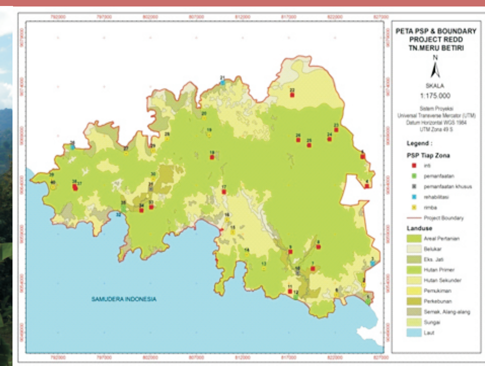
ANALYSIS OF LAND USE, LAND COVER CHANGE AND THE ASSOCIATION CARBON STOCK CHANGE TO ESTABLISH PROJECT BASELINE



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SUMMARY

Meru Betiri National Park (MBNP) located in southern part of East Java is one the National Parks which has been selected as the project site for ITTO activities. The total area of the Park is ± 58,000 ha consisting of various vegetation types from mountainous to coastal areas. MBNP as ITTO project for DA REDD would provide information required by international standard related to credible, measurable, reportable and verifiable (MRV) system for monitoring emission reductions from deforestation and forest degradation and enhancement of forest carbon stocks.

Setting reference level or baseline for GHG emissions is among the more challenging issues in implementing REDD+ projects. Reference level was set based on estimation of carbon stock from ground measurement through establishment of 40 permanent sample plots and remote sensing data to analyse land cover change. Carbon stock in MBNP varied from 28.7 to 166.63 ton C/ha with the highest carbon stock in secondary forest.

Estimation of emission was carried out using IPCC Guideline 2006. The analysis showed that there was sequestration or no emission during the period of analysis in 1997-2010. The sequestration during 1997-2001 was 211.715,56 ton CO_2-eq/year, in 1997 and 242.460,05 in 2010 with annual average of 226.158,75 ton CO_2-eq/year. Sequestration in MBNP during the period of 1997-2010 was mainly contributed from low deforestation rate and even there was land changes from other land to forest land due to activities in rehabilitation zone. Meanwhile, from the official report, there were small figures of logging and fires as sources of emission.

Reference level as Business As Usual (BAU) for emission up to the year 2020 was estimated based on average emission from 1997-2010. Regression anlysis was performed to identify the relationship, however there was no model fit for the existing data. Therefore, scenario of emission from MBNP in the future was made based on possible deforestation and population growth. Based on forecasting analysis in BAU, CO_2 sequestration will increase during 2010-2020 from 242.460,05 ton CO_2 eq in 2010, to 264.420,40 ton CO_2eq in 2020, with average of 253.440,22 tonCO_2 eq/year. BAU scenario assumes constant parameters until 2020, such as annual deforestation rate and annual sequestration. Scenario 1 explores what will happen if efforts are put on rehabilitation activities. In this scenario, it assumes that rate of CO_2 sequestration gained from rehabilitation is 24.859,63 tCO_2eq/year. Scenario 2 shows that protection activity in primary forest of Meru Betiri National Park result the CO_2 sequestration is 170.925,85 t CO_2eq/year.

These preliminary results showed that carbon emissions in Betiri Meru National Park were negative or sequestration, due to small rate of deforestation and vegetation growth. Therefore, for national park as conservation area, REDD+ should be focussed on maintaining conservation or biodiversity and improvement of community awareness and welfare. Voluntary standard of Community and Climate Biodiversity (CCB) is available for REDD+ project focussing on biodiversity and social safeguards. Information on important flora and fauna as biodiverity in MBNP is also included.

Keywords : Reference level, biodiversty, MBNP, REDD+ conservation.

1. INTRODUCTION

Forestry Sector in the context of climate change is included as LULUCF sector (Land use, land use change and forestry). This sector plays important role in carbon cycle, with contribution in global level up to 18% of total global emission (Stern, 2007). Meanwhile in national level, it contributed to about 48 % of total GHG emission (Ministry of Environment, 2009). However, forests also have capability to absorb carbon through their capability to grow, therefore forest can also contribute to global community through its role in reducing GHGs emissions.

International scheme is being developed to include REDD (Reducing Emission from Deforestation and Degradation) as carbon related mechanism to deal with global warming. REDD is basically the activities to reduce emission through avoidance of forest conversion and other activities that cause deforestation and degradation. The idea is enhancing forest carbon stocks through conservation of the existing forests. Undisturbed conservation forests store significant carbon, and therefore avoiding emission to the atmosphere, meanwhile, illegal logging, disturbance and forest encroachment increase carbon emission to the atmosphere.

Indonesia is potential for REDD activities because it has been experiencing planned and unplanned deforestation and degradation. From total forest area of 133.6 million hectares, annual deforestation rate in Indonesia has been 1.1 million ha (Ministry of Forestry, 2009). Reduction to rate of deforestation may reduce emission from forestry sector.

Meru Betiri National Park (MBNP) located in southern part of East Java is one the National Parks which has been selected as the project site for ITTO activities. The total area of the Park is ± 58000 ha consisting of various vegetation types from mountainous to coastal areas. MBNP is rich of biological diversity and community living surrounding the forest which give both positive and negative effects to the sustainability of the forest. MBNP as ITTO project for DA REDD would provide information required by international standard related to credible, measurable, reportable and verifiable (MRV) system for monitoring emission reductions from deforestation and forest degradation and enhancement of forest carbon stocks.

For REDD project, setting reference level or baseline for GHG emissions is an important step and among the more challenging issues in implementing REDD+ projects. There is very little guidance in the agreed texts of the UNFCCC. The annex of decision 2/CP.13 suggests: *Reductions in emissions or increases resulting from the demonstration activity should be based on historical emissions, taking into account national circumstances.*

This activity had objective to make analysis of land use, land cover change and the association carbon stock change to establish project reference level as baseline for REDD+ in MBNP. Baseline of reference level is set based on estimation of carbon stock changes and emission from ground measurement through establishment of 40 permanent sample plots and land cover change based on remote sensing data analysis.

II. SETTING REFERENCE LEVEL (BASELINE)

2.1. Theory

Setting Reference Level is important activity for REDD project. Total emission reduction from project activity is set from the reference level. It is usually estimated from historical data of emission, however there has been no agreement on how to set a reference level. Expert suggestion includes using a 5-year average and updating it every 3 years, and using 10-year averages (e.g., the recent Brazil commitment to reduce emissions). Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD, 2009) recommends using forest cover values from 1990, 2000 and 2005, if better data are not available. Baselines, or reference level, can refer to two different things. First, they can refer to a business-as-usual (BAU) scenario, a prediction about what would happen without any REDD+ actions. Second, they can refer to a crediting baseline, which is similar to an emissions quota.

Business As Usual (BAU) baseline is the benchmark for measuring the effect of a REDD+ intervention, while the crediting baseline is the benchmark for rewarding a carbon rights holder. The term ‘reference level’ is in the sense of crediting baseline. At the international level, reference levels can be seen as modified BAU baselines, which reflect ‘common, but differentiated responsibilities’.

There are basically three approaches to establishing a Reference Level to serve as a performance standard against which future emission can be monitored:

a. An average of past conditions. In which case there needs to be agreement for the time interval covered, when it should commence, and how far into the future it should apply. This could serve as the RL and would be the simplest approach.

b. A modeling approach based on unplanned (unsanctioned) activities and planned land use to meet development goals. In which case a model needs to be selected and the future projection period set.
c. A further option is to consider a mixed RL where emissions from planned and unplanned drivers of deforestation and degradation are considered differently and separately. In this case, emissions from unplanned activities are measured against a RL based on historical unplanned emissions, or an average of historical emissions.

2.2. Reference Level in National Level

The overall reference level of a REDD+ country must be harmonised with the reference levels set for subnational activities, projects and forest owners. A combination of bottom-up and top-down approaches is needed. This harmonisation of reference levels across scales is a challenging task. While setting reference levels involves political decisions, scientists can help predict deforestation.

One approach to understanding the historical context of deforestation in a country might be to use the forest transition theory. This concept has been used to describe a sequence where forest cover first declines and reaches a minimum before it slowly increases and eventually stabilises. The historical component in setting a reference level would consist of assessing the current position of a country or region within the forest transition curve, and modifying future predictions based on that.

The forest transition theory can also be combined with a land rent modelling approach (the von Thünen framework), constrained by land capability and other important factors. Using this combined approach, a country could assess a range of plausible future rates of deforestation and the future shape of the transition curve (Angelsen 2007).

Ministry of Forestry of Indonesia has described criteria for national RL based on UN Doc FCCC/SBSTA/6 (SB 28 Bonn) Annex III Main methodological issues; Reference emission levels "development of REL is based on historical data, by considering inter-alia, trend, starting period and duration of reference period, availability and reliability of historical dan and considering national circumstances. REDD-UNFCCC Meeting on "Methodological issues relating to REL" in Bonn, 2009, stated that REL is total gross emission from geographical area that is estimated for reference time period of REDD.

Decision 4/CP.15 on Methodological guidance for activities relating to REDD and the role of conservation, Sustainable Forest Management (SFM) and enhancement of forest carbon stock in developing countries, describes: in Article 1 (d): To establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems and, if appropriate, sub-national systems as part of national monitoring systems that:

- Use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes;
- Provide estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account national capabilities and capacities;
- Are transparent and their results are available and suitable for review as agreed by the Conference of the Parties;

REL based on historical data and adjusted to national circumstances means that RL (in eq CO2) is calculated from historic deforestation rate (ha/year) multiplied by reference period (year) and emission factors (eq CO_2/ha), by considering deforestation projection as party of national circumstances negotiations. Rahayu (2010) stated that National REL is based on activity data of land coverage change from the data of Landsat 5, Landsat ETM+ for the year 1990, 1996, 2003, 2006 and 2009. Emission/removal factors are based on sample plots of National Forest Inventory (NFI), consisting of : 2735 cluster plots (1990-1996), 2735 cluster plots (1990-1996), 1145 cluster plots (1996-2000), 485 cluster plots (2000-2006) and 2997 cluster plots (2006-2010) as redesign of NFI.

III. METHODOLOGY APPLIED

3.1. Study site

Meru Betiri National Park (MBNP) was established through the enactment of Ministerial Decree No. 277/Kpts-VI/1997. Based on this decree, the area of MBNP covered about 58,000 ha, and is located in Jember and Banyuwangi District, East Java Province. Within the area, nucleus zone is the largest proportion of the MBNP (48.13%), followed by forest zone (39%), rehabilitation zone (6.94%), intensive use and buffer zone (5.94%) (Figure 1).

Each zone has its characteristics and function. Based on Ministerial Decree No. 56/2006, nucleus zone is a pristine and dense forest, characterised by indigenous flora and fauna. Forest zone is a buffer for nucleus zone, and situated between nucleus zone and utilization zone. Rehabilitation zone is a degraded area that needs to be rehabilitated. Buffer zone is an area managed specially for accomodating protection and conservation of natureal park, including ecotourism. Utilization zone is utilized for ecotourism and other environmental services purposes.

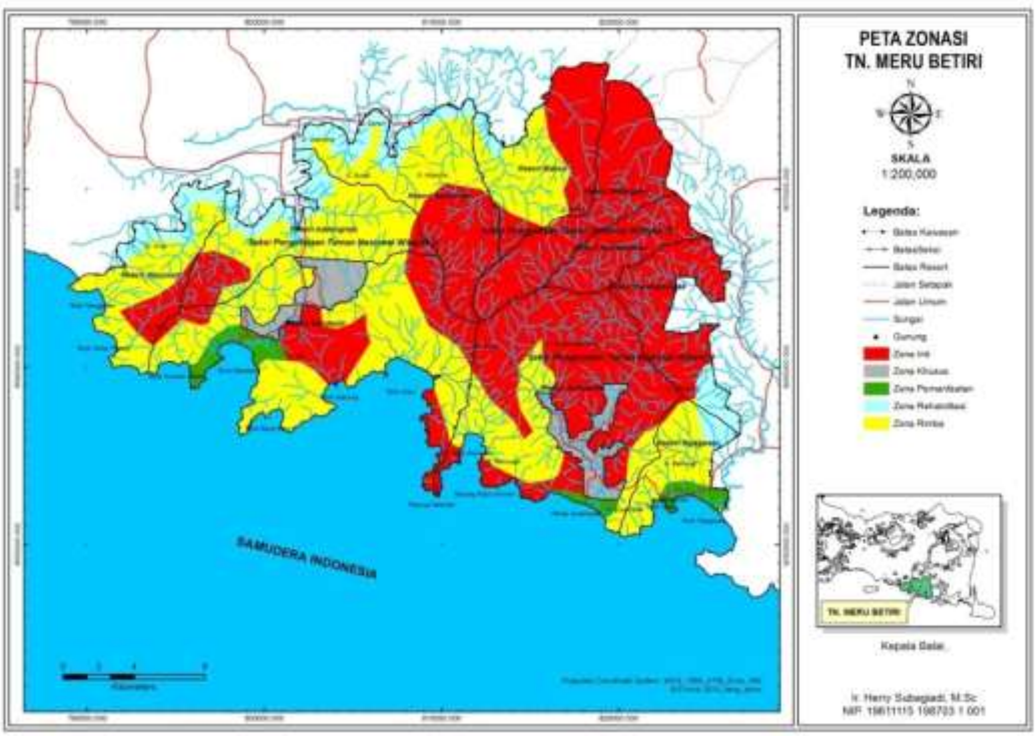

Figure 1. Zonation map of MBNP

2.2. Methods

2.2.1. Remote Sensing Analysis

Detail information on remote sensing analysis is available on Technical Report No. 7. Initial Phase of Measuring Carbon Sequestration For REDD+ In Meru Betiri National Park, Indonesia : Landcover Change Analysis Using Remote Sensing And GIS (Arifanti, *et al*, 2010).

Instrument used for conducting data analysis is a unit of computer equipment with software Erdas Imagine 9.1, Er Mapper 7.0, ArcView 3.2. A handheld GPS is used for ground truthing activities in the study site.

Satellite imageries used are as follows:

(i) Landsat TM 5 Path 117 Row 066 for acquisition for year 1997 and 2001,
(ii) Landsat ETM 7 for acquisition year 2005, 2007, 2010,
(iii) ALOS PALSAR for 2007, 2008 and 2009.

General information of each types of satellite imageries used in this study is described in Table 1.

Table 1. General information of each type of satellite imageries

No	**Sensor**	**Spatial Resolution**	**Temporal Resolution**	**# of bands**
1.	Landsat MS/ETM	30 m	16 days	7 (multispectral)
2.	ALOS PALSAR	50 m	46 days	1 (L band)

The methods used for monitoring of forest cover change using satellite remote sensing can be divided into several steps as follows: (i) Pre-processing including geometric correction, image classification, ground truthing and re-classification, and (ii) generation of land change matrix.

2.2.2. Estimation of Carbon Stock

Carbon stock in MBNP was estimated from PSPs that have been established representing all zones in MBNP. Various design of sample plots have been applied for measurement of carbon stock in forestry project, including 40 x 30 m (JICA-FORDA project), 100 x 100 (National Forest Inventory), 200 x 200 (PSP for monitoring of increment in mineral soil, FORDA, 1993), 30 x 30 m (Dahlan *et al*., 2005), and 20 x 100 m (Asmoro, 2009, Hairiah and Rahayu, 2007, Hairiah *et al*., 2001a and b). Refers to ground based inventory, permanent sample plots (PSP) of 20 x 100 meter are established in MNBP to estimate its carbon stocks (Figure 2).

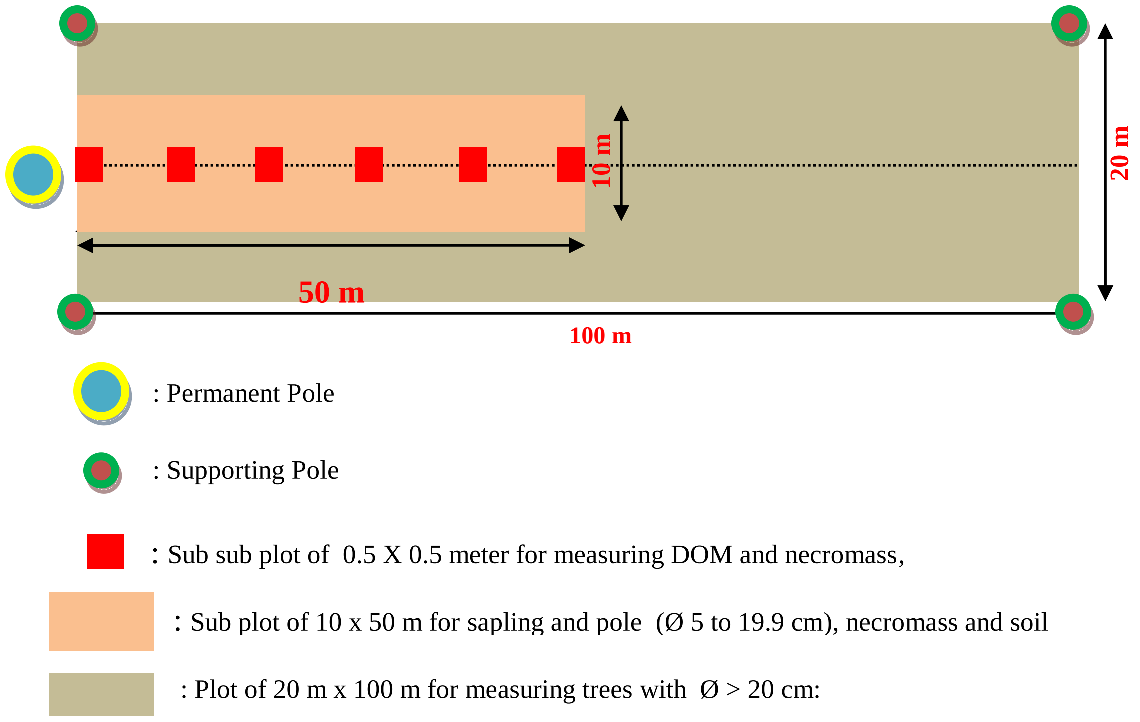

Figure 2. PSP design for measurement of carbon pools in MBNP

Total 40 PSPs were established (see figure) and carbon stock was measured according to IPCC GL 2006, consisting of five carbon pools namely above ground biomass, below ground biomass, necromass, litter and soil.

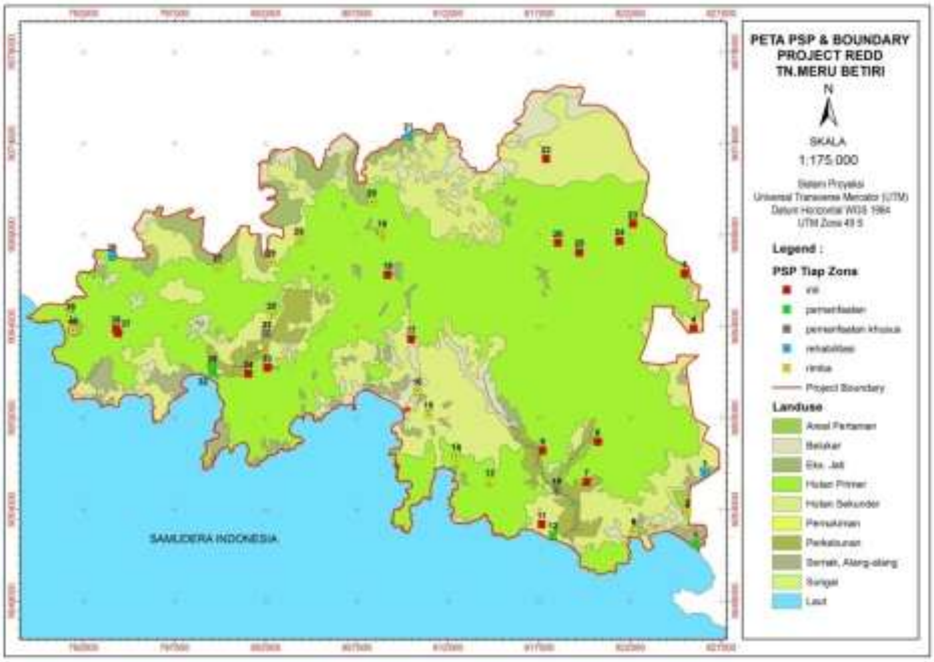

Figure 3. Locations of 40 PSPs representing all zones in MBNP

- *Above Ground Biomass (AGB) Measurement*

Above Ground Biomass is measured for living trees and understorey. AGB of living trees is measured with non-destructive method and applies allometric equation to obtain biomass. The allometric equations for biomass usually consist of information on trunk diameter at breast height DBH (in cm), total tree height H (in m), and wood-specific gravity (in g/cm³). Baker et al. (2004) have shown that ignoring variations in wood density results in poor prediction of the stand (AGB). Therefore, the wood-specific gravity is an important predictive variable in the regression model. The choice of the best predictive allometric equations (models) in estimating AGB is developed by Chave et al. (2005) on the basis of climate and forest stand types. Equation (a) is good for moist forest stand, equation (b) for dry forest stand, and equation (c) for wet forest stand:

$AGB = 0.0509 * \boldsymbol{\rho} D^2 H$ (equation a)

$AGB = 0.112 * (\rho D^2 H)^{0.916}$ (equation b)

$AGB = 0.0776 * (\rho D^2 H)^{0.940}$ equation c)

Where,
ABG = above ground biomass [kg];
ρ = wood specific gravity [g cm^{-3}];
D = tree diameter at breast height [cm]; and
H = tree height [m].

- *Woody Necromass Measurement*

The dead organic matter pool (woody necromass) includes dead fallen trees, and other coarse woody debris above the soil surface. Within the plot, all woody debris and trunks (unburned part), dead standing trees, dead trees on the ground and stumps are sampled. Their height (length) and diameter are recorded, as well as notes identifying the type of wood for estimating specific density.

- *Litter (Non Woody Necromass) Measurement*

Litter consists of leaves and small branches above the ground as non woody necromass. Litter samples are collected from the same quadrants of 0.50 m x 0.50 m (0.25 m2) as used for under storey sample. Basically it is separated from coarse litter and fine litter. Coarse litter is any tree necromass less than 5 cm diameter and/or less than 50 cm length, undecomposed plant materials or crop residues, all unburned leaves and branches. Fine litter is at organic layer (0- 5 cm above mineral soil layer) in the same quadrates, including all woody roots.

- *Soil Samples*

Soil organic carbon determined through samples collected from the default depth prescribed by the IPCC (2006). Soil samples are taken from three layers (depth), 0-10 cm, 10-20 cm dan 20-30 cm at six points on each plot. Soil samples are analyzed in the laboratory as composite samples to identify chemical properties such as pH and C content.

2.2.3. Estimation of Baseline/Reference Level

Baseline has been established based on historical data of emission from 1997 to 2010. Regression analysis was made to make prediction up to the year 2020. Average emission was also used to estimate future prediction. Moreover, estimation of future prediction of emission also considers population growth and deforestation rate. The following steps and assumption are made to establish reference level:

- Preparation of land cover change matrix (LCM) for the period of 1997-2010 into six land categories namely: forest land, crop land, grass land, wet land, settlement and others land
- Estimation of annual rate of forest conversion to other land uses for the period of 1997-2010 that was 32,05 ha
- Collection of data for forest disturbance caused by illegal logging, forest fire and land encroachment. Forest disturbance was estimated from data of report of Meru Betiri National Park during 1997-2010. Logging was 56,367.75 m3/year (1997-2001), 18,803.43 m3/year (2001-2005), 17,493.84 m3/year (2005-2007) and 26,171.75 m3/year (2007-2010). Wood densities used in this analysis were 0.52 ton/m3 (primary forest), 0.48 (secondary forest) and 0.69 ton/m3 (mangrove forest). Biomass expansion factor used in this analysis was 0.7.
- Fuel wood consumption was estimated to be about 180 m3/year (data from report of Meru Betiri National Park)
- Emission from mineral soil due to land cover changes was not taken into account
- Above ground biomass of each forest type was estimated using allometric equation. Mean annual biomass increment was based on data in IPCC Guideline 2006.
- All data are used to calculate emission using worksheet of IPCC Guideline 2006.
- Regression was applied using data of number of population and deforestation rate in 1997-2010 to estimate emission/sequestration prediction until 2020.
- Scenarios of emission were made based on rehabilitation activity and protection of primary forest.
- Interpolation of emission/sequestration data of CO_2 from 1997-2010 was made to estimate emission/sequestration of CO_2 from 2010 until 2020.
- Calculation of emission/sequestration of CO_2 was made from rehabilitation activity and protection of primary forest.

2.2.4. Information on important flora and fauna

As conservation area, biodiversity is important component of national park. Informatiom on flora and fauna is collected from database of MBNP from the result of biodiversity survey.

IV. RESULTS

4.1. Land cover change

Time series analyses for land cover change in MBNP showed there are quite distinct changes in the Northern part of MBNP, namely in the rehabilitation zone. In 1997/1998 during the reformation period, forest encroachment and illegal logging had been occurred in the former forested area in MBNP. Since then the area were barren (approximately 4,023 ha) and slowly it was covered with shrub and bushes (Landsat 2001). Since 2003, the area was assigned as rehabilitation zone where intensive reforestation programs had been conducted. This effort had an impact to land coverage, where forest trees are planted intercropped with dry land agriculture vegetation. Landsat 2010 also showed that the area is currently dominated with shrub mixed and dry land agriculture vegetation.

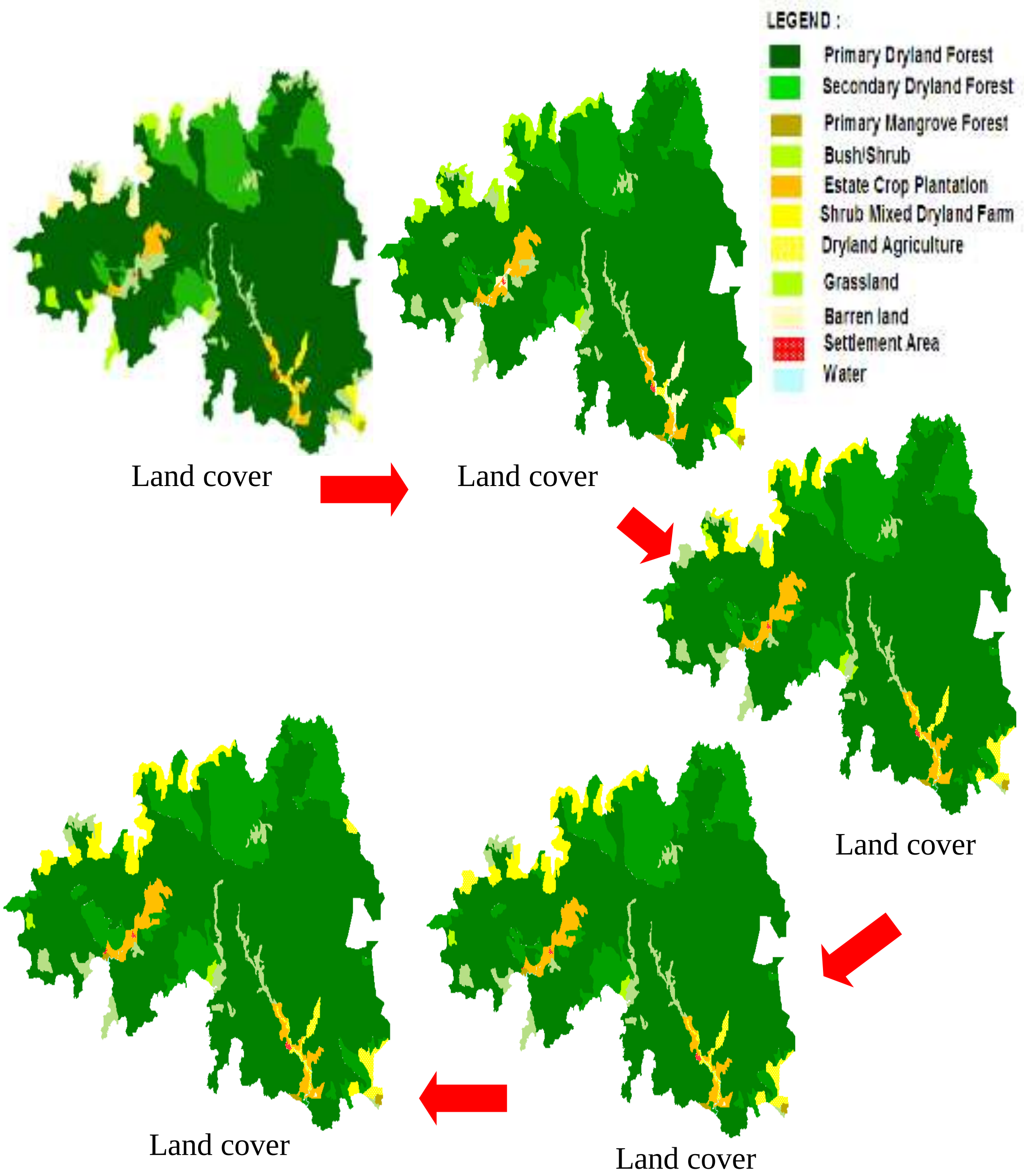

Figure 4. MBNP land cover classification from Landsat 1997, 2001, 2005, 2007 and 2010

Table 2. Land cover classification of MBNP

LAND COVER	1997		2001		2005		2007		2010	
	Ha	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**	**Ha**	**%**
Water	52	0	52	0	52	0	52	0	52	0
Bush/Shrub	2654	5	1965	4	1932	4	1814	3	1814	3
Primary dry land forest	4030	74	3946	72	3921	72	3853	71	3796	70
Secondary dry land forest	7413	14	8810	16	9181	17	9788	18	1031	19
Mangrove forest	71	0	102	0	102	0	101	0	101	0
Settlement	28	0	28	0	28	0	33	0	38	0
Plantation	1058	2	1186	2	1425	3	1394	3	1373	3
Dry land agriculture	0	0	75	0	633	1	872	2	685	1
Shrub mixed dry land	507	1	265	0	1749	3	1812	3	2060	4
Grassland	1084	2	2144	4	242	0	153	0	153	0
Barren land	1385	3	474	1	0	0	6	0	6	0
Total Area (ha)	**5456**	**10**	**5456**	**10**	**5456**	**10**	**5456**	**10**	**5456**	**10**

Table 2 shows that generally, primary dry land forest dominated the area of MBNP, followed by secondary dry land forest, bush/shrub, shrub mixed dry land agriculture, plantation, grassland, dry land agriculture, barren land and settlements. Primary dry land forest was decreased in each study period about 1-2%, or 4 % decrease was indicated from 1997 to 2010. This could be indicated by a quite large amount of illegal trees (65,414 trees) that was cut down in 1998-2009 .

An increase in Secondary forest, Plantation, Dry land agriculture, Shrub mixed dry land agriculture and Grassland was observed during the study period. The use of the rehabilitation zone for involving the local community with the intercropping system was one of the reasons of this increase especially for the increase of dryland and shrub mixed dryland agriculture.

Land use change matrix (LCM) is generated based on 6 land categories of IPCC GL 2006. The adjustment made in LCM is conducted by classifying each land category of IPCC GL 2006 into sub categories of classification of Directorate general of Forest Planning (2006) as follows: Primary dry land forest, Secondary dry land forest and Mangrove forest are reclassified into Forest Land (FL) class; Dry land agriculture, Shrub mixed dry land agriculture and Plantation are reclassified into Cropland (CL) class; Bush/shrub and Grassland are reclassified into Grassland (GL) class; Bare land and Water are reclassified into Other land (OL) class; and Settlement is still classified as Settlement. In LCM, changes in land cover area and its percentage are estimated for (i) land remaining in the same land-use category and

(ii) land converted to a new land-use category. Recapitulation of LCM of MBNP for 1997, 2001, 2005, 2007 and 2010 is presented in Table 3.

Table 3. Recapitulation of Land Change Matrix of MBNP

Category	Data source (Landsat TM 1:50.000)									
	1997		2001		2005		2007		2010	
	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
Total area	54562	100	54562	100	54562	100	54562	100	54562	100
Land category										
A. Forest Land (FL)	47793	88	48372	89	48501	89	48426	89	48381	89
1. FL remaining FL	47793		47428		48216		48316		48324	
2. Land converted to FL	0		944		284		110		56	
B. Crop Land (CL)	1565	3	1526	3	3806	7	4077	7	4118	8
1. CL remaining CL	1565		1186		1496		3684		4016	
2. Land converted to CL	0		340		2311		393		101	
C. Grass Land (GL)	3738	7	4109	8	2174	4	1967	4	1967	4
1. GL remaining GL	3738		2377		2150		1862		1967	
2. Land converted to GL	0		1733		23		105		0	
D. Wetland (WL)	0	0	0	0	0	0	0	0	0	0
1. WL remaining WL	0		0		0		0		0	
2. Land converted to WL	0		0		0		0		0	
E. Settlement (S)	28	0	28	0	28	0	33	0	38	0
1. S remaining S	28		28		28		28		33	
2. Land converted to S	0		0		0		5		4	
F. Other Land (OL)	1438	3	527	1	52	0	59	0	59	0
1. OL remaining OL	1438		77		52		52		59	
2. Land converted to OL	0		449		0		6		0	
G. No Data (ND)	0	0	0	0	0	0	0	0	0	0
1. ND remaining ND	0		0		0		0		0	
2. Land converted to ND	0		0		0		0		0	

Table 3 describes the area and percentage of each land category according to IPCC GL 2006. Forest land has been dominant land cover during all study period. Its coverage from 1997 until 2010 was 89% of the total area. Conversion of land into forest land was fluctuating with the highest in 2001 (944 ha). This phenomenon could be as a result of intensive reforestation and rehabilitation program conducted in the rehabilitation zone, as in 1997 the area was classified as shrubs/bushes and bare land. Within four years period, the shrubs/bushes grew to become secondary forest which is the most likely to be the dominant factor of the increase of forest land in the North Eastern part of MBNP.

Cropland area showed a distinct increase from 2001 to 2005. The changes occurred mostly in the rehabilitation zone in the Northern part of MBNP. Reforestation program in the rehabilitation zone provides the involvement of local community where they can plant agricultural plants between the wooden trees or which is called as intercropping. As a result, in 2005 the shrubs/bushes class which covered a quite large amount in the rehabilitation zone had been converted into cropland (shrub mixed dry land agriculture).

Land converted to Grassland and to Other Land area tends to decrease. Basically this could be used as one of a parameter to measure the success of reforestation program in MBNP. While settlement is quite stable through the study period, because there is almost no settlement expansion in MBNP.

4.2. Biomass or Carbon stock

Above ground carbon stock estimation at several zonation systems in MBNP varied between 28.7 – 145.98 ton/ha as presented in Table 4. Aboveground carbon stock in the nucleus zone is lower than in the forest zone (133.69 ton/ha). Forest zone has the highest carbon stock compared with other zones (145.98 Ton/ha). Because the nucleus zone is delineated based on the home range of Javanese tiger and not based on the vegetation density, therefore the carbon stock in the nucleus zone is lower than in the forest zone with higher vegetation density.

Table 4. Estimated aboveground carbon stock at different zonation systems in MBNP

No	Zone	Carbon stock (Ton/ha)
1	Nucleus	133.69
2	Forest	145.98
3	Use	118.34
4	Intensive use	98.8
5	Rehabilitation	28.7

Based on the land use system in MBNP the carbon stock is estimated between 28.7-166.63 Ton/ha (Table 5).

Table 5. Estimated above ground carbon stock at several land cover types in MBNP

No	Land cover	Carbon stock (Ton/ha)	Remark
1	Natural Forest in nucleus zone	135,02	Contain bamboos
2	Natural Forest in forest zone	166,63	Dense vegetation
3	Plantation	98,8	
4	Bushes	93,38	
5	Paddy fields	28,7	
6	Shrub	24,08	

Natural forest in forest zone has the highest carbon stock of 166.63 Ton/ha. Natural forest in nucleus zone has lower carbon stock than forest in forest zone, i.e. 137.69 Ton/ha. This is because the designation of the nucleus and forest zone of MBNP is not based on vegetation density stratification. Forest zone in MBNP landcover map is actually densed vegetated and has high diameters compared with the forest in nucleus zone that are grown with mix bamboo forest. The highest carbon stock after the natural forest is found in forest plantation estate (133.29 Ton/ha), because it is dominated with old *Hevea braziliensis* trees. The lowest carbon stock is found in shrub and bushes (24.08 Ton/ha). Paddy fields in MBNP are intercropped with forest trees, so it provides 28.7 Ton/ha higher carbon stock than shrub and bushes.

The highest aboveground carbon stock in MBNP is classified as good (166.63 Ton/ha). Carbon stock in the tropical forests in Asia varies between 40-250 Ton/ha for vegetation and 50-120 Ton/ha for soil.

4.3. Reference Level

The analysis was performed using 2006 IPCC methodology. The result showed that there is no CO_2 emission during 1997-2010 in MBNP. The potency of CO_2 sequestration is higher than CO_2 emission, therefore from historical data of emission Meru Betiri National Park is net sinker. Details of CO_2 sequestration from land cover changes in Meru Betiri National Park during 1997-2010 are shown in Table 6.

Table 6. The carbon emission and carbon sequestration from land cover changes in Meru Betiri National Park during 1997-2010

Source of Green House Gas and Sink Category	Emission (Ton CO_2 eq /year)			
	1997-2001	2001-2005	2005-2007	2007-2010
A. Forest Land (FL)				
A.1. FL remaining FL	-189.335,59	-313.356,63	-329.042,49	-300.951,24
A.2. Land converted to FL	-18.811,03	-5.607,98	-3.122,31	-855,65
B. Crop Land (CL)	0,00	0,00	0,00	0,00
B.1. CL remaining CL	16.042,77	20.685,72	84.310,42	60.149,69
B.2. Land converted to CL	-322,26	13.465,21	40.989,85	14.252,77
C. Grass Land (GL)	0,00	0,00	0,00	0,00
C.1. GL remaining GL	0,00	0,00	0,00	0,00
C.2. Land converted to GL	-13.408,60	347,75	4.440,30	0,00
D. Wet Land (WL)	0,00	0,00	0,00	0,00
D.1. WL remaining WL	0,00	0,00	0,00	0,00
D.2. Land converted to WL	0,00	0,00	0,00	0,00
E. Settlement (Set.)	0,00	0,00	0,00	0,00
E.1. Set. remaining set.	0,00	0,00	0,00	0,00
E.2. Land converted to set.	0,00	0,00	689,52	379,35
F. Others Land (OL)	0,00	0,00	0,00	0,00
F.1. OL remaining OL	0,00	0,00	0,00	0,00
F.2. Land converted to OL	14.843,47	0,00	413,20	0,00
Total Emission	-190.991,24	-284.465,98	-201.321,56	-227.025,08

Remark : negative (-) means negative emission or sequestration

Based on historical data, the analysis showed that the rate of CO_2 sequestration was increased during 1997-2010 using model of deforestation rate with population effect (Figure 5). Carbon dioxide sequestration increased during 1997-2010 about 211.715,56 tonCO_2eq/year (1997) to 242.460,05 tonCO_2eq/year (2010), with average 226.158,75 tonCO_2eq/year (Table 7). Based on forecasting analysis in Business as Usual, the CO_2 sequestration will increase during 2010-2020 (Figure 6) about 242.460,05 tonCO_2eq/year (2010) to 264.420,40 tonCO_2eq/year (2020), with average 253.440,22 tonCO_2 eq/year (Table 8). The concept of reference level as Business as Usual in Meru Betiri National Park if refers to past emission is very small or no emission, because there has been no emission in Meru Betiri National Park from historical data. However, MBNP as conservation area will have potential threat in the future such as from population growth and human activities.

Because of that, enhancement of carbon stock through rehabilitation and conservation through protection of primary forest can be regarded as important additionally in REDD+ .

The selection of emission factors and activity data is also crucial. If mean data are derived from a large variation of data sets, this might lead to higher standard deviation, or increase uncertainty. Further assessment are required to improve quality of data and reduce uncertainty such as : (i) improvement the quality of satellite resolution for better certainty of land use/cover area estimates, (ii) evaluation of other techniques used for estimating the carbon stock changes and carbon emission (such as expansion of project boundary, improvement of local data), (iii) development of effective and efficient procedure for estimation carbon stock and emissions, (iv) assessment on the effect of carbon stock increase and carbon emission decrease to the biodiversity conservation and hydrological system (due to low rate of deforestation and degradation in MBNP) and (v) assesment on the drivers of deforestation (population growth and economic) to the carbon emission prediction in the future.

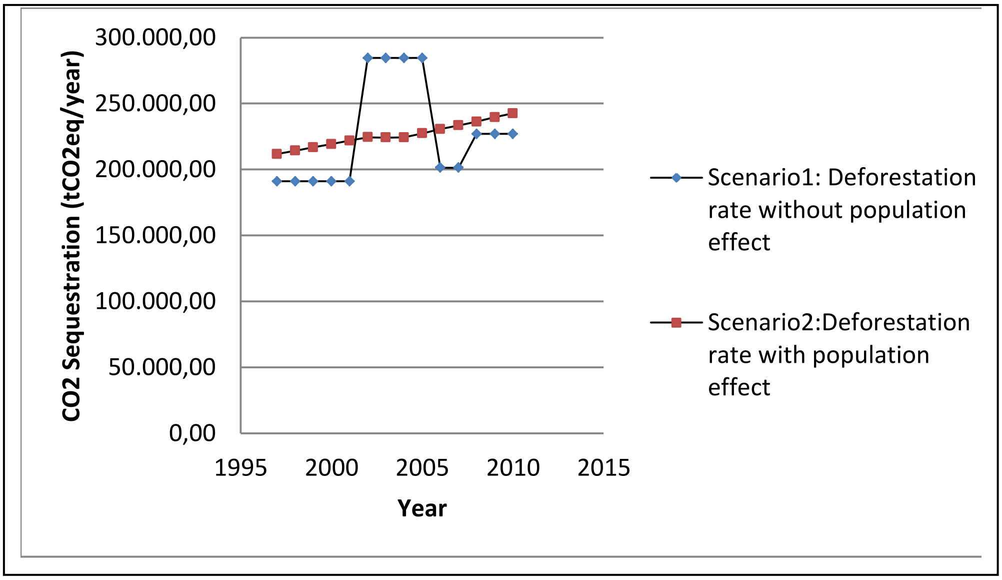

Figure 5. Rate of CO_2 sequestration (tCO_2eq/year) in Meru Betiri National Park during 1997-2010 as historical data

Table 7. Rate of CO_2 sequestration (tCO_2eq/year) in Meru Betiri National Park during 1997-2010 as historical data

Year	CO_2 sequestration (tCO_2eq/year)	
	Scenario 1: Sequestration without population effect	**Scenario 2: Sequestration with population effect**
1997	190.991,24	211.715,56
1998	190.991,24	214.196,55
1999	190.991,24	216.710,51
2000	190.991,24	219.257,44
2001	190.991,24	221.833,21
2002	284.465,98	224.441,96
2003	284.465,98	224.215,29
2004	284.465,98	224.240,02
2005	284.465,98	227.310,35
2006	201.321,56	230.627,95
2007	201.321,56	233.409,79
2008	227.025,08	236.199,87
2009	227.025,08	239.604,02
2010	227.025,08	242.460,05
Average	**226.895,61**	**226.158,75**

The BAU scenarios assume constant parameters until 2020. It assumes annual sequestration of 2,196,04 tCO_2eq/year with cummulative sequestration in 2020 will be 264.420,40 tCO_2eq/year. Scenario 1 considers efforts in rehabilitation activities. In This scenario assumes rate of CO_2 sequestration gained from rehabilitation is 24.859,63 tCO_2eq/year. Scenario 2 shows scenario of protection activity in primary forest of Meru Betiri National Park that result in the CO_2 sequestration of 170.925,85 t CO_2eq/year (Figure 6 and Table 8).

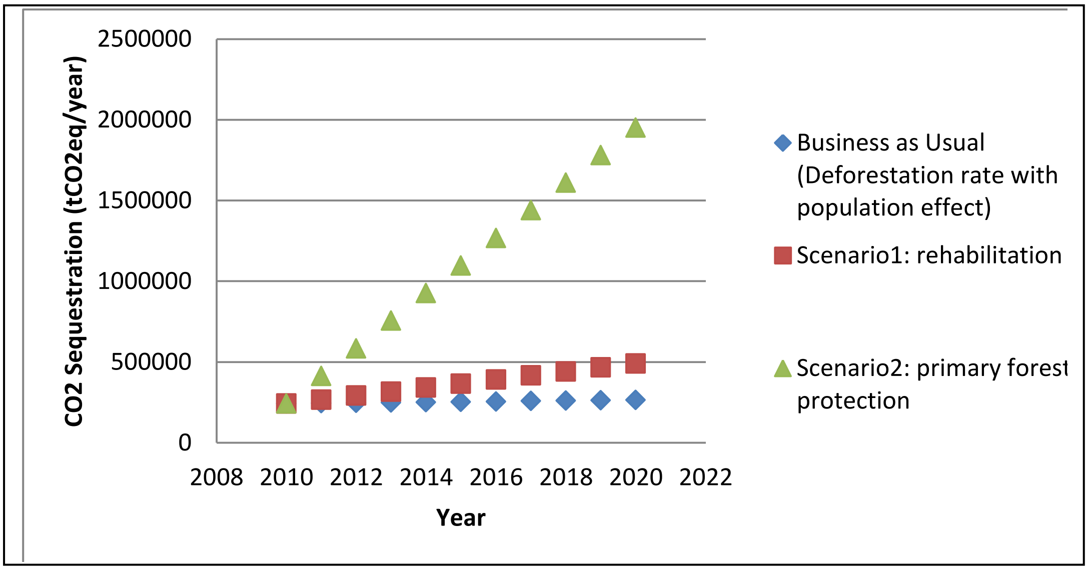

Figure 6. Forecasting analysis on rate of CO_2 sequestration (tCO_2eq/year) in Meru Betiri National Park during 2010-2020

Table 8. Forecasting analysis on rate of CO_2 sequestration (tCO_2eq/year) in Meru Betiri National Park during 2010-2020

Year	Business as Usual (Deforestation rate with population effect)	Scenario1: Rehabilitation	Scenario2: Primary forest protection
2010	242.460,05	242.460,05	242.460,05
2011	244.656,08	267.319,68	413.385,89
2012	246.852,12	292.179,31	584.311,74
2013	249.048,15	317.038,95	755.237,59
2014	251.244,19	341.898,58	926.163,43
2015	253.440,22	366.758,21	1.097.089,28
2016	255.636,26	391.617,85	1.268.015,13
2017	257.832,29	416.477,48	1.438.940,97
2018	260.028,33	441.337,11	1.609.866,82
2019	262.224,36	466.196,75	1.780.792,67
2020	264.420,40	491.056,38	1.951.718,51
Average	**253.440,22**	**366.758,21**	**1.097.089,28**

4.4. Flora and Fauna in Meru Betiri National Park

As conservation area, Meru Betiri National Park has unique biodiversity. The existing REDD+ activity is expected to maintain biodiversity as co-benefit of the REDD+, as required by voluntary carbon standard of CCBA. Regular monitoring is required to ensure positive impact of REDD+.

Some important flora species protected and included in Appendix of CITES such as burahol (*Stelechocarpus burahol*), Bogem (*Sonneratia caseolaris*) and padmosari flower (*Rafflesia zollengiana*) which is only available in MBNP, and some species of orchids and ferns. Some important fauna include leopard (*Pathera pardus*), Wild Buffalo (*Bos javanicus*), Small Deer (*Muntiacus muntjak*), Java Eagle (*Sphizaetus bartelsii*), Peacock (*Pavo muticus*), Green turtle (*Chelonia mydas*) and some species of primates/macacs List of important flora and fauna species are available in Appendix.

V. CONCLUSION

Setting reference level or baseline for GHG emissions is important step of REDD+ project to identify possible emission reduction. Reference level in MBNP was set based on estimation of carbon stock from ground measurement through establishment of 40 permanent sample plots and remote sensing data to analyse land cover change.

Carbon stock in MBNP varied from 28.7 to 166.63 ton C/ha with the highest carbon stock in secondary forest.

Estimation of emission was carried out using IPCC Guideline (2006). There was sequestration or no emission during the period of analysis in 1997-2010. The sequestration was 211.715,56 ton CO2-eq/year, in 1997 and 242.460,05 in 2010 with annual average of 226.158,75 ton CO2-eq/year. Sequestration in MBNP during the period of 1997-2010 was mainly contributed from low deforestation rate and even there was land changes from other land to forest land due to activities in rehabilitation zone. Meanwhile, from the official report, there were small figures of logging and fires as sources of emission.

Reference level as Business As Usual (BAU) for emission up to the year 2020 is estimated based on average emission from 1997-2010. Regression anlysis was performed to identify the relationship, however there was no model fit for the existing data. Therefore, scenario of emission from MBNP in the future was made based on possible deforestation and population growth. Based on forecasting analysis in BAU, CO_2 sequestration would increase during 2010-2020 from 242.460,05 ton CO_2 eq in 2010, to 264.420,40 ton CO_2eq in 2020, with average of 253.440,22 tonCO_2 eq/year. BAU scenario assumed constant parameters until 2020, such as annual deforestation rate and annual sequestration. Scenario 1 explored what would happen if efforts are put on rehabilitation activities. In this scenario, it assumed that rate of CO_2 sequestration gained from rehabilitation is 24.859,63 tCO_2eq/year. Scenario 2 shows that protection activity in primary forest of Meru Betiri National Park result the CO_2 sequestration is 170.925,85 t CO_2eq/year.

VI. RECOMMENDATION

- These preliminary results showed that carbon emissions in Betiri Meru National Park were negative or sequestration due to small rate of deforestation and vegetation growth. Therefore, for national park as conservation area, REDD+ should be focussed on maintaining conservation or biodiversity and improvement of community awareness and welfare. Voluntary standard of Community and Climate Biodiversity (CCB) is available for REDD+ project focussing on biodiversity and social safeguards

- Further analysis of land cover classification should be done using higher resolution sattellite images to produce better results.

- Although forest land is still dominant in the MBNP, careful measures should be taken into account to prevent encroachment, illegal logging and the increasing tendency of shrub mixed dryland agriculture in MBNP.

- Scenarios of threat level (population growth and economic development) against emission level prediction in Meru Betiri National Park is required to predict possible high emission in the future.

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Appendix 1. Important flora in Meru Betiri National Park

No	Species Name		CITES Protection Status
	Indonesia	Scientific	
1	Burahol	*Stelechocarpus burahol*	-
2	Bogem	*Sonneratia caseolaris*	-
3	-	*Tetrastigma papillosum*	-
4	-	*Tetrastigma lanceolarium*	-
5	Anggrek	*Appendicula angustifolia BI*	Appendix 2
6	Anggrek	*Arachnis callosa (BI.) Garay*	Appendix 2
7	Anggrek	*Cymbidium simulans Rolfe*	Appendix 2
8	Anggrek	*Calanthe speciosa (Blume) Lindl*	Appendix 2
9	Anggrek	*Dendrobium anosmum Lindl.*	Appendix 2
10	Anggrek	*Dendrobium secundum (BI.) Lindl*	Appendix 2
11	Anggrek	*Dendrobium tetraedre (BI.) Lindl*	Appendix 2
12	Anggrek	*Dendrobium stuartii F.M. Bail*	Appendix 2
13	Anggrek	*Dendrobium reflexitepalum*	Appendix 2
14	Anggrek	*Dendrobium crumenatum Sw.*	Appendix 2
15	Anggrek	*Dendrobium tetrodon Rchb.f. ex Lindl*	Appendix 2
16	Anggrek	*Eria javanica (Sw.) BI*	Appendix 2
17	Anggrek	*Flixkingeria luxurians (J.J.Sm) A.D Hawke*	Appendix 2
18	Anggrek	*Kingidium deliciosum (Rchb. F) Sweet*	Appendix 2
19	Anggrek	*Liparis condylobulbon Rchb. F*	Appendix 2
20	Anggrek	*Liparis parviflora (Blume) Lind.*	Appendix 2
21	Anggrek	*Micropera pallida (Roxb.) Lindl*	Appendix 2
22	Anggrek	*Maleola baliensis J.J. Sm*	Appendix 2
23	Anggrek	*Oncidium sp*	Appendix 2
24	Anggrek	*Phalaenopsis amabilis (L.) BI*	Appendix 2
25	Anggrek	*Pomatocalpa latifolia (Lindl) J.J. Sm*	Appendix 2
26	Anggrek	*Pomatocalpa naevata J.J Sm*	Appendix 2
27	Anggrek	*Pomatocalpa spicata Breda*	Appendix 2
28	Anggrek	*Pteroceras emarginatum (BI.) Holt*	Appendix 2
29	Anggrek	*Pteroceras sp.*	Appendix 2
30	Anggrek	*Pteroceras zollingeri (Rchb. F) Holt*	Appendix 2
31	Anggrek	*Rhynchostylis retusa (L.) BI*	Appendix 2
32	Anggrek	*Taeniophyllum hasseltii Rchb. F*	Appendix 2
33	Anggrek	*Thrixspermum acutilobum J.J. Sm*	Appendix 2
34	Anggrek	*Thrixspermum arachnites (BI.) Rchb.f*	Appendix 2

35	Anggrek	*Thrixspermum subulatum (BI.) Rchbf*	Appendix 2
36	Anggrek	*Thrixspermum sp*	Appendix 2
37	Anggrek	*Vanda limbata BI*	Appendix 2
38	Paku-pakuan	*Lygodium heterodoxzum. Kunze*	-
39	Paku-pakuan	*Lygodium circinnatum (Burm.f)Swartz*	-
40	Paku-pakuan	*Lygodium dimorfisme*	-
41	Paku-pakuan	*Lygodium sp1*	-
42	Paku-pakuan	*Lygodium sp2*	-
43	Paku-pakuan	*Lygodium reticulatum. Schkuhl*	-
44	Padmosari	*Rafflesia zollingeriana*	-

Source: Meru Betiri National Park database

Appendix 2. Important fauna in Meru Betiri National Park

No	Species Name		CITES Protection Status	Estimation of population
	Indonesia	**Scientific**		
1	Macan Tutul	*Panthera pardus*	Appendix 1	1
2	Banteng	*Bos javanicus*	-	231
3	Kijang	*Muntiacus muntjak*	-	741
4	Elang Jawa	*Sphizaetus bartelsii*	Appendix 2	3
5	Penyu Hijau	*Chelonia mydas*	Appendix 1	840
6	Babi Hutan	*Sus sp*	-	31
7	Merak Hijau	*Pavo muticus*	Appendix 2	62
8	Lutung	*Trachypitechus auratus*	Appendix 2	620
9	Monyet Ekor Panjang	*Macaca fascicularis*	Appendix 2	171
10	Elang sayap Coklat	*Butastur liventer*	Appendix 2	2
11	Elang Hitam	*Ichtinaetus malayensis*	Appendix 2	20
12	Elang Laut Perut Putih	*Haliaetus leucogaster*	Appendix 2	11
13	Elang alap jambul	*Accipter trivirgatus*	Appendix 2	1
14	Elang ular bido	*Spilornis cheela*	Appendix 2	7
15	Cekakak batu	*Lacedo pulchella*	-	16
16	Udang Api	*Ceyx erithacus*	-	3
17	Pekaka Emas	*Pelargopsis capensis*	-	3
18	Cekakak jawa	*Halcyon cyanoventris*	-	5
19	Cekakak Cina	*Halcyon pileata*	-	22
20	Cekakak Sungai	*Todirhamphus chloris*	-	31

21	Raja udang biru	*Alcedo caerulescens*	-	8
22	Pecuk Ular	*Anhinga melanogaster*	-	4
23	Walet sapi	*Collocolia esculenta*	-	111
24	Walet sarang putih	*Collocalia fuciphaga*	-	133
25	Kapinis rumah	*Apus affinis*	-	335
26	Kapinis jarum kecil	*Rhaphidura leucopygtalis*	-	4
27	Bambangan merah	*Ixobrychus cinnamomeus*	-	12
28	Cangak laut	*Ardea sumatrana*	-	7
29	Kuntul besar	*Egretta alba*	-	3
30	Kuntul Karang	*Egretta sacra*	-	21
31	Kekep Babi	*Artamus leucorhynchus*	-	2
32	Julang	*Rhyticeros undulatus*	Appendix 2	184
33	Kangkareng Perut Putih	*Anthracoceros convexus*	Appendix 2	48
34	Jinjing batu	*Hemipus hirundinaceus*	-	1
35	Jinjing bukit	*Hemipus picatus*	-	7
36	Jinjing petulak	*Tephrodornis gularis*	-	2
37	Kepodang ungu jawa	*Coracina javensis*	-	2
38	Kepodang ungu kecil	*Coracina fimbriata*	-	3
39	Sepah hutan	*Pericrocotus flameus*	-	4
40	Takur Bultok	*Megalaima lineata*	-	3
41	Takur tulung tumpuk	*Megalaima javensis*	-	35
42	Takur Ungkut-ungkut	*Megalaima haemacephala*	-	4
43	Cipoh kacat/sirpo	*Aegithina tiphia*	-	7
44	Cica daun besar	*Chloropsis sonnerati*	-	29
45	Cica daun syp biru	*Chloropsis cochinchinensis*	-	11
46	Bangau Sandang Lawe	*Ciconia episcopus*	-	3
47	Dederuk jawa	*Streptopelia bitorquata*	-	18
48	Tekukur biasa	*Streptopelia chinensis*	-	23
49	Uncal buau	*Macropygia emiliana*	-	6
50	Pergam hijau	*Ducula aenea*	-	3
51	Delimukan zamrud	*Chalcophas indica*	-	8
52	Punai kecil	*Treron olax*	-	1
53	Punai penganten	*Treron griseicauda*	-	3
54	Tangkar ongklet	*Platylophus galericulatus*	-	11

55	Gagak Hutan	*Corvus enca*	-	44
56	Bubut Alang-alang	*Centropus bengalensis*	-	4
57	Bubut besar	*Centropus sinensis*	-	3
58	Kedasi hitam	*Surniculus lugubris*	-	2
59	Kedasi ungu	*Chrysococcyx xanthorhynchus*	-	3
60	Wiwik Kelabu	*Cuculus merulinus*	-	3
61	Wiwik Lurik	*Cuculus sonneratii*	-	3
62	Srigunting bukit	*Dicrurus remifer*	-	3
63	Srigunting batu	*Dicrurus paradiceus*	-	7
64	Srigunting kecil	*Dicrurus annectans*	-	1
65	Srigunting hitam	*Dicrurus macrocercus*	-	10
66	Srigunting gagak	*Dicrurus annectans*	-	1
67	Srigunting jambul rambut	*Dicrurus hottentottus*	-	1
68	Cabai Jawa	*Dicaeum trochileum*	-	13
69	Bentet Kelabu	*Lanius schach*	-	52
70	Alap-alap Macan	*Falco severus*	-	2
71	Alap-alap Kawah	*Falco peregrinus*	Appendix 1	3
72	Tepekong Jambul	*Hemiprocne longipennis*	-	5
73	Layang-layang batu	*Hirundo tahitica*	-	18
74	Sikatan Bakau	*Cyornis rufigastra*	-	15
75	Sikatan biru muda	*Cyornis unicolor*	-	1
76	Sikatan dada coklat	*Rhinomyias olivacea*	-	1
77	Kipasan belang	*Rhipidura javanica*	-	9
78	Burung madu kelapa	*Anthreptes malacensis*	-	8
79	Pijantung gunung	*Arachnothera affinis*	-	3
80	Burung Madu Sriganti	*Nectarinia jugularis*	-	3
81	Burung madu bakau	*Nectarinia calcostetha*	-	21
82	Burung madu pengantin	*Nectarina sperata*	-	1
83	Burung madu jawa	*Aethopyga mystacalis*	-	17
84	Burung madu kelapa	*Anthreptes malacensis*	-	1
85	Pijantung kecil	*Aracnothera longirostra*	-	2
86	Kepodang kuduk hitam	*Oriolus chinensis*	-	3
87	Kacembang Gadung	*Irena puella*	-	3
88	Cucak Kuricang	*Pycnonotus atriceps*	-	2

89	Empuloh Janggut jenggot	*Alophoixus bres*	-	80
90	Cucak Kutilang	*Pycnonotus aurigaster*	-	68
91	Cucak kuning	*Pycnonotus melanicterus*	-	23
92	Merbah cerukcuk	*Pycnonotus goiavier*	-	271
93	Cica rante	*Pycnonotus bimaculatus*	-	5
94	Paok pancawarna	*Pitta guajana*	Appendix 2	5
95	Ayam Hutan Merah	*Gallus gallus*	-	38
96	Ayam Hutan Hijau	*Gallus varius*	-	16
97	Caladi gunung kumis biru	*Picus vatatus*	-	2
98	Pelatuk ayam	*Dryocopus javensis*	-	6
99	Caladi ulam	*Picoides macei*	-	2
100	Caladi tilik	*Picoides moluccensis*	-	4
101	Pelatuk besi	*Dinopium javanense*	-	13
102	Pelatuk kijang	*Celeus brachyurus*	-	13
103	Pelatuk kundang	*Reinwardtipicus validus*	-	8
104	Pelatuk tunggir mas	*Chrysocolaptes lucidus*	-	2
105	Kaladibelacan	*Dendrocopos canicapillus*	-	3
106	Bondol jawa	*Lonchura leucogastroides*	-	130
107	Bondol Haji	*Lonchura maja*	-	26
108	Bondol Peking	*Lonchura punctulata*	-	20
109	Bondol Perut Putih	*Lonchura leucogastra*	-	16
110	Trinil pantai	*Actitisn hypoleucos*	-	2
111	Perenjak jawa	*Prinia familiaris*	-	36
112	Perenjak rawa	*Prinia flaviventris*	-	384
113	Perenjak kutub	*Phylloscopus borealis*	-	14
114	Perenjak daun	*Phylloscopus trivirgatus*	-	26
115	Kukuk beluk	*Strix leptogrammica*	-	2
116	Cinenen jawa	*Orthotomus sepium*	-	9
117	Kerak Kerbau	*Acridotheres javanicus*	-	2
118	Tiong emas	*Gracula religiosa*	-	3
119	Gemek tegalan	*Turnix sylvatica*	-	1
120	Gemek loreng	*Turnix suscicator*	-	3
121	Meninting besar	*Enicurus leschenaulti*	-	3
122	Kucing hutan	*Copsychus malabaricus*	Appendix 2	3
123	Anis kuning/punglor	*Turdus opscurus*	-	2

124	Poksai kuda	*Garrulax rufifrons*	-	1
125	Pelanduk Topi hitam	*Pellorneum capistratum*	-	5
126	Tepus gelagah	*Timalea pilieata*	-	2
127	Berencet Besar	*Napothera macrodactyla*	-	3
128	Berkecet biru	*Eritachus cyane*	-	1
129	Kucing hutan	*Copshycus malabaricus*	Appendix 2	8
130	Kucing kampung	*Copshycus saularis*	-	1
131	Penyu Slengkrah	*Lepidochelys olivacea*	Appendix 1	11
132	Penyu Sisik	*Eretmochelys imbricata*	Appendix 1	1