the case where the kinds of forest type in the plot data increases (degraded sub-plots will appear anew) will the number of data points increase and be tabulated, so it was discovered that the data will come out by forest type for each plot and changes (degradation) in the forests will not necessarily being accurately reflected. For this reason, the Study Team requested that the FIPI forest inventory data be provided again, received the data on forest type and growing stock per hectare for all 40 sub-plots, and recalculated. Note that the resubmitted data also had some missing data for the sub-plots in that some too no account of the growing stock (volume/ha = 0), so in this estimate the Study Team treated sub-plots with a growing stock of "0" as non-forest land and excluded them.

1) Application of Forest Inventory Data

The following data was used as the data for each point in time.

(i) National forest resource changes inventory and assessment (Cycle-1) Used for 1990 data
(ii) National forest resource changes inventory and assessment (Cycle-2) Used for 1995 data
(iii) National forest resource changes inventory and assessment (Cycle-3) Used for 2000 data
(iv) National forest resource changes inventory and assessment (Cycle-4) Used for 2005 and 2010 data

2) Adjustment of Data for Each Cycle Data

(i) Confirmation of Location

The data for each Cycle shows the location of each survey plot in terms of latitude and longitude. The Study Team used these coordinates to plot the locations on the GIS map and intersect them with the maps for each province and Bio-Eco-Region, which were created separately, assign each data point a code by province and Bio-Eco-Region, and modify the province code listed in FIPI's original data to the classification on the most recent province classification maps.

(ii) Consideration of Outliers

An analysis of FIPI's original data by forest type shows that the growing stock per hectare by sub-plot for rich evergreen broad-leaved forest (that with the highest average growing stock) is from 0 m^3 to 1,500 m^3, for medium evergreen broad-leaved forest is from 0 m^3 to 1,800 m^3, and even for poor evergreen broad-leaved forest is from 0 m^3 to 1,000 m^3. For this reason, the Study Team excluded the data for sub-plots over 600 m3[6] and evergreen broad-leaved forest (rich, medium, poor, and secondary) of 0 m^3 as outliers (evergreen broad-leaved forest with a growing stock of zero was treated as non-forest, as indicated in the footnote).

3) Apportionment of the Natural Forest Area of Each Province to the Forest Area by Forest Type

The natural forest area by province based on the statistical data mentioned in 1) above was compiled into a list of the post-adjustment province classifications based on the positions obtained in 2) above and the data of all the sub-plots, excluding outliers. Then the number of sub-plots by forest type, Bio-Eco-Region, and province were tabulated. The ratio of the number of sub-plots by province was then assumed to generally match the ratio of areas by forest type for each province, and the natural forest area by province was apportioned via the component ratio of the number of sub-plots for each forest type.

(3) Tabulation of Area by Forest Type for Each Eco-Region

The Study Team tabulated the area by forest type for each Agro-Eco-Region (since each Agro-Eco-Region is

[6] Although we have not found any academic papers that would justify the decision to use 600 m^3 as a cut-off point in particular, when ranking the sub-plot data from highest unit timber volume to lowest, we decided to use the point at which the number of instances declined conspicuously, instead of appearing one after the other, as the threshold. We believe this is a reasonable decision as an expert judgment based on experience observing Vietnam's natural forests.

composed of an aggregation of several provinces, its borders will line up with the borders of one or more provinces) and Bio-Eco-Region based on the natural forest area by forest type apportioned by Bio-Eco-Region and province as described above.

5.2.2 Analysis of Activity Data based on Statistical Data and NFI Data

This section attempts to compare and verify the forest area (hereinafter, "estimated forest area by statistical figures") obtained from the activity data (data apportioned and tabulated using statistical and NFI data) using the method indicated in the previous section by assuming[7] that forest area on the forest distribution map prepared in this development survey as the truth.

(1) Data Verification Method

When comparing and verifying the forest area obtained from two different sets of activities data, initially the Study Team integrated the 12 categories of forest type into four classifications: (1) evergreen forest (forest type codes 1 through 3), (2) recovered forest (forest type code 4), (3) other forests (forest type codes 5 through 11), and (4) plantations (forest type code 12). It would make it easier to compare and verify their trends' disparities and correlation by integrating the forest type categories into several classes that represent each other.

The order of the method is ①state the eight Agro-Eco-Regions as a unit of aggregating data sets; ②sum up the data of every integrated forest type; and ③develop the table as shown in Figure5.2.1 in order to compare the disparity ratio. In addition, comparative visual verification is conducted through developing scatter plots and bar charts of each Agro-Eco-Region based on the resulting area matrix table. Those are shown in Figure 5.2.1 to Figure 5.2.15 and Table 5.2.1 to Table 5.2.5.

(2) Data Verification Results

In analyzing the data shown in Figure 5.2.1 to Figure 5.2.15 and Table 5.2.1 to Table 5.2.5, the following trends can be spotted in terms of conclusions in the "estimated forest area by statistical figures."

Trends in "Estimated Forest Area by Statistical Figures"

1) There is a larger and larger gap between the total value of all forest area and the area on the forest distribution maps the further back in time one goes.
2) There is a major spread in the area disparity ratio for each region at the same points in time and for the same integrated forest types.
3) There is no consistency in the trend of the changes in forest area among the points in time.

Regarding 1), government of Vietnam needs further investigation on the character of the aggregation methods and statistical figures of the forest area. According to the knowledge gained from the Study, for the statistical figures, each year's census data were aggregated based on the increase or decrease of the forest area monitored by FPD under MARD, based on the land use map prepared every five years by MONRE/DONRE. The quality is different from the "snapshot" area figures at each point in time obtained by the forest distribution maps through

[7] Assuming that the forest distribution maps as the true data: 2.4 Verification of Forest Distribution Map (activity data) indicates the precision of discerning forest from non-forest in the satellite images from which the forest distribution made was made is high (approx. 90% or more) is the ground of the assumption.

interpreting the satellite image prepared by the Study. Moreover, in the statistical forest area, the demarcation of forests and non-forests by the government classification, even land-cover forest in the non-forest category (e.g. bare land) there are thought to be many cases where these are not counted as forests in terms of statistical figures.

Note that one reason that could be given for why the further back in time one looks at the total forest area the larger the gap is compared to the area in the forest distribution maps is that the statistical reports for figures for 1990 and 1995 cannot be found, so the estimates that were used were based on data from a different forest inventory report source, such as those of the nearest year by the FAO and other organizations.

Regarding 2), it indicates that there is a limit in how much can be estimated from statistical figures and NFI data. This is thought to be because the allocation of the plots in the NFI data was originally designed to fit the whole country's aggregations within a certain range of error as the parent population for the whole country, and this resource survey data is used in making estimates for each province. Another cause that can be pointed to is the fact that there are regions in which the number of allocated plots is limited, such as the Red River region and the Mekong Delta region. Those regions have originally low distributions of forest ended up with large error factors, and for other reasons the resulting estimates contained uncertainties.

Concerning 3), although the trend in the forest area changes in the bar chart for all forest types shows a uniform increase as with the area changes in the forest distribution maps, it can be seen from the bar charts by integrated forest type for evergreen forest, recovered forest, and other forest that there is no consistent trend that is more conspicuous in the forest are changes. This could be because this estimation method might not necessarily conform to the assumption that "the ratio calculated from the sub-plot total for each forest type and the total number of sub-plots is the same as the ratio between the area for each forest type in the region as a whole and the total area of all forests," or that it is a compound effect of the causes of 1) and 2) above.

In conclusion, since the "estimated forest area by statistical figures" attempted in this development survey entailed high uncertainty, and there was a low correlation between the forest distribution maps and the forest area (the truth and assumptions), the Study conclude that this way of ascertaining the historical change on which to base the RELs/RLs cannot be recommended to be applied in this manner.

Table 5.2.1 Activity Data by Region and Area Comparison (All Forest Types)

(Unit: 1000 ha)

	North West (1)	North East (2)	Red River (3)	Central Coast (4)	South Central (5)	Central Highland (6)	South East (7)	Mekong Delta (8)	Total
1990Map	764.54	2279.64	72.06	2067.48	1416.19	3223.74	1230.14	274.64	11328.43
1990Stats	755.42	899.74	28.16	2060.38	1132.81	3420.08	682.26	158.00	9136.85
Gap Ratio (%)	-1.2	-60.5	-60.9	-0.3	-20.0	6.1	-44.5	-42.5	-19.3
1995Map	941.61	2331.80	83.37	2177.28	1376.66	3050.00	1151.78	331.42	11443.92
1995Stats	595.83	1823.18	78.76	1668.49	1010.20	2932.05	968.45	223.74	9300.70
Gap Ratio (%)	-36.7	-21.8	-5.5	-23.4	-26.6	-3.9	-15.9	-32.5	-18.7
2000Map	1092.06	2697.59	82.61	2339.59	1374.72	2959.06	1181.45	339.49	12066.58
2000Stats	963.44	2342.13	110.67	2135.72	1139.31	2988.02	962.49	270.41	10912.19
Gap Ratio (%)	-11.8	-13.2	34.0	-8.7	-17.1	1.0	-18.5	-20.3	-9.6
2005Map	1325.63	3229.35	86.39	2564.97	1421.47	2992.26	1239.72	357.86	13217.65
2005Stats	1477.82	3028.61	123.50	2484.69	1298.39	2998.72	921.92	310.71	12644.36
Gap Ratio (%)	11.5	-6.2	42.9	-3.1	-8.7	0.2	-25.6	-13.2	-4.3
2010Map	1634.82	3755.21	88.92	2673.92	1510.21	2964.92	1252.79	336.23	14217.03
2010Stats	1572.40	3362.84	127.10	2764.80	1395.49	2925.20	834.54	276.40	13258.77
Gap Ratio (%)	-3.8	-10.4	42.9	3.4	-7.6	-1.3	-33.4	-17.8	-6.7

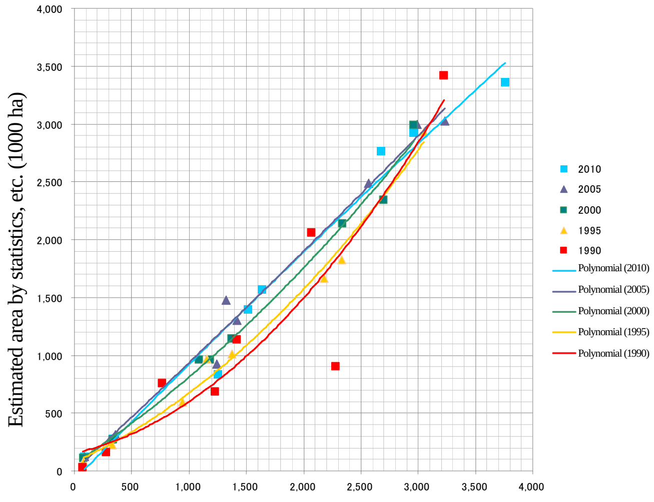


Figure 5.2.1 Comparison of Area in Activity Data (All Forest Types)

Unit: 1000 ha

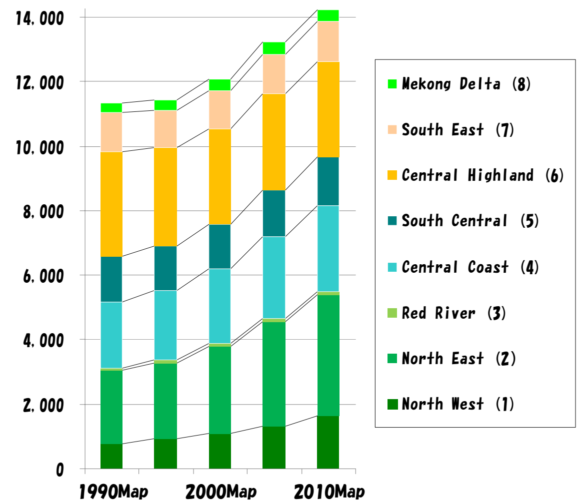


Figure 5.2.2 Area from Forest Distribution Map (All Forest Types)

Unit: 1000 ha

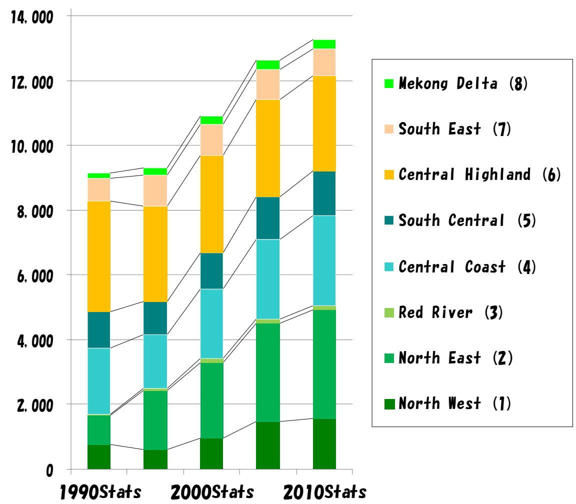


Figure 5.2.3 Estimated Area from Statistical Values, etc. (All Forest Types)

Table 5.2.2 Activity Data by Region and Area Comparison (Evergreen Forest[8])
(Unit: 1000 ha)

	North West (1)	North East (2)	Red River (3)	Central Coast (4)	South Central (5)	Central Highland (6)	South East (7)	Mekong Delta (8)	Total
1990Map	416.76	931.30	4.90	1341.04	858.35	1327.66	231.48	18.98	5130.47
1990Stats	424.63	144.28	0.00	1504.81	854.11	1847.12	160.44	1.57	4936.96
Gap Ratio (%)	1.9	−84.5	−100.0	12.2	−0.5	39.1	−30.7	−91.7	−3.8
1995Map	384.21	857.27	4.41	1287.40	794.76	1248.80	220.08	12.01	4808.94
1995Stats	188.41	214.15	0.00	837.58	652.83	1108.47	148.27	15.30	3165.01
Gap Ratio (%)	−51.0	−75.0	−100.0	−34.9	−17.9	−11.2	−32.6	27.4	−34.2
2000Map	339.32	748.34	3.42	1248.71	740.10	1136.50	203.92	23.65	4443.96
2000Stats	166.16	99.61	2.04	914.89	772.02	1437.02	334.79	31.98	3758.51
Gap Ratio (%)	−51.0	−86.7	−40.3	−26.7	4.3	26.4	64.2	35.2	−15.4
2005Map	303.39	642.61	4.16	1181.00	683.49	1100.71	173.06	15.99	4104.41
2005Stats	457.76	462.29	0.48	1155.80	774.82	1734.06	272.93	36.74	4894.88
Gap Ratio (%)	50.9	−28.1	−88.5	−2.1	13.4	57.5	57.7	129.8	19.3
2010Map	296.82	574.65	4.45	1127.75	672.56	1056.55	165.12	6.76	3904.66
2010Stats	471.03	465.71	0.48	1219.21	771.31	1650.65	251.93	38.58	4868.90
Gap Ratio (%)	58.7	−19.0	−89.2	8.1	14.7	56.2	52.6	470.5	24.7

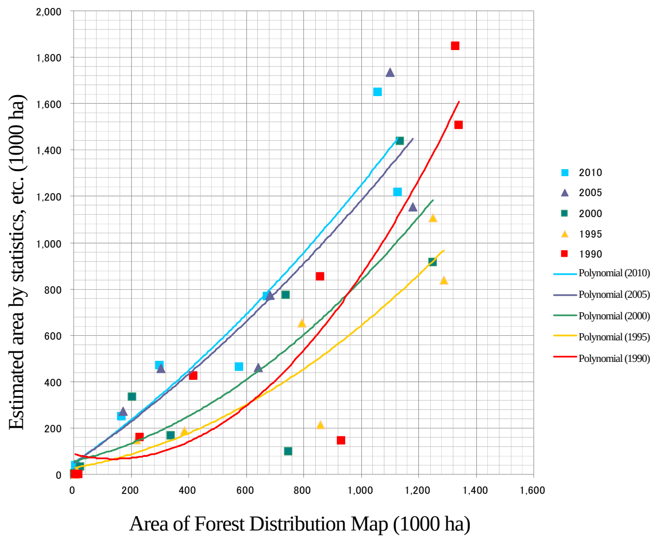


Figure 5.2.4 Comparison of Area in Activity Data (Evergreen Forest)

Unit: 1000 ha

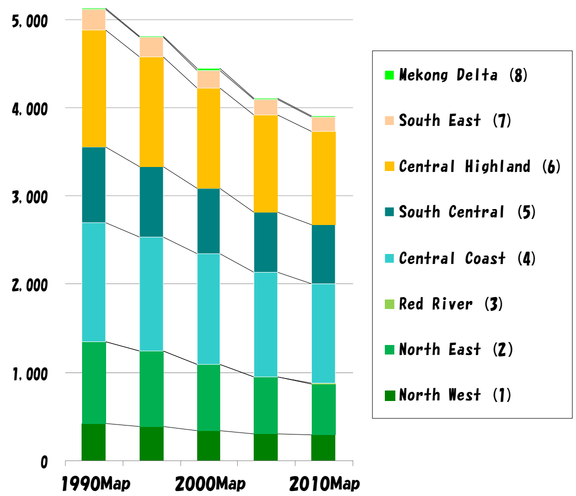


Figure 5.2.5 Areas from Forest Distribution Map (Evergreen Forest)

Unit: 1000 ha

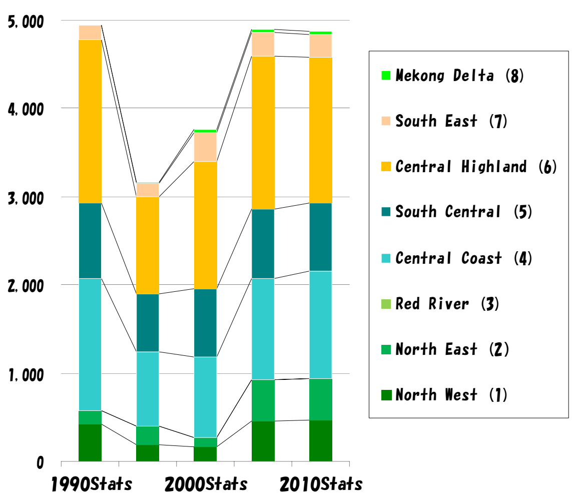


Figure 5.2.6 Estimated Areas from Statistical Figures, etc. (Evergreen Forest)

[8] Evergreen forest: Here "evergreen forest" indicated forest types 1 through 3 (rich evergreen forest, medium evergreen forest, poor evergreen forest) in the 17 categories consolidated into one.

Table 5.2.3 Activity Data by Region and Area Comparison (Recovered Forest)

(Unit: 1000 ha)

	North West (1)	North East (2)	Red River (3)	Central Coast (4)	South Central (5)	Central Highland (6)	South East (7)	Mekong Delta (8)	Total
1990Map	115.85	566.29	4.94	152.78	448.11	572.72	253.55	24.90	2139.14
1990Stats	175.43	197.62	4.70	126.21	216.10	482.07	186.36	8.30	1396.79
Gap Ratio (%)	51.4	-65.1	-4.8	-17.4	-51.8	-15.8	-26.5	-66.7	-34.7
1995Map	272.32	676.01	3.79	253.27	434.30	509.62	225.59	33.26	2408.15
1995Stats	96.39	318.19	15.80	79.21	209.73	353.12	188.98	42.58	1304.00
Gap Ratio (%)	-64.6	-52.9	316.7	-68.7	-51.7	-30.7	-16.2	28.0	-45.9
2000Map	419.93	807.29	3.12	313.85	424.41	526.06	218.16	27.45	2740.28
2000Stats	298.68	572.14	48.46	256.61	144.23	208.68	75.43	11.08	1615.31
Gap Ratio (%)	-28.9	-29.1	1451.2	-18.2	-66.0	-60.3	-65.4	-59.6	-41.1
2005Map	681.90	1034.15	3.30	474.14	405.56	546.42	204.98	33.18	3383.65
2005Stats	561.64	980.73	55.00	495.55	218.77	201.60	116.42	15.62	2645.33
Gap Ratio (%)	-17.6	-5.2	1567.5	4.5	-46.1	-63.1	-43.2	-52.9	-21.8
2010Map	937.28	1255.89	3.03	515.72	380.21	534.21	191.32	31.39	3849.06
2010Stats	579.48	1030.72	54.30	523.21	221.12	193.80	108.23	16.62	2727.48
Gap Ratio (%)	-38.2	-17.9	1692.3	1.5	-41.8	-63.7	-43.4	-47.1	-29.1

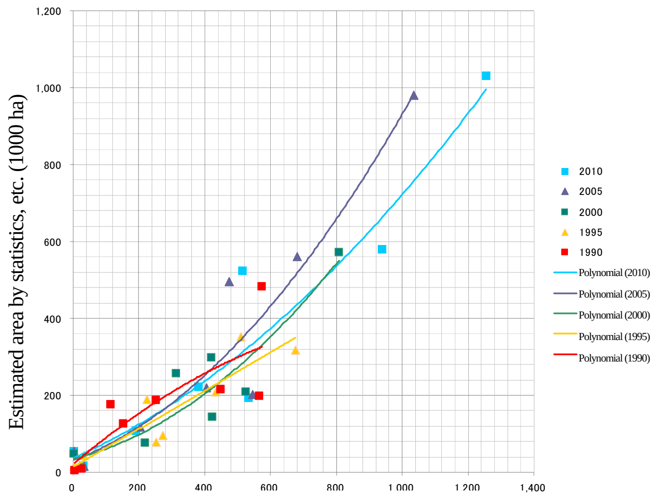


Figure 5.2.7 Comparison of Area in Activity Data (Recovered Forest)

Unit: 1000 ha

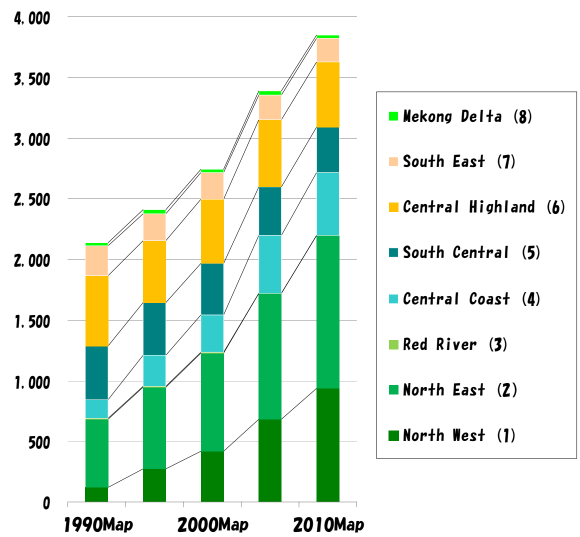


Figure 5.2.8 Areas from Forest Distribution Maps (Recovered Forest)

Unit: 1000 ha

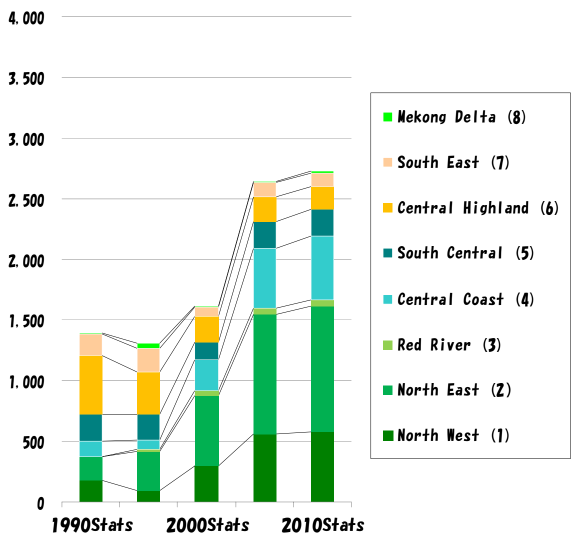


Figure 5.2.9 Estimated Area from Statistical Figures, etc. (Recovered Forest)

Table 5.2.4 Activity Data by Region and Area Comparison (Other Forest[9])

(Unit: 1000 ha)

	North West (1)	North East (2)	Red River (3)	Central Coast (4)	South Central (5)	Central Highland (6)	South East (7)	Mekong Delta (8)	Total
1990Map	212.60	618.79	52.63	409.78	37.88	1269.67	569.41	213.36	3384.13
1990Stats	94.97	297.80	2.70	264.79	16.41	1024.52	288.21	72.83	2062.23
Gap Ratio (%)	−55.3	−51.9	−94.9	−35.4	−56.7	−19.3	−49.4	−65.9	−39.1
1995Map	248.94	603.42	54.24	442.80	34.25	1198.35	496.06	239.08	3317.15
1995Stats	226.71	961.30	13.00	515.21	38.53	1385.59	543.96	98.92	3783.22
Gap Ratio (%)	−8.9	59.3	−76.0	16.4	12.5	15.6	9.7	−58.6	14.1
2000Map	257.19	629.62	54.58	469.61	24.64	1174.34	457.52	224.25	3291.75
2000Stats	419.57	1209.08	4.51	664.12	53.06	1281.05	415.27	20.15	4066.81
Gap Ratio (%)	63.1	92.0	−91.7	41.4	115.4	9.1	−9.2	−91.0	23.5
2005Map	257.84	647.86	54.05	473.03	20.44	1138.94	382.90	234.94	3209.99
2005Stats	357.52	779.59	3.62	348.54	23.80	918.66	333.87	5.15	2770.75
Gap Ratio (%)	38.7	20.3	−93.3	−26.3	16.4	−19.3	−12.8	−97.8	−13.7
2010Map	271.79	643.69	55.59	446.19	17.51	1088.51	344.47	227.29	3095.05
2010Stats	371.89	796.21	3.62	367.68	22.86	871.25	303.78	5.30	2742.59
Gap Ratio (%)	36.8	23.7	−93.5	−17.6	30.5	−20.0	−11.8	−97.7	−11.4

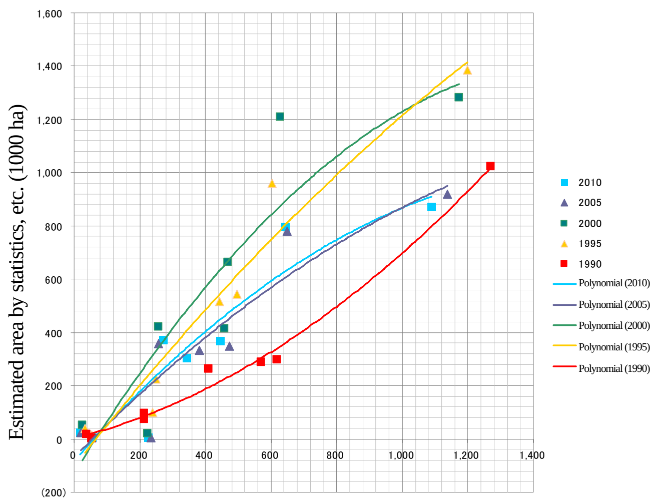


Figure 5.2.10 Comparison of Area in Activity Data (Other Forest)

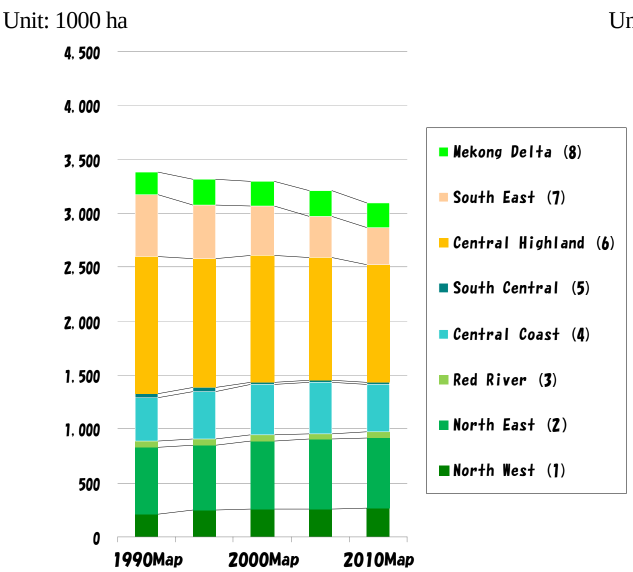


Figure 5.2.11 Area from Forest Distribution Maps (Other Forest)

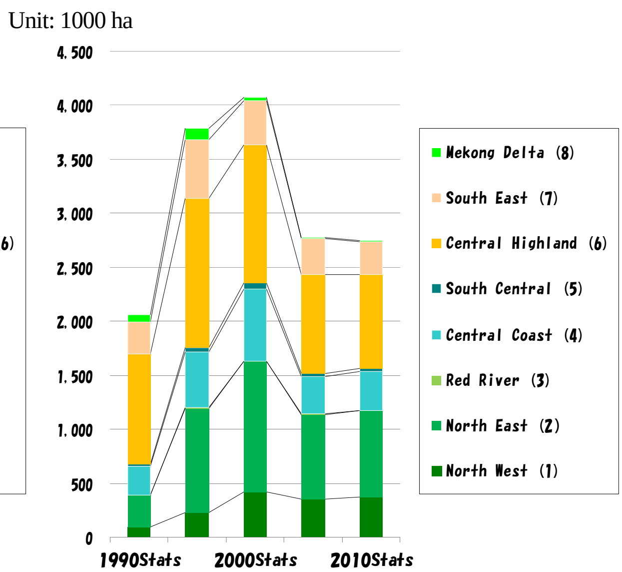


Figure 5.2.12 Estimated Area from Statistical Figures, etc. (Other Forest)

9 Other forest: Here "other forest" indicated forest types 5 through 11 in the 17 categories (other forest types besides evergreen forest, recovered forest, and plantations) consolidated into one.

Table 5.2.5 Activity Data by Region and Area Comparison (Plantation)

(Unit: 1000 ha)

	North West (1)	North East (2)	Red River (3)	Central Coast (4)	South Central (5)	Central Highland (6)	South East (7)	Mekong Delta (8)	Total
1990Map	19.32	163.26	9.60	163.87	71.85	53.68	175.70	17.40	674.70
1990Stats	60.39	260.04	20.76	164.57	46.19	66.37	47.25	75.30	740.87
Gap Ratio (%)	212.5	59.3	116.3	0.4	-35.7	23.6	-73.1	332.7	9.8
1995Map	36.14	195.11	20.92	193.81	113.35	93.24	210.06	47.06	909.68
1995Stats	84.32	329.54	49.96	236.49	109.11	84.87	87.24	66.94	1048.47
Gap Ratio (%)	133.3	68.9	138.8	22.0	-3.7	-9.0	-58.5	42.3	15.3
2000Map	75.63	512.34	21.49	307.42	185.57	122.16	301.85	64.14	1590.59
2000Stats	79.03	461.30	55.66	300.10	170.00	61.27	137.00	207.20	1471.56
Gap Ratio (%)	4.5	-10.0	159.0	-2.4	-8.4	-49.8	-54.6	223.1	-7.5
2005Map	82.49	904.73	24.89	436.81	311.97	206.20	478.78	73.75	2519.61
2005Stats	100.90	806.00	64.40	484.80	281.00	144.40	198.70	253.20	2333.40
Gap Ratio (%)	22.3	-10.9	158.8	11.0	-9.9	-30.0	-58.5	243.3	-7.4
2010Map	128.93	1280.98	25.85	584.26	439.92	285.66	551.88	70.78	3368.26
2010Stats	150.00	1070.20	68.70	654.70	380.20	209.50	170.60	215.90	2919.80
Gap Ratio (%)	16.3	-16.5	165.8	12.1	-13.6	-26.7	-69.1	205.0	-13.3

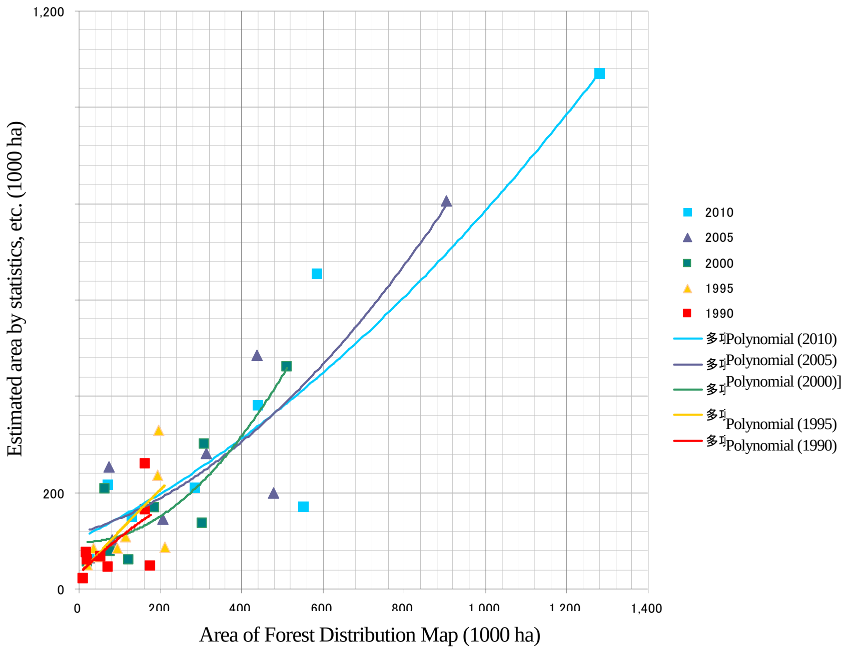


Figure 5.2.13 Comparison of Area in Activity Data (Plantation)

Unit: 1000 ha

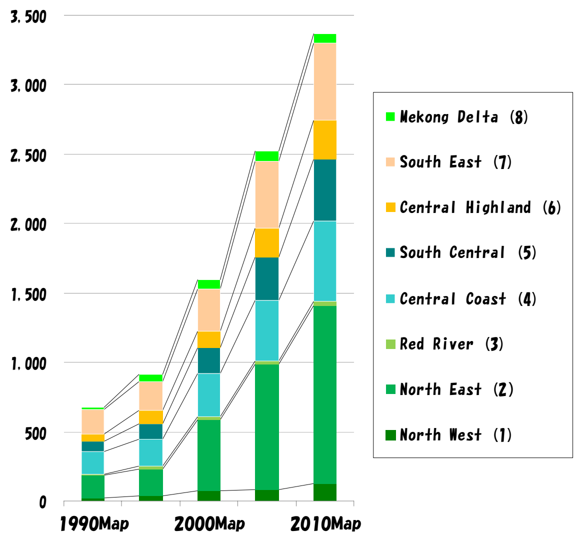


Figure 5.2.14 Area from Forest Distribution Map (Plantation)

Unit: 1000 ha

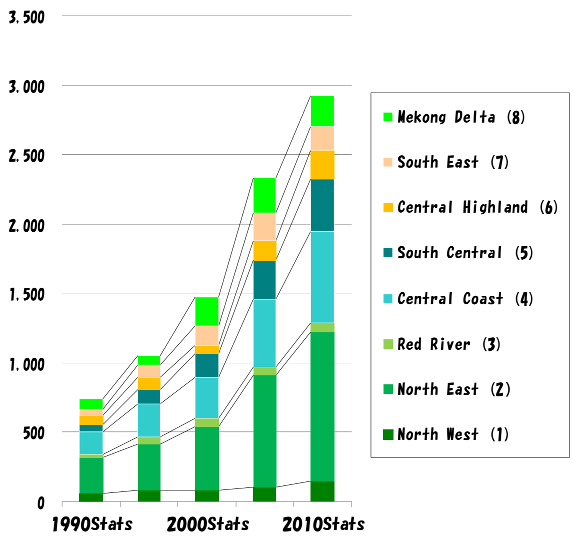


Figure 5.2.15 Estimated Area from Statistical Figures, etc. (Plantation)

6. Development of Thematic Map at the National Level

Two types of thematic maps were developed based on the Forest Distribution Maps which were also prepared in the Study. One is the Map of potential areas for implementation of A/R CDM projects, and the other is the Map of Forest Change.

In this chapter, procedures and methodology on how to develop these maps are to be introduced while showing the results in the following sections.

6.1 Map of potential areas for implementation of A/R CDM projects

The map to show distribution of potential areas to implement afforestation and reforestation project activities under CDM was prepared on the basis of the forest distribution maps of 1990 and 2010 prepared by the Study, by means of the following procedure.

1) Extracting the following land categories in the forest distribution map of 1990.
   - Limestone areas
   - Bare land
   - Bodies of water
   - Residential areas
   - Other land

   In short, all of the non-forested land categories are extracted.

2) Extracting the following land categories in the forest distribution map of 2010.
   - Bare land

   The limestone areas, bodies of water, residential areas, and other land were excluded, taking into consideration practicability to implement afforestation and reforestation activities.

3) Extracting the areas extracted in both 1) and 2), produce maps of the lands eligible for implementing A/R CDM project activities.

4) Categorizing the eligible lands extracted in 3) in accordance with the level of additionality; for simplification, this trial considers only the distance between a plantation and the main road as a parameter to analyze the additionality (detailed description is provided in section 7.1).
   - areas within 5 km from roads: A/R activities are considered feasible as BAU (IRR > 10%).
   - areas between 5 km and 11 km from roads: A/R activities are feasible only if they are implemented under CDM.
   - areas more than 11 km from roads: A/R activities are not feasible if they are implemented under CDM (operational costs exceed the combined benefit of timber production and estimated value of tCER).
   - Consequently, A/R activities are considered additional to the BAU scenario if they are implemented in lands located between 5 km and 11 km away from roads.

5) Extracting the areas lying between 5 km and 11 km from roads within the eligible lands extracted in 3) as the potential areas to implement A/R CDM project activities.

Figure 6.1.1 shows the map of potential areas to implement A/R CDM project activities in Vietnam.

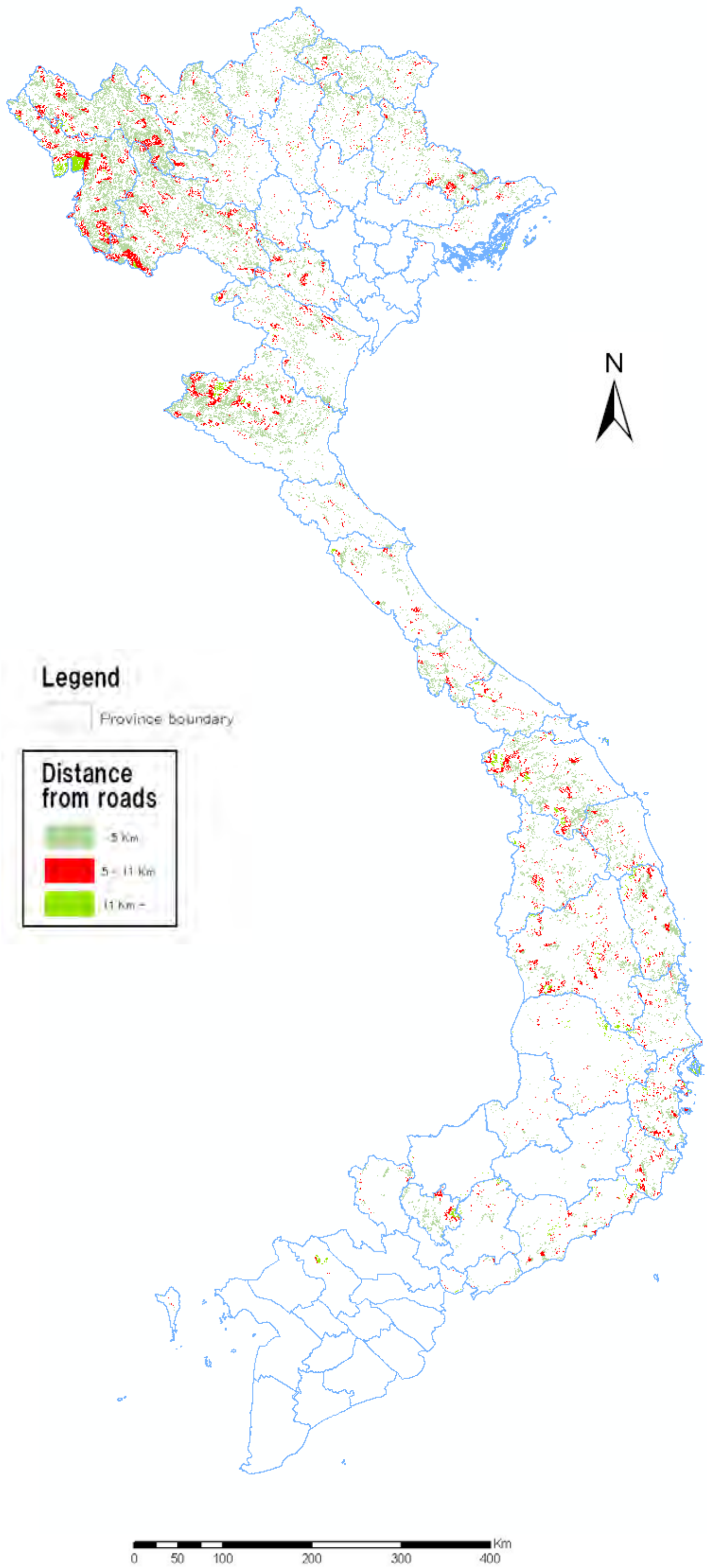


Figure 6.1.1 Map of potential areas to implement A/R CDM project activities

It is found from the map that most of the eligible lands to implement A/R CDM project activities are located in the northern and central parts of the country and little eligible land is found in the southern part of the country. On the basis of the map shown in Figure 6.1.1, areas of the eligible lands to implement A/R CDM project activities were calculated. Results of the calculation are summarized in Table 6.1.1

Table 6.1.1 Area of the eligible land for A/R CDM

Region	Province	Area of the eligible land for A/R CDM (ha)			
		0 - 5 km	5 - 11 km	11 km -	Total
Northwest	Son La	296,611	97,540	3,015	397,166
	Hoa Binh	48,483	20,548	29	69,060
	Lai Chau	254,186	61,696	4,139	320,021
	Dien Bien	233,789	98,605	39,314	371,708
	Sub-total	833,069	278,389	46,497	1,157,955
Northeast	Lao Cai	109,300	16,977	606	126,883
	Yen Bai	66,787	16,060	141	82,988
	Ha Giang	83,302	9,193	71	92,566
	Tuyen Quang	26,260	5,800	1,071	33,131
	Lang Son	87,998	29,736	831	118,565
	Bac Giang	7,378	1,685	0	9,063
	Phu Tho	12,397	3,728	0	16,125
	Vinh Phuc	1,546	1,560	0	3,106
	Cao Bang	96,206	11,730	0	107,936
	Bac Kan	55,661	9,993	310	65,964
	Thai Nguyen	7,444	2,201	0	9,645
	Quang Ninh	29,683	10,592	6,420	46,695
	Sub-total	583,962	119,255	9,450	712,667
Red river delta	Ha Noi	131	574	0	705
	Bac Ninh	0	0	0	0
	Hai Duong	0	0	0	0
	Hai Phong	260	430	0	690
	Ha Nam	179	137	0	316
	Ninh Binh	3,182	170	0	3,352
	Hung Yen	0	0	0	0
	Thai Binh	0	0	0	0
	Nam Dinh	0	0	0	0
	Sub-total	3752	1311	0	5063
North central	Thanh Hoa	97,634	25,994	3,012	126,640
	Nghe An	237,493	71,694	11,388	320,575
	Ha Tinh	23,327	5,103	37	28,467
	Quang Binh	50,064	12,837	1,952	64,853
	Quang Tri	53,651	13,806	185	67,642
	Thua Thien Hue	19,484	11,417	2,743	33,644
	Sub-total	481,653	140,851	19,317	641,821

South Central	Da Nang	2,184	659	225	3,068
	Quang Nam	110,151	53,902	15,006	179,059
	Quang Ngai	41,959	13,012	1,340	56,311
	Binh Dinh	60,125	25,044	7,622	92,791
	Phu Yen	36,796	11,612	2,736	51,144
	Khanh Hoa	37,999	25,597	10,587	74,183
	Sub-total	289,214	129,826	37,516	456,556
Central highland	Lam Dong	4,926	966	212	6,104
	Gia Lai	68,815	50,881	12,138	131,834
	Dac Lac	9,544	8,778	7,444	25,766
	Dac Nong	7,154	2,867	742	10,763
	Kon Tum	49,287	18,188	3,256	70,731
	Sub-total	139,726	81,680	23,792	245,198
Southeast	Binh Duong	27,878	10,530	4,088	42,496
	TP. HCM	167	655	415	1,237
	Ninh Thuan	24,779	14,934	3,631	43,344
	Binh Thuan	26,408	15,744	6,524	48,676
	Dong Nai	7,787	3,761	4,028	15,576
	Binh Phuoc	259	656	692	1,607
	Tay Ninh	11,759	3,544	399	15,702
	Ba Ria Vung Tau	5,416	1,811	0	7,227
	Sub-total	104,453	51,635	19,777	175,865
Mekong river delta	Long An	0	0	0	0
	Dong Thap	56	839	3,325	4,220
	An Giang	0	0	0	0
	Can Tho	0	0	0	0
	Kien Giang	921	625	583	2,129
	Tien Giang	0	0	0	0
	Ben Tre	0	0	0	0
	Vinh Long	0	0	0	0
	Tra Vinh	0	0	0	0
	Hau Giang	0	0	0	0
	Soc Trang	0	0	0	0
	Bac Lieu	0	0	0	0
	Ca Mau	0	0	0	0
	Sub-total	977	1464	3908	6349
Total		2,436,806	804,411	160,257	3,401,474

As explained in the procedure of preparing the map of potential areas for implementation of A/R CDM project activities, the eligible land is divided into three classes according to distance from the road, the parameter to identify whether it is additional to the BAU to implement an A/R CDM activity in a given area. As a result of the calculation, the total area of each class of the eligible land is identified as follows.

Area of the eligible lands within 5 km from roads: 2,436,806 ha

Area of the eligible lands between 5 km and 11 km from roads:	804,411 ha
Area of the eligible lands more than 11 km away from roads:	160,257 ha
Total area of the eligible land for A/R CDM:	3,401,474 ha

It is considered feasible to implement A/R CDM project activities in areas between 5 km and 11 km from roads. Therefore, the total area of the potential land for implementation of A/R CDM project activities in Vietnam is estimated at 804,411 ha.

6.2 Map of Forest Change

The map to show Forest change was prepared on the basis of the forest distribution maps of 2000 and 2010, by means of the following procedures. (Forest change here means deforestation area extracted from composite forest distribution maps of 2000 and 2010.)

1) Create composite forest distribution maps of 2000 and 2010 by using the overlay function of GIS software.
2) Extract the forested land by specifying query condition (Ftype2000: codes 1 to 12) in the attribute table of the composite maps.
3) Extract all the areas but the forested areas by specifying query condition (Ftype2010: codes 13 to 17) in the attribute table of the composite maps.
4) Extract the areas selected in both 1) and 2) process as the deforestation area from 2000 to 2010.

The map of Forest Change (Deforestation area) in Vietnam is shown in Figure 6.1.2.

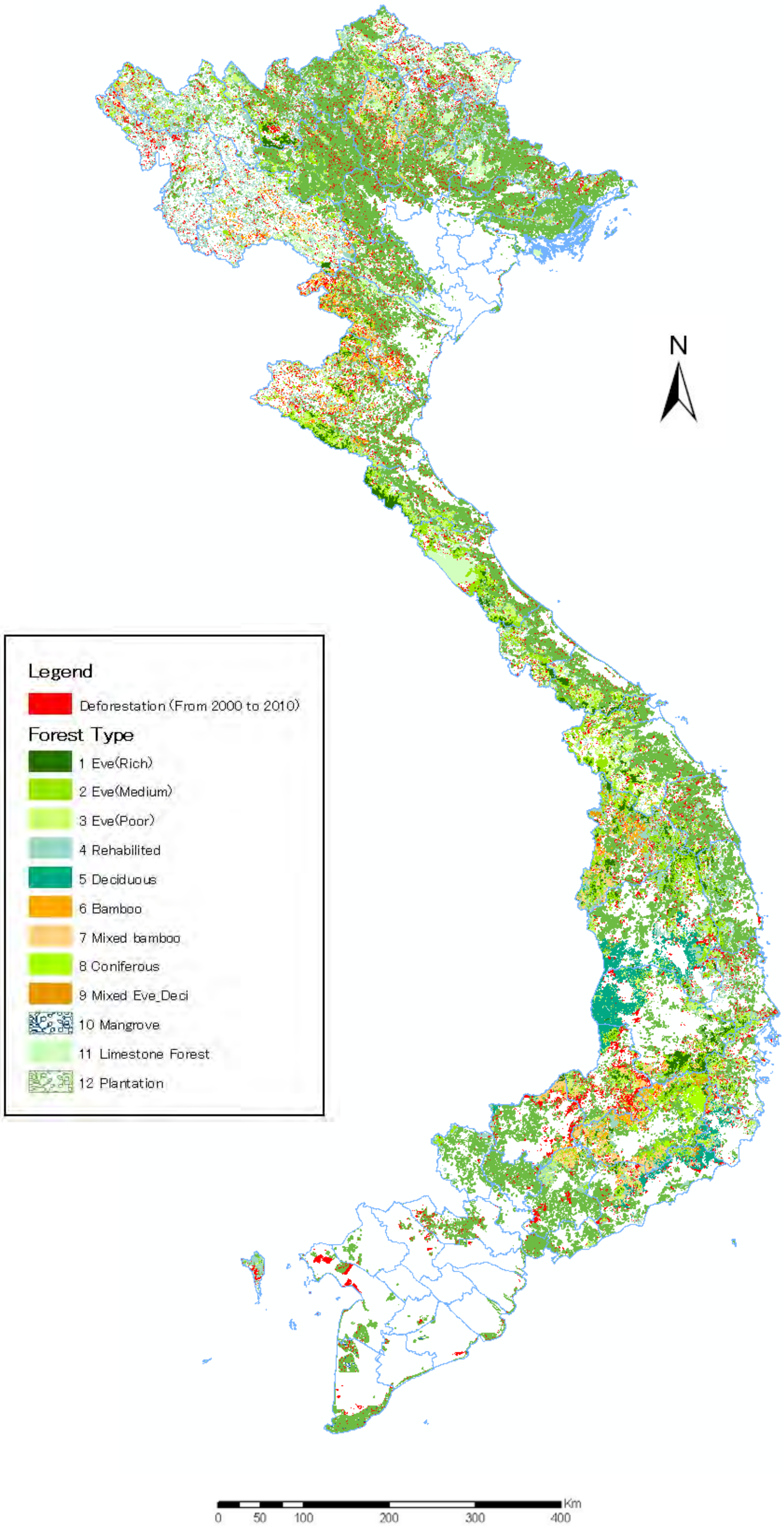


Figure 6.1.2 Map of Forest Change

7. Analyzing Costs and Benefits for A/R CDM and REDD+

This chapter tries to estimate costs and benefits on the national scale that can be incurred or earned through implementation of the A/R CDM and REDD+ activities, using the data developed by the Study as well as the existing data.

7.1 Cost and Benefit Analysis of Potential A/R CDM project

This section makes a trial calculation of costs and benefits pertaining to implementation of afforestation or reforestation project activities under CDM, assuming that all the lands considered potential lands to implement A/R CDM projects in Vietnam are afforested or reforested under CDM. Although it is not realistic for all the potential lands in the country to be afforested or reforested, the trial calculation is performed in order to estimate potential benefits of A/R CDM projects on the national scale.

The Study has searched data related to afforestation or reforestation project implementation through the Ministry of Agriculture and Rural Development (MARD), the Department of Agriculture and Rural Development (DARD), Vietnam Forestry University (VFU), and other relevant organizations. The Study then collected the data on growth of the major species planted in Vietnam and costs and revenues of project activities. On the basis of these data and the map of potential areas to implement A/R CDM project activities introduced in section 6.1, costs and benefits of the A/R CDM projects are estimated.

For afforestation or reforestation purpose, Vietnam is generally divided into eight agro-ecological regions on the basis of geographic location: Northwest; Northeast; Red River Delta; North Central Coast; South Central Coast; Central Highland, Southeast, and Mekong River Delta. There are recommended species listed for each region in Decision No. 16/2005/QĐ-BNN dated March 15, 2005. The species used in the estimation of the costs and benefits should comply with this decision. *Acacia auriculiformis* are recommended in all eight regions, and therefore, this trial calculation assumes that all the potential lands for implementation of A/R CDM projects are planted with *Acacia auriculiformis*.

Table 7.1.1 shows general information associated with planting *Acacia auriculiformis*; the figures provided in the table are used in this trial calculation. A project scenario used in this trial calculation is afforestation or reforestation by 15-year rotation. Within this cycle, thinning operation is applied twice, in the 9th year and the 13th year.

Table 7.1.1 Values used as a basis for cost and benefit analysis on planting Acacia auriculiformis

Item	Value	Remarks
Area (ha)	1	
Rotation (year)	15	
(m^3/ha)	6.53	used as chipwood
(m^3/ha)	20.37	used as chipwood
Estimated standing volume at felling (m^3/ha)	134.81	
Timber use rate (%)	80	
Chipwood use rate (%)	20	
Timber price (USD/m^3)		
Roundwood (d>15cm): C=40cm	42.5	
C=50cm	55.0	
C=60cm	62.5	
Chipwood price (USD/m^3)	28.8	
Discount rate (%)	10.0	

Source: Vietnam Forestry University

(1) Estimation of benefit (carbon credits, etc.) derived from implementation of A/R CDM projects

Benefits of implementing A/R CDM projects are estimated on 1) profit of selling timber products and 2) carbon credits (Certified Emission Reduction/CER) earned on the basis of the "net anthropogenic greenhouse gas removals by sinks" attained by implementation of the project.

1) Profit of selling timber products

In this trial calculation, it is assumed that trees are harvested three times within a 15-year cycle: the 1st thinning at the 9th year; the 2nd thinning at the 13th year; and the main harvesting at the 15th year. On the basis of the figures provided in Table 7.1.1, the revenue from timber production can be estimated as provided in Table 7.1.2.

Table 7.1.2 Estimated revenue from sales of the timbers in a 15-year cycle

Year	Item	Products	Quantity (m^3)	Unit price (USD)	Amount (USD)
9	The 1st thinning	Chipwood	6.53	28.80	**188.06**
13	The 2nd thinning	Chipwood	20.37	28.80	**586.66**
15	Felling	Timber	107.85		
		C=40cm	26.96	42.50	1,145.89
		C=50cm	40.44	55.00	2,224.37
		C=60cm	40.44	62.50	2,527.69
		Chipwood	26.96	28.80	776.51
	Total				**6,674.46**

Source: Vietnam Forestry University

2) Carbon credits

The crediting period for a proposed afforestation or reforestation project activity under the CDM shall be either a maximum of 20 years, which may be renewed at most two times (total duration is 60 years), or a maximum of 30 years with no chance for renewing the credit. A project participant can select the type of credits (tCER or lCER) he or she wishes to earn.

In this trial calculation, it is assumed that a fast-growing species (*Acacia auriculiformis*) is planted for the purpose of commercial timber production. Therefore, the crediting period is assumed to be 30 years and the tCER will be selected. Furthermore, the replacement of the expired credit is assumed to be imposed on the buyer of the credit and hence this matter will not be covered in this trial.

Estimation of the "net anthropogenic greenhouse gas removal by sinks" will be made, taking into consideration the following points.

(a) Actual net greenhouse gas removals by sinks

Among the five carbon pools, the above-ground and belowground biomasses are considered for the calculation. Regarding the aboveground biomass, the volume data are based on the growth data provided by the Vietnam Forestry University and converted into carbon mass using the equation and default values provided in the IPCC guidelines. Calculation of the belowground biomass is also based on the equation provided in the IPCC guidelines.

On the basis of a growth table of *Acacia auriculiformis* provided by the Vietnam Forestry University, carbon stock of the species can be identified by the following equation:

$$N(t)i = NA(t)i + NB(t)i \text{ (ton}CO_2\text{/ha)}$$

Where:

N(t)i: Total carbon stock in each strata at time t under the project scenario
NA(t)i: Carbon stock above ground at time t under the project scenario
NB(t)i: Carbon stock below ground at time t under the project scenario

$$NA(t)i = T(t)i \times Cfrac$$
$$NB(t)i = Exp(-1.085+0.9256 \times \ln T(t)i) \times 0.5$$
$$T(t)i = SV(t)i \times WD \times BEF$$

Where:

SV(t)i: Stem volume at time t under the project scenario
WD: Wood density (t.d.m/m^3)
BEF: biomass expansion factor to convert stem biomass to total aboveground biomass

Default values on *Acacia auriculiformis*: (IPCC 2003, 2006)

WD	0.515
BEF	1.4
Cfrac	0.5

Applying the equation provided above, amount of CO_2t/ha/year for 15 years of *Acacia auriculiformis* plantation can be estimated as shown in Table 7.1.3.

Table 7.1.3 Cumulative amount of CO2 removed by 1 ha of Acacia auriculiformis plantation

Year	**SV(t)i:** Stem volume (m^3/ha)	**T(t)i:** Above ground biomass (t.d.m./ha)	**NA(t)i:** Carbon stock in above ground (tC/ha)	**NB(t)i:** Carbon stock in below ground (tC/ha)	**N(t)i:** Carbon stock (tC/ha)	Actual net CO_2 removals by sinks (tCO_2/ha)	Baseline CO_2 removals by sinks (tCO_2/ha)	Net anthlopogenic CO2 removals by sinks (tCO_2/ha)
0	0.00	0.00	0.00	0.00	0.00	0.00	16.23	-16.23
1	2.00	1.44	0.72	0.24	0.96	3.51	16.23	-12.72
2	4.00	2.88	1.44	0.45	1.89	6.94	16.23	-9.29
3	6.04	4.35	2.18	0.66	2.84	10.40	16.23	-5.83
4	14.61	10.53	5.27	1.49	6.76	24.79	16.23	8.56
5	26.31	18.97	9.48	2.57	12.06	44.22	16.23	**27.99**
6	39.98	28.83	14.41	3.79	18.21	66.75	16.23	50.52
7	54.23	39.10	19.55	5.03	24.58	90.12	16.23	73.89
8	61.37	44.25	22.12	5.64	27.76	101.80	16.23	85.57
9	82.68	59.61	29.81	7.43	37.24	136.53	16.23	120.30
10	97.00	69.94	34.97	8.61	43.58	159.80	16.23	**143.57**
11	112.77	81.31	40.65	9.90	50.56	185.37	16.23	169.14
12	103.30	74.48	37.24	9.13	46.37	170.03	16.23	153.80
13	113.95	82.16	41.08	10.00	51.08	187.29	16.23	171.06
14	125.27	90.32	45.16	10.92	56.08	205.61	16.23	189.38
15	134.81	97.20	48.60	11.68	60.28	221.03	16.23	**204.80**

Source: Vietnam Forestry University

The values of SV(t)i provided in the above table are based on the growth model developed by the Vietnam Forestry University.

(b) Baseline net greenhouse gas removals by sinks

The potential areas identified in this trial are bare lands at present and non-forested areas as of 1990. Therefore, the present conditions can be regarded to have continued over the past 20 years. It is fairly reasonable to assume that human-induced activities such as shifting cultivation have impeded the vegetation from growing in the areas with these conditions. On the basis of analysis of natural succession of fallowed land after shifting cultivation carried out by the Vietnam Forestry University, a regression equation for the baseline scenario for regenerated vegetation for 15 years is shown as follows.

$Y = 20.663Ln(X) + 20.113$

Where: Y: tons of CO_2 sequestrated in vegetation

X: number of fallowed years

From the above equation, the baseline scenario has been identified as shown in the Table 7.1.4. Under the conditions where no shifting cultivation takes place, the vegetation gradually recovers and eventually becomes forests. On the contrary, in the areas that were identified as non-forested in 1990 and 2010, human activities such as shifting cultivation are expected to take place and the vegetation does not recover to become forests. In order to simplify calculation, this trial averages conditions of the vegetation that are expected to repeat this cycle. Trends of the baseline scenarios are shown in Figure 7.1.1.

Table 7.1.4 Result of calculation of baseline

Years past in the fallow	Baseline without shifting cultivation	Baseline with shifting cultivation	Average of Baseline with shifting cultivation
Year 1	20.11	0	16.23
Year 2	34.44	0	16.23
Year 3	42.81	0	16.23
Year 4	48.76	20.11	16.23
Year 5	53.37	34.44	16.23
Year 6	57.14	42.81	16.23
Year 7	60.32	0	16.23
Year 8	63.08	0	16.23
Year 9	65.51	0	16.23
Year 10	67.69	20.11	16.23
Year 11	69.66	34.44	16.23
Year 12	71.46	42.81	16.23
Year 13	73.11	0	16.23
Year 14	74.64	0	16.23
Year 15	76.07	0	16.23

Source: Vietnam Forestry University

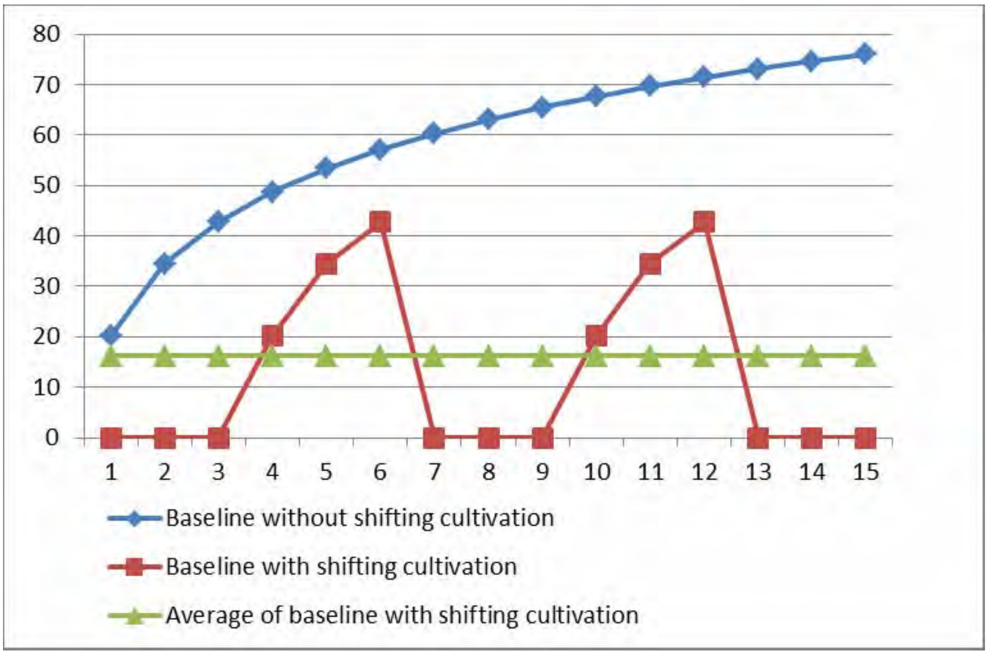


Figure 7.1.1 Diagram of Baseline scenario

(c) Leakage

Leakage is disregarded in this trial calculation.

(2) Estimation of costs pertaining to implementation of potential A/R CDM project

Costs pertaining to implementation of A/R CDM projects include the cost of afforestation/reforestation activities and the cost of the process to earn the credit approved in the CDM framework. The respective types of costs shall be estimated as follows.

1) Costs of afforestation/reforestation activities

The Study has collected the data on the costs itemized in Table 7.1.5 and Table 7.1.6. These data are multiplied by the total areas or total harvest volumes for each category derived from the map of potential areas for A/R CDM project activities and the values will be estimated.

Table 7.1.5 Costs associated with planting and managing the plantation in a 15-year rotation

Year	No.	Items	Unit	Quantity	Unit price (VND)	Amount (VND)	Amount (USD)
1	**I**	**Direct costs**				**13,032,798**	**651.64**
	1	***Labour***				***8,904,798***	***445.24***
	-	Vegetation clearing	manday/ha	28.58	52,223	1,492,533	74.6
	-	Digging and filling up holes	manday/ha	73.94	52,223	3,861,369	193.1
	-	Transportation and fertilizing	manday/ha	2.90	52,223	151,447	7.6
	-	Seedlings moving and planting	manday/ha	12.79	52,223	667,932	33.4
	-	Replanting	manday/ha	1.79	52,223	93,479	4.7
	-	Tending	manday/ha				0.0
	+	*Vegetation clearing*	manday/ha	*32.54*	*52,223*	*1,699,336*	*85.0*
	+	*Tending*	manday/ha	*16.06*	*52,223*	*838,701*	*41.9*
	-	Protection	ha	1	*100,000*	100,000	5.0
	2	***Material***				***4,128,000***	***206.40***
	-	Seedlings	seedling	2,200	540	1,188,000	59.4
	-	Fertilizer NPK	kg	600	4,900	2,940,000	147.0
	II	**Other costs**				**1,960,000**	**98.00**
	-	Designing	ha	1	100,000	100,000	5.0
	-	Checking up	ha	1	10,000	10,000	0.5
	-	Equipment	ha	1	150,000	150,000	7.5
	-	Technique monitoring	ha	1	1,700,000	1,700,000	85.0
	Total					**14,992,798**	**749.64**
2	***1***	***Labour***				***2,562,314***	***128.12***
	-	Tending	manday			2,462,314	123.1
	+	Clearing	manday	32.54	52,223	1,699,336	85.0
	+	Tending	manday	14.61	52,223	762,978	38.1
	-	Equipment	ha	1	100,000	100,000	5.0
	-	Protection	ha	1	100,000	100,000	5.0
	Total					***2,562,314***	***128.12***
3	***1***	***Material***					0.0
	-	Clearing	manday	31.49	52,223	1,644,502	82.2
	-	Equipment	ha	1	100,000	100,000	5.0
	-	Protection	ha	1	100,000	100,000	5.0
	Total					***1,844,502***	***92.23***
4 - 15	***1***	***Labour***				100,000	5.0
	-	Protection	ha	1	100,000	100,000	5.0
	Total					***100,000***	***5.00***

Source: Vietnam Forestry University

Table 7.1.6 Costs associated with thinning and harvesting in a 15-year rotation

Year	No.	Items	Unit	Quatity	Unit price (VND)	Amount (VND)	Amount (USD)
9	1	Thinning design	ha	1	100,000	100,000	5.00
		Total				**100,000**	**5.00**
	2	Thinning	m^3	1	60,000	60,000	3.00
	3	Skidding	m^3/km	1	50,000	50,000	2.50
	4	Loading	m^3	1	30,000	30,000	1.50
	5	Transporting	m^3	1	100,000	100,000	5.00
		Total				**240,000**	**12.00**
13	1	Thinning design	ha	1	100,000	100,000	5.00
		Total				**100,000**	**5.00**
	2	Thinning	m^3	1	60,000	60,000	3.00
	3	Skidding	m^3/km	1	50,000	50,000	2.50
	4	Loading	m^3	1	30,000	30,000	1.50
	5	Transporting	m^3	1	100,000	100,000	5.00
		Total				**240,000**	**12.00**
15	1	Clear felling	m^3	1	60,000	60,000	3.00
	2	Barking	m^3	1	25,000	25,000	1.25
	3	Skidding	m^3/km	1	50,000	50,000	2.50
	4	Loading	m^3	1	30,000	30,000	1.50
	5	Transporting	m^3	1	100,000	100,000	5.00
		Total				**265,000**	**13.25**

SouSource: Vietnam Forestry University

2) Cost of process to earn the credit

In this trial, the scale of one project is assumed to be 10,000 ha. The following items of costs are quoted from existing trial data, and the values for the total areas of each category will be estimated.

- Planning (first year only):
  - Data to prove eligibility of the land (output of the Study)
  - Environmental impact assessment/socio-economic impact assessment: 30,000 US Dollars[10] (3 US Dollars/ha)
  - Setting the baseline: 15,000 US Dollars (1.5 US Dollars/ha)
- Validation by DOE (first year only): 25,000 US Dollars (2.5 US Dollars/ha)
- Registration to the CDM Executive Board (first year only): 10,000 US Dollars (1 US Dollar/ha)
- Monitoring (first year and every 5 years afterward): 30,000 US Dollars/monitoring (3 US Dollars/ha)
- Verification and certification by DOE (first year and every 5 years afterward): 25,000 US Dollars/verification (2.5 US Dollars/ha)

10 Figures of the costs are based on a trial study carried out by Mitsubishi UFJ Research and Consulting

(3) Analysis of costs and benefits

This section combines the information given in the previous sections of this chapter and tries to estimate net benefit of implementing an A/R CDM project per hectare. In order to exercise investment analysis to justify the additionality, this trial simplifies the calculation and the only parameter to examine the "additionality" is distance from the road to the plantation and associated cost of transportation of the logs from the harvesting site to the main road.

If the plantation is located along the road, cost of skidding the logs from the harvesting sites to the main road is low; the net present value of the net revenue would be 532.38 US Dollars and the internal rate of return is estimated as 14%, which exceeds the discount rate set in this trial (10%) as shown in Table 7.1.7. Consequently, an afforestation or reforestation project is likely to be business as usual.

Table 7.1.7 Costs and benefits analysis associated with 1 hectare of Acacia auriculiformis plantation located by the main road

Year	Revenue (USD)	Costs (USD)			Income (USD)	Discount factor	Present cash flow (USD)
		Investment	Thinning and Felling	Total			
1	0	749.64	0	749.64	-750	0.9091	-681.49
2	0	128.12	0	128.12	-128	0.8264	-105.88
3	0	92.23	0	92.23	-92	0.7513	-69.29
4	0	5.00	0	5.00	-5	0.6830	-3.42
5	0	5.00	0	5.00	-5	0.6209	-3.10
6	0	5.00	0	5.00	-5	0.5645	-2.82
7	0	5.00	0	5.00	-5	0.5132	-2.57
8	0	5.00	0	5.00	-5	0.4665	-2.33
9	188.06	5.00	67.04	72.04	116	0.4241	49.21
10	0	5.00	0	5.00	-5	0.3855	-1.93
11	0	5.00	0	5.00	-5	0.3505	-1.75
12	0	5.00	0	5.00	-5	0.3186	-1.59
13	586.66	5.00	198.52	203.52	383	0.2897	110.98
14	0	5.00	0	5.00	-5	0.2633	-1.32
15	6,674.46	5.00	1,449.21	1,454.21	5,220	0.2394	1,249.69
NPV of 1 ha (USD)							**532.38**
IRR							14.0%

As the distance between the plantation and the main road increases, the cost of skidding the logs also increases and the net present value of the profit nearly becomes zero if the plantation is located 5 kilometers away from the main road (Table 7.1.8). Consequently, in this trial, this is considered to be the threshold of afforestation/reforestation that can be implemented under business as usual. CDM is then considered as an option to offset the deficit.

Table 7.1.8 Costs and benefits analysis associated with 1 hectare of Acacia auriculiformis plantation located 5-kilometer away from the main road

Year	Revenue (USD)	Costs (USD)			Income (USD)	Discount factor	Present cash flow (USD)
		Investment	Thinning and Felling	Total			
1	0	749.64	0	749.64	-750	0.9091	-681.49
2	0	128.12	0	128.12	-128	0.8264	-105.88
3	0	92.23	0	92.23	-92	0.7513	-69.29
4	0	5.00	0	5.00	-5	0.6830	-3.42
5	0	5.00	0	5.00	-5	0.6209	-3.10
6	0	5.00	0	5.00	-5	0.5645	-2.82
7	0	5.00	0	5.00	-5	0.5132	-2.57
8	0	5.00	0	5.00	-5	0.4665	-2.33
9	188.06	5.00	148.66	153.66	34	0.4241	14.59
10	0	5.00	0	5.00	-5	0.3855	-1.93
11	0	5.00	0	5.00	-5	0.3505	-1.75
12	0	5.00	0	5.00	-5	0.3186	-1.59
13	586.66	5.00	453.14	458.14	129	0.2897	37.23
14	0	5.00	0	5.00	-5	0.2633	-1.32
15	6,674.46	5.00	3,134.33	3,139.33	3,535	0.2394	846.28
NPV of 1 ha (USD)							**20.61**
IRR							10.2%

If afforestation/reforestation projects are implemented at 5 kilometers away from the main road under CDM, net profit is estimated to be 610.28 US Dollars per hectare for the net present value and IRR is expected to be 15.0% (Table 7.1.9). As the distance between the plantation and the road becomes longer the net profit will decrease and will become zero for the net present value at 11 kilometers away from the main road (Table 7.1.10). This means that CDM is not feasible at distances of 11 kilometers or further from the road.

Table 7.1.9 Costs and benefits analysis associated with implementation of A/R CDM project under the conditions where the project area is located 5-kilometer away from the main road

Year	Revenue (USD)			Costs (USD)				Income (USD)	Discount factor	Present cash flow (USD)
	Timber sales	tCER	Total	A/R activities	Thinning/ Felling	CDM Process	Total			
1	0		0.00	749.64	0	13.50	763.14	-763.14	0.9091	-693.76
2	0		0.00	128.12	0		128.12	-128.12	0.8264	-105.88
3	0		0.00	92.23	0		92.23	-92.23	0.7513	-69.29
4	0		0.00	5.00	0		5.00	-5.00	0.6830	-3.42
5	0	139.94	139.94	5.00	0	5.50	10.50	129.44	0.6209	80.37
6	0		0.00	5.00	0		5.00	-5.00	0.5645	-2.82
7	0		0.00	5.00	0		5.00	-5.00	0.5132	-2.57
8	0		0.00	5.00	0		5.00	-5.00	0.4665	-2.33
9	188.06		188.06	5.00	148.66		153.66	34.40	0.4241	14.59
10	0	717.87	717.87	5.00	0	5.50	10.50	707.37	0.3855	272.72
11	0		0.00	5.00	0		5.00	-5.00	0.3505	-1.75
12	0		0.00	5.00	0		5.00	-5.00	0.3186	-1.59
13	586.66		586.66	5.00	453.14		458.14	128.52	0.2897	37.23
14	0		0.00	5.00	0		5.00	-5.00	0.2633	-1.32
15	6,674.46	1,024.01	7,698.47	5.00	3,134.33	5.50	3,144.83	4,553.64	0.2394	1,090.10
16	0		0.00	749.64	0		749.64	-749.64	0.2176	-163.14
17	0		0.00	128.12	0		128.12	-128.12	0.1978	-25.35
18	0		0.00	92.23	0		92.23	-92.23	0.1799	-16.59
19	0		0.00	5.00	0		5.00	-5.00	0.1635	-0.82
20	0	139.94	139.94	5.00	0	5.50	10.50	129.44	0.1486	19.24
21	0		0.00	5.00	0		5.00	-5.00	0.1351	-0.68
22	0		0.00	5.00	0		5.00	-5.00	0.1228	-0.61
23	0		0.00	5.00	0		5.00	-5.00	0.1117	-0.56
24	188.06		188.06	5.00	148.66		153.66	34.40	0.1015	3.49
25	0	717.87	717.87	5.00	0	5.50	10.50	707.37	0.0923	65.29
26	0		0.00	5.00	0		5.00	-5.00	0.0839	-0.42
27	0		0.00	5.00	0		5.00	-5.00	0.0763	-0.38
28	586.66		586.66	5.00	453.14		458.14	128.52	0.0693	8.91
29	0		0.00	5.00	0		5.00	-5.00	0.0630	-0.32
30	6,674.46	1,024.01	7,698.47	5.00	3,134.33	5.50	3,144.83	4,553.64	0.0573	260.96
NPV of 1 ha (USD)										**610.28**
IRR										15.0%

Table 7.1.10 Costs and benefits analysis associated with implementation of A/R CDM project under the conditions where the project area is located 11-kilometer away from the main road

Year	Revenue (USD)			Costs (USD)				Income (USD)	Discount factor	Present cash flow (USD)
	Timber sales	tCER	Total	A/R activities	Thinning/ Felling	CDM Process	Total			
1	0		0.00	749.64	0	13.50	763.14	-763.14	0.9091	-693.76
2	0		0.00	128.12	0		128.12	-128.12	0.8264	-105.88
3	0		0.00	92.23	0		92.23	-92.23	0.7513	-69.29
4	0		0.00	5.00	0		5.00	-5.00	0.6830	-3.42
5	0	139.94	139.94	5.00	0	5.50	10.50	129.44	0.6209	80.37
6	0		0.00	5.00	0		5.00	-5.00	0.5645	-2.82
7	0		0.00	5.00	0		5.00	-5.00	0.5132	-2.57
8	0		0.00	5.00	0		5.00	-5.00	0.4665	-2.33
9	188.06		188.06	5.00	246.61		251.61	-63.55	0.4241	-26.95
10	0	717.87	717.87	5.00	0	5.50	10.50	707.37	0.3855	272.72
11	0		0.00	5.00	0		5.00	-5.00	0.3505	-1.75
12	0		0.00	5.00	0		5.00	-5.00	0.3186	-1.59
13	586.66		586.66	5.00	758.69		763.69	-177.03	0.2897	-51.28
14	0		0.00	5.00	0		5.00	-5.00	0.2633	-1.32
15	6,674.46	1,024.01	7,698.47	5.00	5,156.48	5.50	5,166.98	2,531.49	0.2394	606.02
16	0		0.00	749.64	0		749.64	-749.64	0.2176	-163.14
17	0		0.00	128.12	0		128.12	-128.12	0.1978	-25.35
18	0		0.00	92.23	0		92.23	-92.23	0.1799	-16.59
19	0		0.00	5.00	0		5.00	-5.00	0.1635	-0.82
20	0	139.94	139.94	5.00	0	5.50	10.50	129.44	0.1486	19.24
21	0		0.00	5.00	0		5.00	-5.00	0.1351	-0.68
22	0		0.00	5.00	0		5.00	-5.00	0.1228	-0.61
23	0		0.00	5.00	0		5.00	-5.00	0.1117	-0.56
24	188.06		188.06	5.00	246.61		251.61	-63.55	0.1015	-6.45
25	0	717.87	717.87	5.00	0	5.50	10.50	707.37	0.0923	65.29
26	0		0.00	5.00	0		5.00	-5.00	0.0839	-0.42
27	0		0.00	5.00	0		5.00	-5.00	0.0763	-0.38
28	586.66		586.66	5.00	758.69		763.69	-177.03	0.0693	-12.28
29	0		0.00	5.00	0		5.00	-5.00	0.0630	-0.32
30	6,674.46	1,024.01	7,698.47	5.00	5,156.48	5.50	5,166.98	2,531.49	0.0573	145.08
NPV of 1 ha (USD)										**-3.85**
IRR										10.0%

Assuming that the price of tCER is 5 US Dollars/tCO_2, benefit of selling the tCER in the 30-year project period would be:

US$139.94 per hectare at the fifth and twentieth years

US$717.87 per hectare at the tenth and twenty-fifth years

US$1,024.01 per hectare at the fifteenth and thirtieth years

According to section 6.1, the total area of potential lands to implement A/R CDM project activities in Vietnam is estimated at 804,411 ha.

If all potential lands for implementation of A/R CDM projects in the country were afforested or reforested, the total gross benefit from the tCER would be:

US$112,569,275 at the fifth and twentieth years

US$577,462,525 the tenth and twenty-fifth years

US$823,724,908 at the fifteenth and thirtieth years

The net present value of the net benefit of the A/R CDM project implementation in the country would be

243,909,997 US dollars (Table 7.1.11). In this calculation, costs of thinning or felling are estimated, assuming the distance between the harvesting site and the main road is 8 kilometers (median of the distance between 5 kilometers and 11 kilometers).

Table 7.1.11 Potential revenue and costs associated with implementation of A/R CDM project in Vietnam

Year	Revenue (USD)			Costs (USD)				Net income (USD)	Discount factor	Present cash flow (USD)
	Timber sales	tCER	Total	A/R activities	Thinning/ Felling	CDM Process	Total			
1	-		-	603,018,574	0	10,859,549	613,878,122	-613,878,122	0.9091	-558,071,020
2	-		-	103,057,696	0		103,057,696	-103,057,696	0.8264	-85,171,650
3	-		-	74,186,896	0		74,186,896	-74,186,896	0.7513	-55,737,713
4	-		-	4,022,055	0		4,022,055	-4,022,055	0.6830	-2,747,118
5	-	112,569,275	112,569,275	4,022,055	0	4,424,261	8,446,316	104,122,960	0.6209	64,652,166
6	-		-	4,022,055	0		4,022,055	-4,022,055	0.5645	-2,270,345
7	-		-	4,022,055	0		4,022,055	-4,022,055	0.5132	-2,063,950
8	-		-	4,022,055	0		4,022,055	-4,022,055	0.4665	-1,876,318
9	151,277,533		151,277,533	4,022,055	158,979,768		163,001,823	-11,724,290	0.4241	-4,972,244
10	-	577,462,525	577,462,525	4,022,055	0	4,424,261	8,446,316	569,016,210	0.3855	219,380,381
11	-		-	4,022,055	0		4,022,055	-4,022,055	0.3505	-1,409,706
12	-		-	4,022,055	0		4,022,055	-4,022,055	0.3186	-1,281,551
13	471,915,757		471,915,757	4,022,055	487,404,691		491,426,746	-19,510,989	0.2897	-5,651,638
14	-		-	4,022,055	0		4,022,055	-4,022,055	0.2633	-1,059,133
15	5,369,009,043	823,724,908	6,192,733,951	4,022,055	3,334,611,392	4,424,261	3,343,057,708	2,849,676,243	0.2394	682,189,836
16	-		-	603,018,574	0		603,018,574	-603,018,574	0.2176	-131,234,411
17	-		-	103,057,696	0		103,057,696	-103,057,696	0.1978	-20,389,416
18	-		-	74,186,896	0		74,186,896	-74,186,896	0.1799	-13,343,165
19	-		-	4,022,055	0		4,022,055	-4,022,055	0.1635	-657,638
20	-	112,569,275	112,569,275	4,022,055	0	4,424,261	8,446,316	104,122,960	0.1486	15,477,214
21	-		-	4,022,055	0		4,022,055	-4,022,055	0.1351	-543,503
22	-		-	4,022,055	0		4,022,055	-4,022,055	0.1228	-494,093
23	-		-	4,022,055	0		4,022,055	-4,022,055	0.1117	-449,176
24	151,277,533		151,277,533	4,022,055	158,979,768		163,001,823	-11,724,290	0.1015	-1,190,316
25	-	577,462,525	577,462,525	4,022,055	0	4,424,261	8,446,316	569,016,210	0.0923	52,517,919
26	-		-	4,022,055	0		4,022,055	-4,022,055	0.0839	-337,472
27	-		-	4,022,055	0		4,022,055	-4,022,055	0.0763	-306,793
28	471,915,757		471,915,757	4,022,055	487,404,691		491,426,746	-19,510,989	0.0693	-1,352,957
29	-		-	4,022,055	0		4,022,055	-4,022,055	0.0630	-253,548
30	5,369,009,043	823,724,908	6,192,733,951	4,022,055	3,334,611,392	4,424,261	3,343,057,708	2,849,676,243	0.0573	163,310,823
NPV (USD)										**243,909,997**
IRR										12.8%

7.2 Costs and Benefits of REDD+

In this section, simple trial calculation of the cost and benefit in REDD+ activities at national level is conducted.

7.2.1 Estimation of Benefits

With regard to the trial calculation of the benefit, the premises are specified as follows.

In SBSTA under UNFCCC, setting up RELs/RLs as the basis of the benefit of REDD+ is argued with consideration of the national circumstances. The 661 programs are assumed to be the biggest influential factor when considering national circumstance in Vietnam. Forest conservation, forest restoration, and afforestation are incorporated into this program. Although it is better for Vietnam to make the trial calculation of a benefit originally based on RELs/RLs with consideration of national circumstances under normal conditions, the examination and analysis of national circumstances have not yet started and are a future subject. In addition, in order to consider the 661 programs as national circumstances, it is indispensable to grasp the policy effect of the 661 programs appropriately. However, analysis made so far on the policy effect of the 661 program might not be approved as transparency and robust methods under UNFCCC.　Therefore, in this section, REDD+ benefit shall be examined, assuming that BAUs extrapolated from the past trends would be equal to RELs.

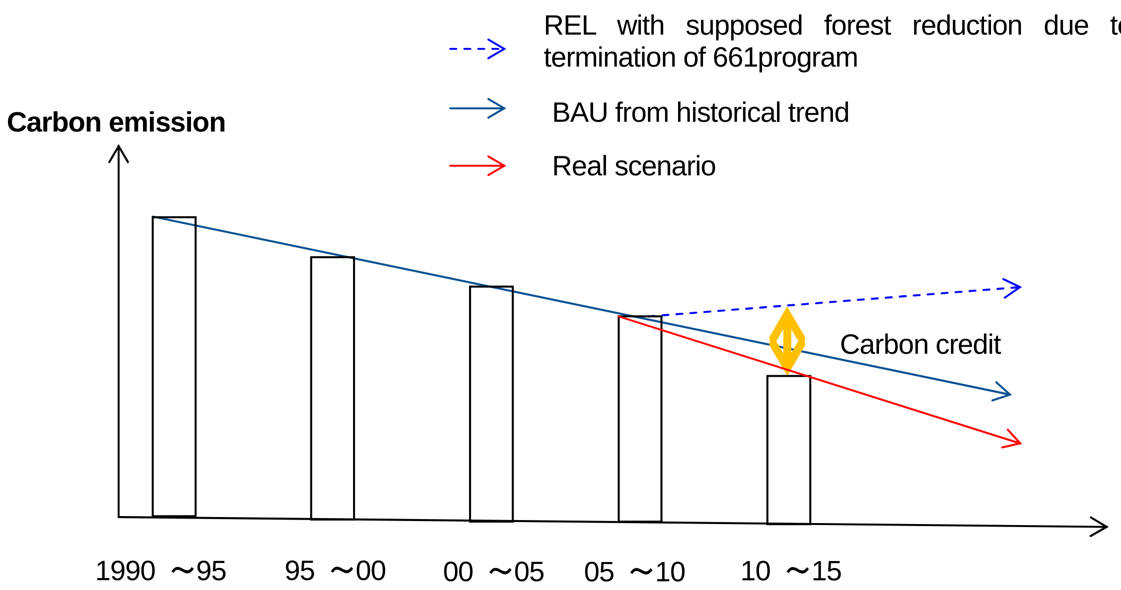


Figure 7.2.1 Model figure in the case of setting REL to be a loss of forests by 661 due to the termination of 661 program

In order to facilitate an understanding of the relation among the RELs, BAUs, and REDD+ benefits, an example model figure with national circumstances is shown in Figure 7.2.1. This figure is a model of setting RELs with correctionof future extrapolation under the assumption that the forest developed by the 661 programs will disappear after the completion of the 661 programs. As shown in this figure, originally, the difference between the actual scenario represented by the red line and RELs with consideration of national circumstances represented by the blue dotted line would be the basis to calculate thecredit to be acquired. However, in order to conduct cost and benefit analysis based on this, it is necessary to scrutinize the information about the 661 program as pointed out above.

In this section, trial calculation of the benefits is conducted based on the difference between BAU and zero emission, by which the maximum amount of the credit to be acquired is estimated against the given BAU. Figure 7.2.2 shows the REL at the national level based on the method of averaging historical trends, which was prepared by the Study Team (refer to Chapter 4). The value of the benchmark of this REL in 2015 is 331 MCO_2 tons. Trial calculation is conducted based on the premise that the emission of CO_2 would become zero.

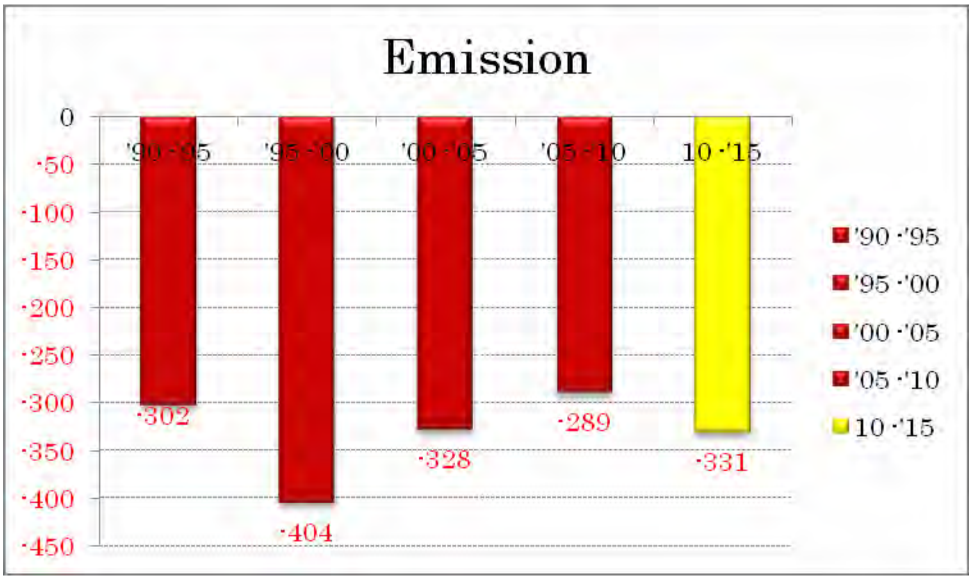


Figure 7.2.2 REL at national level by use of average figure of historical trend (Unit: MCO_2t)

If 5.5 US$/$CO_2$ ton, which is an average price for offsets across the primary forest carbon markets in 2010 according to "State of Forest Carbon Markets 2011," is multiplied by this 331 MCO_2 tons, the result becomes US$1,820,500,000; let this value be a REDD+ benefit in this trial calculation.

7.2.2 Estimation of Costs

Next, the cost concerning implementation of the REDD+ activities is estimated, considering forest protection as the REDD+ activities reducing emissions of 331 MCO_2 tons, which has become the requisite to acquire the amount of benefit estimated in section 7.2.1. The items of expenditure added up as expenses were taken as the following.

(1) Forest protection activity cost

Based on the unit price of the forest protection activities by the 661 programs, the cost for forest conservation activity is set at 200,000 VND/ha/year for this trial calculation. Meanwhile, it is difficult to identify where deforestation and forest degradation occur at national level. Therefore, for the achievement of zero emission from forest with the assumption of the trial calculation of the REDD+ benefit mentioned above, policy and measures of forest to be protected at the national level should be theoretically adopted. Based on this assumption, cost of the protection activity under the policies is estimated. According to the forest distribution map of 2010 prepared by the Study, total area of forests is 14,217,000 ha. In addition, it is assumed that these activities are conducted for four years from 2012 to 2015.

In the case of the calculation based on this, the result becomes 200,000VND/ha/year x 14,217,000 ha x 4 year÷21,000 VND/US$= 541,600,000 US$

(2) Monitoring cost

Next, monitoring cost was presumed by the following methods.

The monitoring cost consists of satellite imagery purchase, satellite imagery analysis expenses, and field survey expenses by monitoring activities in 2015. Total cost of the monitoring based on the following estimation is US$2,236,000.

The premises and price of each trial calculation are as follows.

Images purchase: US$1,773,000 (141,800,000 JPY÷80JPY/US$)
The forest distribution map obtained by the study in year 2010 was prepared using satellite imagery of SPOT and ALOS. Most parts of SPOT imagery were provided by MONRE and the missing parts were provided by the Study for the complement. Satellite imagery which has the same or better resolution level than both SPOT and ALOS should be needed for the monitoring in 2015. However, the volume of imagery that will be provided by MONRE for year 2015 is uncertain, as is estimated cost of SPOT imagery covering the whole national land in this trial calculation. For the calculation, the necessary number of the scenes can be calculated by dividing the area of national land by unit area per scene of SPOT imagery. Then the cost of multiplying the number of scenes and unit price per scene of SPOT imagery is calculated.

Satellite Imagery analysis expenses: US$163,000
The expense of satellite imagery analysis was estimated based on the expense of the analysis when the forest distribution map of 1990 was prepared in the Study. Visual interpretation as a technique of satellite imagery analysis is applied for the estimation of expense, while it can be anticipated that a more efficient method, such as a semi-automatic method, will be developed by the year 2015. Therefore, the expense mentioned in this section is based on the techniques which could be employed with visual interpretation as of year 2010.
Field survey expenses: US$300.000
For the satellite imagery analysis, field surveys are needed at three stages. They are 1) collection of training sample data, 2) correction of analysis results for land classification, and 3) verification of the results.

1) It is difficult to estimate the expense for the collection of training sample data, because the data can be acquired by field surveys, as well as from complementary information such as forest status maps. In this calculation, necessary expense was estimated assuming that two technical staff members could carry out the field survey over two weeks per province. In addition, unit personnel expense for the FIPI technical staff was applied for the estimation.
US$4,000 /province x 63 provinces = US$252,000

2) The expense of correction of analysis results for land classification was also estimated assuming that the same duration is necessary with the collection of training sample data.

US$4,000 /province x 63 provinces = US$252,000

3) Necessary expense for the verification of the analysis results varies with two methods, which are internal verification and third-party verification. In this calculation, the expense was estimated under the assumption that the verification survey is conducted by random sampling in each province based on the method of internal verification by two technical staff members over 10 days per province.
US$2,500/province x 63 provinces = US$157,500

Total cost is US$661,500 by summing the three kinds of expenses mentioned above. Meanwhile, field survey should be conducted only in forest areas. Therefore, assuming that forest coverage rate as of 2015 is forecasted as 45%, the final expense of the field surveys is approximately US$300,000.

(3) Transaction cost

Two kinds of transaction costs are assumed: the transaction cost of forest conservation activities; the transaction cost of monitoring.

Ten percent of the cost of the activity mentioned in 7.2.2 (1) as transaction cost for the activity, and 10% of cost of the monitoring mentioned in 7.2.2 (2) as transaction cost for the monitoring are added up.

Transaction cost of the activity： US$541,600,000 x 0.1＝US$54,160,000
Transaction cost of the monitoring：US$2,236,000 x 0.1＝US$223,600
The total becomes US$54,383,600 if the two transaction costs are added together.

(4) Total cost

The total cost is shown in the following table.

Items	Amount
Forest protection activity cost	541,600,000 US$
Monitoring cost	2,236,000 US$
Transaction cost	54,383,600 US$
Total	598,219,600 US$

7.2.3 Analysis of Costs and Benefits

Comparing US$1,820,500,000 of REDD+ benefit mentioned in 7.2.1 and US$598,219,600 of REDD+ cost mentioned in 7.2.2 in this trial calculation, a surplus of US$1,222,280,400 can be generated.

However, it should be noted that the surplus is a figure based on the assumptions of the trial calculation mentioned above. In reality, 1) it is impossible for the reduction of forest to be zero (in other words, it is impossible for all forest to be protected); the figure of surplus has to be smaller than the surplus based on this trial calculation, 2) the method of averaging historical trend for extrapolation for the future was taken for this trial calculation, but it is not assured that the method will be approved by the UNFCCC at present; therefore, if other extrapolation methods such as a polynomial model are adopted, the benchmark value will be smaller than 331 MCO_2t, which is used for this trial calculation. Moreover, regarding the cost estimation, the transaction cost in this calculation is estimated as 10% of other costs; however, it may involve the possibility of cost increase.

Taking into account the factors mentioned above, the surplus of US$ 1,222,280,400 inevitably has to be smaller.

Finally, the total REDD+ benefit necessary to offset the cost given in the trial calculation is estimated. Dividing total cost of US$598,219,600 by 5.5 US$/CO_2 tonmakes approximately 109 MCO_2 tons. Therefore, if the emission of 109 MCO_2 tons from deforestation and forest degradation is reduced as compared with the benchmark value in 2015, at least the cost given in the trial calculation can be offset.

8. Model Land Survey

As a part of the study, several case studies called “Model land surveys” were carried out. Each survey entailed a critical analysis of the potential of REDD+ implementation at the local level, identifying the present conditions of deforestation and forest degradation and estimating the economic costs/benefits and carbon benefits of the provisional REDD+ measures. These surveys were conducted in Binh Phuoc, Dak Nong, Nghe An, and Kon Tum Provinces, and the results indicated the potential REDD+ measures in each province.

Since the results of the model land survey are presented in Interim Report 2 of the Study and in the booklet titled “The Economic Feasibility of Reduction of Emission from Deforestation and Forest Degradation in Vietnam: Case Studies in Forest Conservation, Community Forest Management, Forest Plantation, and Rubber Development” which was prepared as one of the outputs of the Study and is the final version of the report on the results, description in this chapter is a summary of the results. For the full version of report on the results, please refer to the report or booklet mentioned above.

8.1 Objective

It is generally accepted that the forces driving deforestation and forest degradation in Vietnam are roughly divided into five categories: 1) conversion of forest to large-scale commercial agricultural lands (e.g. rubber plantations); 2) encroachment in the form of small-scale agricultural development by local people; 3) unsustainable forest management; 4) exploitation of forests for material supply (timber, fuel wood, and other forest products); and 5) other development (e.g. road, hydroelectric power plants, resettlement, industrial land mining) (DOF, 2009).

The objective of the model land survey was to examine actual situation of deforestation and forest degradation at the local level and to explore the potential of climate change mitigation in the forest sector by quantifying financial costs/benefits and carbon benefits through provisional project implementation.

8.2 Survey Specification

Based on the results of preliminary surveys carried out in November 2009, and in January and June 2010, the following four themes were selected for implementation.
The surveys were subcontracted to Research Centre for Forest Ecology and Environment (RCFEE), Forest Science Institute of Vietnam (FSIV) and Vietnam Forestry University (VFU). The surveys were completed by March 2011.

	Survey title	Subcontractor
1	Reduction of emission from deforestation and forest degradation by mitigating rubber plantation development in Binh Phuoc Province	RCFEE
2	Reduction of emission from deforestation and forest degradation through implementation of CFM and enhancement of forest management by forest company in Dak Nong Province	FSIV
3	Reduction of emission from deforestation and forest degradation through development of forest plantation in shifting cultivation site in Nghe An Province	VFU
4	Reduction of emission from deforestation and forest degradation through participation of community in forest management and protection in Kon Tum Province	FSIV

8.3 Survey Methods

The surveys varied in their methodologies. The surveys had six components: 1) literature review, 2) description of driving forces of deforestation, 3) socio-economic survey, 4) selection of REDD+ activities, 5) carbon analysis, and 6) leakage and risk assessment.

(1) Literature review on survey area/site

Literature reviews on natural and socio-economic conditions of the survey area were carried out from statistical (provincial and district level) and other available data.

(2) Specification/description of driving forces of deforestation

The survey analyzed direct and indirect causes for deforestation by different levels (proximate causes, mediating factors, trigger events, and underlying forces).

(3) Socio-economic survey

1) Specification of deforestation process

The survey attempted to clarify the characteristics of deforestation drivers through stakeholder interviews.

2) Estimation of economic benefits of natural forest and agricultural development by local people

The survey estimated economic benefits from natural forests by local people and from development activities by developers (natural forests by local people, crop cultivation by local farmers, timber harvest by forest companies/local communities, rubber plantation by agroforestry companies, etc.). The present value of each land use/conversion was calculated.

3) Assessment of land ownership

The survey assessed the land ownership in the process of deforestation.

4) Workshop on attitude of local people towards large-scale agricultural development (only in Binh Phuoc Province)

(4) Elaboration of REDD+ activities

Potential REDD+ activities to maintain forests and/or reduce deforestation were elaborated upon. The activities specified were: 1) rubber plantation development by replacing cashew plantations, 2) introduction of CFM in natural forests currently managed by forest companies, 3) forest plantations in shifting cultivation sites, and 4) CFM and Community-based Forest Protection (CBFP) in high-stock natural forests. The survey analyzed costs and benefits of the activities. Net present values of land use options were also estimated based on cost and benefit projection.

(5) Carbon Analysis

1) Analysis of historical deforestation

Change of the forest areas in the past was analyzed for the survey site by using satellite images.

2) Assessment of actual carbon stock (only in Dak Nong and Nghe An Provinces)

Actual carbon stocks in existing forests were assessed in each land use type in the study at Dak Nong. Baseline carbon accumulation after abandoning shifting cultivation was assessed in the study at Nghe An.

3) Estimation of carbon benefit by REDD+ activity

The survey estimated carbon benefit associated with REDD+ activities by using conservative carbon price.

4) Leakage and risk assessment

Leakage and risk for the implementation of REDD+ activities were assessed.

8.4 Results of Surveys

8.4.1 Reduction of Deforestation and Forest Degradation by Alternative Rubber Plantation Development in Binh Phuoc Province

Rubber plantations are being developed overwhelmingly in Binh Phuoc Province. Natural forest area in Binh Phuoc has been reduced to half in the last nine years. According to the statistical data and the rubber development master plan, 15,000 ha of rubber plantations were developed in 2008 and development of 37,000 ha of rubber plantations is planned by 2020. The plan is beyond the national strategy (Decision by the Prime Minister) which allocated 25,000 ha of new rubber plantations to the South East South region. According to the guideline, rubber plantation is allowed to replace only forest with low forest resource (<50m^3 for timber and bamboo mixed forest).

In order to calculate the potential to mitigate deforestation through rubber plantation development, the benefits received by the local population from natural forests were surveyed and alternative strategies were elaborated on. Dong Nai Protection Forest Management Board (PFMB) was selected for the survey due to the large remaining forests with high carbon stock used by the local population.

Economic analysis of land use

The economic analysis showed high economic potential of rubber plantations, reflecting the high rubber price. Net Present Value (NPV) of rubber plantation was eight times that of medium timber forests, although a large amount of initial investment is required. Local authority prioritizes economic development and a large amount of investments from Ho Chi Minh City is expected for further rubber development.

Dependence on natural forest by local people

However, it should be noted that local people are largely dependent on natural forest resources. The result of socio-economic survey suggested that approximately 20% of the income of local people was from natural forests, utilizing vegetables, firewood, and timber. Average income (including cash and direct benefits from forest) of one household was 4,160 USD/household/year and total annual economic benefits from natural forests for one household are approximately 815 USD/household/year (mainly vegetables). A workshop with local people demonstrated the mixed feelings of villagers towards rubber plantations: threats of income loss from natural forests and the expectation of income from rubber plantations. Also, since rubber plantations take away the lands which local people encroached, it may cause further encroachment on other forest land.

Income structure of local people

The survey suggested that the income of local people is largely from sales of cashew nuts (73%), which occupied 90% of their lands (3.8 ha). However, the productivity of cashews was low (1.5 ton/ha). Therefore, local farmers were interested in replacing cashew with rubber if funds are available.

Analysis of historical deforestation and forest degradation

Analysis of historical deforestation and forest degradation showed that forest areas in Binh Phuoc have decreased dramatically in the last decade. Approximately 56,075 ha of forest were lost during 2000 – 2009, 0.9% per year (6,230 ha/year). It is important to point out that most of deforestation took place in forests with smaller carbon stock (bamboo forest, stocked regenerated timber forest, and bamboo/timber mixed forest) where the conversion to agricultural lands was relatively easy.

Comparison of cost and carbon credit between BAU and alternative scenario

The changes of NPV and carbon stock between BAU (rubber plantations development on natural forests) and an alternative scenario (rubber plantation development by replacing cashew plantations) were estimated. The results suggest that the economic loss from utilizing cashew plantation replacing natural poor and stocked regenerated forests was much larger than potential carbon credits earned by reducing carbon loss from natural forests.

However, it should be noted that carbon credit could play a significant role to support the cost of cashew/rubber replacement by local people. Thirty-seven percent of the initial material cost for rubber plantation development can be covered with carbon credits (US$3/$CO_2$ton) and the remaining initial cost can be paid by less than one percent of the income from resin sales that start in the 7th year. This suggests that it may not be difficult for local land plantation owners to pay back the credits.

8.4.2 Reduction of Deforestation and Forest Degradation through Implementation of Community Forest Management and Enhancement of Forest Management by a Forest Enterprise in Dak Nong Province

In recent years, Dak Nong Province has experienced rapid economic growth and deforestation and forest degradation. The economic growth rate of Dak Nong has been considerable: 13.6% during 2004-2006 and 15.4% during 2006 – 2008. The development pressure caused by a large number of immigrants searching for agricultural lands to survive or to have a better life is inevitable.

The objective of the survey was to determine the potential of reduction of deforestation and forest degradation through introduction of CFM and improved forest management by forest companies in Dak Nong Province.

The surveys were carried out at two sites: Village 6 in Tuy Duc district (117 households with 716 people, mainly M'Nong people, Located 20 km away from the district town) where forests are allocated to the local village; and Nam Nung Forest Company (Total area: 10,654 ha).

Deforestation and forest degradation in Dak Nong Province

In the period between 1990 and 2005, the four forest/land types (medium forest, poor forest, timber and bamboo mixed forest, and bare land) decreased significantly. On the other hand, the area of the four land types (agricultural land, coffee, rubber and cashew, and stocked regenerated forest) increased considerably.

In the period between 2005 and 2010, the total area of medium forests decreased by 70%, approximately 26,000 ha/year on average, which were replaced by poor and rehabilitated forests, as well as agricultural lands. On the other hand, the area of forest lands without forests increased by 33% (1,610. ha/year on average), showing the rapid conversion to perennial crop cultivation (coffee, rubber, pepper, etc.).

Carbon stock change in Dak Nong Province

Dak Nong Province has experienced significant carbon stock loss over the last two decades. The carbon stock reduced by 34,327,149 CO_2ton, (2,288,477 CO_2ton/year) between 1990 and 2005, and 29,946,693 CO_2ton (5,989,339 CO_2ton/year) between 2005 and 2010. This suggests the carbon value loss was approximately 18 million USD/year (3 USD/CO_2ton), which is a significant value for Dak Nong Province.

Deforestation and carbon stock change in Village 6 between 2005 and 2010

Forest lands in Village 6 were reduced by 22% (46% of poor forests and 33% of bamboo forests) between 2005 and 2010, whereas bare lands and agricultural lands increased by 81% and 7%, respectively.

Carbon stock change in the period of 2005-2010 was 19,935 CO_2 ton of carbon (3.6 CO_2ton/ha/year). During the period, according to Community Forest Management Plan, 802 m^3 (0.73m3/ha) of timber was harvested and 3,737 tons of fuel wood was consumed in the villages by 117 village households (17.5 kg per household).

Deforestation and carbon stock change in Nam Nung Forest Enterprise between 2005 and 2010

Between 2005 and 2010, large areas of medium forests and mixed bamboo forests were reduced (51% and 46%, respectively) and poor forests and rubber/forest plantations increased (167% and 137%, respectively) in natural forests of Nam Nung Forest Enterprise. The carbon stock loss between 2005 and 2010 was estimated at 495,809 CO_2 ton (7.3 CO_2ton/year/ha).

Timber harvest in Nam Nung Forest Enterprise

Harvesting method is selective cutting of economically valuable trees with intensity between 22.0% and 27.4% of total volume. Total harvested volume during 2005 and 2010 was 4,083 m^3 (0.30 m^3/ha on average).

Comparison of timber production and carbon stock efficiency in Village 6 and Nam Nung Forest Enterprise

CFM in Village 6 produced 2.8 times more timber per hectare than Nam Nung Forest Enterprise but lost approximately a half the carbon, suggesting that CFM could save approximately 120 CO_2ton of carbon per 1 m^3

of timber production (equivalent to approximately 360 USD at 3USD/CO_2ton).

8.4.3 Development of Forest Plantation on Shifting Cultivation Site in Nghe An Province

Large areas of natural forests were deforested/degraded by shifting cultivation in Nghe An Province. The lands were degraded after intensive use of the cultivation for a few years, causing soil erosion. Due to the expanding timber market of fast growing species, forest plantation is commonly found in the area near the coast, providing income for forest managers. However, in remote areas where the timber market is not accessible, shifting cultivation is largely practiced and thus lands are being degraded.

On the other hand, along with economic growth, the demand for electric power has been rapidly increasing in Vietnam. In order to supply more electricity, the government of Vietnam is rapidly constructing hydroelectric power stations where power potential is existent. It is considered that through mitigating deforestation and forest degradation, carbon credits may be able to contribute to watershed management of a hydroelectric power station by replacing shifting cultivation with forest plantation.

The objective of the survey was to determine the potential to establish forest plantations on shifting cultivation sites by using carbon credits. Shifting cultivation areas in a watershed of Ban Ve hydro-power station in Yen Na and Luong Minh communes, Tuong Duong district (Thai and Kho Mu people) were selected for the survey sites. Yen Na and Luong Minh communes are located along the Nam Chu River, where the Ban Ve hydro-power dam was recently constructed.

Eligibility of plantation scheme

The percent of eligible areas for A/R CDM (non-forest as of 1990) was lower than that for voluntary scheme (non-forest as of 2000), suggesting that using the voluntary scheme has a much larger potential. Non forests as of 1990 were 15.7% and 6.3% in the Yen Na and Luong Minh communes, respectively, whereas non forests as of 2000 were 24.7% and 40.7%, respectively.

Farm productivity of shifting cultivation

Upland rice is the major crop of agriculture production produced by shifting cultivation (83% and 74% of total income in Luong Minh and Yen Na, respectively) followed by corn (12% and 17%, respectively). Gross revenues were estimated at 233 USD/ha/year (90 USD/ha/year including fallows) in Luong Minh and 184 USD/ha/year (71 USD/ha/year including fallows) in Yen Na.

Carbon estimation of shifting cultivation and forest plantation

Based on the growth tables, carbon accumulation values of *Acacia mangium* and *Acacia auriculiformis* were compared and *Acacia auriculiformis* was identified as the better species due to the higher growth in 15 years (Figure 8.1).

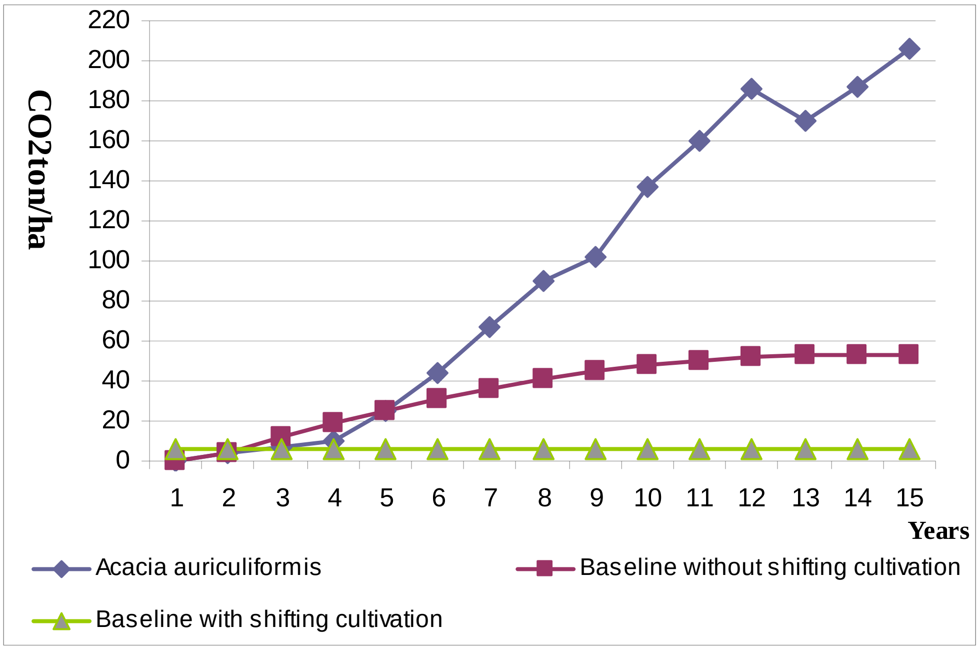


Figure 8.1 Carbon accumulation of Acacia auriculiformis plantation and Baseline Scenario

<u>Comparison between shifting cultivation and Acacia plantation</u>

Net present value of net revenue of shifting cultivation was compared with Economic benefit of Acacia plantations (wood/chip sales and carbon credits). The result suggest that at Yen Na, where shifting cultivation is less profitable, forest plantations were more profitable than shifting cultivation, whereas at Luong Minh, where local people rely on shifting cultivation, shifting cultivation was economically more profitable. This result suggests that forest plantation with carbon credits can be promoted on shifting cultivation sites where shifting cultivation is not very profitable (other job opportunities are available).

8.4.4 Reduction of Emission from Deforestation and Forest Degradation by Forest Protection and Reduced Impact Logging through Community Participation in Kon Tum Province

In the last decade, Kon Tum Province has undergone dynamic change in forest management. Currently four types of forest ownership are practiced in the province: 1) Forest Companies, 2) Protection Forest Management Board, 3) long-term village ownership, and 4) Communes through PPC. Community-based Forest Protection (CBFP) is being carried out in protection forests, whereas CFM is planned in production forests owned by local villages.

The objective of the survey is to determine the potential of community participation in natural forest management for increasing future carbon stock in Kon Plong District. In the survey, provisional implementation of CFM and CBFP models for Vi Ch'Ring Village was compared.

<u>Carbon stock change in Kon Tum Province and Kon Plong District between 1990 and 2010</u>

In Kon Tum Province carbon stock in natural forests was reduced between 1990 and 2000 by 1.9 million CO_2 tons (3.0 CO_2ton/ha) but increased between 2000 and 2010 by 3.2 million CO_2 ton (3.5 CO_2 ton/ha). As a whole in the period between 1990 and 2010, carbon stock of natural forests in Kon Tum increased 0.25 CO_2ton/ha/year. In Kon Plong District carbon stock in natural forests was reduced significantly between 1990 and 2000 but increased slightly between 2000 and 2010. As a whole, carbon stock loss in natural forests in the last two decade was 2.6 million CO_2ton (1.2 CO_2ton/ha/year), most of which occurred in the period of 1990 and 2000 by large reduced areas of rich and medium forests.

Cost benefit and carbon stock change in CFM and CBFP models

The survey results demonstrated that carbon benefit was larger than forest protection cost in the CBFP model, suggesting the potential of REDD+ implementation by this model in the village. The cost of CBFP may be compensated by carbon credits for the forest with timber volume above 285m^3/ha. The survey recommends implementation of CBFP by carbon credits for such high carbon stocked forests.

In the CFM model, carbon credits are lower than forest protection cost due to the carbon loss by timber harvest, but total benefit was five times larger than that of CBFP due to the profit from timber logging, suggesting that a large potential of CFM implementation either with or without carbon credits.

However, carbon credits from natural growth account for 19% of net economic benefits of timber sales and carbon, suggesting a sufficient role of carbon credits in CFM implementation. It should be noted that the most of carbon credits stem from protected forests (no harvest zone) in the management plan. The survey recommends implementing CFM with protected forests for carbon credits.

8.5 Conclusions and Recommendations

(1) Reduction of deforestation and forest degradation by mitigating rubber plantation development in Binh Phuoc Province

The survey suggests that the economic loss from replacing cashew plantations with rubber plantation development instead of natural poor and stocked regenerated forests was much larger than potential carbon credits earned by reducing carbon loss from natural forests. However, 37% of the initial material cost for rubber plantation development is covered with carbon credits (US$3/$CO_2$ton) and the remaining initial cost can be paid by less than one percent of the income from resin sales that start in 7 years.

The survey recommends carrying out a national level study on potential of rubber plantation development on cashew plantations (e.g. soil conditions, organizing land owners, financial support) and incorporating the results in REDD+ strategy.

(2) Reduction of deforestation and forest degradation through implementation of CFM and improved forest management by forest companies in Dak Nong Province

The survey showed that CFM in Village 6 in Dak Nong Province produced 2.8 times more timber per hectare than Nam Nung Forest Enterprise but lost approximately half the carbon, suggesting that CFM could save approximately 120 CO_2ton of carbon per 1 m^3 of timber production (equivalent to approximately 360 USD at 3USD/CO_2ton).

The survey recommends carrying out a national level study on potential of CFM implementation in high stock natural forests owned by forest companies by using carbon credits and incorporating the results in REDD+ strategy.

(3) Reduction of emission from deforestation and forest degradation through development of forest plantation in shifting cultivation sites in Nghe An Province

The survey suggested that forest plantation with carbon credits can be promoted on shifting cultivation sites close to main roads where shifting cultivation is economically less profitable (other job opportunities are available) (e.g. Yen Na commune) than in remote areas where villagers' lives rely on shifting cultivation (e.g. Luong Minh commune).

The survey recommends carrying out a national level study on potential of forest plantation development on shifting cultivation sites focusing on areas with low productivity and close to main roads where timber can be shipped out easily.

(4) Reduction of emission from deforestation and forest degradation by forest protection and reduced impact logging through community participation in Kon Tum Province

The survey results demonstrate that carbon benefit was larger than forest protection cost in the CBFP model. The cost of forest protection is compensated by carbon credits for forests with timber volume above $285m^3$/ha. The survey recommends ensuring the cost of the forest protection scheme (e.g. Decision 30A) for high carbon stocked forests by incorporating carbon credits produced by the REDD+ scheme.

In the CFM model, carbon credits are lower than forest protection cost due to the carbon loss by timber harvest, but total benefit was five times that of CBFP due to the profit from timber logging. Carbon credits from natural growth account for 19% for net economic benefits of timber sales and carbon in the CFM model. The survey recommends implementing CFM combined with protected forests and incorporating the carbon credits produced from the carbon stock gain by the REDD+ scheme.

9. Preparation of the Basic Plan for REDD+ Development in Dien Bien Province

Explanation on the basic plan for REDD+ development in Dien Bien Province is described in this chapter.

The objective of preparation of "the Basic Plan for REDD+ Development in Dien Bien Province" is to contribute to the development of the mechanism on REDD+ and other measures while improving the livelihoods of the rural population and maintaining biodiversity in the province, and to clarify the process of developing the REDD+ pilot activities toward realization of their implementation.

For developing the REDD+ pilot activities, it is important to strengthen forest governance to maintain/enlarge areas of forest plantations, forest protection, and restoration by providing the stakeholders with incentives toward those activities, considering the livelihood improvement of ethnic minorities and biodiversity conservation. For this strengthening, it is indispensable that the capacity of provincial/local organizations with regard to REDD+ be developed through the implementation of REDD+ pilot potentially eligible for the credit payment. Since the preparation of the basic plan is in a process of implementation, the preparation could play a role of capacity development.

In addition, regarding the plan's standing, the Vietnamese Government is now preparing the National REDD+ Program (NRP) and also intends to prepare a REDD+ Program for every province according to the NRP. Therefore, the plan is set for the readiness stage to contribute to establishment of the Provincial REDD+ Program in Dien Bien Province to be developed in the future.

9.1 Methodology of the Preparation

For the preparation of the basic plan, the following methods and procedures were followed.

1) Implementation of Survey on Natural Resources and Socio Economic Conditions for REDD + Activities in Dien Bien Province by Sub-Contract.

"Survey on Natural Resources and Socio Economic Conditions for REDD + Activities in Dien Bien Province" (hereinafter referred to as "the Survey") was conducted by sub-contract for collecting secondary and statistical data of whole communes in the Province and collecting information on natural resources and socio economic conditions for REDD + in the 80 villages of 40 communes. The report of the Survey by sub-contractor is shown in the Appendix 12.

2) Implementation of the Study by Japanese members of the Study Team

Field surveys by members of the Study Team combined with supervision of the Survey as the sub-contract work were conducted as a complement to the Survey. In addition, the members held interviews on REDD+with related organizations. The members also studied any related information on REDD+.

3) Organizing Awareness-raising Workshop on REDD+

An awareness-raising workshop on REDD+ was organized for the related officers on REDD+ in DARD, Sub-DoF, FPD, DPC, FPMB, NRMB to facilitate their understanding of REDD+ and recognition of the necessity of the basic plan.

4）Organizing a Workshop to Present and Discuss the Draft Initial Basic Plan for REDD+ Development in Dien Bien Province

A workshop to present and discuss the draft initial basic plan was organized for the related officers on REDD+ in PPC, DARD, DONRE, Sub-DoF, FPD, DPC, FPMB, and NRMB. Natural and socio-economic conditions were presented and discussed as the initial basic plan, including the dynamism of forest regarding REDD +in Dien Bien Province, draft potential REDD+ activities, proposal of methods for selection of prioritized area for each potential REDD+ activity.

5）Selection of Prioritized Area for Each Potential REDD+ Activity

Prioritized area in commune units for each potential REDD+ activity were selected for the implementation of REDD+ activities in Dien Bien Province.

6）Presentation and Discussion on the Basic Plan for REDD+ Development in Dien Bien Province

A workshop to present and discuss the basic plan will be organized for the related officers on REDD+ in PPC, DARD, DONRE, Sub-DoF, FPD, DPC, FPMB, and NRMB.

9.2 The Basic Plan for REDD+ Development in Dien Bien Province

The contents of the basic plan are as follows,

Introduction

1. Objectives of Basic Plan for REDD+ Development in Dien Bien Province

2. Natural and Socio-economic Conditions Regarding REDD +in Dien Bien Province
2.1 Status of Forest Lands and Forest Resources
2.1.1 Land Allocation by District and Forestry Land by Category and District
2.1.2 Latest Forested Land Area by Forest Type
2.1.3 Change of Forest Resources with Carbon Stock since 1990
2.1.4 Driving Force of Deforestation and Forest Degradation
2.1.5 Other Related Factors
2.2 Socio-economic Conditions
2.2.1 Demographics
2.2.2 Status of Income
2.2.3 Farming system
2.2.4 Paddy Area per Capita
2.2.5 Forestry Activities by Locals and Private Sector
2.2.6 Land Allocation

3 Conditions for REDD + Implementation
3.1 Social Acceptability for REDD+ Implementation
3.2 Economic Feasibility for REDD+ Implementation

4 Forestry Policy/Program and Institutional framework in Dien Bien Province
4.1 Review of Program 661 of Five Million Hectare Reforestation Program (5MHRP)
4.2 Forest Protection and Development Plan (FPDP) 2009 – 2020

Since the basic plan was printed in a separate volume as the Annex I of the Report, please refer to the volume for details of the basic plan.

10. Development of Method to Estimate Forest Carbon Stock in Dien Bien Province

This Chapter described the development of an allometric equation of tree biomass and biomass expansion factor of single tree level by biomass measuring survey of dominant tree species. First, the estimation of forest biomass and carbon stocks based on allometric equations, biomass expansion factors, and every tree census data of the 90 survey plots in the Muong Nhe Nature Reserve is described. Furthermore, the development of conversion factors for estimation of forest biomass per unit area from growing stock per unit area of the forest is explained.

Section 1 explains the allometric equations, the biomass expansion factors, and the R/S ratio. Particularly, the details of the biomass measuring survey of 30 trees of the dominant species and the tree census of the 90 survey plots to obtain data on Muong Nhe Nature Reserve to calculate these formulas and factors are shown.

Section 2 examins the advantages and disadvantages of the biomass expansion factors and the allometric equations respectively obtained in Section 1. Based on the results, the Study calculated the aboveground and belowground biomass of each tree in the 90 plots using an allometric equation for aboveground biomass and R/S ratio. Then, the data are tabulated for each plot, and converted to aboveground and belowground biomass per hectare. After that, the carbon stocks per hectare are estimated for each plot.

In Section 3, the Study develops conversion factors and R/S ratio which can estimate aboveground and belowground biomass per hectare directly from growing stock per hectare and aboveground biomass per ha, using growing stock, aboveground biomass, and belowground biomass of the 90 plots. These conversion factors and R/S ratio aim at establishing a simple method to easily estimate forest biomass for local technicians.

Section 4 summarizes the issues for higher accuracy of the allometric equations and biomass expansion factors which were developed in this development study. In addition, the need for survey of the Re-growth forests is mentioned, which was not covered in the Study.

10.1 Forest biomass measurement survey in Muong Nhe Natural Reserve in Dien Bien Province

10.1.1 Objective, methodology, and study site

(1) Objective

The objectives of the survey are to develop or measure the following items that can be applied to measurement of carbon stock in the evergreen broad leaves forest in northwest part of Vietnam.

- The biomass expansion factor that can be applied to all classes of diameter at breast height or the biomass expansion factor based on each class of diameter at breast height.
- The root/shoot ratio that can be applied to all classes of diameter at breast height or the root/shoot ratio based on each class of diameter at breast height.
- The wood density of the major species in the evergreen broad leaves forest

The above are to be applied to estimating forest carbon stock at one time that serves as the basis to estimate change of the forest carbon stock over time.

(2) Methodology

a. Setting sampling plots

A total of 90 sampling plots of 50m x 50m are selected in the forests of different carbon stock levels covered within the evergreen broad leaves forest, consisting of 30 plots each from rich forest, medium forest, and poor forest.

For setting the plots in each forest type, a standard plot sampling method is employed based on expert judgment. For instance, a sampling plot which meets the conditions and definition of rich forest can be set as a sample plot for rich forest even though the sample plot is allocated in medium forest on the forest distribution map base.

b. Measurement of the trees in the sampling plots

In every sample plot, the name of tree species, DBH, and total tree height of all trees having the DBH of 5 cm or larger are identified and measured.

A total of 30 trees of 3 dominant species in terms of population and appearance frequency are selected from the 90 plots for biomass measurement. The dominant tree species are identified after survey of 30 plots. The number of trees sampled in each diameter class shall reflects the total number of trees of the corresponding diameter class found in the first 30 sampling plots.

c. Measurement of the samples

The trees selected for biomass measurement are cut down and their roots dug up. The exact DBH and total height of each sample tree are measured and recorded. Then, the parts of the trees, including stems, branches, and leaves, are separated and their fresh biomass are weighed. For the roots, a hole is dug in accordance with extension of the canopy and all the roots are collected and weighed for fresh root biomass.

After completion of fresh biomass measurement of sample trees, sampling is employed to take a sample of every tree organ (stem, branch, leaf, and roots). The weight of sample is 200 – 500 grams. Fresh weight of all samples are weighted exactly and coded for dried mass analysis in a laboratory.

For wood density analysis, disc wood samples of 2 cm thickness at 0 m in height, 1.3 m in height, the midpoint of tree height, and the top point of tree height are taken and coded for analysis in a laboratory for wood density.

d. Laboratory work

All samples of each tree organ collected in the field are dried in a drying oven at a temperature of 105°C for 72 hours to measure absolute dry weight and to calculate the ratio of dry weight to fresh weight for each organ.

Analysis of wood density follows TCVN 8048 – 2 (2009). To analyze wood density of sample trees, the volume of every disc wood sample is measured, then the sample is oven-dried and its dry weight measured.

e. Data input and analysis

1) Standing wood volume of survey forests area is calculated as follows:

$$M = \frac{10.000}{S}\sum_{i=1}^{n} Vi \qquad (1)$$

Where: M is standing wood volume of forest; S is flat area of sample plot in m^2; and *Vi* is the tree volume of tree number i and tree volume (*Vi*) is calculated by the following formula:

$$Vi = \frac{DBHi^2}{4} * \pi * Hi * f \qquad (2)$$

Where: *DBHi* is diameter at breast height of tree i; *Hi* is total tree height of tree i; and *f* is form factor of the tree. The default value of form factor for natural forest is 0.45 (FIPI 1995).

2) Total dry weight (TDW) for each organ of the sample trees:

Total dry weight for each organ of sample trees is calculated based on total fresh weight of each organ measured in the field and the ratio of dry weight to fresh weight calculated for each organ in the laboratory. The formula is *TDW* calculation is as follows:

$$TDW = TFW\,\frac{SDW}{SFW} \qquad (3)$$

Where: *TDW* is total dry weight; *TFW* is total fresh weight; *SDW* is absolute sample dry weight; and *SFW* is fresh sample weight;

3) Regression analysis:

Statistics in ExCel are used to analyze relative correlation between different organs on the basis of DBH and the dry weight of each organ for each forest carbon stock level. For example, DBH – total dry weight of above ground organs; DBH – dry weight of each organ, etc. The correlation between biomass and DBH will be set up in power and logarithms forms.

4) Calculation of Biomass Expansion Factor (BEF) and Root shoot ratio (RS):

The biomass expansion factor is calculated for every sample tree. BEF is calculated by the following formula:

$$BEF = \frac{TDWa}{TDWs} \qquad (4)$$

Where: *TDWa* is total dry weight of aboveground organs (The same AGB); *TDWs* is total dry weight of a stem;
The root/shoot ratio (*RS)* is generated by the following formula:

$$RS = \frac{TDWb}{TDWa} \qquad (5)$$

Where: *TDWb* is total dry weight of tree belowground organs (The same BGB); and *TDWa* is total dry weight of tree aboveground organs.

5) Wood density:

Wood density of every wood disc for each sample tree species is analyzed in the laboratory and is calculated by the following formula:

$$WD = \frac{SDWc}{SV} \qquad (6)$$

Where: *WD* is wood density in g/cm^3; *SDWc* is dry weight of sample cube; and *SV* is volume of a sample cube.

(3) Study site

The study site is in core-zone of the Muong Nhe NR in Muong Nhe District of Dien Bien Province of Vietnam. The Muong Nhe NR is located in the Northwest part of Vietnam and shares borders with China in the north, with Cha Cang commune of Muong Nhe district in the southeast; with Muong Te district in the east; and with Laos in the west.

The Muong Nhe NR area is distributed on six frontier communes of Muong Nhe district: Sin Thau, Chung Trai, Muong Nhe, Muong Toong, Nam Ke, and Quang Lam. Total area of Muong Nhe NR is 169,962 ha, of which natural forest area is about 82,200 ha, estimating at 48% of total area; the other land includes agricultural land and unused land area (Dien Bien FPD 2008). Evergreen broad leave forest is the dominant forest type in Muong Nhe NR. There are 156 families of flora and a total of 740 tree species. The number of tree species for the 10 biggest flora families is about 264 (Dien Bien FPD 2008).

Muong Nhe NR has high mountainous topography which is strongly separated by high slope gradients. The highest peak is Pu Pa Kun at 1.892m. The topography lowers from northwest to southeast (Dien Bien FPD 2008).

According to Dien Bien FPD (2008), there are three major soil types in Muong Nhe NR. Bright yellow humus soils with light texture commonly distribute in the areas with elevation of 1,600 – 1,800m. Reddish yellow humus soils with light to medium texture are found in the areas having elevation of 700 – 1,600m; and yellowish red soils developed on shale and sandstone and with medium texture are found in the area with elevation of less than 700 m.

The area is influenced by tropical monsoon climate regime. As the block of Hoang Lien Son mountain range, Muong Nhe NR is lightly influenced by northeast wind, the winter normally ends sooner and the temperature is not too low compared to other high mountain areas. There are two distinct seasons, the rainy and dry seasons. The rainy season starts from April and lasts until October. The mean annual temperature is 22.5°C, the absolutely highest temperature is 39°C, and the lowest temperature is 7°C. The mean annual rainfall is about 1,950 mm, which is mainly from the rainy season, from June to August, accounting for 80% of total annual rainfall. Mean humidity is about 85%.

10.1.2 Results and Discussion

(1) Wood standing volume and tree species composition

A total of 90 sample plots were studied for different carbon stock levels: poor, medium, and rich forest. As regulated by Circular No. 34/2009/TT-BNNPTNT, poor, medium, and rich forests were classified by wood standing volume (MARD 2009). Per this regulation, poor forest is forest having standing wood volume less than 100 m^3 ha^{-1}; medium forest has standing wood volume from 100 – 200 m^3 ha^{-1}, and rich forest has standing volume over 200 m^3 ha^{-1}. The data on tree density and standing wood volume of 90 sample plots are shown in Table 10.1.1.

Table 10.1.1 Standing wood volume of sample plots

Forest type	No. of sample plots	Average density (tree/ha)	Average standing wood volume (m^3/ha)	Standard deviation (m^3)
Poor forest	29	1,324	75.51	21.44
Medium forest	31	1,353	156.00	24.67
Rich forest	30	1,068	254.58	61.44
Average		**1,248**	**160.69**	**35.85**

The results show that poor forest and medium forest have similar values of average tree density. Meanwhile, rich forest has an average tree density of about 1,068 trees/ha. The differences in the density of the forest types clearly reflect competitive principles in the evolution progress of natural forests. The plot data also show that the average wood standing volume of natural forests in Muong Nhe NR ranges from 75.51 m^3/ha to 254.58 m^3/ha, depending on the status of forests. The mean standing wood volume is 75.51 ± 21.44 m^3/ha for poor forest; 156.00 ± 24.67 m^3/ha for medium forests; and 254 ± 61.44 m^3/ha for rich forests. This means that there is big variation of standing wood volume among rich forests, with smaller variations for medium forests and still smaller for poor forests.

Considering wood volume distribution by diameter class, trees are divided into 5 classes: 5-15-cm, 15-25-cm, 25-35-cm, 35-45-cm, and 45 cm or bigger. The analysis of standing wood volume distribution by diameter class is shown in Figure 10.1.1 for the three forest types. The results show that, for poor forest, the wood volume mainly concentrates on diameter class of 15 – 25 cm, with about 27.3 m^3/ha, and the lowest wood volume is in the diameter class of bigger than 45 cm (1.57 m^3/ha). Standing wood volume distribution of medium forest is 45.39 m^3/ha for the diameter class of 15-25 cm; 41.26 m^3/ha for the diameter class of 25-35 cm; 25.63 m^3/ha for the diameter class of 35-45 cm; 22.94 m^3/ha for the diameter class of 5-15cm; and 18.90 m^3/ha for the diameter class of more than 45 cm. For rich forest, the bigger the diameter class, the bigger the wood standing volume; volume ranged from 25.38 m^3/ha to 63.69 m^3/ha.

The details of plot information and data on tree density, and mean, minimum, and maximum DBH and total tree height as well as tree volume of each surveyed plot are shown in Annex 1 for poor forest plots, in Annex 2 for medium forest plots, and in Annex 3 for rich forest plots.

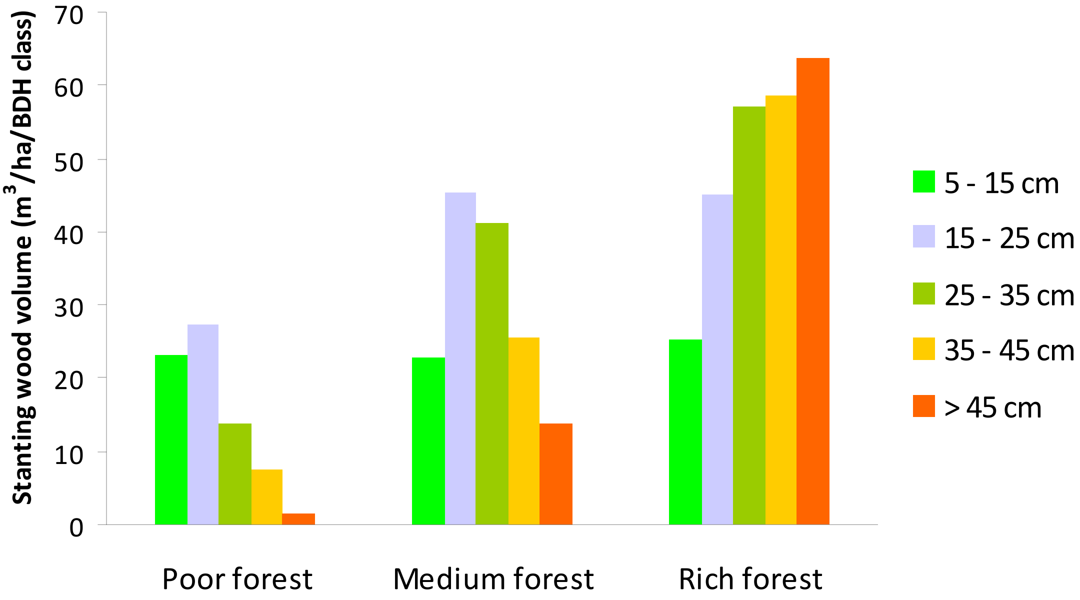


Figure 10.1.1 Standing wood volume distribution of the three forest types by diameter classes

Based on plot survey data, tree species composition is also considered. Tree composition is a structural standard, which shows the density of a species or species group in the forest. For mixed forests, tree species composition is a special factor showing the role of a species or species group in developing wood standing volume of forests. Tree species composition formula was used to describe the role of one species in the forests. In the Study, Important Values (IV, %) was used to develop the formulas for tree species composition for each forest type.

The data from 90 sample plots consisting of 30 plots for each forest carbon level (poor, medium, and rich) show that tree species composition in the study area is quite abundant and complicated. The total number of plant species found in the poor forest and medium forest is about 80 species and in rich forest is 90 species.

Tree data of each sampling plot of each forest type were combined to calculate Important Values. The composition of the whole trees with DBH larger than 5 cm is shown in Table 10.1.2 below. Dominant species covered 63.38%, 72.91%, and 67.35% for poor forests, medium forests, and rich forests, respectively. De (*Castanopsis indica*) has IV from 20.05 to 26.96%, which plays a very important role in tree species composition of all forest types and is an absolutely dominant species in the natural evergreen broadleaf forests in Muong Nhe NR. The Important Values of Cheo tia (*Engelhardtia roxburghiana)* and Thau Tau *(Aprosa didoica)* are ranked as the second and the third dominant species. It must be noted that there are a few valuable tree species and a large number of tree species with low economic values in the areas. The good dominant timber tree species are De (*Castanopsis indica*), Cheo tia (*Engelhardtia roxburghiana),* and Voi Thuoc *(Schima wallichii).* The dominant species having low economic values in the area are Thau Tau *(Aprosa didoica),* Thanh Nganh (*Cratoxylon polyanthum),* and Ba soi *(Mallotus paniculatus).*

Based on tree species composition, the formulas for tree species composition for the poor, medium, and rich forests were developed as follows:

- Poor forest: 20.05 De + 12.06 Cheo tia + 10.97 Thau tau + 7.01 Voi thuoc + 6.82 Thanh nghanh + 6.47 Ba soi + 36.62 Other species.
- Medium forest: 28.22 De + 15.49 Thau tau + 12.71 Cheo tia + 8.55 Voi thuoc + 7.12 Thanh nganh + 27.91 Other species.
- Rich forest: 36.96 De + 15.78 Thau tau + 9.53 Voi thuoc + 5.38 Cheo tia + 32.35 Other species.

Table 10.1.2 Tree species composition of by Important Values

Forest type	No of Species	Dominant species (%)	Other species (%)	Dominant species (%)
Poor forest		63.38	36.62	De (20.05%), Cheo tia (12.06%), Thau tau (10.97%), Voi thuoc (7.01%), Thanh nganh (6.82%), Ba soi (6.47%)
Medium forest		72.09	27.91	De (28.22%), Thau tau (15.49%), Cheo tia (12.71%), Voi thuoc (8.55%), Thanh nganh (7.12%)
Rich forest		67.65	32.35	De (36.96%), Thau tau (15.78%), Voi thuoc (9.53%), Cheo tia (5.38%)

(2) Biomass of sample trees

A total of 30 sample trees were cut down for fresh biomass measurement, including 10 sample trees for De gai (*Castanopsis indica*); 10 sample trees for Cheo tia (*Engelhardtia roxburghiana*), and 10 sample trees for Voi thuoc (*Schima wallichii*). These sample tree species are dominant tree species for the study area as mentioned in subsection 10.1.2.1 above. The DBH of sample trees ranges from 5 to 47 cm. The details of cut sample trees for biomass measurement are given in Table 10.1.3 and fresh biomass measurement data of sample trees are given in Annex 4.

Table 10.1.3 Sample trees by BDH class and tree species in Muong Nhe NR

Name of tree species	Number of sample trees by DBH class					
	5-15	15-25	25-35	35-45	45 - 55	Total
1. Castanopsis indica	1	2	2	4	1	10
2. Engelhardtia roxburghiana	1	3	1	4	1	10
3. Schima wallichii	1	2	2	4	1	10

To determine dry mass of tree organs, the fresh weights of all sample trees by tree organs are measured, and as mentioned in Section 2.2, 120 samples were taken for dried mass analysis in the laboratory. The analysis shows that the ratio of dried weight to fresh weight has the highest value for the stem, followed by root and branch for all 3 tree species (see Table 10.1.4). The ratios for stem, branch, leaf, and root of *Castanopsis indica* are 0.570, 0.540, 0.440, and 0.550, respectively. These values of stem, branch, leaf, and root for *Engelhardtia roxburghiana* are 0.595, 0.474, 0.430, and 0.551 respectively. The dried weight and fresh weight ratio of *Schima wallichii* is 0.520 for stem; 0.450 for branch; 0.390 for leafs; and 0.440for root. Details of analysis results on ratio of dried weight to fresh weight by tree organ of 30 sample trees species are shown in Annex 5.

Table 10.1.4 Ratio of dried weight to fresh weight of tree organs

Name of tree species	Dried weight to fresh weight by tree organs			
	Stem	Branch	Leave	Root
Castanopsis indica	0.570 ± 0.010	0.540 ± 0.017	0.440 ± 0.010	0.550 ± 0.014
Engelhardtia roxburghiana	0.595 ± 0.012	0.474 ± 0.012	0.430 ± 0.006	0.551 ± 0.014
Schima wallichii	0.520 ± 0.012	0.450 ± 0.009	0.390 ± 0.010	0.440 ± 0.021

Based on the fresh weight of different tree organs of 30 sample trees and dried weight to fresh weight ratio of every tree organ, the dried mass of every organ of each sample trees is calculated. The details of data on dried biomass of tree organs by sample trees and DBH are shown in Table 10.1.5.

It is seen that the dried biomass of sample trees generally increases with increasing DBH. Total dried mass of *Schima wallichii* with DBH of 6.5 cm and total height of 8.4 m is 17.37 kg and that for biomass of this tree with DBH of 45.0 cm and total tree height of 25.7 m is 1,723.59 kg. The dried mass of *Castanopsis indica* with DBH of 5.0 cm and total height of 7.9m is 8.91 kg, but its biomass for tree size with DBH of 45.0 cm and tree height of 26.1 m is 1,676.58 kg. The biomass of *Engelhardtia roxburghiana* with DBH of 5.0 cm and tree height of 10.5 m is 7.69 kg and its biomass for tree with DBH of 47.0 cm and tree height of 22.5 m is 1,705.23 kg.

However, it must be noted that there is often a very big difference in dried biomass among sample trees of the same species with the same DBH size.

Table 10.1.5 Dried biomass of sample trees by tree organs

ID	Name of sample trees	Sample tree size		Dried mass by tree organs (kg/tree)				
		DBH (cm)	H (m)	Stem	Branch	Leave	Root	Total
1	*Schima wallichii*	6.5	8.4	9.01	4.67	0.88	2.81	17.37
2	*Schima wallichii*	15.0	15.2	65.81	24.62	7.87	24.03	122.34
3	*Schima wallichii*	23.2	22.3	282.93	27.24	6.51	45.14	361.81
4	*Schima wallichii*	25.0	15.5	192.60	32.16	9.93	65.47	300.17
5	*Schima wallichii*	25.4	22.0	246.98	57.33	15.73	54.36	374.40
6	*Schima wallichii*	35.0	16.2	488.51	103.11	33.84	91.78	717.24
7	*Schima wallichii*	35.0	24.0	679.47	174.29	42.10	170.71	1,066.57
8	*Schima wallichii*	35.0	16.0	593.38	138.45	35.55	178.24	945.62
9	*Schima wallichii*	44.1	24.5	1,039.14	220.32	37.95	229.14	1,526.54
10	*Schima wallichii*	45.0	25.7	1,192.78	167.82	44.55	318.45	1,723.59
11	*Castanopsis indica*	5.0	7.9	5.51	0.94	0.51	1.94	8.91
12	*Castanopsis indica*	15.0	19.5	78.54	28.13	7.40	12.62	126.68
15	*Castanopsis indica*	23.5	21.5	312.56	159.03	26.21	74.80	572.60
13	*Castanopsis indica*	25.0	18.5	230.64	44.97	12.63	77.86	366.10
14	*Castanopsis indica*	26.3	20.0	316.34	82.88	15.08	85.52	499.81
16	*Castanopsis indica*	35.0	18.0	436.90	195.13	14.57	119.05	765.65
17	*Castanopsis indica*	36.0	24.0	934.79	337.06	38.25	202.62	1,512.72
18	*Castanopsis indica*	36.2	22.7	661.26	219.96	38.09	134.25	1,053.56
19	*Castanopsis indica*	44.0	20.0	610.30	250.31	26.90	198.07	1,085.58
20	*Castanopsis indica*	45.0	26.1	1,002.72	387.32	63.06	223.48	1,676.58
21	*Engelhardtia roxburghiana*	5.0	10.5	5.42	0.65	0.47	1.16	7.69
22	*Engelhardtia roxburghiana*	15.0	18.4	58.83	9.81	4.25	16.34	89.23
23	*Engelhardtia roxburghiana*	24.3	22.8	278.36	59.76	15.44	86.75	440.32
24	*Engelhardtia roxburghiana*	24.5	21.6	288.79	39.70	23.37	59.32	411.18
25	*Engelhardtia roxburghiana*	25.0	22.0	286.72	34.26	13.04	70.42	404.45
26	*Engelhardtia roxburghiana*	35.0	22.2	510.68	132.84	34.04	182.29	859.85
27	*Engelhardtia roxburghiana*	35.9	17.4	606.74	189.65	47.52	254.84	1,098.76
28	*Engelhardtia roxburghiana*	36.2	22.5	621.36	142.68	30.63	175.07	969.74
29	*Engelhardtia roxburghiana*	41.3	19.2	828.67	174.32	53.79	328.38	1,385.17
30	*Engelhardtia roxburghiana*	47.0	22.5	1,026.23	224.10	66.79	388.10	1,705.23

To see how biomass of tree organs contributes to total tree biomass, an analysis of biomass portion distribution by DBH class was conducted. The biomass of each tree organ (stem, branch, leaf, and root) of every sample tree is considered by 4 DBH classes: 5-15 cm; 15-25 cm; 25-35 cm: and 35-45 cm. The data on biomass portion of each tree species by DBH class are shown in Figure 10.1.2.

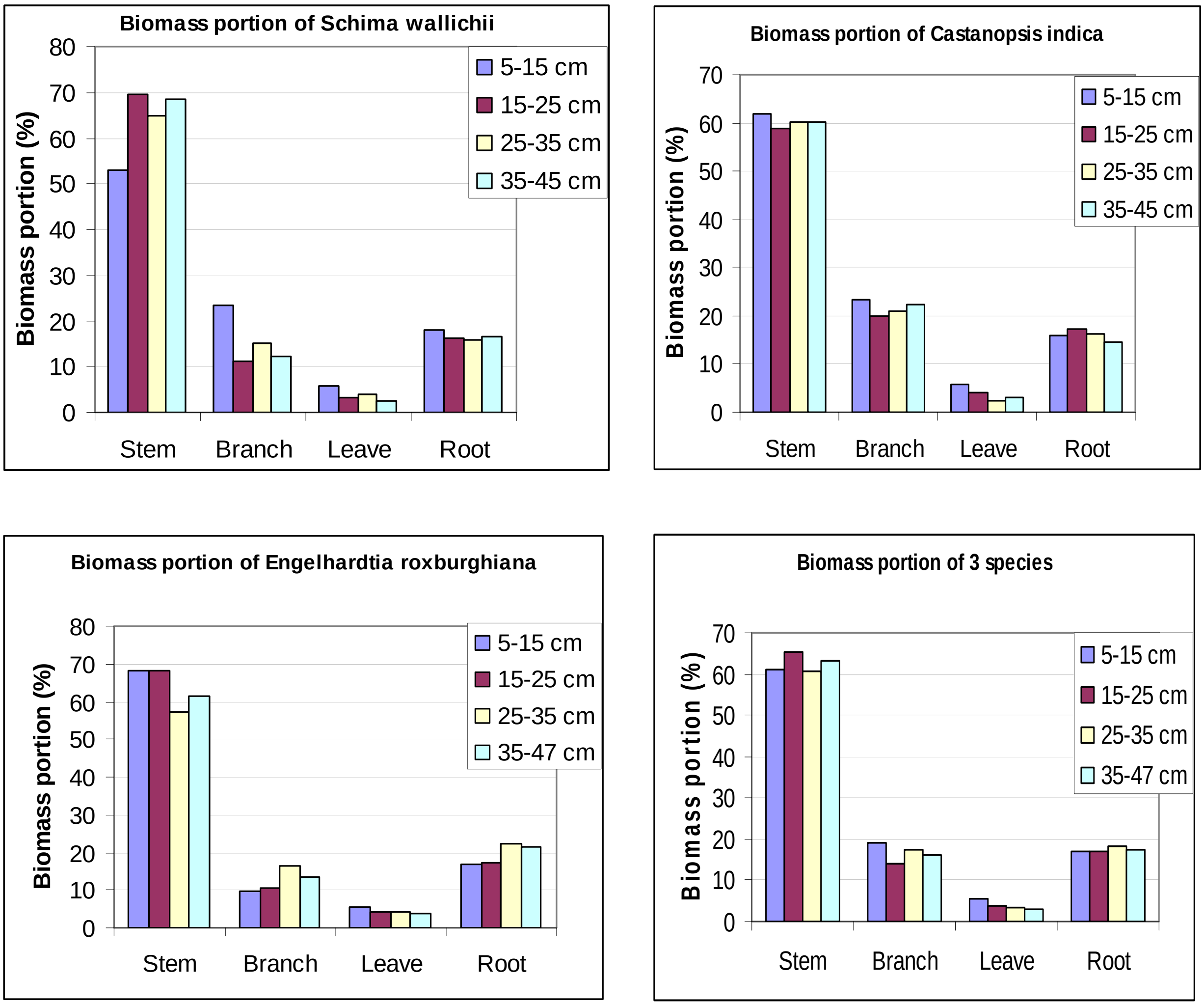


Figure 10.1.2 Biomass portion (%) of tree organ of sample trees by BDH class.

Generally there is not a clear rule or tendency for biomass portion of different tree organs in relation with DBH sizes, except that root biomass is relatively stable. The stem biomass portion of *Schima wallichii* ranges from 52.8 – 69.4 %; that for *Castanopsis indica* ranges from 58.7 – 61.9 %; and that for *Engelhardtia roxburghiana* ranges from 57.3 – 68.1%. The mean value of stem biomass portion for all these 3 tree species is 60.7 – 65.4% of total tree biomass.

There is also a relatively clear rule for distribution of branch biomass portion by increase of DBH size for all tree species studied. The branch biomass portion tends to decrease with increasing DBH size. The portion of branch biomass of *Schima wallichii* is 11.1 – 24.4 % of total tree biomass; this portion is 20.0 – 23.4% of total tree biomass for *Castanopsis indica;* and 9.7 – 16.3 % of total tree biomass for *Engelhardtia roxburghiana.* The average value of branch biomass portion for all 3 tree studied species is 13.9 – 18.9 % of total tree biomass and seems to decrease with increasing DBH size of trees.

With regards to leaf biomass, there is also declining tendency when DBH increases. Portion of leaf biomass of *Schima wallichii* decreased from 5.7% (at DBH size 5-15 cm) to 2.54% of total tree biomass (at DBH size of 35-45 cm). The same rule holds for leaf biomass of *Castanopsis indica*; this figure reduces from 5.7% of total tree biomass (at DBH size of 5-15 cm) to 3.1% (at DBH size of 35-45 cm). Leaf biomass of *Engelhardtia roxburghiana* decreases from 5.4 % (at DBH class of 5-15 cm) to 3.6% of total tree biomass (at DBH class of 35-47cm). Commonly the leaf biomass portion decreases with increasing DBH size and accounts for 5.6 – 3.1 % of total tree biomass for all 3 species.

There is a small change in root biomass when DBH size increases. The root biomass portion is 15.8 – 17.9% of total tree biomass for *Schima wallichii*; 14.3 – 17.1 % of total tree biomass for *Castanopsis indica;* and 16.6 – 22.2 % of total tree biomass for *Engelhardtia roxburghiana.* The mean value of root biomass portion for all 3 tree species ranges from 16.8 – 18.1 % of total tree biomass.

(3) Development of BEF and Root/Shoot ratio

Biomass Expansion Factor (BEF) is a factor generated from the ratio of total dried mass of the whole tree to total dried mass of the stem. BEF can also be used for estimating the biomass of whole trees if stem biomass is known. Therefore, the BEF of all sample trees was calculated and the correlation between DBH and BEF was tested (see Figure 10.1.3 and details of BEF for 30 sample trees).

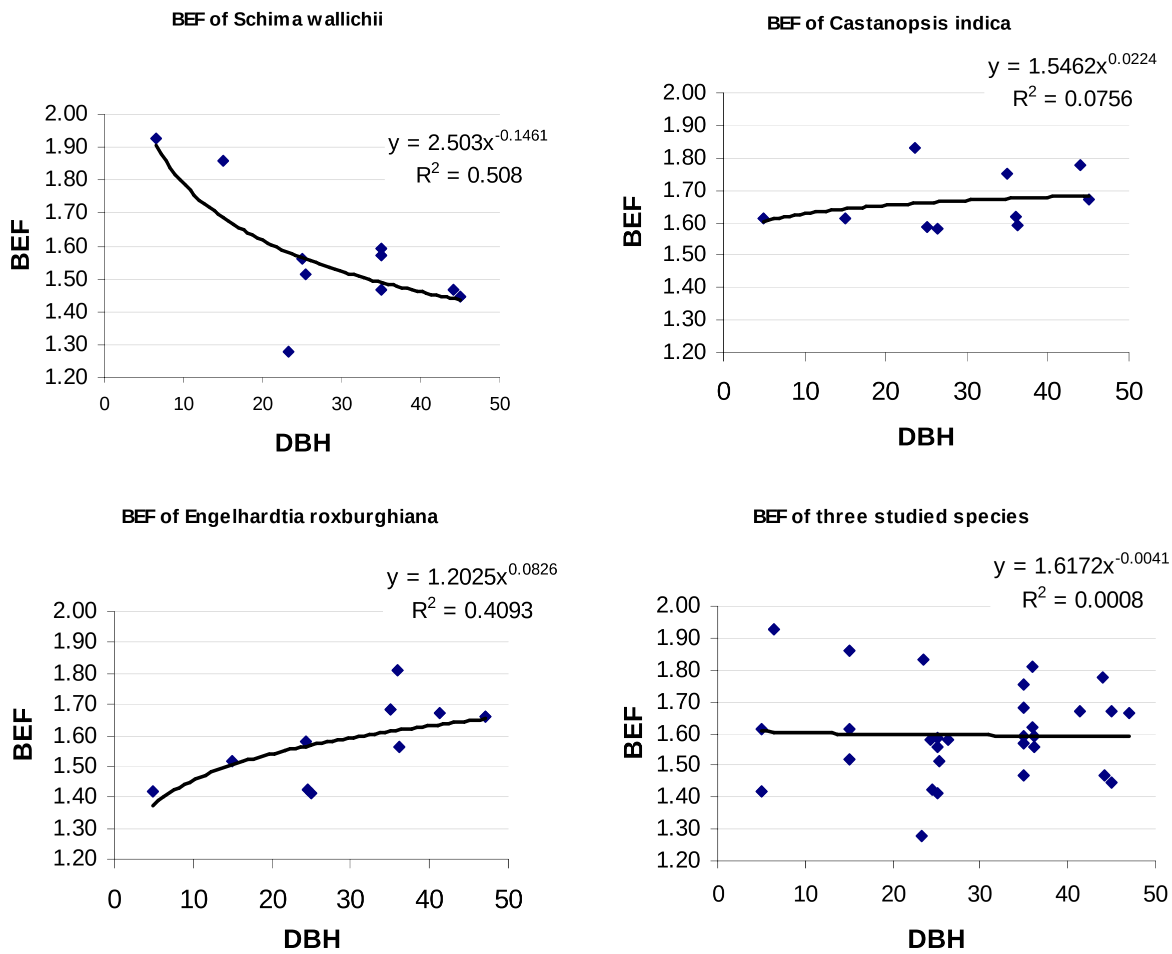


Figure 10.1.3 Relationship between DBH and BEF of studied tree species

The analysis results indicate that there is a correlations between DBH and BEF for *Schima wallichii* (r = 0.71) and *Engelhardtia roxburghiana* (r = 0.63). However, the correlation of DBH and BEF is very loose for *Castanopsis indica* and a combination of three species.

The values of BEF by DBH class are also different for different tree species studied. The mean value of BEF for *Schima wallichii* is 1.62 for DBH of 5-15 cm; 1.31 for DBH of 15-25 cm; 1.26 for DBH of 25-35 cm; and 1.26 for DBH of 35-45 cm. The BEF values for *Castanopsis indica* by DBH class of 5-15 cm, 15-25 cm, 25-35 cm and 35-45 cm are 1.26, 1.52, 1.28, and 1.44 respectably. Values of BEF for *Engelhardtia roxburghiana* range from 1.21 to 1.31 for trees with DBH of 5 – 47 cm.
The overall BEF for all 3 studied tree species is 1.36 for DBH class of 5-15 cm; 1.34 for DBH class of 15-25 cm; 1.25 for DBH class of 25-35 cm; and 1.34 for DBH class of 35-45 cm (see details of BEF in Table 10.1.6).

Table 10.1.6 Values of BEF by DBH class of sample trees

Species	**DBH class**				
	5-15 cm	15-25 cm	25-35 cm	35-45 cm	Mean
Schima wallichii	1.61593	1.30651	1.25718	1.26373	1.30619
Castanopsis indica	1.26255	1.52246	1.27970	1.43501	1.40419
Engelhardtia roxburghiana	1.20677	1.24257	1.16498	1.31107	1.26548
All 3 species	1.36175	1.34081	1.24775	1.33660	1.32529

The root/shoot ratio is also a conversion factor that allows estimation of belowground biomass of trees and/or forests from aboveground biomass. This factor is commonly used when there is no equation for estimating belowground biomass. The root/shoot ratio is calculated as the ratio of belowground biomass (root biomass) to aboveground biomass (the sum of stem, branch, and leaf biomass).

As explained, root/shoot ratio (R/S) is calculated for every sample tree in Muong Nhe NR and is shown in Annex 6. The R/S for each sample tree species by DBH class is summarized in Table 10.1.7.

Table 10.1.7 Root shoot ratio of sample trees by DBH class

Species	**DBH class**				
	5-15 cm	15-25 cm	25-35 cm	35-45 cm	Mean
Schima wallichii	0.1931	0.1935	0.2244	0.1946	0.2002
Castanopsis indica	0.2791	0.1305	0.2383	0.1724	0.1878
Engelhardtia roxburghiana	0.1770	0.2127	0.2108	0.2793	0.2423
All 3 species	0.2164	0.1837	0.2272	0.2154	0.2101

The RS for *Schima wallichii* ranges from 0.19 – 0.22 and its mean value is 0.20 ± 0.04; RS for *Castanopsis indica* is from 0.13 – 0.28 and the mean value is 0.18 ± 0.06; the mean value of RS for *Engelhardtia roxburghiana* is 0.24 ± 0.05; and RS value for all 3 tree species is 0.21 ± 0.05.

(4) Wood density of sample trees

Analysis of wood density was conducted for 30 sample trees. A total of 4 wood discs were sampled from each sample tree and 120 wood discs were collected for wood density analysis in the laboratory. Sub-sampling is then applied in the laboratory during the analysis of wood density. A total of sub-sampling for *Schima wallichii* is 130; that for *Castanopsis indica* is 175; and that for *Engelhardtia roxburghiana* is 148. The WD of each sample trees was analyzed at zero moisture content and at a moisture content of 12%. The data on WD analysis of sample trees are shown in Table 10.1.8 and Table 9, and a summary of WD analysis is shown in Annex 7 for *Schima wallichii*; Annex 8 for *Castanopsis indica;* and Annex 9 for *Engelhardtia roxburghiana.*

Table 10.1.8 Wood density of sample trees at zero moisture content

Species	Statistics description						
	N	Max (g/cm^3)	Mean (g/cm^3)	Min (g/cm^3)	Error (s_r)	Variation (%)	Precision factor (%)
Schima wallichii	130	0.949	0.732	0.596	0.005	7.420	0.651
Castanopsis indica	175	1.043	0.780	0.470	0.009	15.340	1.160
Engelhardtia roxburghiana	148	0.799	0.591	0.397	0.006	11.945	0.982

At zero moisture content, the WD for *Schima wallichii* is 0.732 ± 0.005 g/cm^3, that for *Castanopsis indica* is 0.780 ± 0.009 g/cm^3, and that for *Engelhardtia roxburghiana* is 0.591 ± 0.006 g/cm^3. As the Vietnam National Wood standard, the wood of *Schima wallichii* and that of *Castanopsis indica* are in the medium weight wood group (WD is from 0.65 – 0.79). Meanwhile, the wood of *Engelhardtia roxburghiana* is in the light wood group (WD is from 0.50 - 0.64).

Analysis of WD at moisture content of 12% for 3 sample tree species shows that WD of *Schima wallichii* is 0.757 g/cm^3; that for *Castanopsis indica* is 0.799 g/cm^3, and that for *Engelhardtia roxburghiana* is 0.623 g/cm^3. This means that the wood of *Schima wallichii* and that of *Castanopsis indica* belong to the medium weight wood group and that of *Engelhardtia roxburghiana* is in the light wood group (see Table 10.1.9).

Table 10.1.9 Wood density of sample trees at 12% moisture content

Species	Statistics description						
	n	Max (g/cm^3)	Mean (g/cm^3)	Min (g/cm^3)	Error (s_r)	Variation (%)	Precision factor (%)
Schima wallichii	130	0.979	0.757	0.625	0.005	7.410	0.650
Castanopsis indica	175	1.057	0.799	0.500	0.009	14.678	1.110
Engelhardtia roxburghiana	148	0.846	0.623	0.423	0.006	11.708	0.962

(5) Allometric equations for biomass estimation

To estimate tree biomass, it is always suggested that a specific allometric equation for certain forest type be prepared. Many variables have been used in allometric equations for estimating biomass, with diameter at breast height (1.3 m, DBH) being the most widely used (Snowdon *et al*. 2000). Other variables, such as height to tree top (*H*), are closely correlated with DBH within a given site, particularly where the stand is relatively young. In addition, DBH is a variable of forests that can be measured exactly as compared with other inventory parameters, particularly in natural forests. There are a number of correlation models, but most of studies have shown that a good correlation is normally in the form of a power or logarithm. Therefore, the Study used two models for development of allometric equations for biomass estimation. Model 1 is expressed as $y = a X^b$ and model 2 ss $Ln(y) = a Ln(X) + b$.

a. Development of allometric equations using model $y = aX^b$

The correlation between biomass of tree organs (stem - Ws, branch - Wb, leaf - Wl, aboveground biomass - AGB, root - Wr and total biomass - TW) and DBH was analyzed for each studied tree species and all 3 species together.

Developed allometric equations for *Schima wallichii urghiana* show that there is a strong correlations between biomass of stem, AGB, and TW, and DBH (r > 0.99) and good correlation between biomass of root, branch, and leaf (r =0.96 – 0.98) (see Table 10.1.10 and Figure 10.1.4 for details). Although the correlation of equations is rather good, parameters a and b do not exist for some equations, as P value is greater than 0.05. In such cases, it is recommended that equations for biomass of branch and leaf and DBH not be used.

Table 10.1.10 Descriptive statistics of allometric equations for Schima wallichii

Equation type	Coefficient				Sig_F	r
	a	P_a	b	P_b		
$Ws = 0.080*DBH^{2.501}$	0.080	0.014	2.501	< 0.001	< 0.001	0.994
$Wb = 0.094*DBH^{1.986}$	0.094	0.179	1.986	< 0.001	< 0.001	0.959
$Wl = 0.020*DBH^{2.038}$	0.020	0.172	2.038	< 0.001	< 0.001	0.963
$AGB = 0.165*DBH^{2.360}$	0.165	0.012	2.360	< 0.001	< 0.001	0.994
$Wr = 0.036DBH^{2.330}$	0.036	0.054	2.330	< 0.001	< 0.001	0.987
$TW = 0.201*DBH^{2.355}$	0.201	0.008	2.355	< 0.001	< 0.001	0.995

For *Castanopsis indica*, parameters (a) of all allometric equations were not highly significant (P value > 0.05); meanwhile, all shape parameters (b) were highly significance (P < 0.05). This result means that the equations also were not statistically accepted and could not be applied in biomass inventory despite strong correlation of the equations (r = 0.951 - 0.986) (see Table 10.1.11 and Figure 10.1.5);

Table 10.1.11 Descriptive statistics of allometric equations for Castanopsis indica

Equation type	Coefficient				Sig_F	r
	a	P_a	b	P_b		
$Ws = 0.146*DBH^{2.323}$	0.146	0.062	2.323	< 0.001	< 0.001	0.986
$Wb = 0.016*DBH^{2.666}$	0.016	0.206	2.666	< 0.001	< 0.001	0.974
$Wl = 0.028*DBH^{1.951}$	0.028	0.210	1.951	< 0.001	< 0.001	0.951
$AGB = 0.174*DBH^{2.373}$	0.174	0.079	2.373	< 0.001	< 0.001	0.984
$Wr = 0.049*DBH^{2.236}$	0.049	0.052	2.236	< 0.001	< 0.001	0.986
$TW = 0.226*DBH^{2.346}$	0.226	0.058	2.346	< 0.001	< 0.001	0.986

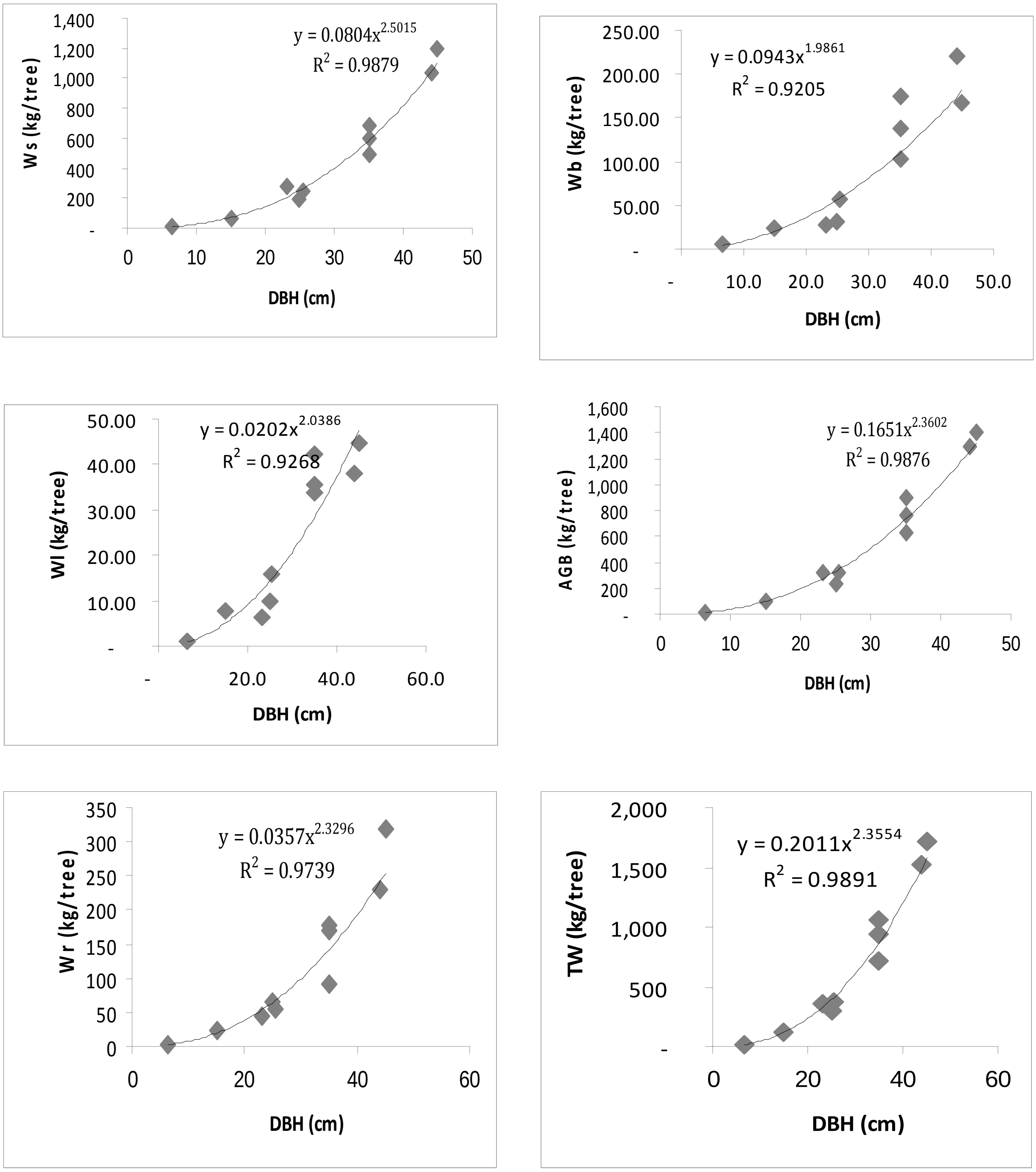


Figure 10.1.4 Correlation of biomass and DBH for Schima wallichii

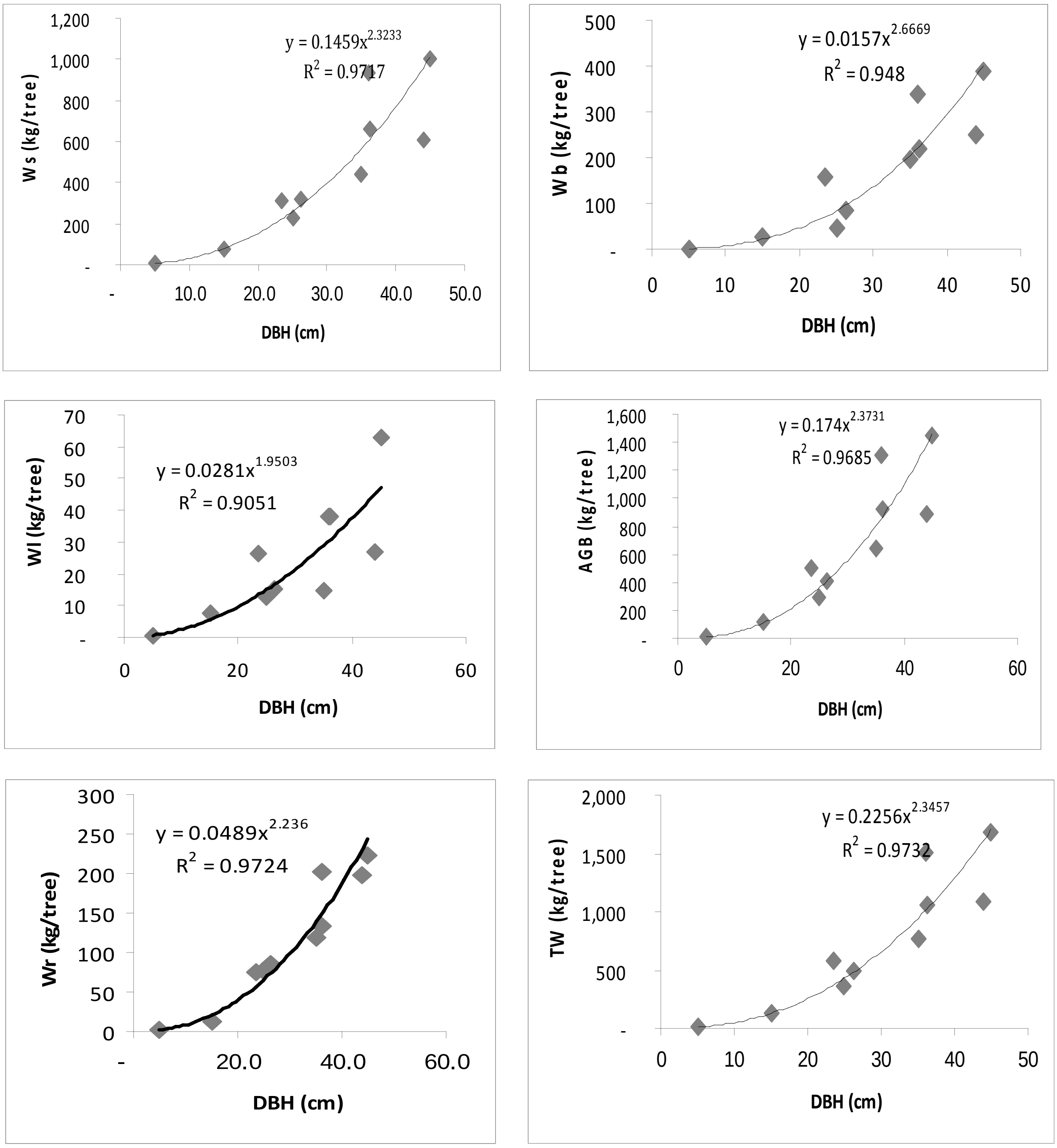


Figure 10.1.5 Correlation of biomass and DBH for Castanopsis indica

The relationship between biomass of different tree organs and DBH for *Engelhardtia roxburghiana* shows that there are high correlations (r > 0.99) and all parameter a and b exist, as P values are smaller than 0.05 (see Table 10.1.12 and Figure 10.1.6 for details). This means that these equations exist and can be applied.

Table 10.1.12 Descriptive statistics of allometric equations for Engelhardtia roxburghiana

Equation type	**Coefficient**				**Sig_F**	**r**
	a	**P_a**	**b**	**P_b**		
$Ws = 0.115*DBH^{2.392}$	0.115	0.003	2.392	< 0.001	< 0.001	0.997
$Wb = 0.007*DBH^{0.728}$	0.007	0.038	0.728	< 0.001	< 0.001	0.992
$Wl = 0.012*DBH^{2.252}$	0.012	0.023	2.252	< 0.001	< 0.001	0.991
$AGB = 0.128*DBH^{2.432}$	0.128	0.002	2.432	< 0.001	< 0.001	0.997
$Wr = 0.15*DBH^{2.658}$	0.15	0.008	2.658	< 0.001	< 0.001	0.996
$TW = 0.138*DBH^{2.475}$	0.138	0.001	2.475	< 0.001	< 0.001	0.997

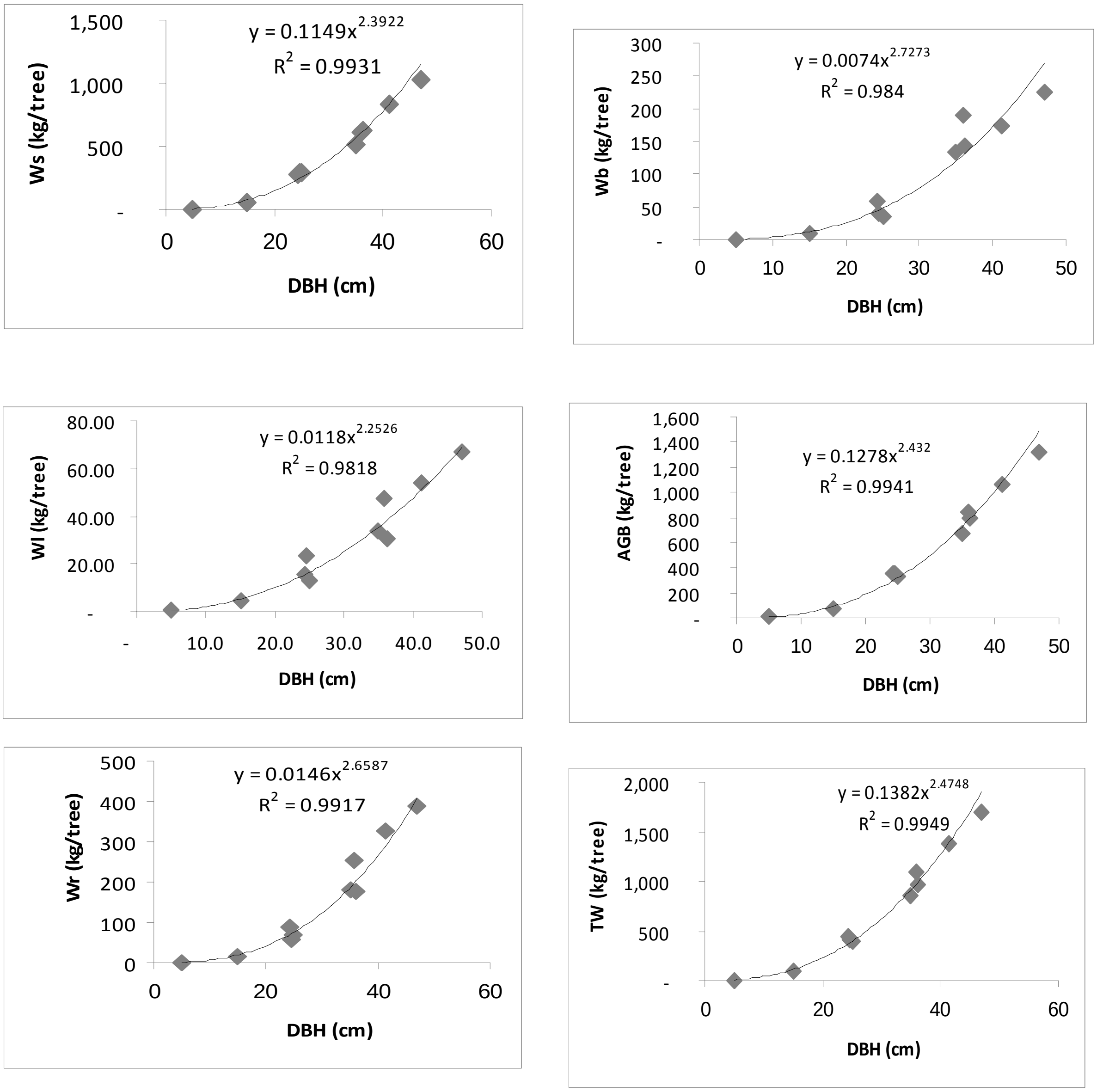


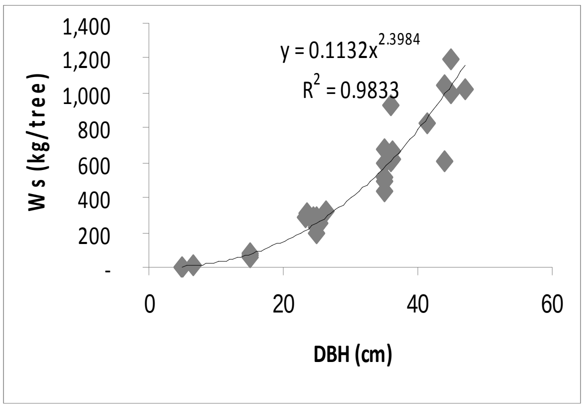
Figure 10.1.6 Correlation of biomass and DBH for Engelhardtia roxburghiana

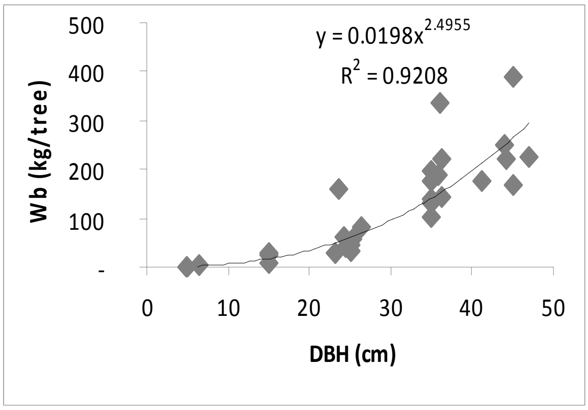
The equations for estimation of biomass for all 3 studied tree species are also analyzed. The statistical results show that all equations exist, as P values for parameters a and b are smaller than 0.05 ($P < 0.05$) and there are strong correlations between biomass of stem, AGB, root, and TW with DBH. The other correlation of leaf and branch biomass with DBH is relatively high (see Table 10.1.13 and Figure 10.1.7 for details). This means that these equations are applicable to biomass estimation.

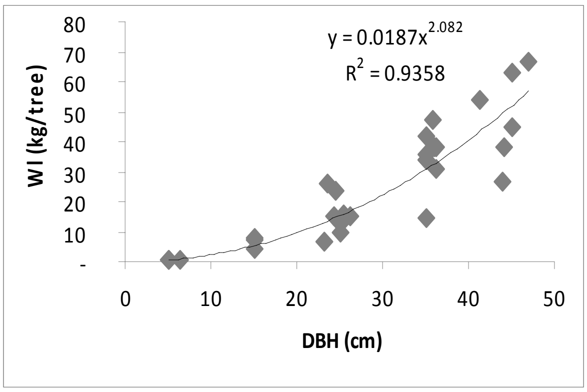
Table 10.1.13 Descriptive statistics of allometric equations for the 3 studied tree species

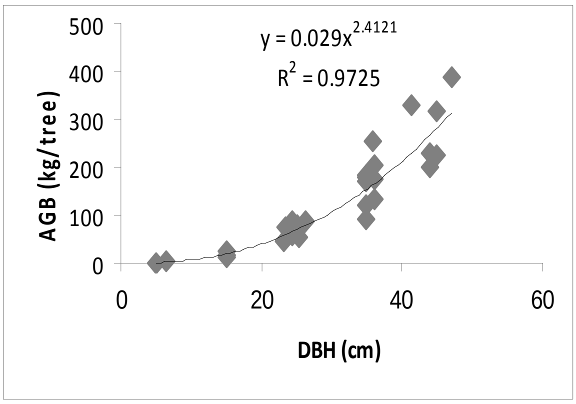
Equation types	**Coefficient**				**Sig_F**	**r**
	a	**P_a**	**b**	**P_b**		
$Ws = 0.113*DBH^{2.398}$	0.113	< 0.001	2.398	< 0.001	< 0.001	0.992
$Wb = 0.020*DBH^{2.495}$	0.020	0.036	2.495	< 0.001	< 0.001	0.960
$Wl = 0.019*DBH^{2.082}$	0.019	0.006	2.082	< 0.001	< 0.001	0.967
$AGB = 0.153*DBH^{2.390}$	0.153	< 0.001	2.390	< 0.001	< 0.001	0.991
$Wr = 0.029*DBH^{2.412}$	0.029	< 0.001	2.412	< 0.001	< 0.001	0.986
$TW = 0.183*DBH^{2.394}$	0.183	< 0.001	2.394	< 0.001	< 0.001	0.992

As mentioned above in connection with the correlation analysis, recommendatioms are that, for each dominant species in particular, use allometric equations to estimate stem biomass, aboveground biomass, and total biomass of individual trees. In the Study, these equations ensure that scaling and shape parameters have high significance ($p < 0.05$) and allometric coefficients show very close relationships between independent and dependent covariance. All joined allometric equations for the dominant tree species group exist and can be applied in biomass inventory in natural forests in Muong Nhe district in particular and natural evergreen broadleaf forest in northwest Vietnam.









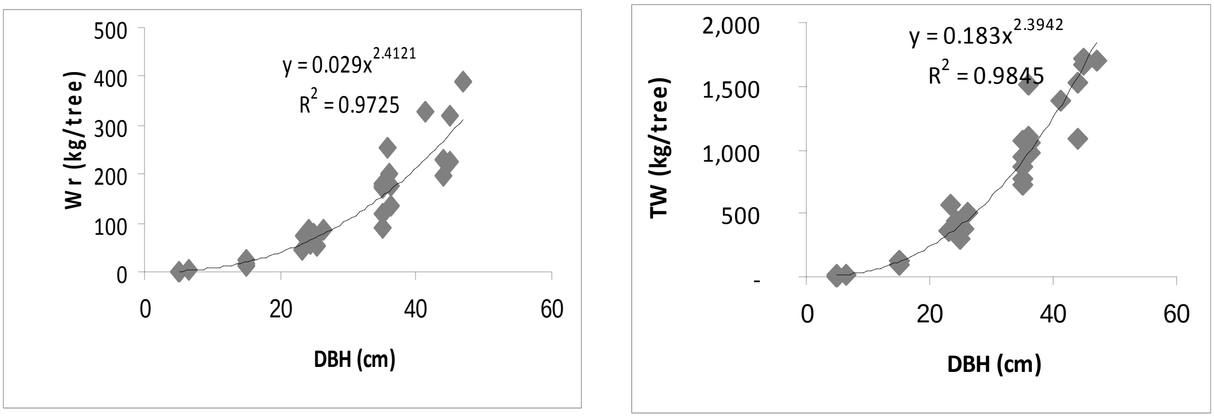


Figure 10.1.7 Correlation of biomass and DBH for all 3 studied tree species

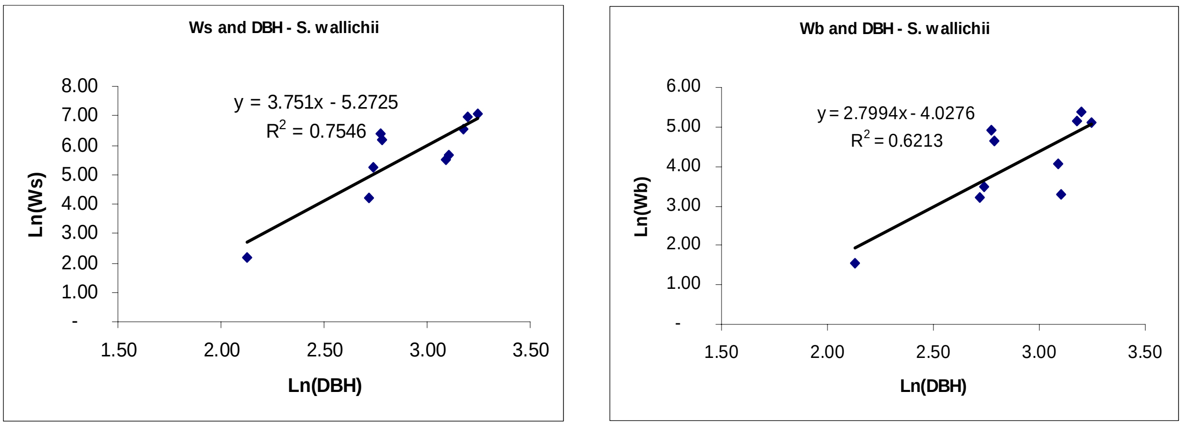
b. Development of allometric equations using model Ln(y) = a Ln (X) + b

The correlation of biomass and DBH in logarithm form was analyzed for each tree species and for all 3 tree species combined. The analysis shows that in general the correlation of biomass and DBH in logarithm form is not as good as its correlation in the form of a power function.

The relationship between biomass of different tree components and DBH for *Schima wallichii* is rather good (r = 0.83 – 0.86) for correlation of biomass of stem, root, AGB, and total biomass. The details of correlation are shown in Table 10.1.14 and Figure 10.1.8.

Table 10.1.14 Allometric equations for biomass estimation for Schima wallichii

#	Allometric equation	r
1	Ln(Ws) = 3.751 Ln(DBH) - 5.2725	0.8687
2	Ln(Wb) = 2.7994 Ln(DBH) - 4.2076	0.7882
3	Ln(Wl) = 2.8101 Ln(DBH) - 5.4271	0.7734
4	Ln(AGB) = 3.5088 Ln(DBH) - 4.3094	0.8612
5	Ln(Wr) = 3.3622 Ln(DBH) - 5.5153	0.8302
6	Ln(TW) = 3.4843 Ln(DBH) - 4.0564	0.8575



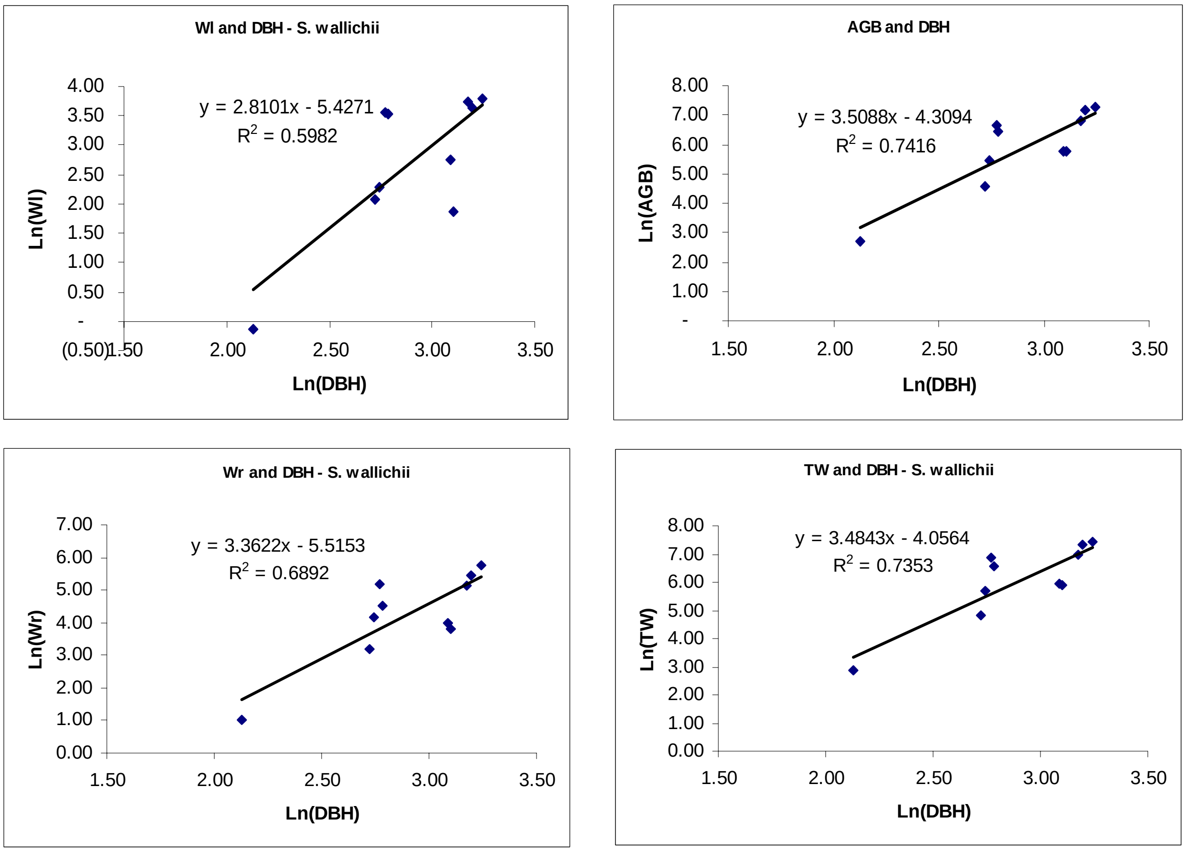


Figure 10.1.8 Relationship between DBH and Stem biomass (Ws); Branch biomass (Wb); Leave biomass (Wl); above ground biomass (AGB); root biomass (Wr) and total biomass (TW) of Schima wallichii

There is a better correlation for *Castanopsis indica*, as most of correlation factors are from 0.93 – 0.96 (see details in Table 10.1.15 and Figure 10.1.9).

Table 10.1.15 Allometric equations for biomass estimation for Castanopsis indica

#	Allometric equation	r
1	Ln(Ws) = 4.3742 Ln(DBH) - 7.3145	0.9306
2	Ln(Wb) = 5.0947 Ln(DBH) - 10.559	0.9327
3	Ln(Wl) = 3.9646 Ln(DBH) - 8.9581	0.9698
4	Ln(AGB) = 4.4924 Ln(DBH) - 7.3259	0.9342
5	Ln(Wr) = 3.946 Ln(DBH) - 7.472	0.8726
6	Ln(TW) = 4.3986 Ln(DBH) - 6.8781	0.9276

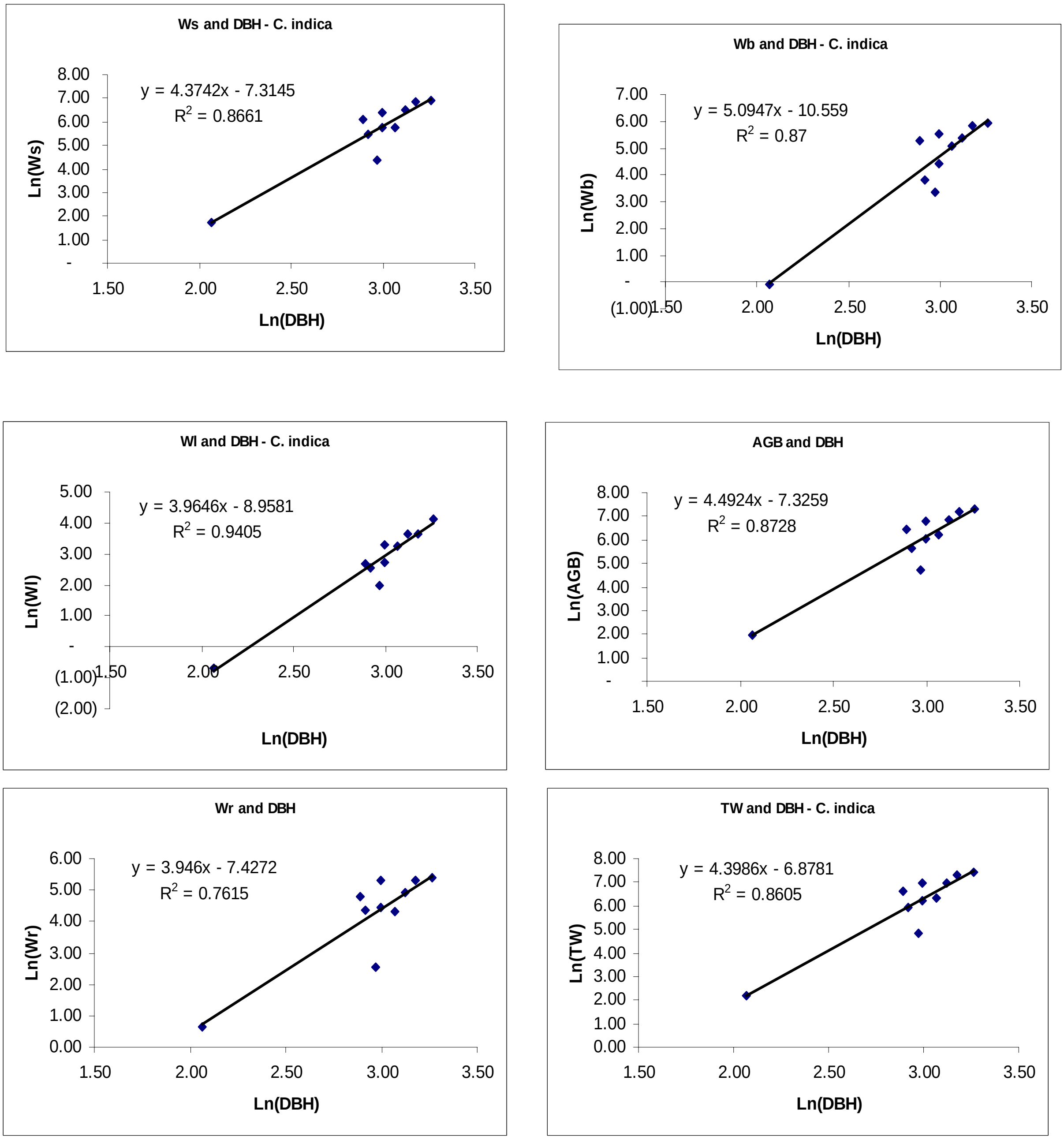


Figure 10.1.9 Relationship between DBH and Stem biomass (Ws); Branch biomass (Wb); Leave biomass (Wl); above ground biomass (AGB); root biomass (Wr) and total biomass (TW) of Castanopsis indica.

Regression analysis for *Engelhardtia roxburghiana* shows not very high correlation between biomass and DBH. The allometric equations and correction factors are shown in Table 10.1.16 and Figure 10.1.10.

Table 10.1.16 Allometric equations for biomass estimation for Engelhardtia roxburghiana

#	**Allometric equation**	**r**
1	Ln(Ws) = 5.5422 Ln(DBH) - 10.912	0.8342
2	Ln(Wb) = 6.0364 Ln(DBH) - 14.041	0.7933
3	Ln(Wl) = 4.9774 Ln(DBH) - 11.965	0.7910
4	Ln(AGB) = 5.573 Ln(DBH) - 10.772	0.8257
5	Ln(Wr) = 5.8613 Ln(DBH) - 13.603	0.7932
6	Ln(TW) = 5.6238 Ln(DBH) - 10.703	0.8190

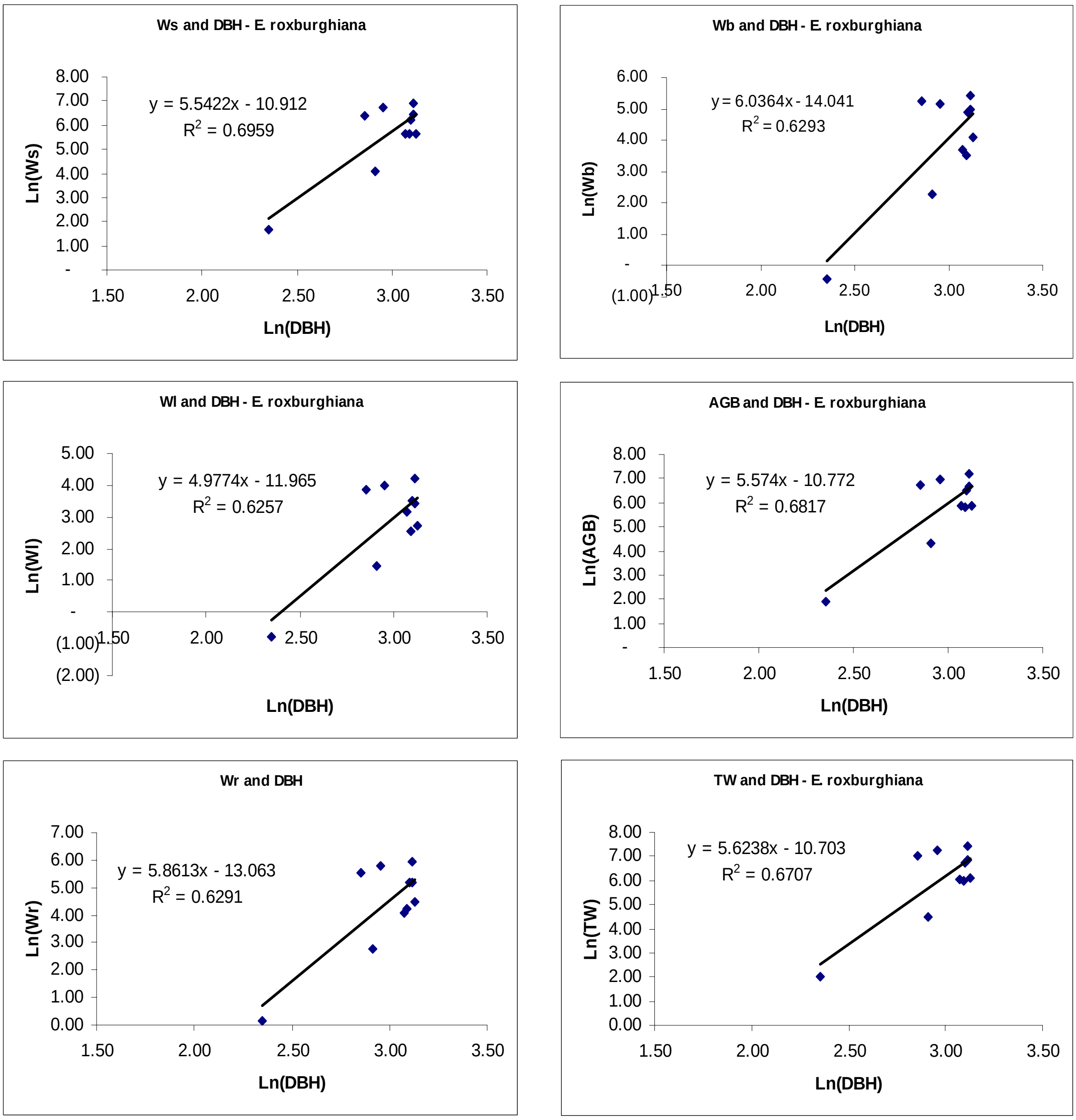


Figure 10.1.10 Relationship between DBH and Stem biomass (Ws); Branch biomass (Wb); Leave biomass (Wl); above ground biomass (AGB); root biomass (Wr) and total biomass (TW) of Engelhardtia roxburghiana.

Correlation of biomass and DBH from 3 studied tree species also indicates that there is not close correlation ($r < 0.86$). The details are in Table 10.1.17 and Figure 10.1.11.

Table 10.1.17 Allometric equations for 3 studied tree species

#	Allometric **equation forms**	r
1	Ln(Ws) = 0.1732 Ln(DBH) + 1.9728	0.8627
2	Ln(Wb) = 4.2773 Ln(DBH) - 8.4257	0.7986
3	Ln(Wl) = 3.6636 Ln(DBH) - 8.0115	0.8266
4	Ln(AGB) = 4.2489 Ln(DBH) - 6.6329	0.8552
5	Ln(Wr) = 4.0575 Ln(DBH) - 7.6639	0.8055
6	Ln(TW) = 4.2166 Ln(DBH) - 6.3483	0.8485

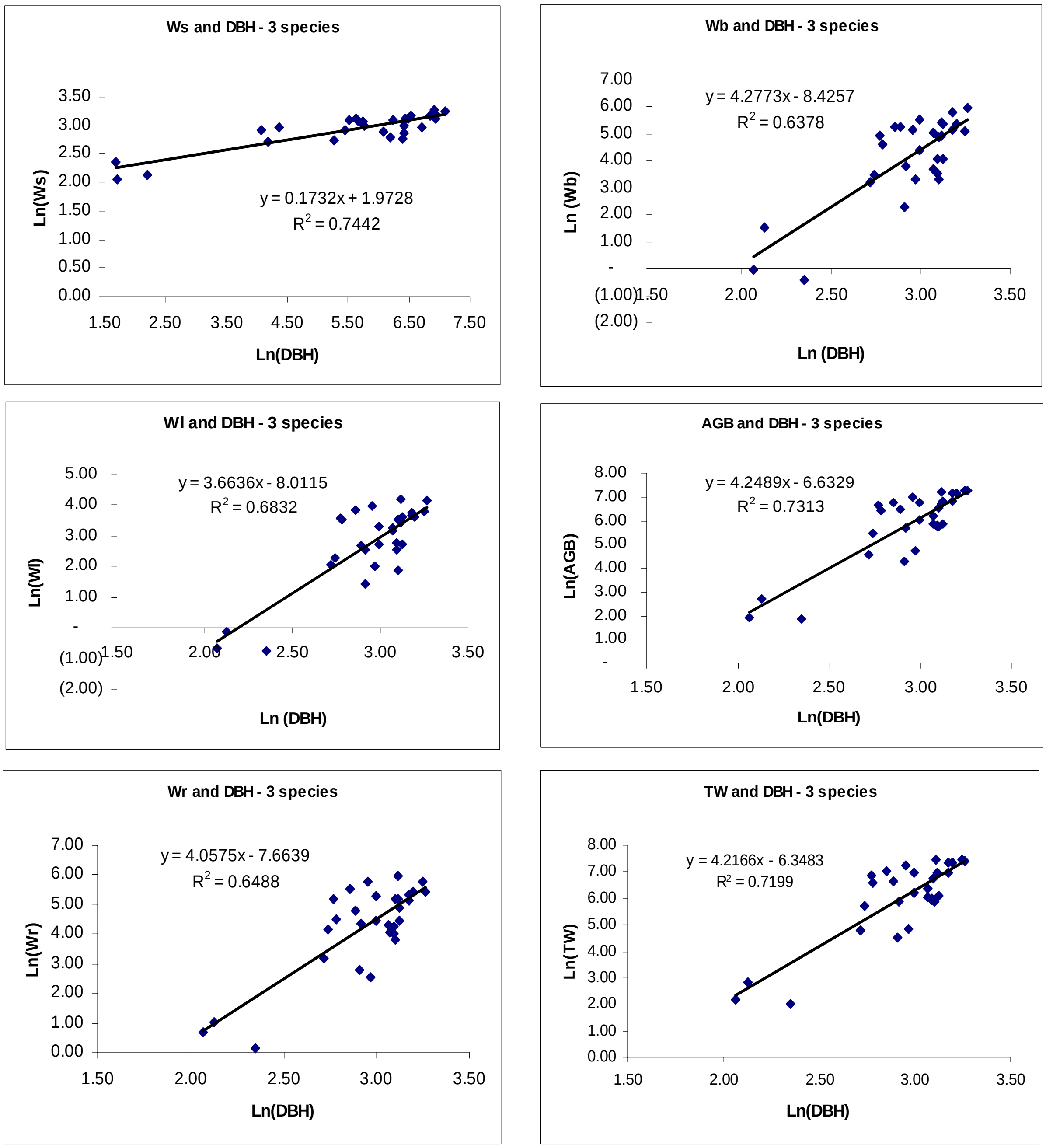


Figure 10.1.11 Relationship between DBH and Stem biomass (Ws); Branch biomass (Wb); Leave biomass (Wl); above ground biomass (AGB); root biomass (Wr) and total biomass (TW) of all 3 studied tree species.

10.1.3 Conclusions and recommendations

(1) Conclusions

Based on the data of 90-plot survey and 30 sample trees for biomass measurement and wood density analysis in Muong Nhe NR, the following conclusions were drawn:

Mean standing wood volume of poor forests is 75.51 ± 21.44 m^3/ha; that of medium forests is 151.98 ± 24.67 m^3/ha; and that for rich forests 254.58 ± 61.44 m^3/ha. There is a large variation of standing wood volume for rich forests, and smaller for variation for medium forests and still smaller for poor forests. In poor forests, standing wood volume mainly comes from trees with DBH class of 5-15 and 15 – 25 cm; in medium forests, trees with DBH class of 15 – 25 and 25 – 25 cm contribute greatly to standing wood volume; and in rich forest,s standing wood volume is mainly from DBH class of 25 – 45 cm.

Three species, *Schima wallichii*, *Castanopsis indica,* and *Engelhardtia roxburghiana,* are found to be the dominant species in the study area. Therefore, these species were selected for cutting for biomass measurement. The distribution of biomass of different tree organs varies slightly among studied tree species. The mean portion of stem biomass is 62.6% of total tree biomass, followed by branch biomass of 16.5%, root biomass of 17.3%, and leaf biomass of 4.0%.

Values of BEF depend greatly on tree species and tree size. The mean of BEF for *Schima wallichii* is 1.568; that for *Castanopsis indica* is 1.664; and that for *Engelhardtia roxburghiana* is 1.574. The mean of BEF for all 3 studied tree species is 1.602. Also, value of RS varies among studied tree species. The mean RS for *Schima wallichii* is 0.20; that for *Castanopsis indica* is 0.187; that for *Engelhardtia roxburghiana* is 0.242; and that for all 3 tree species is 0.210.

Wood density of three studied tree species was also analyzed at zero and 12% moisture. The WD for *Schima wallichii* at zero moisture content is 0.732 g/cm^3 and that at 12% of moisture is 0.757 g/cm^3. The WD values of *Castanopsis indica* at zero and 12% moisture are 0.780 and 0.799 g/cm^3 respectively. This value is 0.591 g/cm^3 at zero moisture and 0.623 g/cm^3 at 12% of moisture for *Engelhardtia roxburghiana.*

There is always a relationship between biomass of tree organs and DBH, and the correlation in power form is better than that in the logarithm form. In all equations, biomass of stem, aboveground biomass, and total biomass of trees indicate close correlation with DBH of trees (r = 0.95 – 0.99).

(2) Recommendations

The BEF, RS and allometric equations are developed for Muong Nhe NR; it is therefore suggested that application of these to other places needs to be checked. It is strongly recommended that the allometric equations in power form should be used for estimation of stem biomass, aboveground biomass, and total biomass for each studied tree species and/or for timber evergreen forest in Muong Nhe NR. As the limitation of observed DBH ranges (from 5 – 45 cm), it is also suggested to consider the application of these equations for trees with DBH bigger than 45 cm.

10.2 Biomass Estimates for each of the 90 plots in the Tree Study Area

10.2.1 Objective

In Section 10.1, the study team prepared biomass expansion factors (hereinafter, “BEF”) and allometric equations at the individual tree level by species for the three dominant species, in order to estimate the biomass of evergreen broad leaved trees in northern Vietnam.

Section 10.2 uses the results of Section 10.1 to calculate the biomass and carbon stock for each plot from the survey data for each tree in the 90 plots, and based on this, the biomass and carbon stock per-unit area are estimated.

10.2.2 Selection of Methods Used in Biomass Estimation

This sub-section, explains the process of biomass estimation by two methods using the BEF and biomass allometric equations developed in Section 10.1. The BEF and allometric equations derived from this development study for the three dominant tree species were examined. In light of these, this section determines the method to be used for biomass estimation.

In estimating the aboveground biomass (hereinafter, “AGB”) using BEF, the BEF is multiplied by wood density (hereinafter, “WD”) and the total stem volume of each tree as shown in the following formula.

$$AGB = V * WD * BEF$$

AGB is aboveground biomass, V is total stem volume, WD is wood density, and BEF is the biomass expansion factor.

In this development study, since BEFs are being developed for the three dominant tree species, the Study decided to apply a different type of BEF for each of the three dominant species. For other species, the BEF of *Engelhardtia roxburghiana* is used, which has the lowest calculated biomass of the three. WD is quoted from a table that summarizes WD values for 300 species of trees in Vietnam.

Meanwhile, a biomass allometric equation prepared in this development study, as shown below, uses the diameter at breast height (hereinafter, “DBH”) of each tree as a variable to estimate AGB.

$$AGB = a * DBH^{b}$$

AGB is aboveground biomass, *a* and *b* are factors, and DBH is diameter at breast height.

Figure 10.2.1 shows the results of calculations of AGB for 30 felled survey specimen trees using estimation methods of expansion factor and allometric equations.

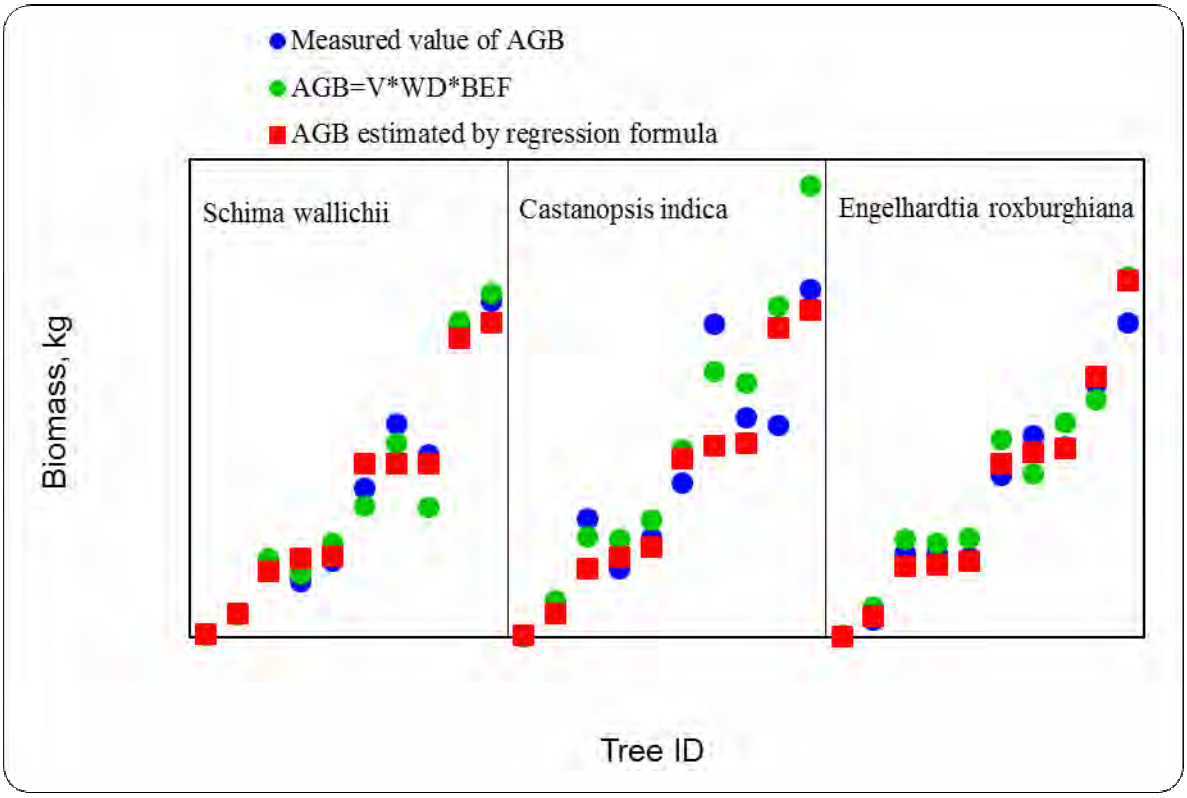


Figure 10.2.1 A comparison of the specimen trees' measured AGB and their estimated AGB calculated using estimation methods of the expansion factor and the allometric equation

When estimating AGB using the expansion factor method, there were some cases in which the calculated value overestimated the measured value. In contrast, the biomass estimation calculated using the allometric equation came closer to the actual biomass measurements.

In the referred list of WDs for expansion factor method, there are several different values even though they are for the same species of trees and they are measured under the same condition of moisture content percentage. Therefore, it seemed better to verify the WD to use. The Study team decided to employ an estimation method for biomass that uses allometric equations in this development study. However, since the correlation between the leaf and branch biomass and DBH was somewhat weak, the Study team decided not to estimate the biomass of each tree organ and add them up but to estimate the AGB directly from the DBH and the AGB allometric equation.

The biomass allometric equation is generally used by applying the allometric equation for each tree species. However, in the formula for *Castanopsis indica*, the p-value of the coefficient *a* is 0.079, which means that accuracy is somewhat low. Therefore, in order to estimate AGB for *Castanopsis*, the Study team decided to use the integrated allometric equation for the three dominant tree species. Note that the estimate of AGB yielded by the integrated allometric equation for the three dominant tree species is more conservative than the estimate yielded by the allometric equation for *Castanopsis indica* alone.

For AGB estimates for tree species besides the three dominant ones, use of the allometric equation is decided for *Engelhardtia roxburghiana*, since it yields the most conservative estimates of biomass.

By multiplying AGB of each estimated tree by the root/shoot ratio (hereinafter, “R/S”), the belowground biomass (hereinafter, “BGB”) of all trees is estimated. To estimate BGB, the following formula is used.

$$BGB = AGB * (R/S)$$

BGB is belowground biomass, AGB is aboveground biomass, and R/S is root/shoot ratio.

In performing the calculation, the calculated mean of the R/S ratio for each tree species is applied to the three dominant tree species, and the R/S of *Castanopsis indica* is applied for the other tree species, from which the most conservative BGB is calculated among the R/S of the three tree species.

The stem volume is tablulated and AGB and BGB of all the trees are calculated for each plot and converted into per-hectare growing stock and biomass.

The biomass, which had been converted into per-hectare biomass, is multiplied by the following carbon fraction to calculate the carbon stock of each plot.

$$Carbon\ Fraction = 0.47$$

The carbon fraction is generally about 0.5, but the Studydecided to use 0.47 to account for the tropical and subtropical trees, based on the FRA (2010) guidelines.

10.2.3 Results and Discussion

A single tree AGB was estimated by using the biomass allometric equation and the results added up by each plot and then converted to AGB per-hectare. Figure 10.2.2 shows a scatter plot with per-hectare growing stock for each plot of forest on the *x* axis and the estimated per-hectare AGB on the *y* axis.

Also, Figure 10.2.3shows a scatter plot with per-hectare AGB for each plot of forest on the *x* axis and the estimated per-hectare BGB on the *y* axis.

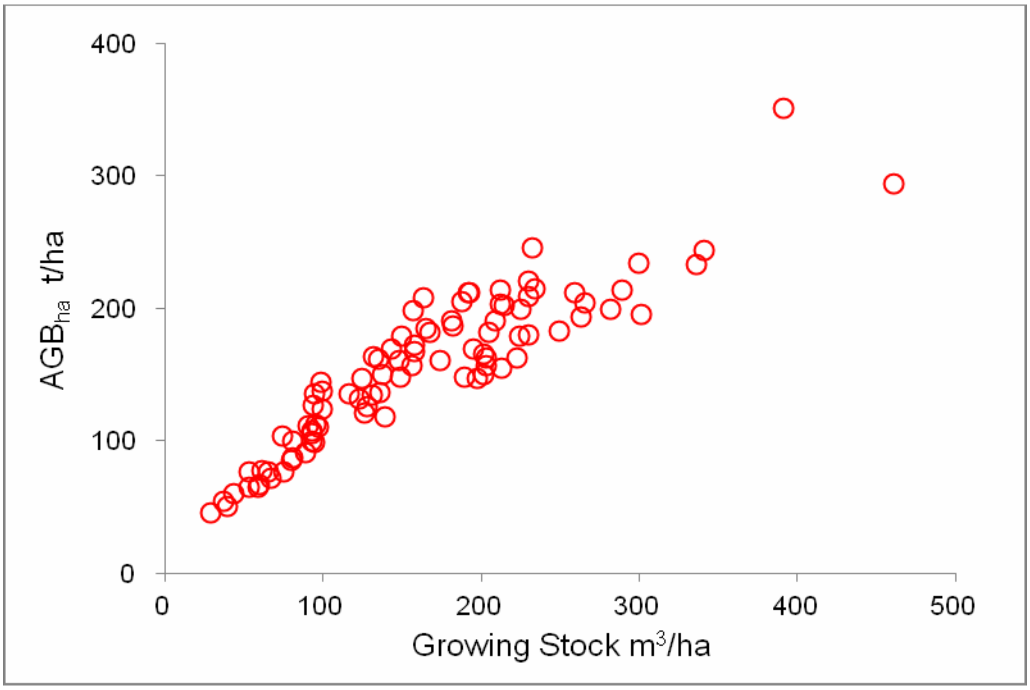


Figure 10.2.2 The relationship between per-hectare growing stock and AGB for the 90 plots

AGB_{ha} is the per-hectare above ground biomass.

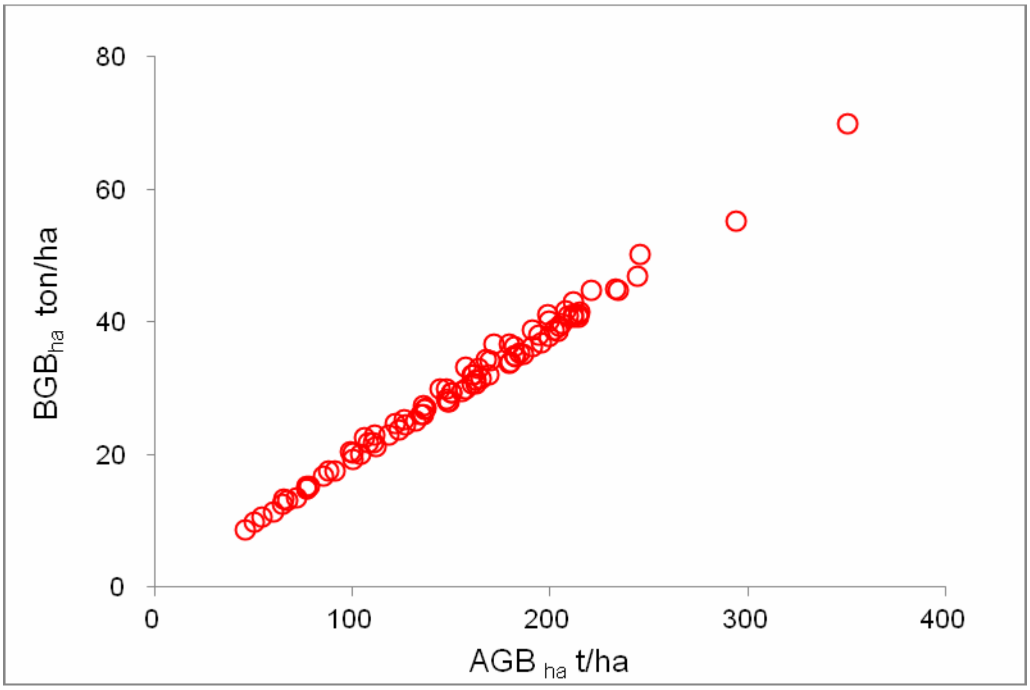


Figure 10.2.3 The relationship between per-hectare AGB and BGB for the 90 plots

AGB_{ha} is per-hectare aboveground biomass; BGB_{ha} is per-hectare belowground biomass.

Although variance can be seen in the per-hectare AGB, it was proportional to the growing stock. Since there were no major outliers in the AGB estimates, it seems that nearly appropriate estimates were obtained overall.

The correlation between BGB and AGB was proportional as AGB increased. Compared to the relationship between AGB and growing stock, the correlation between BGB and AGB shows little variance and shows a consistent relationship.

However, since there are low AGB values in certain plots even though they are high volume forests, it seems that the estimation method also requires improvement.

In the Study, the allometric equations used in AGB estimation were the allometric equations for two of the three dominant tree species and an integrated allometric equation for the three tree species. Since the allometric equation for *Engelhardtia roxburghiana* was applied for all tree species other than the three dominant ones, their AGB estimates could have exhibited variance. This variance is thought to be related to the tree species composing the plots. In other words, if most of the species arising on the plot are tree species other than the three dominant ones, the allometric equation for *Engelhardtia roxburghiana*, which yields conservative values, is used, which could mean that the biomass is underestimated. Consequently, in preparing the allometric equation it seems desirable to prepare biomass allometric equations for five or six species besides those prepared in this development study for the three dominant species.

Furthermore, it seems that the study obtained sufficient data on growing stock at 50 to 300 m^3/ha, but the data on poor forests at less than 50 m^3/ha and rich forests at 300 m^3/ha or greater are less than sufficient at this time. Accordingly, it seems desirable to perform sample plot surveys on poor forests and rich forests to collect additional data.

Table 10.2.1 classifies the 90 plots on which sample plot surveys were performed into poor forest (growing stock < 100 m^3/ha), medium forest (100 to 200 m^3/ha), and rich forest (> 200 m^3/ha), showing the tabulated values for their per-hectare mean growing stock, mean AGB, and mean BGB.

Also, Table 10.2.2 shows the mean carbon stock for each forest type in the 90 plots.

Table 10.2.1 Per-hectare mean growing stock, mean AGB, and mean BGB for each forest type in the 90 plots

Growing Stock Level m^3/ha	Forest Type	Number of Plot	Growing Stock m^3/ha	Above Ground Biomass t/ha	Below Ground Biomass t/ha
<100	Poor	29	76	92	18
100 - 200	Medium	31	156	164	33
>200	Rich	30	255	205	40
Mean			163	155	30

The mean growing stock values for the poor, medium, and rich forest types were 76 m^3/ha, 156 m^3/ha, and 255 m^3/ha, respectively. The mean AGB values the poor, medium, and rich forest types were 92t/ha, 164t/ha, and 205t/ha, respectively. The mean BGB values fo the poor, medium, and rich forest types were 18t/ha, 33t/ha, and 40t/ha, respectively.

Table 10.2.2 Mean carbon stock for each forest type in the 90 plots
(Showing divided between above ground portion and below ground portion)

Growing Stock Level m^3/ha	Forest Type	Carbon in Above Ground Biomass t/ha	Carbon in Below Ground Biomass t/ha
- 100	Poor	43	9
100 - 200	Medium	77	15
200 -	Rich	96	19
Mean		73	14

The mean carbon values in AGB fo the poor, medium, and rich forest types were 43t/ha, 77t/ha, and 96t/ha, respectively. The mean carbon value in BGB for the poor, medium, and rich forest types were 9t/ha, 15t/ha, and 19t/ha, respectively.

Multiplying the mean values of the aboveground and belowground biomass and carbon stock obtained in this development study by the forest area for each forest type should enable us to calculate the biomass and carbon level for evergreen broad leaf natural forest in Muong Nhe Nature Reserve (hereinafter, "MNNR").

In addition, substituting the tree data for the 90 plots in this provisional calculation into the tree data for each plot in Cycle-4 should enable us to apply it to the estimation of biomass and calculation of carbon stock on the evergreen broad leaved natural forest in Dien Bien Province and northern Vietnam.

10.3 Calculating the Conversion Factor for Estimating the Biomass per Unit Area from the Growing Stock

10.3.1 Objective

In carrying out REDD+ activities in Dien Bien Province and elsewhere, there needs to be a simple method by which local technicians can estimate forest carbon stock. To this end, using the results of Section 10.2, the conversion factor (the biomass conversion expansion factor; hereinafter, "BCEF") is calculated for directly estimating aboveground biomass per unit area from growing stock, as well as the root/shoot ratio (hereinafter, "R/S_{ha}") for directly estimating belowground biomass per unit area.

By deriving BCEF, per-hectare AGB is calculated from the per-hectare growing stock obtained in NFI or elsewhere.

10.3.2 Methodology

BCEF is calculated by the following formula, using the per-hectare AGB and growing stock tabulated for each plot.

$$BCEF = \frac{AGB_{ha}}{Growing\ Stock_{ha}}$$

BCEF is the biomass conversion expansion factor, AGB_{ha} is the per-hectare aboveground biomass (t/ha), and Growing $Stock_{ha}$ is the per-hectare growing stock (m^3/ha).

R/S_{ha} is calculated as follows, using per-hectare AGB and BGB.

$$R/S_{ha} = \frac{BGB_{ha}}{AGB_{ha}}$$

R/S_{ha} is the root/shoot ratio for deriving the per-hectare belowground biomass; BGB_{ha} is per-hectare belowground biomass; AGB_{ha} is per-hectare aboveground biomass.

BCEF values obtained from these calculations are classified into the following three standards for growing stock levels: *a*, *b*, and *c*.

a: The poor (growing stock < 100 m^3/ha), medium (100 to 200 m^3/ha), and rich (> 200 m^3/ha) forest types commonly used in Vietnam

b: Growing stock < 50 m^3, 50 to 100 m^3, 100 to 150 m^3, 150 to 200 m^3, 200 to 250 m^3, and > 250 m^3

c: The summarized standard for BCEF in the guidelines of the FRA (2010); that is, growing stock < 10 m^3/ha, 11 to 20 m^3/ha, 21 to 40 m^3/ha, 41 to 60 m^3/ha, 61 to 80 m^3/ha, 80 to 120 m^3/ha, 120 to 200 m^3/ha, and > 200 m^3/ha

The classified BCEF we tabulated for each growing stock level and their mean was taken.

Also, R/S_{ha} is calculated by AGB level into the following two standards, *d* and *e*, and we took their mean.

d: AGB < 100 t/ha, 100 to 150 t/ha, 150 to 200 t/ha, > 200t/ha

e: The summarized standard for BCEF in the guidelines of the FRA (2010); that is, AGB < 125 t/ha and > 125 t/ha

For R/S_{ha} the forest type is not classified because there was no existing documentation on the AGB level for poor, medium, and rich forest.

10.3.3 Results and Discussion

The relationship between the results of calculation of BCEF and the per-hectare growing stock of the 90 plots is shown in Figure 10.3.1.

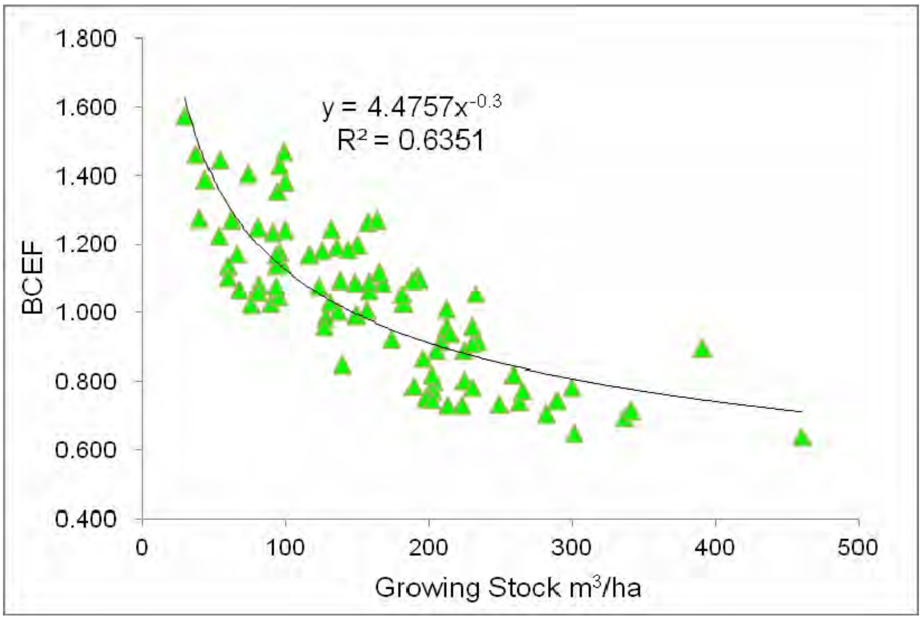


Figure 10.3.1 The relationship between the calculated BCEF and the per-hectare growing stock of the 90 plots

BCEF tended to be greater than 1 if per-hectare growing stock was less than 200 m^3/ha, but less than 1 if it was more than 200 m^3/ha. In stands where the growing stock level was especially low, BCEF was nearly 1.6.

Although re-growth forests were not covered in this development study and no data were obtained, as far as the distribution in Figure 10.3.1 shows, stands of less than 50 m^3/ha could yield a higher BCEF.

The calculated BCEF values are classified along the classification standards *a*, *b*, and *c*, and the results of taking their means are shown in Tables 10.3.1, 10.3.2, and 10.3.3.

Table 10.3.1 BCEF classification by classification standard a

Forest Type	Number of Plots	BCEF
Poor	29	1.234
Medium	31	1.059
Rich	30	0.817
Total	90	

Table 10.3.2 BCEF classification by classification standard b

Growing Stock Level m^3/ha	Number of Plots	BCEF
<50	4	1.423
50-100	25	1.204
100-150	14	1.074
150-200	17	1.046
200-250	19	0.861
>250	11	0.741
Total	90	

Table 10.3.3 BCEF classification by classification standard c

Growing Stock Level m^3/ha	Number of Plots	BCEF
21-40	3	1.436
41-60	5	1.258
61-80	5	1.187
80-120	17	1.201
120-200	30	1.055
>200	30	0.817
Total	90	

In accordance with the distribution in Figure 10.3.1, the BCEF values under any classification standard were high, at 1.204 to 1.436, for low growing stock levels of less than 100 m^3/ha, and were low, at about 0.8, for high growing stock levels.

For classification standards *b* and *c*, *c* provides a finer classification of BCEF at low growing stock levels. The distribution in Figure 10.3.1 shows a large fluctuation at a growing stock level of less than 100 m^3/ha. Accordingly, it is thought that adopting standard *c* is a good idea for BCEF at low growing stock levels.

However, classification standard *c* becomes a blunt classifier at growing stock levels of 120 m^3/ha or more. Figure 10.3.1 also shows fluctuations around where the growing stock level is 150 m^3/ha and 250 m^3/ha. Accordingly, it seems that classification standard *b* should be adopted when the growing stock level is 100 m^3/ha or greater, since that standard classifies in 50 m^3/ha intervals.

Table 10.3.4 shows a BCEF classification that is halfway between classification standards *b* and *c*.

Table 10.3.4 BCEF classification halfway between classification standards b and c

Growing Stock Level m^3/ha	Number of Plot	BCEF
21-40	3	1.436
41-60	5	1.258
61-80	5	1.187
80-100	16	1.203
100-150	14	1.074
150-200	17	1.046
200-250	19	0.861
>250	11	0.741
Total	90	

In actually using the BCEF, it is desirable to adopt classification standard *a* when an easy estimate is needed, and to adopt the halfway classification standard in Table 17 when a more detailed AGB estimate is needed.

However, when applying BCEF by classifications based on growing stock levels, since one BCEF value will be used for one growing stock range, the per-hectare AGB could be overestimated or underestimated near the top and bottom of the range. Considering such cases, it seems one can also use a method to determine BCEF using the regression formula for the approximating curve in Figure 10.3.1 (The following formula).

$$BCEF = 4.4757 * \left(GrowingStock\ m^3/ha\right)^{-0.3}$$

The method of determining the BCEF by the regression formula seems to enable derivation of BCEF values that match the per-hectare growing stock more directly based on the BCEF classification tables. However, in the per-hectare growing stock and BCEF regression formula obtained this time, it may be that some BCEF values are too high in forest stands with little growing stock.

Accordingly, at the current stage, it seemsthat BCEF values could be determined based on the regression formula for forest stands with growing stock of 50 m^3/ha or more, for which sufficient data are deemed to have been gathered, and use the BCEF in the classification table for forest stands with growing stock of less than 50 m^3/ha.

Furthermore, since a method for substituting for the regression formula is necessary for calculations, if expedience rather than precision is the goal, the use of a method that applies the BCEF classification tables is also deemed to be sufficiently robust for evaluation purposes.

Next, the relationship between per-hectare AGB and R/S_{ha} for each plot is shown in Figure 10.3.2.

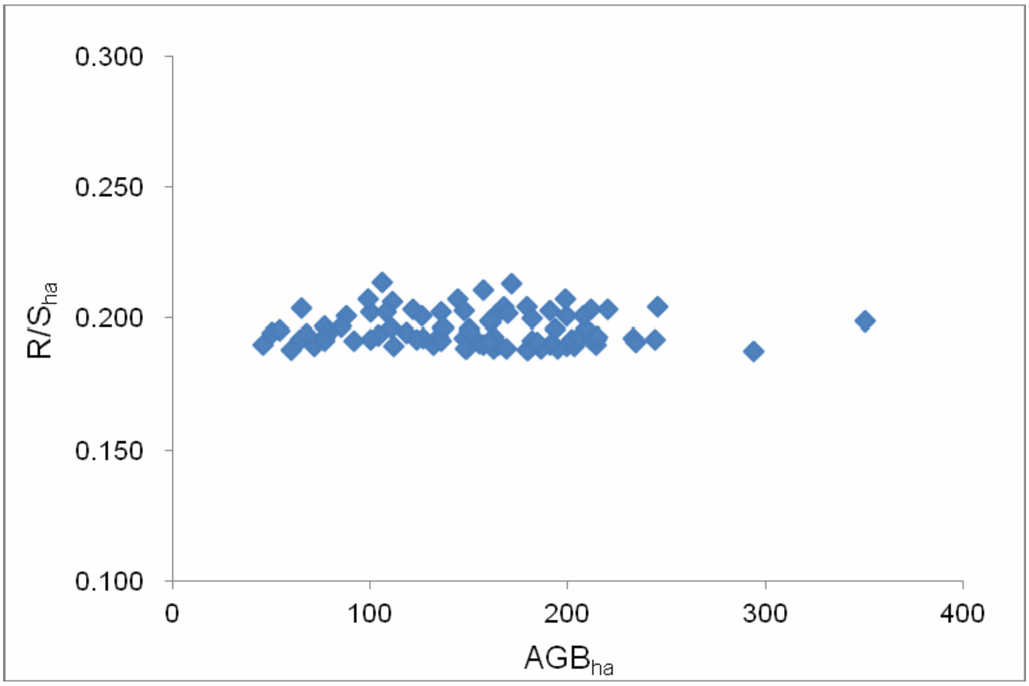


Figure 10.3.2 The relationship between per-hectare AGB and R/S_{ha} for each of the 90 plots

Since no correlation can be seen between per-hectare AGB and R/S_{ha} in the graph, it seems that nearly constant values were indicated at all AGB levels.

The results of classifying the calculated R/S_{ha} according to classification standards *d* and *e* and taking the mean are shown in Tables 10.3.5 and 10.3.6.

Table 10.3.5 R/Sha classification by classification standard d

AGB Level	Number of Plots	R/S_{ha}
<100	16	0.195
100-150	24	0.197
150-200	31	0.196
>200	19	0.195
Total	90	0.196

Table 10.3.6 R/Sha classification by classification standard e

AGB Level	Number of Plots	R/S_{ha}
<125	27	0.197
>125	63	0.196
Total	90	0.196

The mean value of the R/S_{ha} for each AGB level was around 0.196 in all the classification standards. In the classification standards in the FRA (2010) guidelines, the R/S figures change at the 125 t/ha AGB level, but no major changes in the figures were recognized, due to differences in AGB level for the R/S_{ha} obtained in this development survey.

The BCEF obtained in this development study was almost equal to that obtained in the FRA (2010). Although the BCEF ended up being close to the FRA (2010) figure, the BCEF in this development study was derived from a survey of 30 felled trees and a sample plot survey of 90 plots, and the BCEF classification is considered to reflect a correlation between growing stock and BCEF, so it seems to align with the current conditions of the natural forest in Dien Bien Province.

Similarly, since the R/S_{ha} is also derived from the felled tree survey and the sample plot survey, it seems that it more closely aligns with the current conditions in the natural forest in Dien Bien Province than the FRA (2010) figures do.

10.4 Further Considerations

The Study prepared biomass allometric equation for the three dominant tree species in the evergreen broad leaved natural forests in Dien Bien Province. Since these species are included in plant families that are seen widely in the evergreen broad leaved forests in northern Vietnam, the integrated allometric equation for the three tree species seems appropriate for be application to biomass estimation for evergreen broad leaved forests not only in Dien Bien Province, but also throughout northern Vietnam.

To increase the accuracy of biomass estimation going forward, it seems desirable to prepare biomass allometric equations for five or six other tree species besides the three dominant ones on which the felled tree survey was performed.

Table 10.4.1 shows the mean growing stock for the top ten species by growing stock in the MNNR based on the survey results of the 90 plots. The three tree species, *Schima wallichii*, *Castanopsis indica*, and *Engelhardtia roxburghiana,* account for approximately 60% of the growing stock in the felled tree survey performed this time.

Expanding to the top six species would encompass some 72% of the growing stock, and expanding to the top ten species would encompass about 81% of the growing stock. Accordingly, by performing a supplemental survey on three to seven varieties, it seems that there could be prepared an allometric equation that is suited to tree species that encompass most of the biomass in the evergreen broad leaved natural forests of Dien Bien Province.

Table 10.4.1 Mean growing stock of the top ten species by growing stock in the MNNR

SP name	Average Growing Stock (m^3/ha)	%
Castanopsis indica	67.0	41%
Schima wallichii	20.0	12%
Engelhardtia roxburghiana	9.0	6%
Aporosa dioica	8.8	5%
Manglietia fordiana	6.5	4%
Betula alnoides	6.1	4%
Michelia hypolampra	4.4	3%
Cratoxylum cochinchinense	3.7	2%
Mallotus paniculatus	3.3	2%
Machilus thumbergii	2.9	2%

When performing supplemental surveys, the increase in tree species will come with an increase in specimen trees, which would be expected to cause difficulties in carrying out the surveys. It could also be difficult to secure the specimen trees themselves, because the species besides the three dominant ones arise less frequently.

Consequently, in performing supplemental felled tree surveys, consideration should be given to preparing allometric equations by species for those that arise especially infrequently, as well as to placing within the scope of possibility the goal of creating an integrated formula for species of evergreen broad leaved natural forest trees besides the dominant ones that also arise.

Moreover, since some of Vietnam's forest stands include bamboo, it seems that the development of a biomass allometric equation and expansion factor for bamboo will be an issue going forward.

In this development study, we developed a BCEF to be applied to evergreen broad leaved forests in northern Vietnam. However, the data for the sample plot survey used in BCEF calculation was not really sufficient for stands with growing stock of less than 50 m^3/ha or more than 300 m^3/ha.

The approximating curve in Figure 10.3.1 shows that the slope gets larger in the range where growing stock is less than 50 m^3/ha. Therefore, for stands in which growing stock is less than 50 m^3/ha, the BCEF could be larger than 1.4.

In light of this, additional sample plot survey data for stands with growing stock of 50 m^3/ha seems essential for increasing the precision of BCEF. In Figure 10.3.1, although the slope of the approximating curve levels off and stabilizes in the high growing stock region, increasing the data for stands with growing stock around the 300 m^3/ha level seems likely to further boost the accuracy of the BCEF.

In Dien Bien Province and each province of northern Vietnam as well, re-growth forests can be seen in many places. Even if re-growth forests and poor evergreen broad leaved forest are similar in terms of growing stock, the species comprising the forest are pioneer species in the case of re-growth forest versus climax species in the case of poor forests, so there seem to be qualitative differences. For this reason, the coefficients such as BEF and BCEF, as well as the biomass allometric equation, which are obtained by surveying a re-growth forest seen to be different that those of a poor forest.

In this development study, re-growth forests were not subject to survey, although coefficients and biomass allometric equations that apply to those re-growth forests will need to be developed individually going forward to estimate forest biomass with high accuracy.

11. Provision of Information to Potential Investors

Provision of information to potential investors mentioned in this chapter is one of major seven components of the Study. Main contents of the component are 1) setting up a home page where the necessary information for REDD+ implementation is presented, including outputs of the Study, and 2) organizing seminars for REDD+ implementation in Japan as well as in Vietnam.

11.1 Results of the Questionnaire Survey

Prior to setting up the home page, a questionnaire survey for potential investors of projects for climate change mitigation in the field of forestry was implemented. Then, the contents of the home page were elaborated based on the results of the questionnaire survey as well.

The questionnaire survey was implemented in the year 2010. Since the results of the questionnaire survey are presented in Interim Report 2 of the Study, description of this section is the summary of the results. For the full version of report on the results, please refer the report mentioned above.

The Study Team prepared three kinds of questionnaires: one for potential investors, one for consultants, and one for the buyers of credits. The Study Team contacted 20 entities consisting of 18 Japanese entities and 2 foreign entities and received responses to the questionnaire from 10 entities among the 20 entities.

Regarding the breakdown of 12 entities from which the Team received responses to the questionnaires, there are six (6) entities from among investors, three (3) entities from among consultants, and three (3) entities from among buyers,. The reason for the difference between 10 entities and 12 entities is that there are cases where the same entity responded to both the questionnaire for investors and that for buyers. Results of the survey can be found in chapter 5.2 of the main part of Interim Report 2. Only main results of the responses to the question items to which responses by description are required are mentioned in this summary, and they are as follows.

1) Necessity of the following information on legislation, institution, administration, and social conditions, etc.

- Legislation on REDD+ in Vietnam
- REDD+ initiatives in Vietnam
- Procedure, scheme, and model case for investment in REDD+ projects
- Mechanism of transferring credit of emission right
- Focal point with contact persons in Vietnam to implement REDD+ projects.
- Status of NGO and consultants which can provide service for implementation of REDD+ projects
- Project land for plantations which foreign companies can obtain
- Intention of local peoples' committee and local people
- Permission, cost, etc. pertaining to harvesting the plantations and use of timber products

2) Necessity of the following information on natural conditions, etc.

- Suitable sites for the REDD+ projects such as area, land ownership, status of deforestation and forest degradation, status of surrounding communities, etc.
- Land use change map and vegetation map between 1990 and present
- Prospect of growth of the current vegetation

3) The following issues are pointed out.

- It is important to establish RLs and/or RELs and stipulate regulations from distribution of credits from emission right, which stipulated in Vietnam REDD+ legislation from the points of view of how much profit can be gained from emission trade.
- It is necessary to obtain information on concrete programs (including necessary funds) for forest conservation such as projects which contribute to reduce logging activity in the local community.
- It is difficult to develop projects on REDD+ without regulation or a course action on how credits are distributed to each individual project.

According to the results of survey, the following issues could be analyzed.

At present, there are many uncertain factors for implementation of REDD+ projects, compared with other investment projects. In addition, the factors are controlled by international negotiation in UNFCCC and there are many external conditions in the factors that cannot overcome by effort of firms; for example, a carbon market for REDD+ has not yet been established. In this context, it is assumed that it is difficult for firms to decide whether or not they should implement REDD+ projects.

One of concerns of the buyer of the credit is effectiveness on the institution of credits; in other words, finally whether or not there is possibility that credit of REDD+ can be used as compliance to achieve Japanese target for reducing emission. Therefore, it is assumed there is no intension to buy the credits because of problems on replacing credit in the A/R CDM scheme and ownership in the REDD+ scheme.

11.2 Contents of the Website

This section describes contents of the website to introduce the activities of the Study, which is one of the final outputs in the component “Provision of information to potential investors” of the Study. Contents of the website are based on the results of the questionnaire survey, which are described in section 10.1. Information to be provided on the website was analyzed, taking into consideration what information can break the barrier for potential investors to make an investment. Meanwhile, other information collected through implementation of the Study was also analyzed by the Team on its applicability to promote implementation of REDD+ by potential investors.

On the basis of the above criteria, the Team established the website to provide the information listed in Table 11.1.1. There are six sub-sites set beneath the homepage of the website. Site 1 introduces overall achievement of the JICA Study. Site 2 through site 4 provide basic information that can be taken into consideration when the REDD+ is designed. Site 5 provides information on how to contact the NGOs and consultants that can support implementation of the field level activities. Site 6 introduces publications on REDD+. The website can be accessed at http://www.jpn-vn-redd.org.

Table 11.1.1 Contents of the web site

Item	Title	Contents
Home	Introduction of the JICA Study	- Introduction of the JICA Study - Objectives of setting up the website
Site 1	About the JICA Study	- General description; framework of the JICA Study - Outputs of the JICA Study

1-1	Development of the forest maps	- Forest change maps (1990, 1995, 2000, 2005, 2010) - A/R CDM potential area map
1-2	Model land survey	- Compilation of the model land survey: Binh Phuoc case; Dak Nong case; Nghe An case; and Kon Tum case
1-3	Setting a REL and cost/benefit estimation	- Measures to set RELs/BAUs in the national level - A/R CDM cost and benefit analysis
1-4	Providing information to investors	- Method of the questionnaire survey - Important issues based on the survey result
Site 2	Background information (natural conditions)	- Introduction
2-1	Geographical (topographical) data	- Landscape - Geology - River system
2-2	Meteorological data	- Overview on climate - Temperature - Precipitation - Wind direction - Meteorological Observatory - Statistical database (other website to be referred)
2-3	Soil data	- General condition - Development of forest soil survey - Distribution of forest soil type (and its characteristics)
2-4	Natural disasters	- Record of typhoon and flood and fire in the past - Introduction of other web-sites to be referred
2-5	Species for planting	- National standard on species to be planted - Fast growing (exotic) species – yield table, etc. - Indigenous species – yield table, etc.
2-6	Biodiversity	- Distribution of biodiversity/endangered species
Site 3	Background information (socio-economic conditions)	- Introduction
3-1	Ethnic minorities	- Distribution (list) of ethnic minorities - Brief description of each ethnic group
3-2	Laws related to land use	- Land law/forest protection laws/decisions, etc. - Land ownership of forestlands (procedure of how to obtain Red-book) - Land-use right related to forestlands - Property right of the products (timber, NTFP)
3-3	Relevant statistical data	- Data on population, industries, etc.
Site 4	Background information (political, administrative and other conditions that can affect implementation of forest- related projects)	- Introduction
4-1	Political and administration system	- List of relevant authorities of in province, district and commune levels - Introduction of departments where the data and information are available
4-2	Protected areas	- Distribution (list) of protected areas (special-use forest) - Outlines of protection forests
Site 5	Local NGOs and consultants	- List of Vietnamese and international NGOs and consultants associated with REDD+
Site 6	Publication on REDD+	- Introduction of important documents (references)

11.3 Seminar for REDD + Implementation

In order to inform to potential investors about relevant REDD+ issues and its activities, several significant workshops have been held while the survey has been conducted. Workshop and seminar presentations are intended for improvement of the relevant REDD+ knowledge on the part of potential investors. Three main workshops and seminars for potential investors are mentioned in this chapter.

Firstly, “Workshop on Model land survey” was held in October, 2010. There were 27 Participants and 20 organizations, including non-governmental organizations (NGOs) such as Fauna and Flora International, Center for Sustainable Rural Development (SRD), World Wide Fund for Nature (WWF), TRONBENBOS and International, and Netherlands and Development Organizations (SNV). In addition, the officials of the Royal Norwegian Embassy also participated in this workshop.

The workshop program summary is as follows.

-Introduction to the JICA Study
-Introduction to the model land survey
-Potential of reduction of emission from deforestation and forest degradation in Vietnam
-Reduction of emission from deforestation and forest degradation through mitigation of rubber plantation development in Binh Phuoc Province
-Reduction of emission from deforestation and forest degradation through CFM and enhancement of forest management by forest enterprise in Dak Nong Province
-Discussion; Q/A
-Reduction of emission from deforestation and forest degradation through man-made forest development on shifting cultivation site in Nghe An Province
-Reduction of emissions from deforestation and forest degradation through community-based forest management in Kon Tum Province
-Wrap-up of the discussion

The workshop ended with a remark that a wide range of study experiences from carbon measurement and socio-economic analysis to policy analysis conducted in the model land survey are very valuable and are essential for REDD+ implementation. Also, the experience of the multidisciplinary survey should be involved for the realization of better REDD+ implementation of Vietnam.

Secondly, for potential investors and those who are interested in REDD+ activities, a seminar on promotion of REDD+ activity in Vietnam was held in October, 2011 in Tokyo. There were 81 participants from 25 private companies, 8 agencies, 7 NGOs, and 6 universities.

The seminar program summary is as follows.

-Compliments
-Congratulatory speeches
-Introduction to the seminar and the JICA Study
-Computation of RELs and forest dynamics since 1990 based on forest distribution map in Vietnam
-Discussion
-Model land survey results for 4 provinces in Vietnam
-The preparation of basic Plan for REDD+ Development in Dien Bien Province

-Discussion
-The current status of REDD+ development and prospective view, policy, action, and implementation structure in Vietnam
- Wrap-up of the discussion

The objective of this seminar is for potential investors to promote REDD+ activity in Vietnam. The results of the survey so far were presented by the Study team. As well as giving an explanation of setting RELs and RLs as the technical portion of REDD +, "Basic Plan for REDD+ Development in Dien Bien Province" was also introduced. Furthermore, two experts in REDD+ in Vietnam, including a Vice Minister of the Ministry of Agriculture and Rural Development, were invited as a guest speaker and a guest from Vietnam. They introduced the current status and prospective view with the relevant policy and implementation structure towards REDD+ activity in Vietnam by the Vietnamese Government. As a whole, the seminar attracted favorable comments and opinions through active exchange of views among the participants.

Thirdly, "Technical workshop on verification of NFI data" was held in August, 2011. There were 30 participants from 14 organizations: FAO, FFI, FIPI, FORMIS, FPT, FSIV, ICRF, RCFEE, VAST, UN-REDD Vietnam, US Forest Service, VFU, VIDAGIS Co., Ltd, and VNFOREST.

The objective of the workshop was to share and discuss the results of verification of NFI data (Cycle-4) based on the field survey in 2011 conducted by the study team. The verification results between the value of verification and QA/QC and its contribution to emission factor were explained.

The workshop program summary is as follows.
-Overview of the Workshop
-Sharing Experience of the Field Survey
-Results in the analysis of measurement methodology and verification of Cycle data
-Break
-Recommendation for National Forest Inventory
-Wrap-up of the discussion

Recommendations were given towards the next NFI (Cycle-5) regarding the measurement methodology, the process of volume estimation, sampling design, and verification system to improve the accuracy and repeatability of NFI as well as verification. In a Q & A session, NFA project of Cycle-5 planning by FAO commented that they would positively consider the ideas presented by the study team.