Estimating aboveground forest carbon stock in protected area:

A case study of Bukit Tigapuluh National Park, Indonesia

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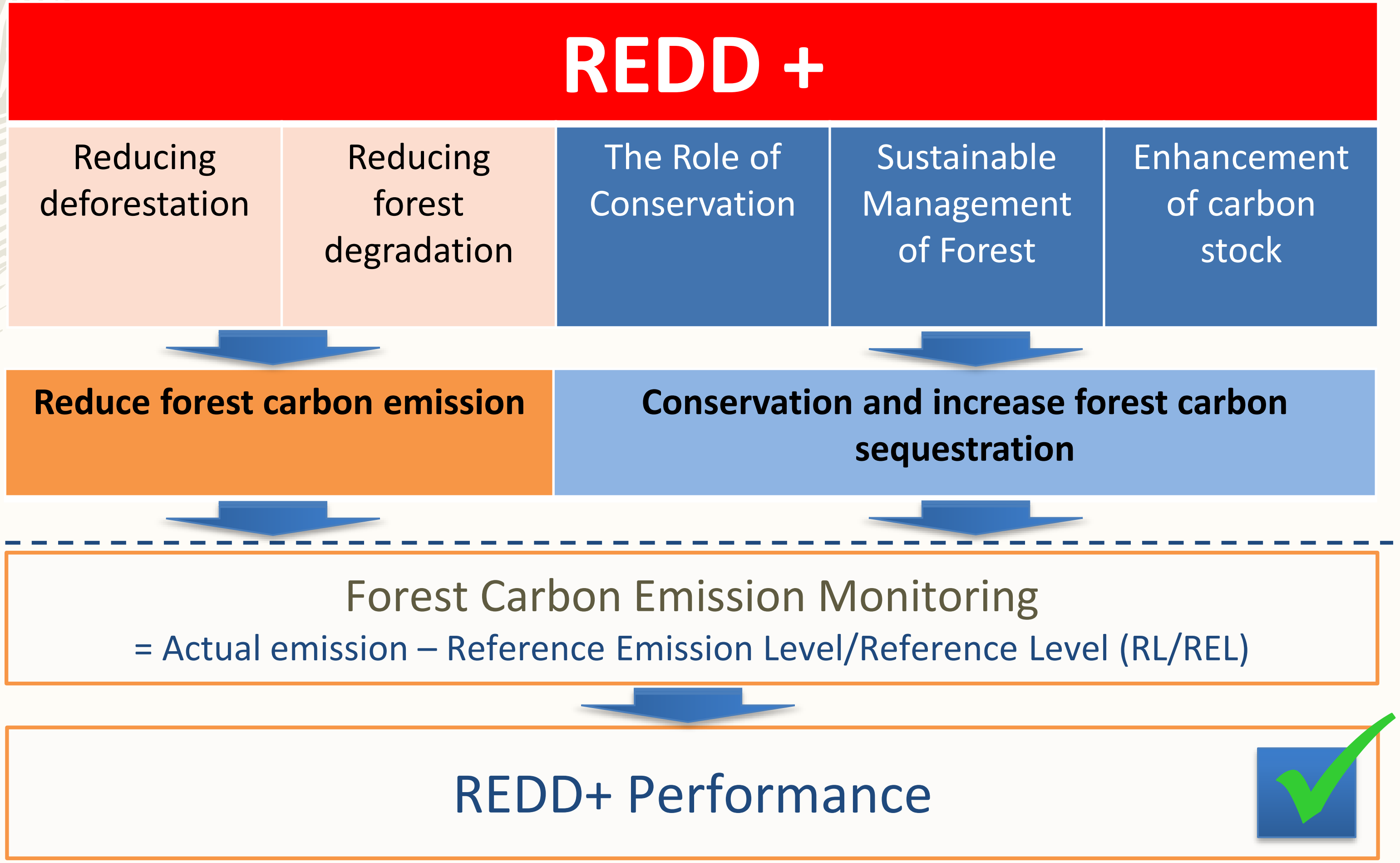
Introduction

- Forest plays an important role in the global carbon cycle as global carbon pools and carbon sinks or sources. The process of photosynthesis produces oxygen and carbon as plant's living parts (e.g. woods, barks, leaves, etc) as an output stored within the trees (Namayanga, 2002)
- There are extensive international awareness concerned to the balance of carbon pools and fluxes in the forest under climate change issues because of the increased of atmospheric CO2 concentration (Louman et al., 2011)

Introduction

- The UN Framework Convention on Climate Change (UNFCCC) introduced reducing emissions from deforestation and forest degradation (REDD) as an international fund- or credit-based mechanism for reducing carbon emissions and protecting forest ecosystems.
- REDD and its development into REDD+, has received enormous interest from developing countries as a potential source of international funding for forestry sector (Brofeldt et al., 2014).
- Estimation of forest carbon stocks in a specific location is very important for measuring the performance of REDD+, especially with higher detail (Tier 3)

Reduce Emission from Deforestation and Forest Degradation Plus (REDD+)



Forest Carbon Stock in National Parks

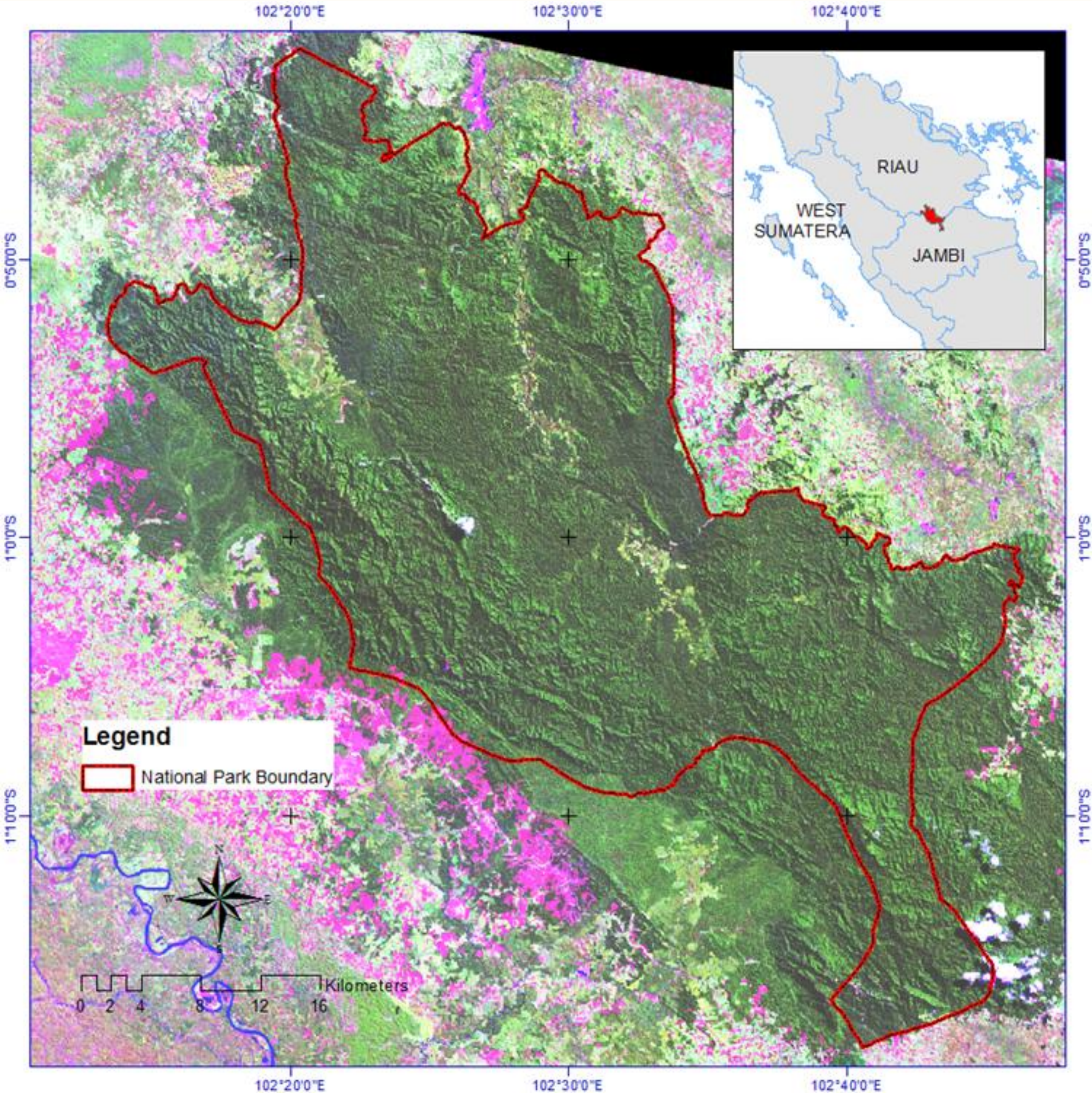
- Most of Indonesia's last remain natural forest are located in the national parks
- These parks are also at alarming risk of deforestation and degradation, in spite of Government willingness to protect these areas. To date, many national parks suffering massive deforestation and forest degradation
- Estimation of aboveground biomass in national park is very important to invest our knowledge for grasping the role of conservation activity in REDD+, aside of their high biodiversity condition

Objectives

- To analyze the characteristic of forest stands in Bukit Tigapuluh National Park using terrestrial forest inventory data
- To estimate carbon stock of natural forest in Bukit Tigapuluh National Park using combination of spatial data and terrestrial forest inventory data

Study Area

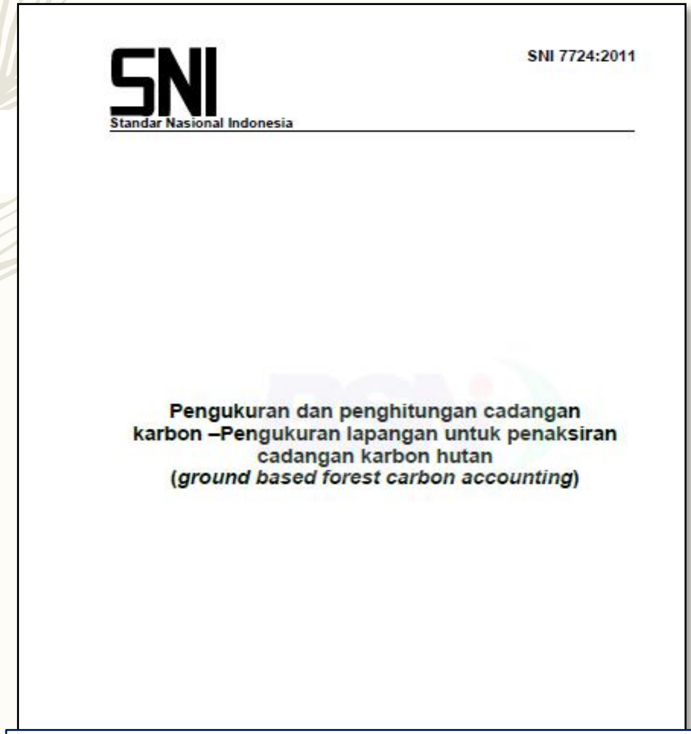
Bukit Tigapuluh National Park (TNBT) is a 144,000 ha of conservation area located in Riau Province (approx 70%) and Jambi (approx 30%)



Materials and Methods

A. Forest Inventory plot

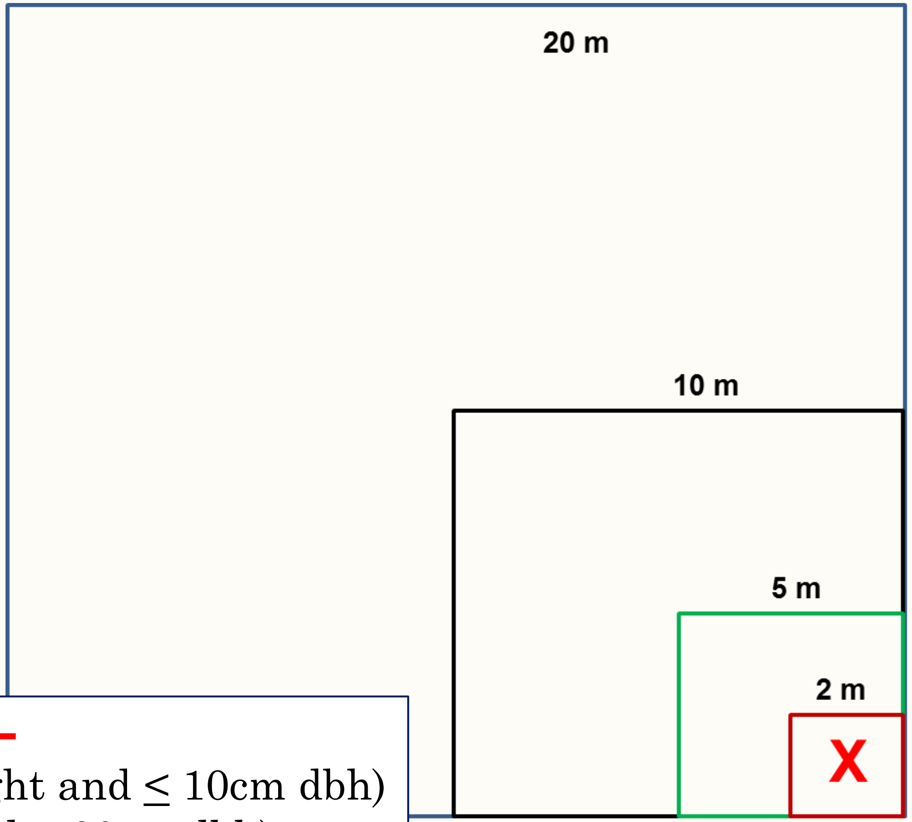
Based on the National Standard on Forest Carbon Inventory, we modified a single plot into 5 plots (Cluster)



SNI 7724:2011

SNI
Standar Nasional Indonesia

Pengukuran dan penghitungan cadangan karbon –Pengukuran lapangan untuk penaksiran cadangan karbon hutan
(ground based forest carbon accounting)



~~2x2m : Seedling (≤ 1,5m height)~~
5x5m : Sapling live and dead (≥ 1,5m height and ≤ 10cm dbh)
10x10m : Pole live and dead (> 10cm dbh and ≤ 20cm dbh)
20x20m : Trees live and dead (> 20cm dbh)

Materials and Methods

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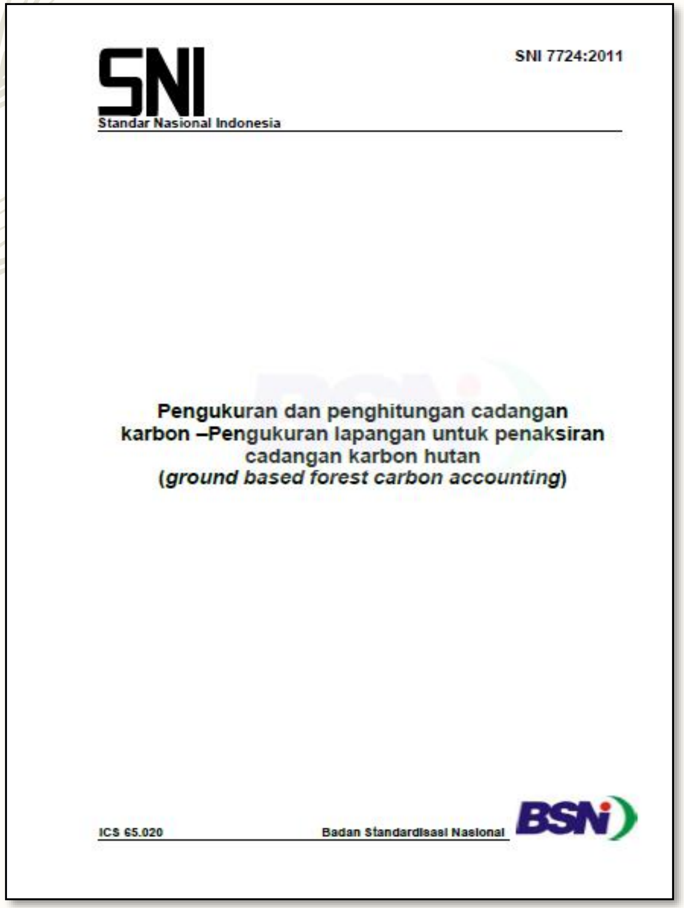

SNI

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Pengukuran dan penghitungan cadangan karbon –Pengukuran lapangan untuk penaksiran cadangan karbon hutan
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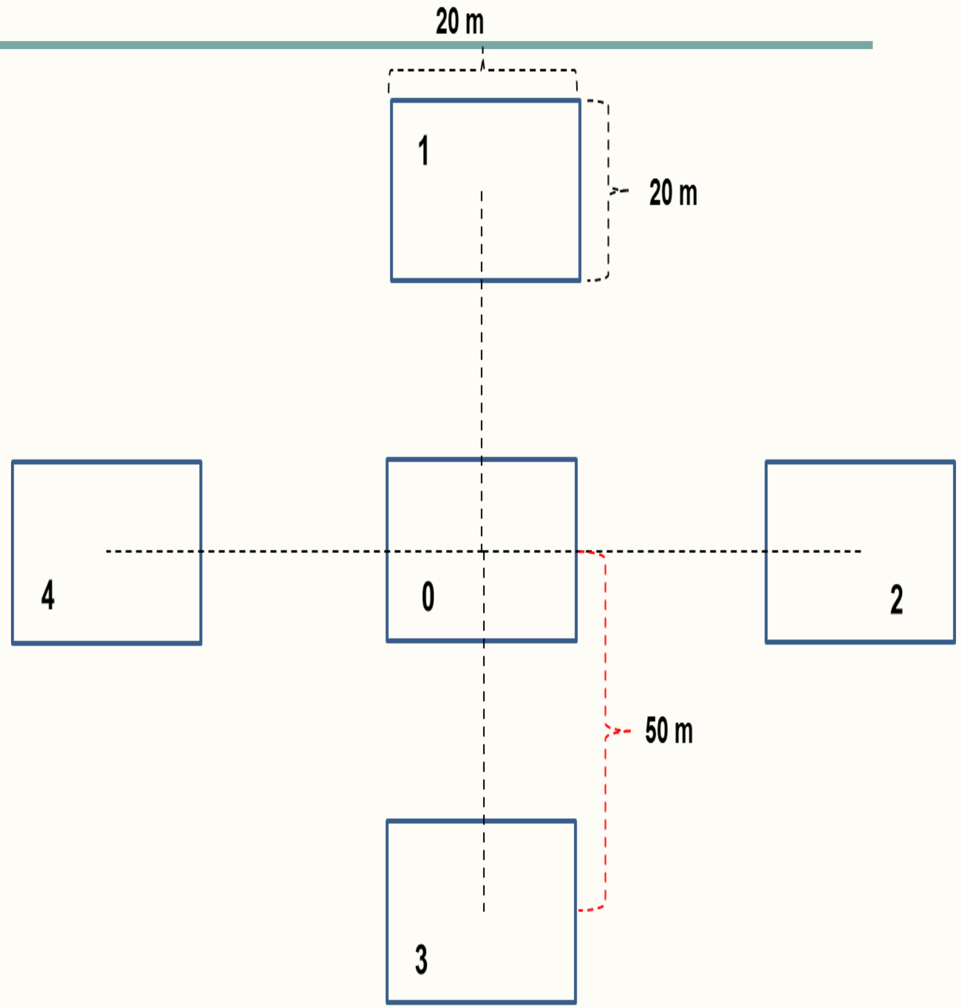
ICS 65.020

Badan Standardisasi Nasional

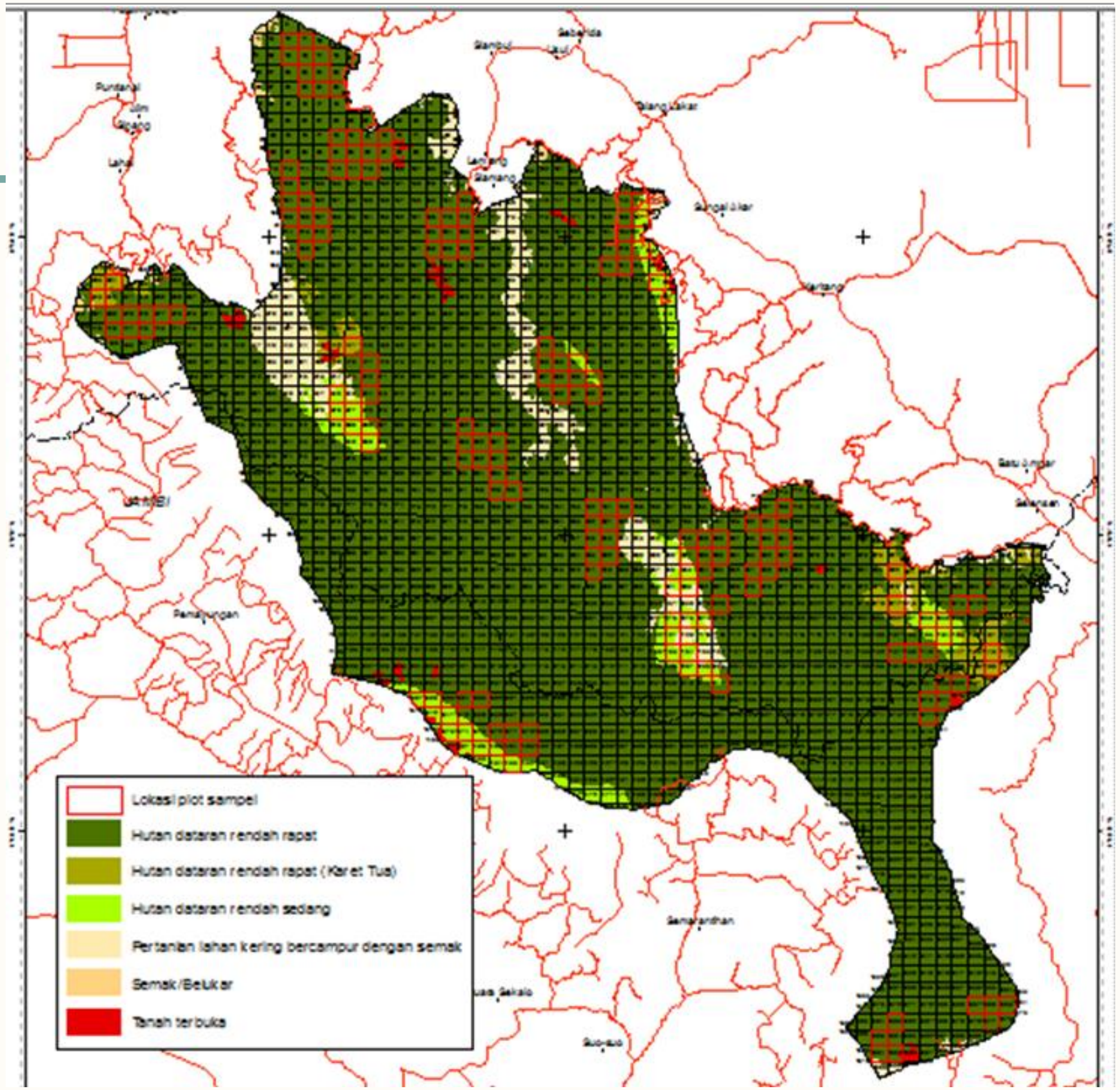
BSN



Materials and Methods

B. Sampling Design

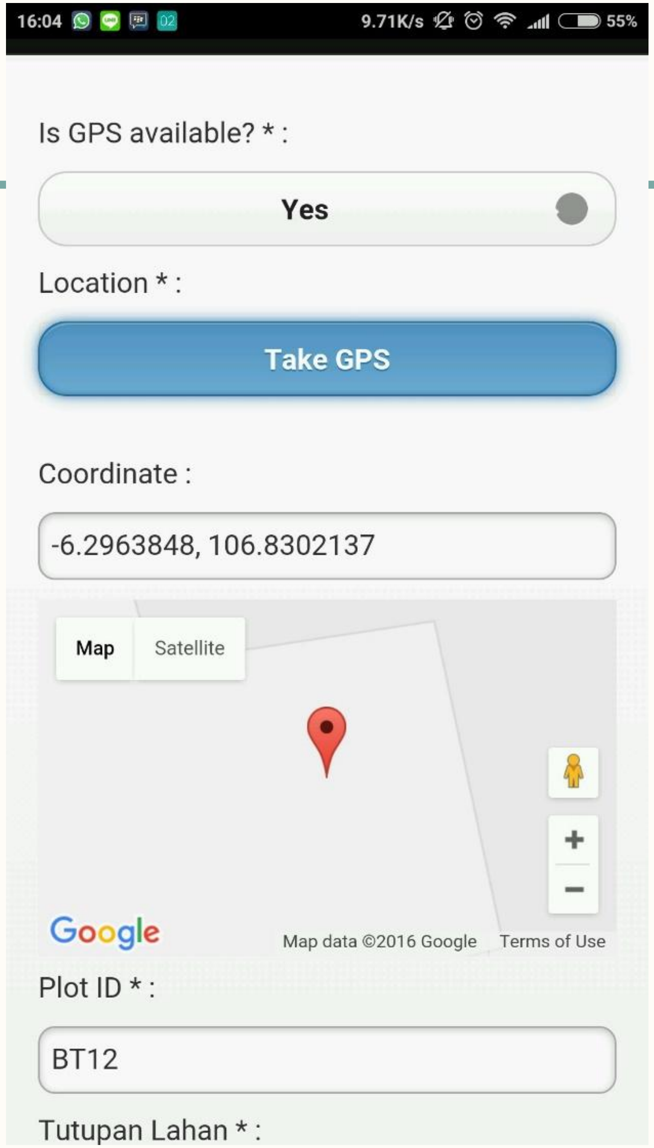
- 1 km^2 mesh grid was developed
- 10% from this mesh grid was selected to be sampled (in total 168 samples in 17 locations) consists of sample for Dryland Primary Forest (DPF/ 115 samples) and sample for Dryland Secondary Forest (DSF/ 53 samples)
- From each selected grid, a cluster plot was generated inside (randomly)
- Terrestrial forest inventory were taken intermittently from Oct 2016 to Dec 2017

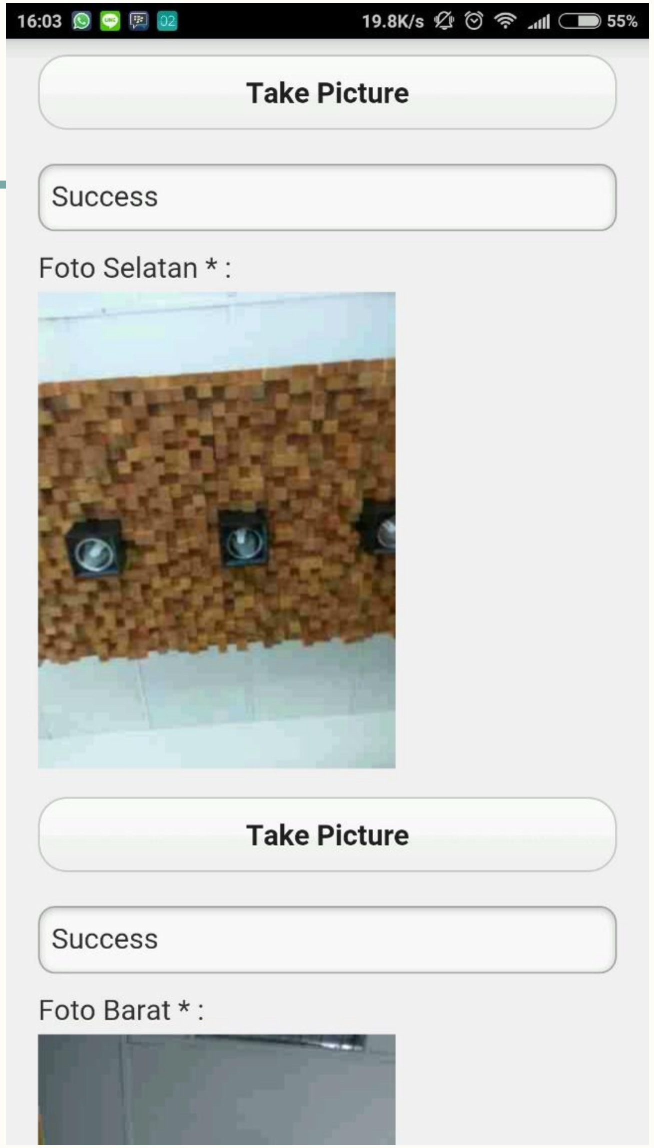


Materials and Methods

C. Supporting Smartphone Application

- A supporting smartphone application was used to assist surveyor to capture location coordinates as well as actual pictures heading to north, east, south, west and looking upward for each cluster plot
- The data was consolidated in https://forestclimate.wwf.id





Materials and Methods

D. Allometric Equation (Aboveground Biomass)

D.1. Living Trees

- We adopted allometric equation from Chave *et al.*, (2005) for dry tropical forest ecosystem since most of the forested area stands on mineral soil.

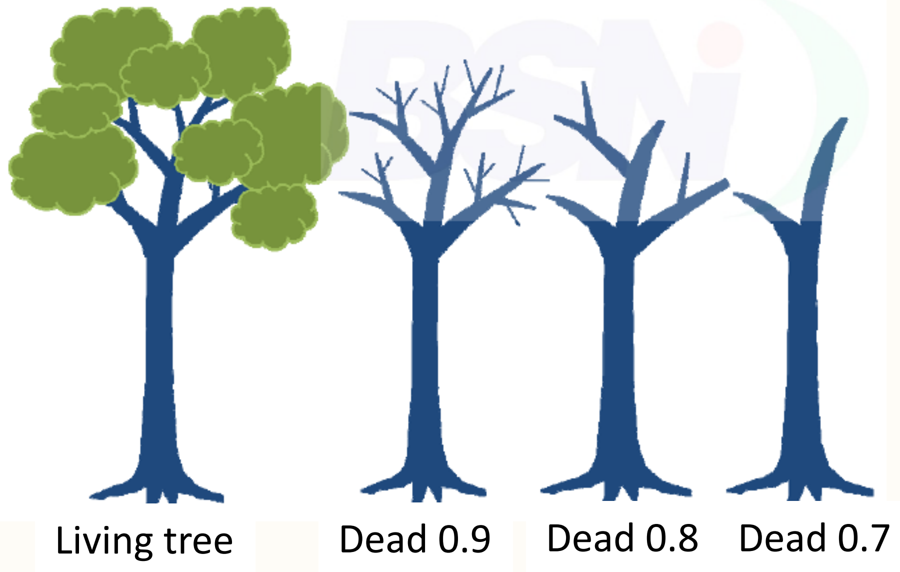
$$\text{AGB} = exp(-1.499 + 2.148\, ln(D) + 0.207\, (ln(D))^2 - 0.0281(ln(D))^3) \times WD$$

Note : AGB is aboveground biomass (in kg) ; D is diameter at breast height (in cm) ;
WD = Wood Density (in g/cm^3)

- Aboveground biomass measure are converted into carbon mass (C) by multiplying AGB with 0.47 (IPCC, 2006)

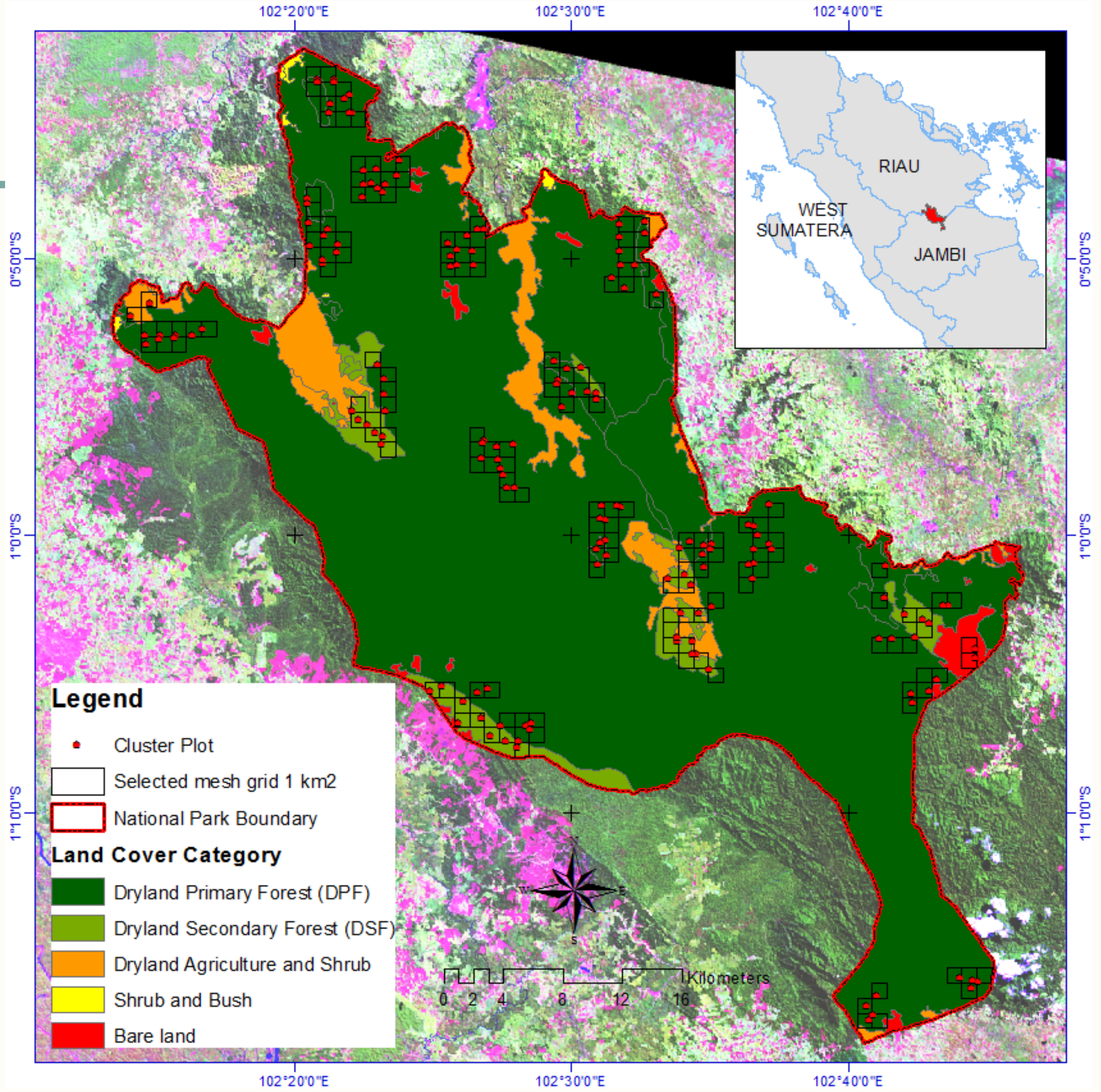
D.2. Dead Trees (Necromass)

- Constant values of 0.7; 0.8 and 0.9 will be multiplied to the AGB of a single dead trees using similar allometric equation



Materials and Methods

E. Land Cover Maps



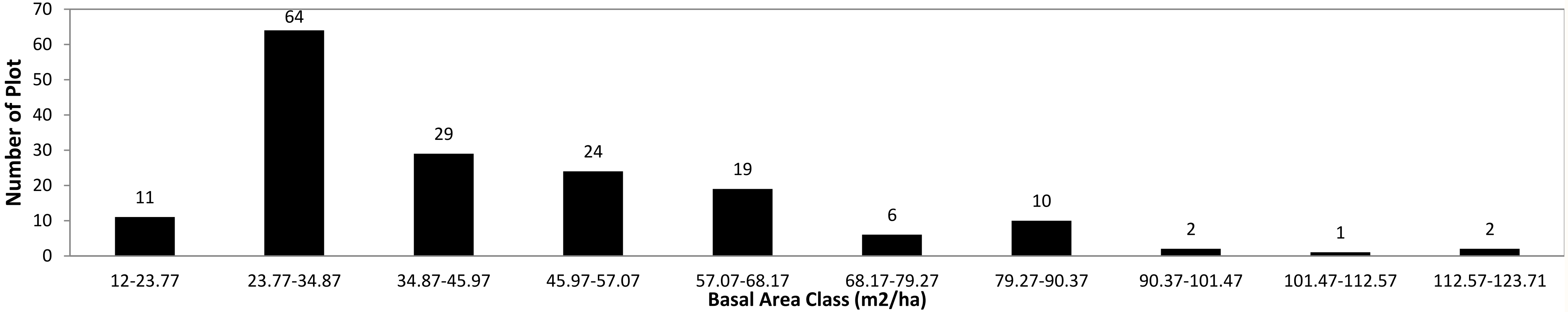
Results and Discussion

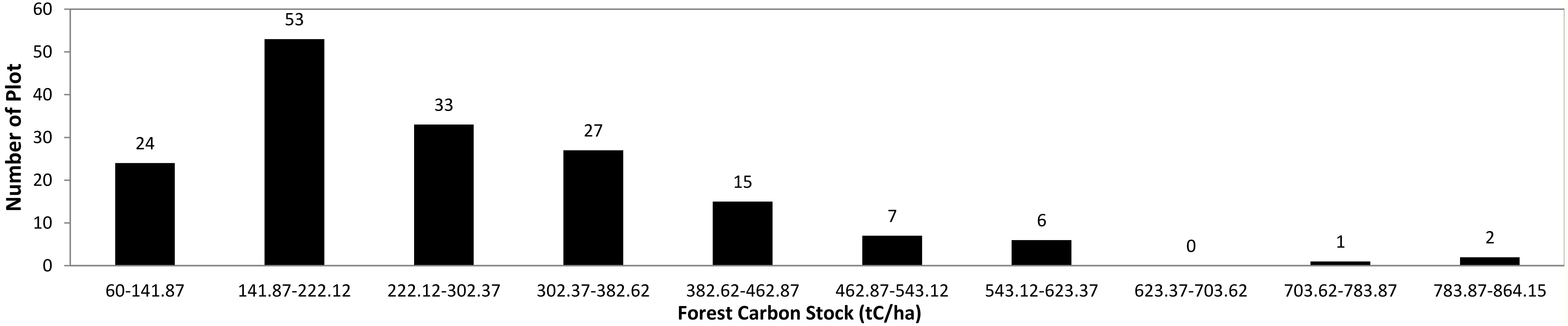
A. Floristic Characteristics

No.	Family	Species	Individual	No.	Family	Species	Individual	No.	Family	Species	Individual
1.	Alangiaceae	1	31	21.	Elaeocarpaceae	1	11	41.	Papilionaceae	1	27
2.	Ampelidaceae	1	1	22.	Euphorbiaceae	31	1330	42.	Pinaceae	1	29
3.	Anacardiaceae	18	957	23.	Fagaceae	9	230	43.	Pittosporaceae	1	6
4.	Annonaceae	7	228	24.	Flacourtiaceae	3	66	44.	Rosaceae	2	4
5.	Apocynaceae	6	90	25.	Guttiferae	14	216	45.	Rubiaceae	8	136
6.	Auricariaceae	1	6	26.	Icacinaceae	1	1	46.	Rutaceae	3	17
7.	Barringtoniaceae	1	83	27.	Lauraceae	15	1356	47.	Salicaceae	1	3
8.	Bignoniaceae	2	3	28.	Leguminosae	23	783	48.	Sapindaceae	9	312
9.	Bombacaceae	5	55	29.	Linaceae	1	68	49.	Sapotaceae	15	521
10.	Boraginaceae	2	6	30.	Loganiaceae	1	12	50.	Simaroubaceae	2	41
11.	Burseraceae	10	285	31.	Magnoliaceae	2	4	51.	Sterculiaceae	5	230
12.	Celastraceae	3	289	32.	Melastomataceae	4	53	52.	Styracaceae	1	10
13.	Chrysobalanaceae	1	23	33.	Meliaceae	18	135	53.	Symplocaceae	1	14
14.	Combretaceae	1	11	34.	Moraceae	12	864	54.	Theaceae	2	76
15.	Compositae	1	8	35.	Myristicaceae	8	259	55.	Thymelaceae	4	15
16.	Cupressaceae	1	2	36.	Myrtaceae	11	970	56.	Tiliaceae	2	9
17.	Datiscaceae	1	4	37.	Olacaceae	4	429	57.	Torricelliaceae	1	59
18.	Dilleniaceae	4	138	38.	Oleaceae	3	21	58.	Ulmaceae	2	298
19.	Dipterocarpaceae	32	2572	39.	Oxalidaceae	1	28	59.	Unidentified	1	600
20.	Ebenaceae	4	104	40.	Palmae	3	17	60.	Verbenaceae	3	72

Results and Discussion

B. Forest Stand Characteristics





Results and Discussion

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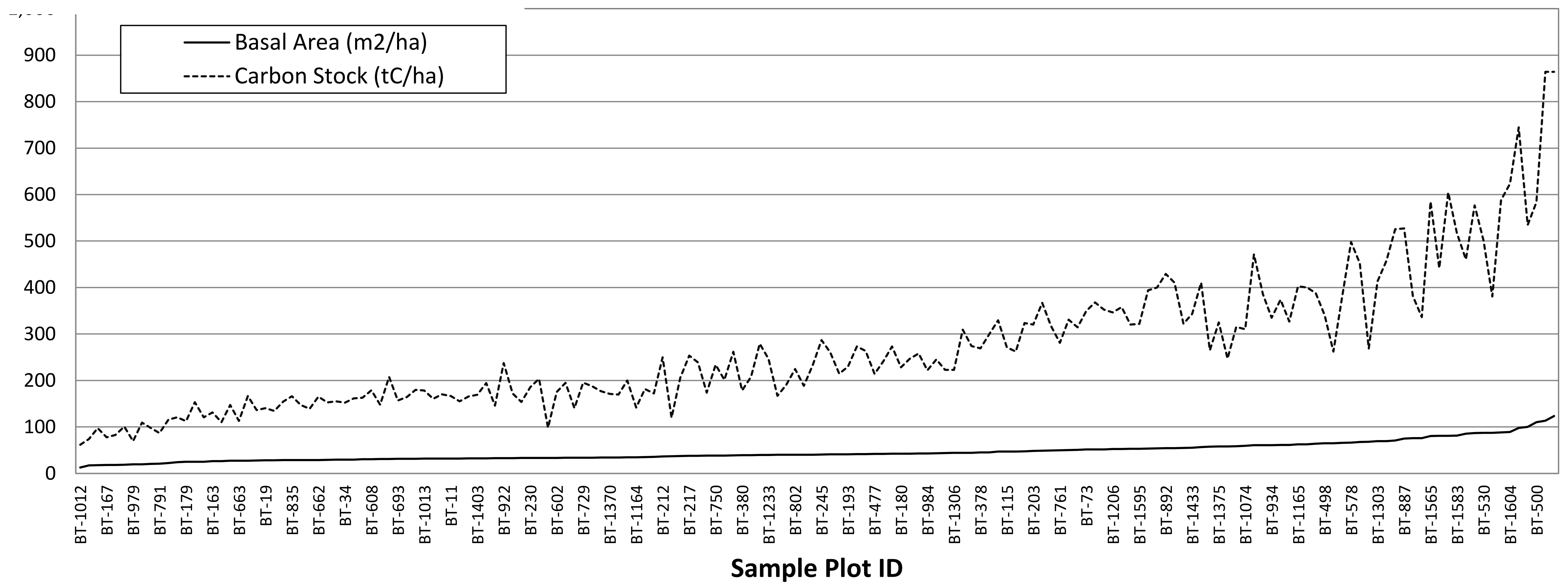
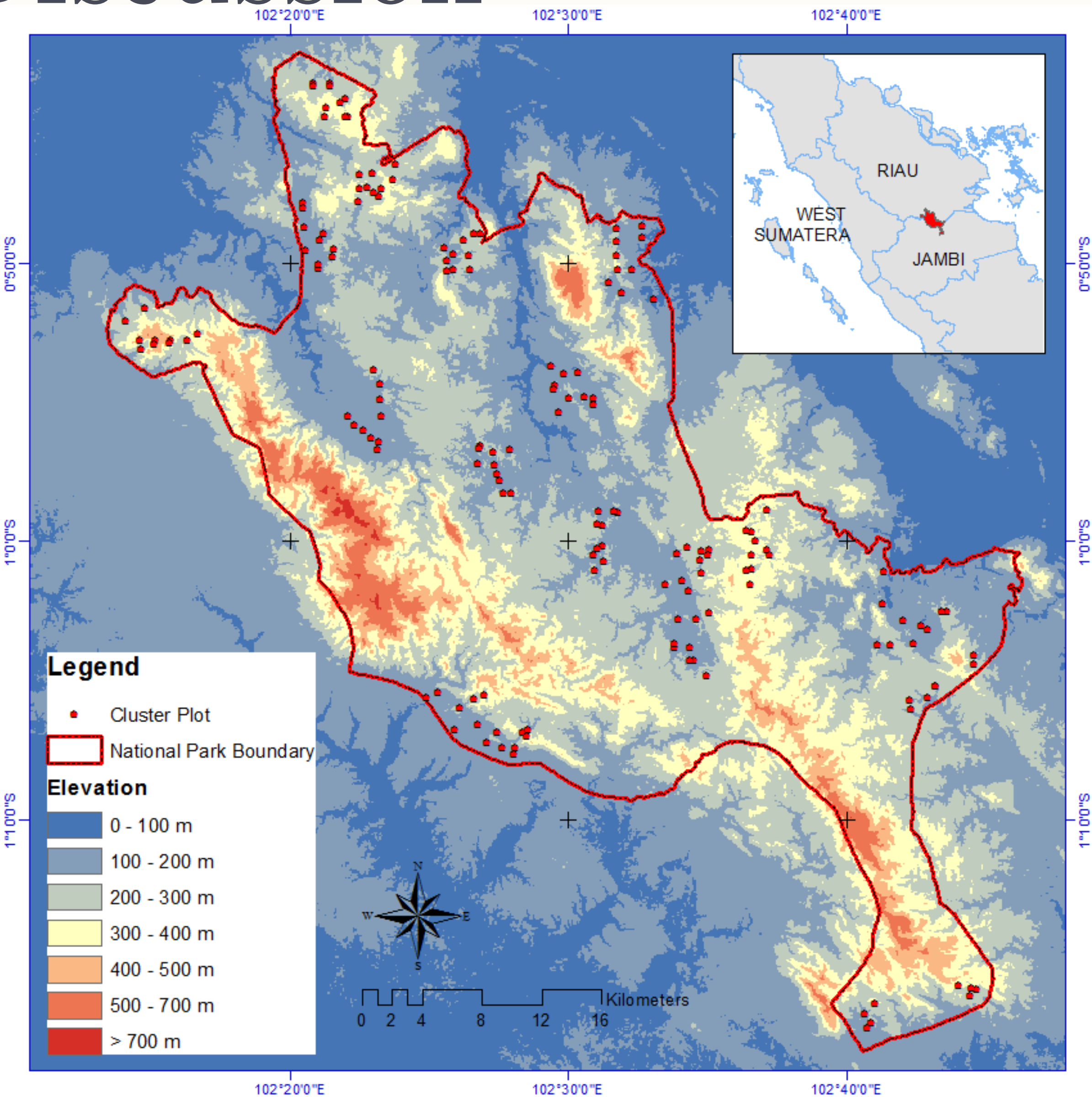


Results and Discussion

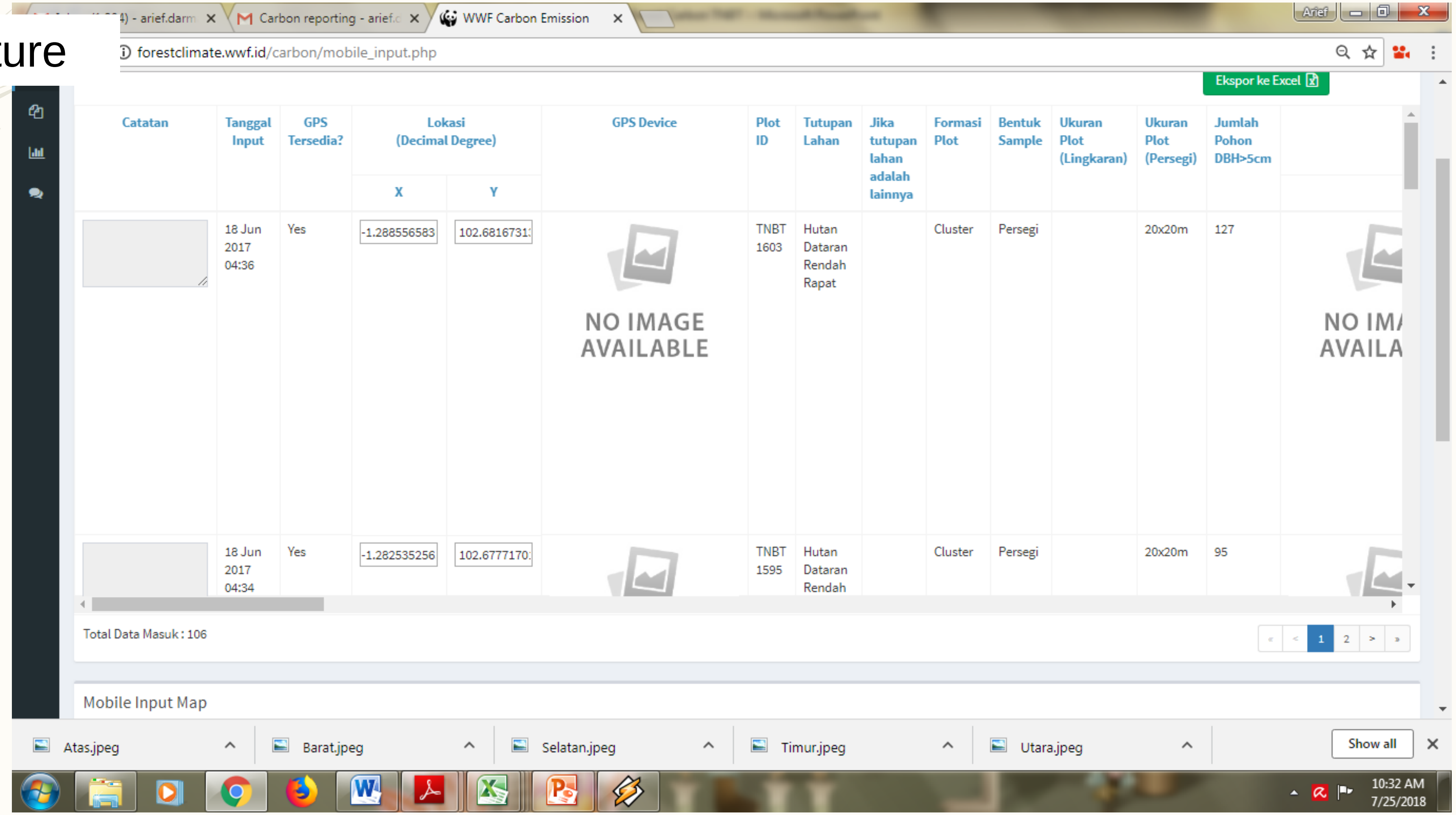
B. Forest Stand Characteristics

Height (m asl)	Total Plot	Mean Basal Area (m^2/ha)	Mean Carbon Stock (tC/ha)
below 100	2	51.33	234.49
100 – 200	83	45.90	263.13
200 – 300	58	49.18	300.88
300 – 400	21	38.81	226.31
above 400	4	33.90	180.18



Results and Discussion

C. Supporting IT Infrastructure



Results and Discussion

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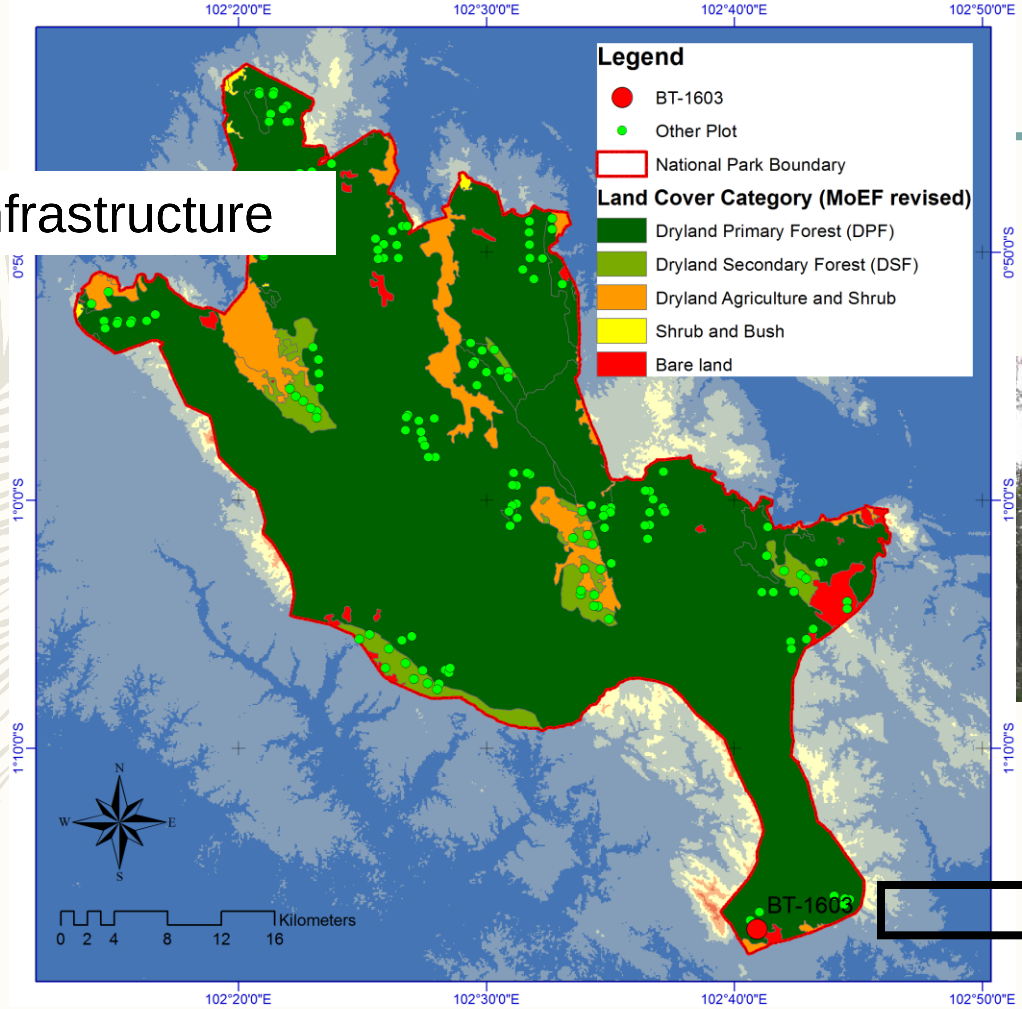
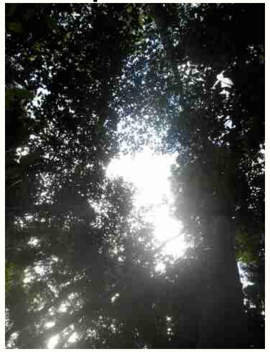


Plot BT-1603

North

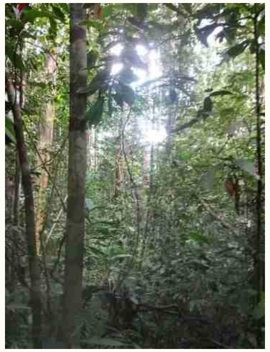
West

Upward



East

South



Results and Discussion

D. Aboveground Forest Carbon Stock

Forest Cover type	Statistical Analysis: Mean (Mj)	Standard Deviation (SD)	Sample Count (n)	*t-statistic at* 95% (t)	Confidence Interval (CI)	Lower Bound	Upper Bound	*Sampling Error* (%)
First assumption								
Forested area	269.25	146.69	168	*1.96*	95.59	173.66	364.84	*8.24*
Second assumption								
DPF	287.03	154.46	115	*1.96*	28.23	258.80	315.26	*9.84*
DSF	230.67	120.77	53	*1.98*	32.85	197.82	263.52	*14.24*

Land cover category	Area (ha)	Carbon density/stock (tC/ha)			Total carbon sequestered (tC)		
		Mean	Lower	Upper	Mean	Lower	Upper
First assumption							
Forested area	133,051	269.25	247.07	291.43	35,823,639	32,872,312	38,774,966
Second assumption							
DPF	126,992	287.03	258.80	315.26	36,449,909	32,864,849	40,034,969
DSF	6,059	230.67	197.82	263.52	1,397,691	1,198,664	1,596,717
Total	133,051				37,847,600	34,063,514	41,631,686

Results and Discussion

Forest stand and carbon stock characteristics in various tropical lowland evergreen forests							
No.	Locality	Basal area (m2/ha)	Biomass (t/ha)	Carbon stock (tC/ha)	Range of dbh (cm)	Sample area	Authors
1.	Borneo (Sebulu, East Kalimantan)	36.8	509	239.23	≤152	1 ha	(Yamakura et al., 1986)
2.	Sumatera Landscape (Jambi, Bengkulu, South Sumatra, Lampung)	31.7 ± 0.5	361 ± 7	180	10 – 210	70.2 ha	(Laumonier et al., 2010)
3.	East Kalimantan, Pasir Mayang Sumatra	32.98	316 – 378	149 – 178	10 – 140	12 ha	(Rutishauser et al., 2013)
4.	NFI Sumatra (DPF)	NA	268.6 ± 22	135 ± 10	NA	92 ha	(MoEF, 2016)
5.	NFI Sumatera (DSF)	NA	182.2 ± 10	85.6 ± 4.7	NA	265 ha	(MoEF, 2016)
6.	Borneo	25 – 48	457.1	214.8	NA	83 plot	(Slik et al., 2010)
7.	Gunung Palung NP, West Kalimantan	39.6 ± 1.4	622 ± 33	292.3 ± 15.5	>10	4.8 ha	(Paoli et al., 2008)
8.	**Bukit Tigapuluh NP, Riau – Jambi**	**45.93**	**572.9 ± 47**	**269.2 ± 22.2**	**5 – 295**	**33.6 ha**	**This study**

Conclusion

- Bukit Tigapuluh National Park secured a significant forest carbon stock which has been estimated as 269.2 + 22.2 tC/ha or in total 35,823,639 + 2,951,071 tC, being sequestered in approximately 133,051 hectares of tropical rain forest.
- This result was higher than other study located in non-protected area, but was lower estimates than other study located in protected area i.e. Gunung Palung National Park, West Kalimantan. This study and Paoli et al. (2008) supported an argument that protected areas possess higher figure of carbon stock compare to other forest management unit.
- High amount of forest carbon biomass in the protected areas shall be very important assets for conducting the role of conservation for REDD+. Therefore, the management of BTNP shall enlarge their perspectives for climate change mitigation action aside for biodiversity conservation and life-support system. REDD+ readiness for protected areas need to be completed as soon as possible, since REDD+ has been a commitment of Indonesia’s Government for implementing Nationally Determined Contribution (NDC).

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