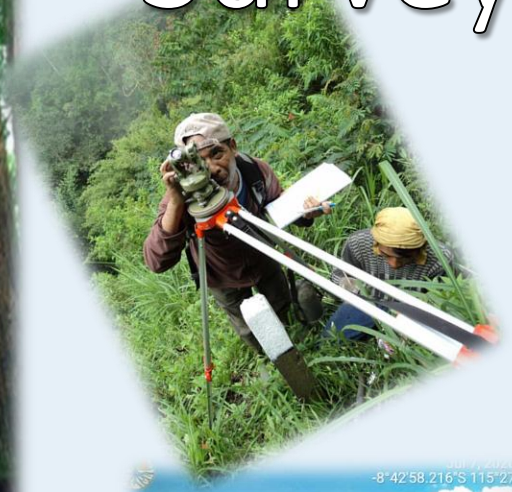
Application of GNSS for Forest Survey and Mapping in Indonesia



by:

Emba Tampang Allo

Ministry of Environment and Forestry

The Republic of Indonesia

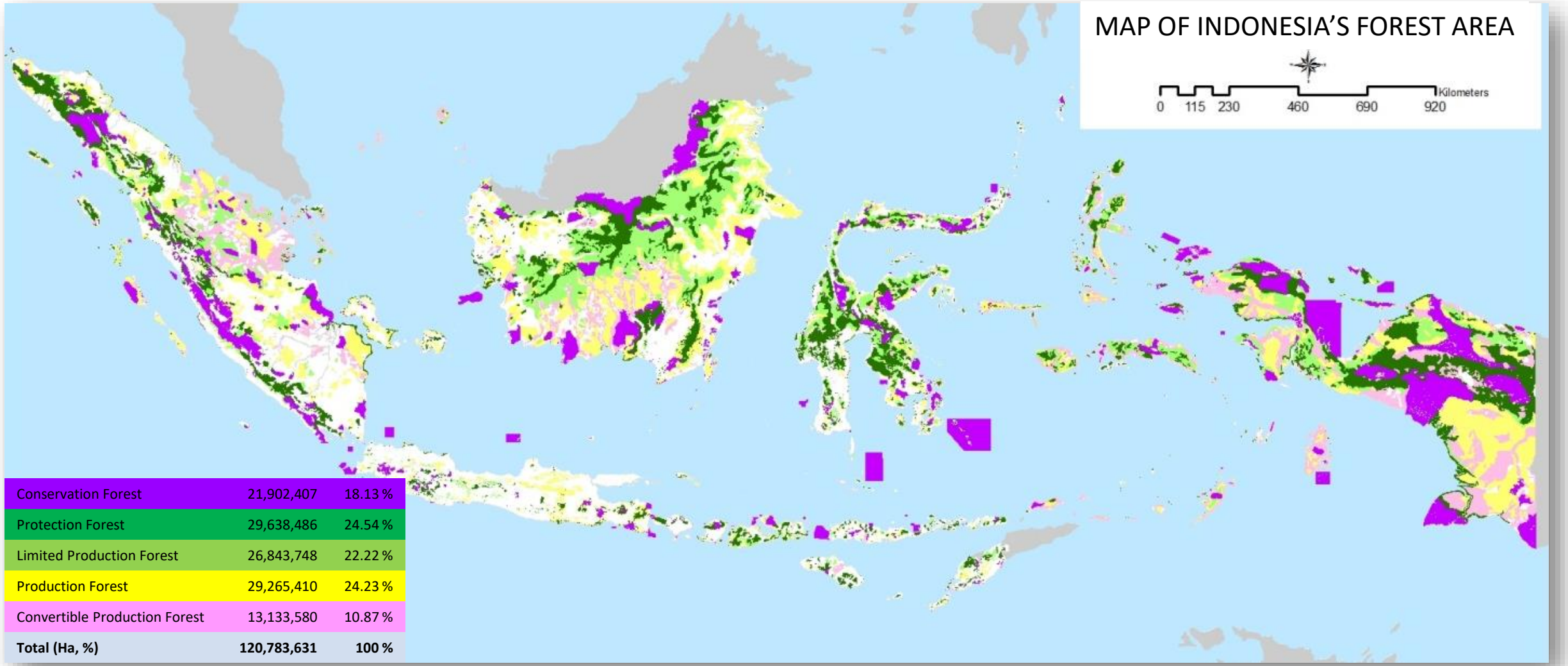
Outline

1 (Map) Reposition

2 Forest Inventory

3 Aerial Survey

FOREST AREA IN INDONESIA



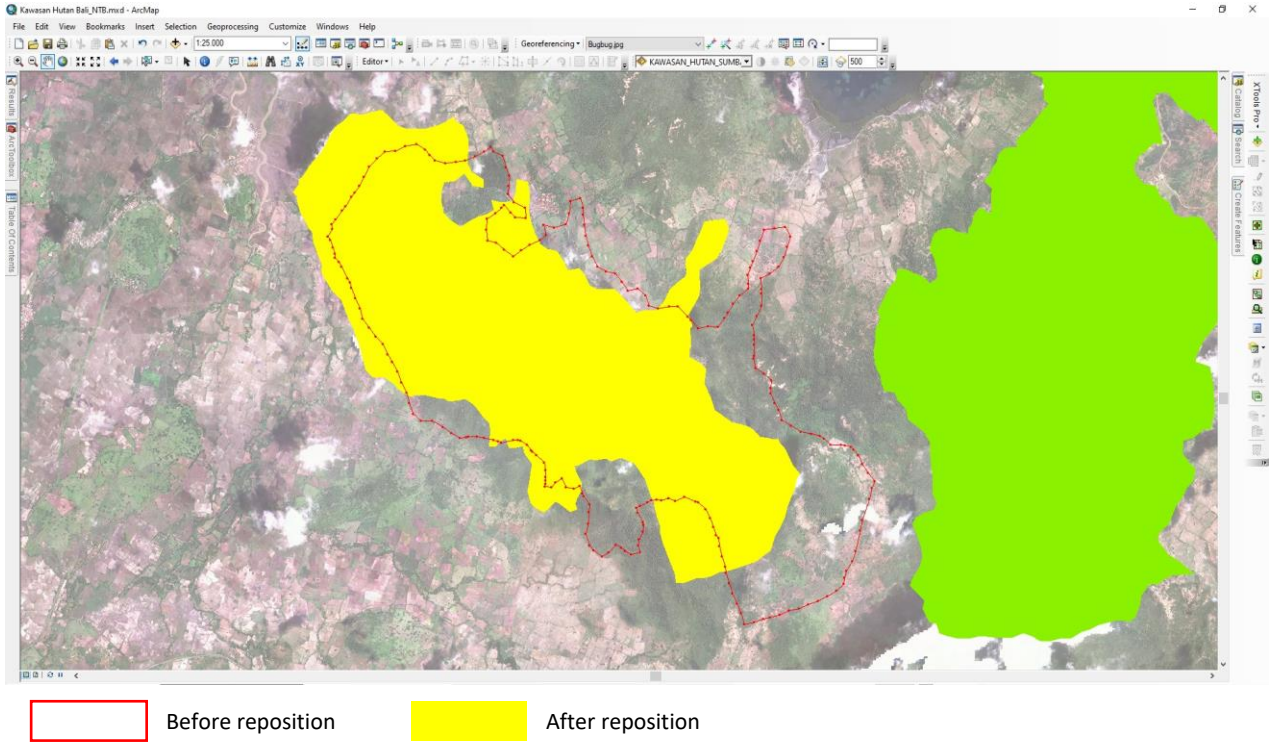
Conservation Forest	21,902,407	18.13 %
Protection Forest	29,638,486	24.54 %
Limited Production Forest	26,843,748	22.22 %
Production Forest	29,265,410	24.23 %
Convertible Production Forest	13,133,580	10.87 %
Total (Ha, %)	**120,783,631**	**100 %**

Forest area occupies 63.66% of the total country (land) area

Boundary Reposition

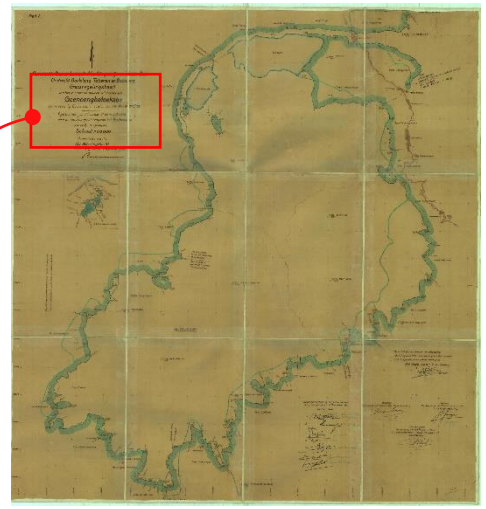
(for older forest area map)

- Difference of forest area boundary in the field and map (analogue, and digital/GIS)
- Source of errors: manual drawing (scale/unit reading, and drawing), conversion process from analogue to digital map (georeferencing, digitizing)

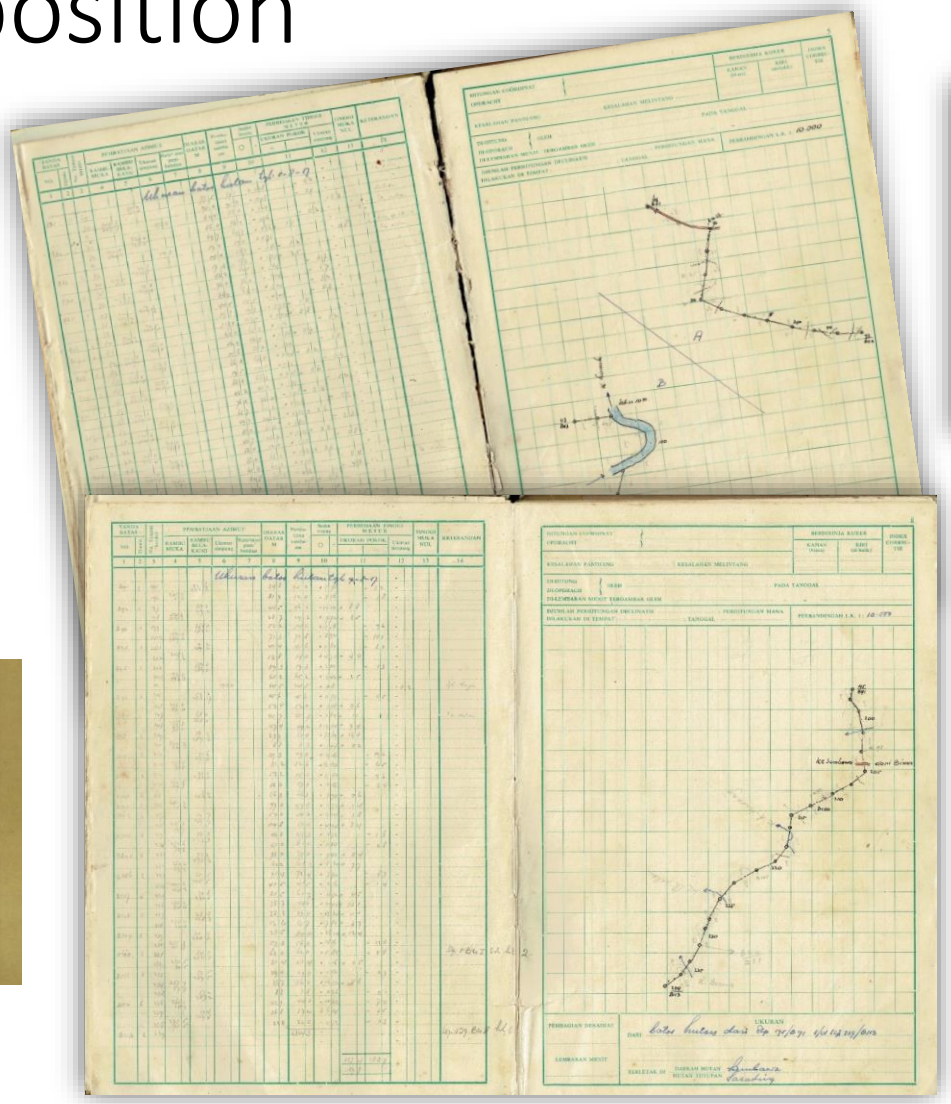


Boundary Reposition

data sources…



Old forest area map



Measurement book

Recorded using RTK GPS

Boundary marks

#Terrestrial surveys were previously applied for forest survey and mapping. Nowadays, forest survey and mapping using at least differential GPS, at some areas using RTK GPS

Forest Inventory

- National Forest Inventory since the 80s
- Systematic sample plots (clusters) in forest area with a grid of 5 x 5 km or 10 x 10 km
- 1 Ha/plot
- Each cluster consists of 16 Record Units (RU)
- Revisit (re-enumerate) every 5 years.

Forest Inventory

NATIONAL FOREST INVENTORY OF INDONESIA

4. PERMANENT PLOT A

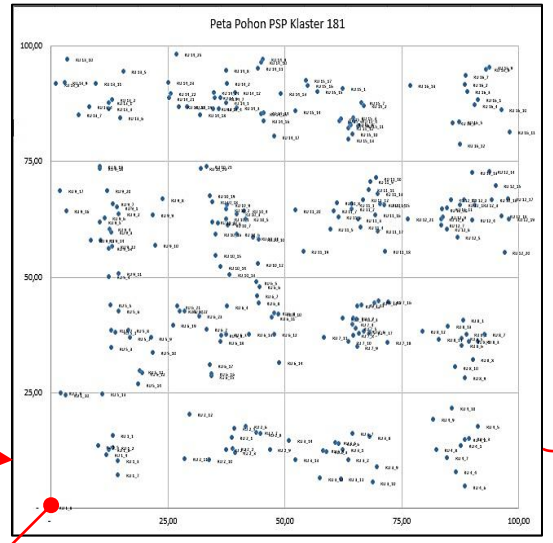
Enumerator : Embo Tampang Allo, S.Hut,M.Sc
Checked :

SHEET ...1... OF ....

CRUE NUMBER OF CLUSTER		HECTAR & PLOT	RECORD UNIT	SEKTOR DEGREES	PARTITION			CONTROL	RECORD TYPE	PROVINCE	LAND SYSTEM	ALTITUT	LAND CATEGORY	FOREST TYPE	STAND CONDITION	YEAR OF LOGGING	TERRAIN	SLOPE	ASPEC	TREES AND POLES	CREW NUMBER	MONTH	YEAR
Zone : 51																							
W.E	N.S																						
430200	9868500	5	2	-	-	1	2	0	0	-	23	9	11	5	15	3	-	4	3	1	12	1	5	17

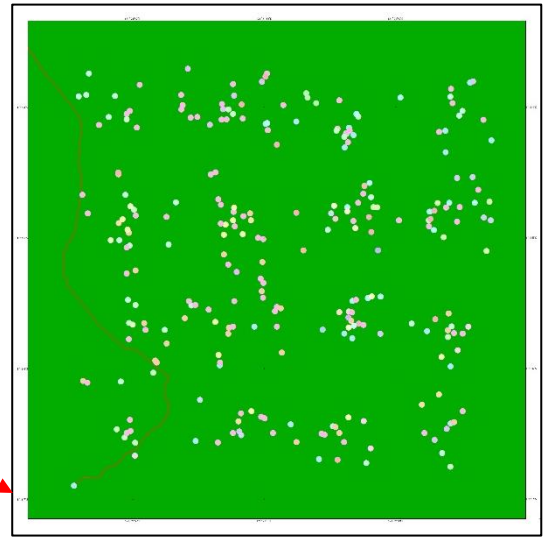
5 m 5 - 19.9 Cm
25 x 25 m 20+ Cm

NAME OF SPECIES	RECORD TYPE	COMMERCIAL NUMBER	SPECIES CODE	DBH of D 0.2 m AB	DAMAGE	BUTTRE HEIGHT	D 0.2 m AB	BOLE HEIGHT	TREE HEIGHT	GRADE	INVESTATION	TREE CLASS	CROWN CLASS	CROWN POSITION	READING FOR POLE AND TREE HEIGHT BUTTRESS AND DIAMETERS ABOVE D 0.2 AB: HOR. DISTANCE	HEIGHT OF BASE	PERCENT BASE	% CROWN POINT	% TOP OF TREE	HOR. DISTANCE	PERCENT BASE	% BUTTRESS	FULL BASE	1M BASE	% 2.2 m AB	BUTTRESS D0.2 AB: FULL BASE	1m BASE	AZIMUT TO TREE	HORIZONT DISTANCE TO TREE
				0.1 Cm		0.01 m	0.1 Cm	0.1 m	0.1 m						0.01 m	0.1 m				0.01 m				0.1			0.1		
Kume	6	1		18,7	0																						25	3,0
Simponokio	6	2		14,2	0																						77	1,5
Kayu lemon	6	3		9,8	0																						105	2,0
Manebombana	6	4		24,5	0			10,2	14,3	1	0	1	1	1	7,4	1,3	3	124	178								0	0
Manebombana	6	5		23,4	0			7,9	12,8	1	0	1	2	1	7,3	1,3	2	97	159								22	5,0
Gora	6	6		26,5	0			10,0	13,9	1	0	2	1	2	7,5	1,3	-1	117	167								40	6,7
Manebombana	6	7		21,2	0			9,7	13,2	1	0	1	1	1	7,5	1,3	-1	113	158								60	7,6
Manebombana	6	8		37,5	0			12,1	15,2	1	0	1	2	2	8,5	1,2	-3	124	161								65	8,2
Manebombana	6			32,5	0			8,6				1	1														90	9,4
Manebombana																												4,2



Tree position in a 1-Ha plot, local coordinate

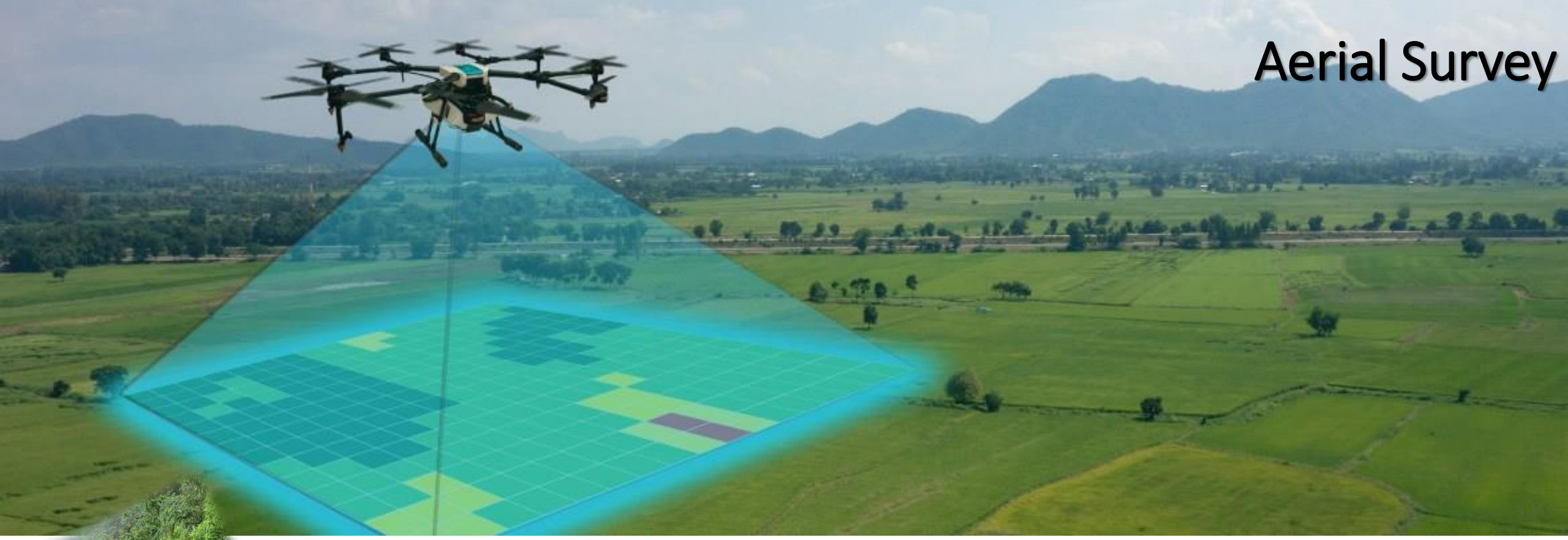
The cluster centre, recorded using GPS



Tree position, global coordinate (in protected forest area)

#Only position of the plot centre recorded using GPS to minimize biases. Tree position mapped using distance, and azimuth from the centre of each RU.

Aerial Survey

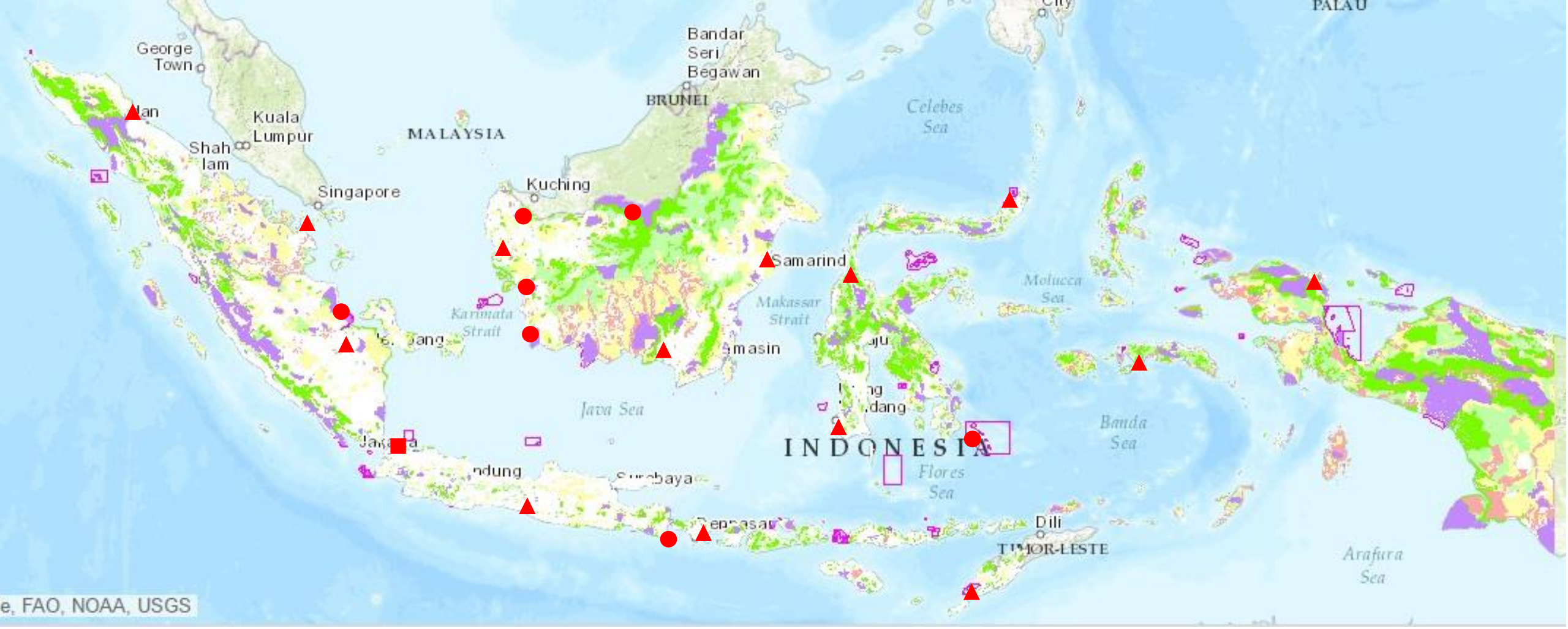


Terrestrial Survey

Aerial Survey

Microlight - Trike

- Visual Flight Rule (VFR)
- Machine Type: Rotax 582 UL, 2 cylinders
- Wing 15 feet
- Composite propellers
- 2 passengers
- Runway; 350 x 6 m (minimum)
- Landing area: runway (asphalt, grass), beach, water, any open areas
- Fuel consumption ± 15 litre/hour
- Fuel tank capacity 70 litre
- Cruising speed ± 60 mph (normal wind)
- Payload 300 kg
- Ballistic parachute, Two ways air band, GPS.
- Aerial camera system (trikes operated by Forestry Planning Agencies)



Microlight - Trike

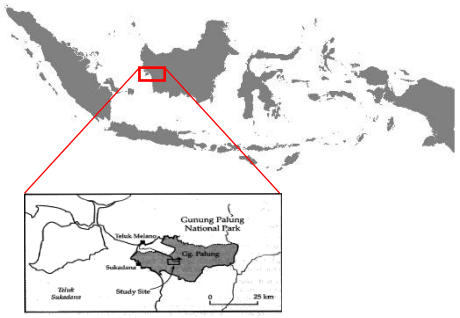
Ministry of EF operates 27 trikes:

- ● **12 trikes at 7 National Parks;**
- ▲ **14 trikes at 14 Forestry Planning Agencies;**
- ■ **1 trike at Directorate of Forest Resources Inventory and Monitoring**

FOREST MONITORING & PROTECTION

- Real-time surveillance

Aerial camera



Loc/Doc: Gunung Palung National Park

Real-time data/imaging

Ground base, GPNP Office

#Aerial monitoring to prevent forest area encroachment, illegal logging, wildlife poaching, etc

FOREST MONITORING & PROTECTION

- Forest fire (hotspots observation)

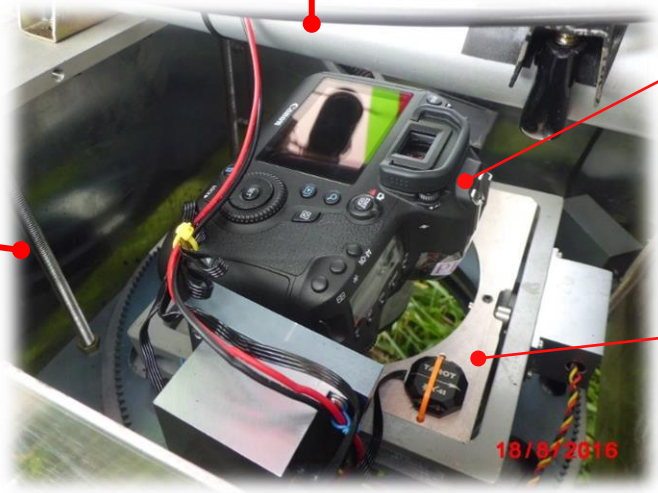
Loc/Doc: Gunung Palung National Park

AERIAL SURVEY FOR FORESTRY PLANNING

- Forest inventory
- Socio-economy aerial survey
- Image interpretation ground-truthing
- Tree mapping
- Forest border monitoring
- Forest Management Unit development
- Forest Utilization Concession Evaluation
- Forestland encroachment surveillance
- DEM extraction
- Official visit
- etc

Aerial Camera System

Forestry Planning Agencies



DSLR Canon 6D

Gyroscope

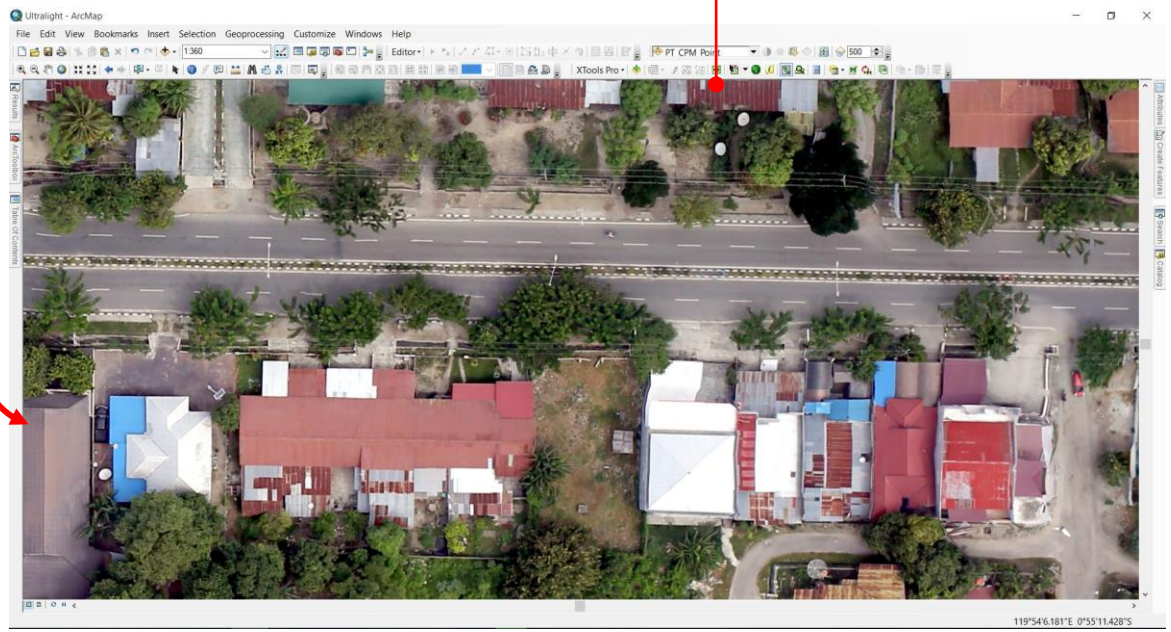
Imaging Process

Image Acquisition

- Flight height: 500 m above avg elevation
- Flight speed: 50 mph (92,6 kph)
- Over-lap: 70%, Side-lap: 40%
- Scale 1:14,000
- Pixel resolution: 9 cm
- Area/scene: 17,46 Ha
- Flight path interval: 300 m
- Photo base: 100 m
- Flight direction: N – S, S – N

GCPs

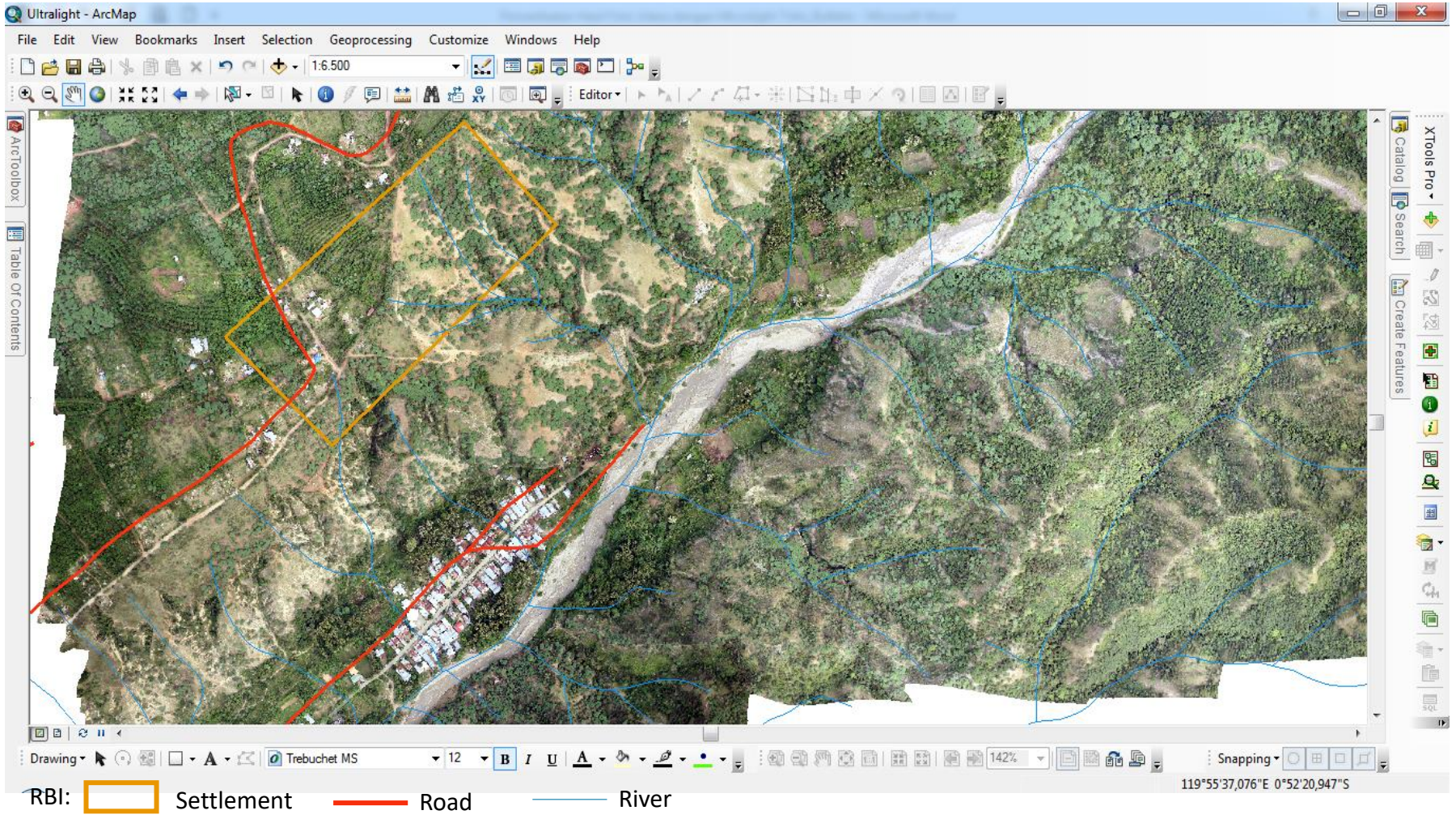
Doc. : Forest Planning Agency Region Samarinda



Captured Image, geo-referenced

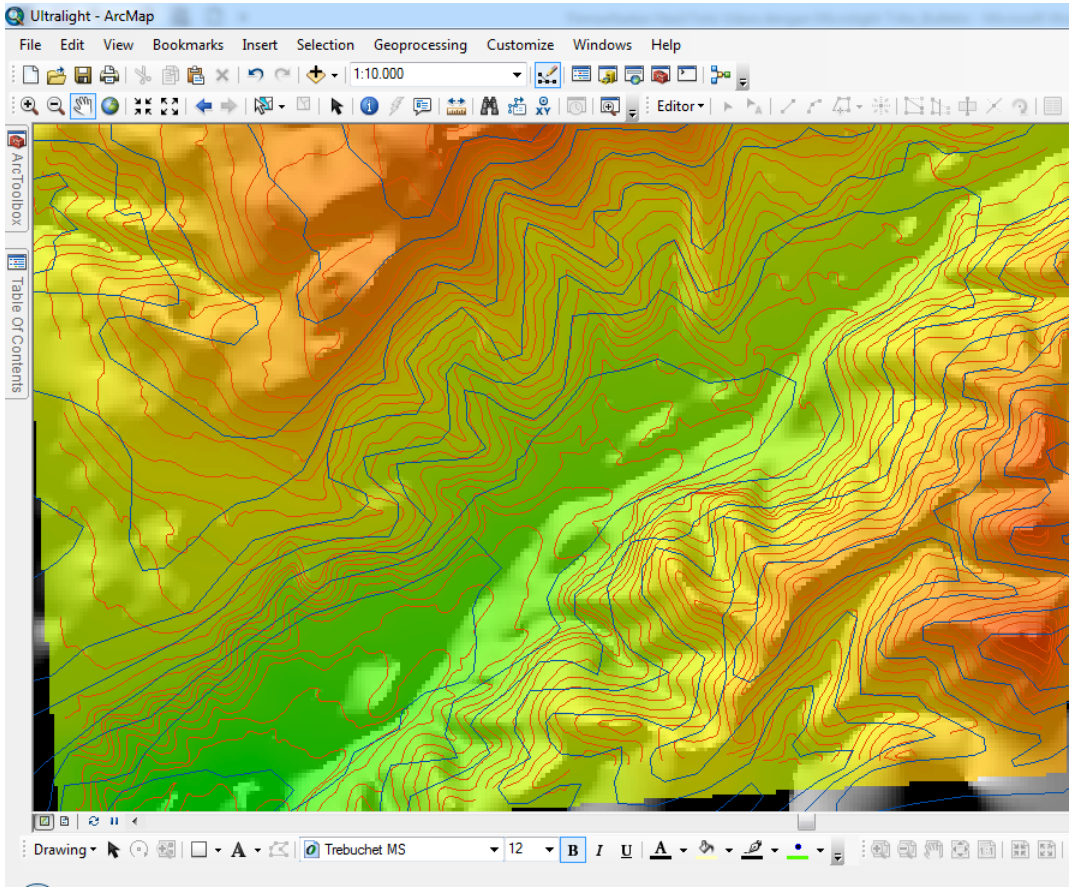
Loc: Palu – Central Sulawesi, November 2016

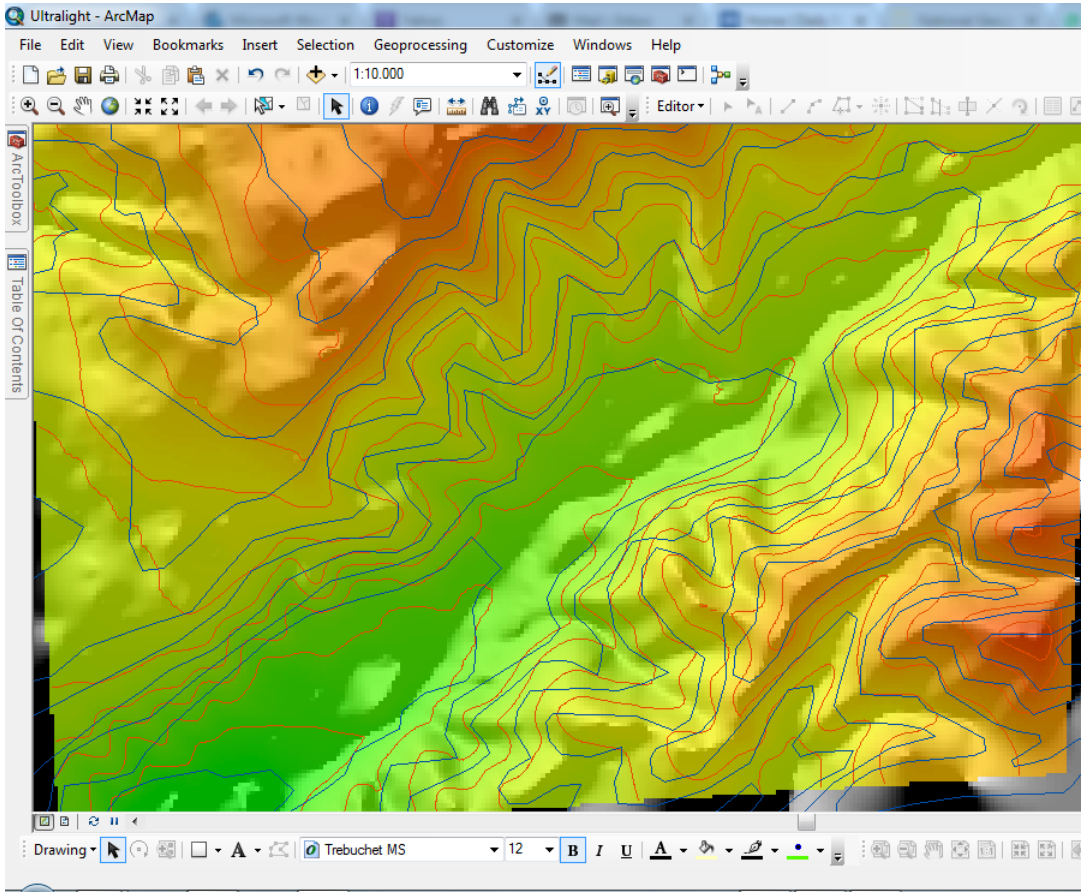
Image analysis



Topographic Map improvement

Image analysis



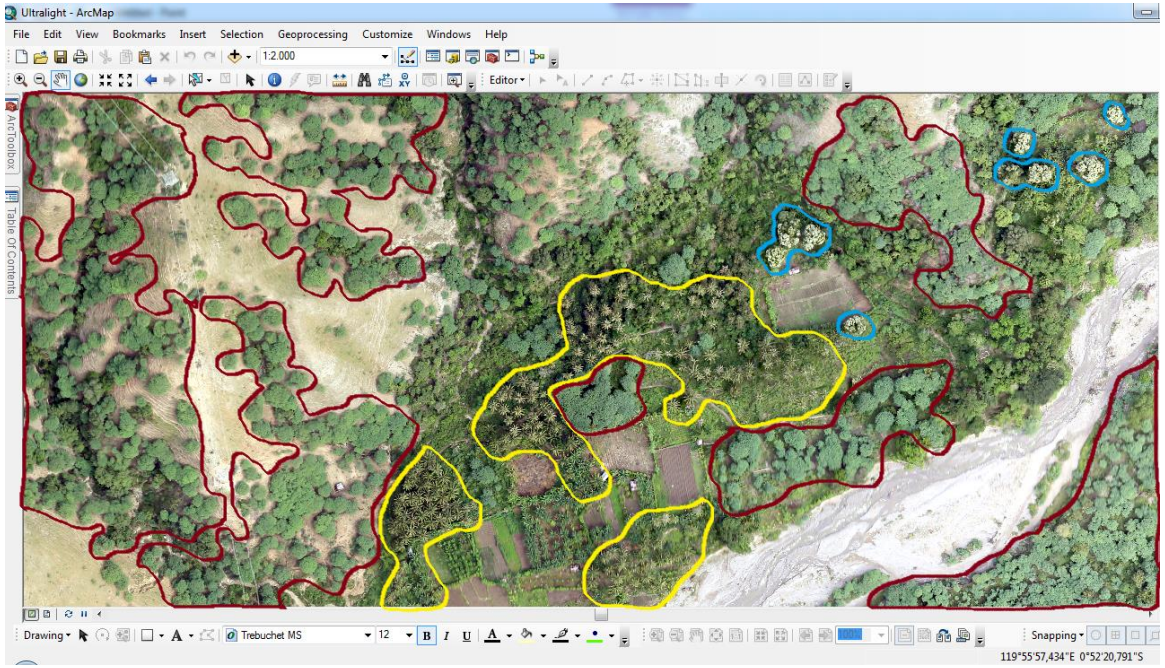


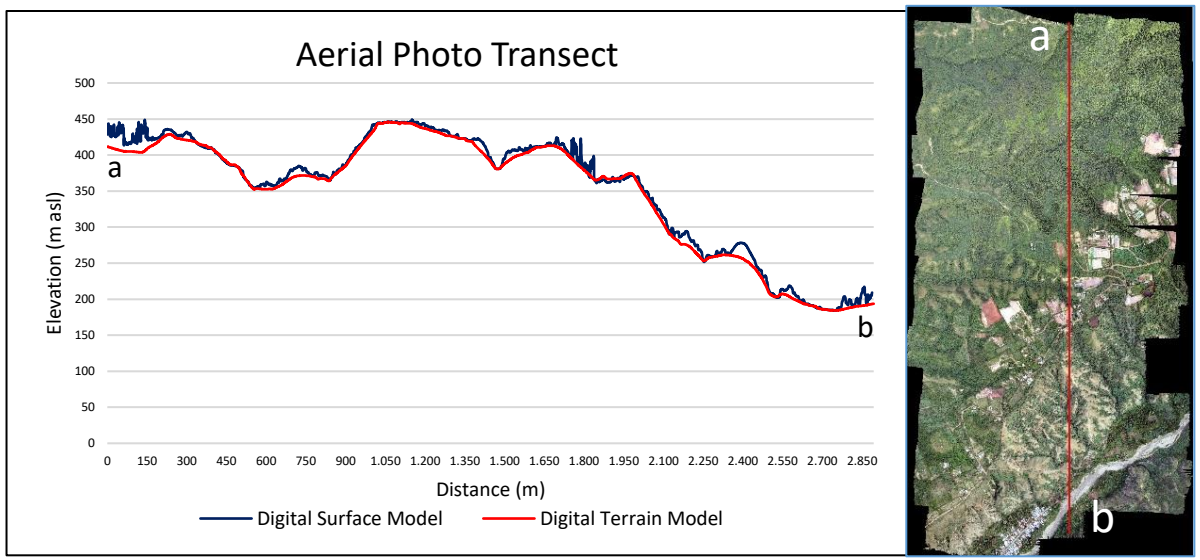
RBI Contour
Extracted Contour

DEM, and Contour extraction

Compared with 25 m RBI Contour Map; Left: interval 10 m, Right: interval 25 m

Image analysis

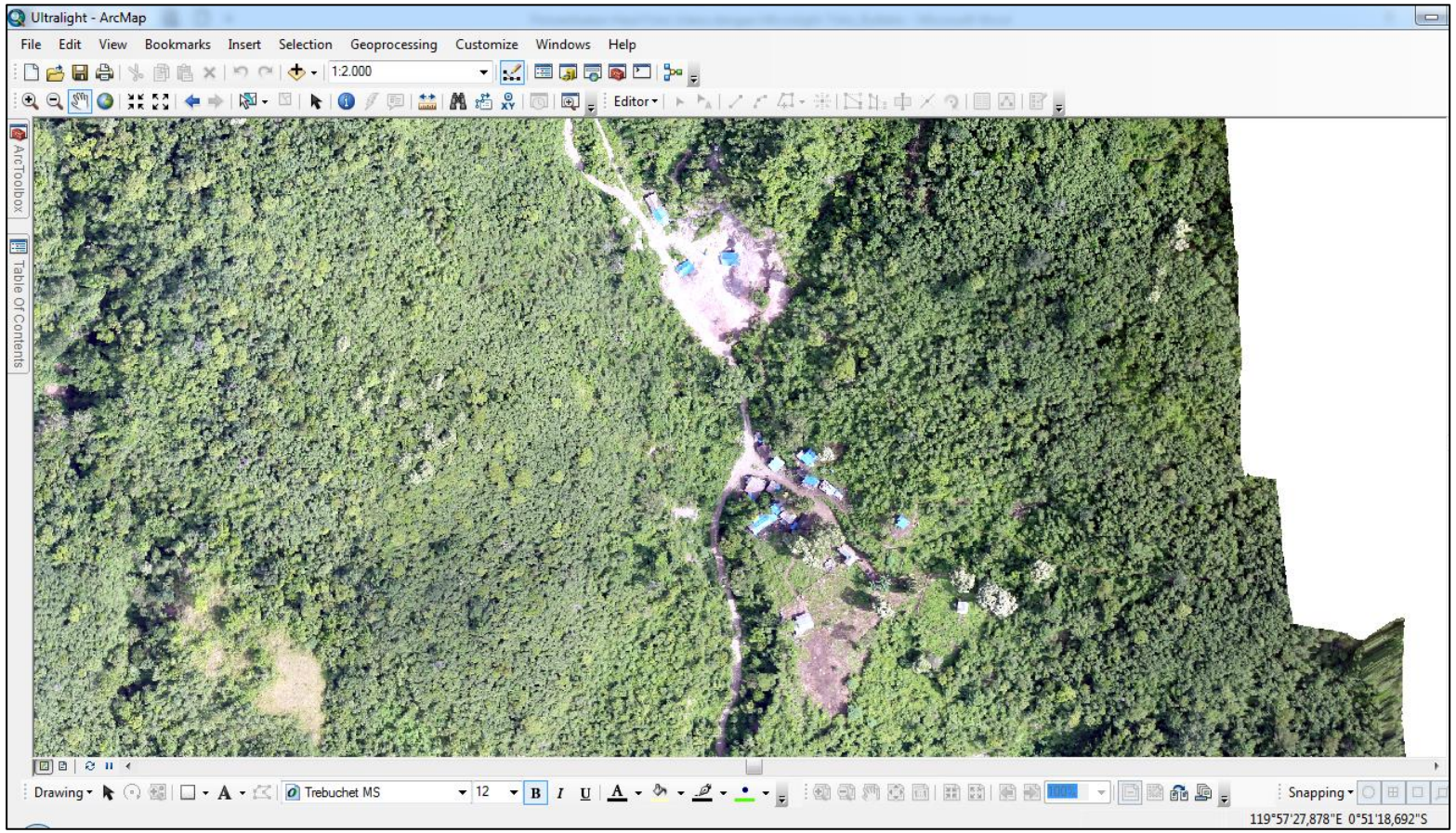




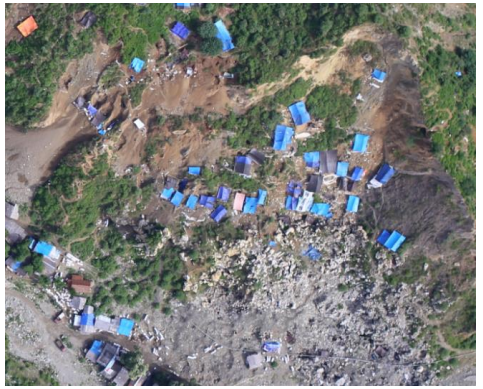
Forest/vegetation Inventory

Left: Species delineation, Right: Tree height estimation/extraction

Image analysis



Oblique



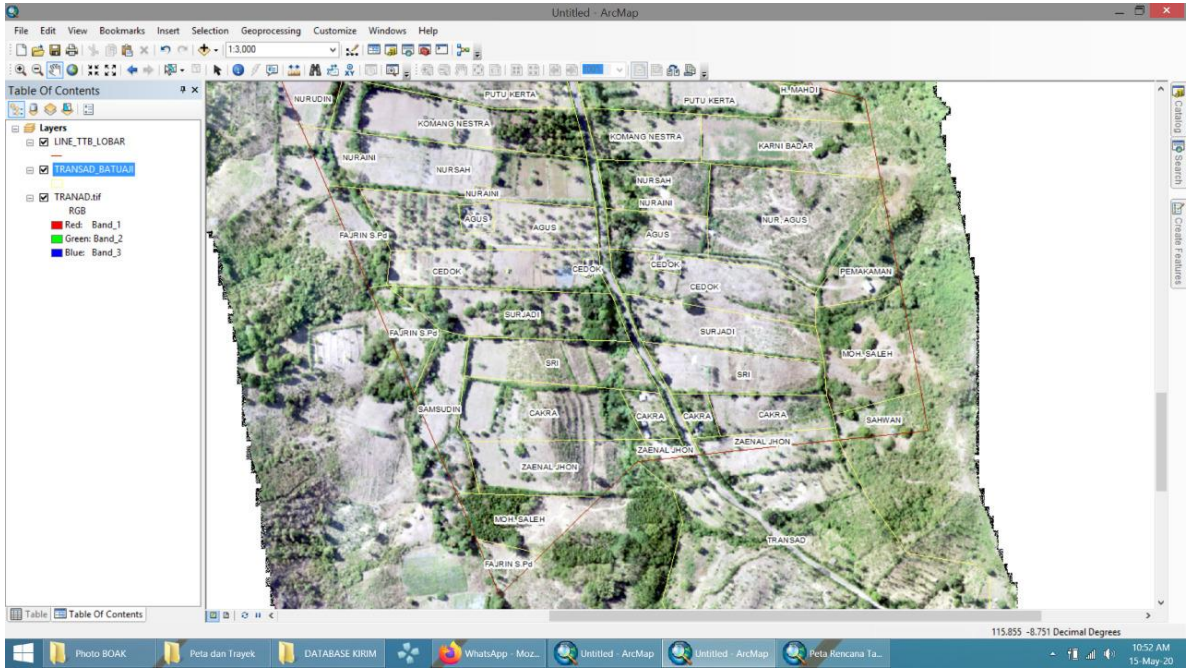
Vertical

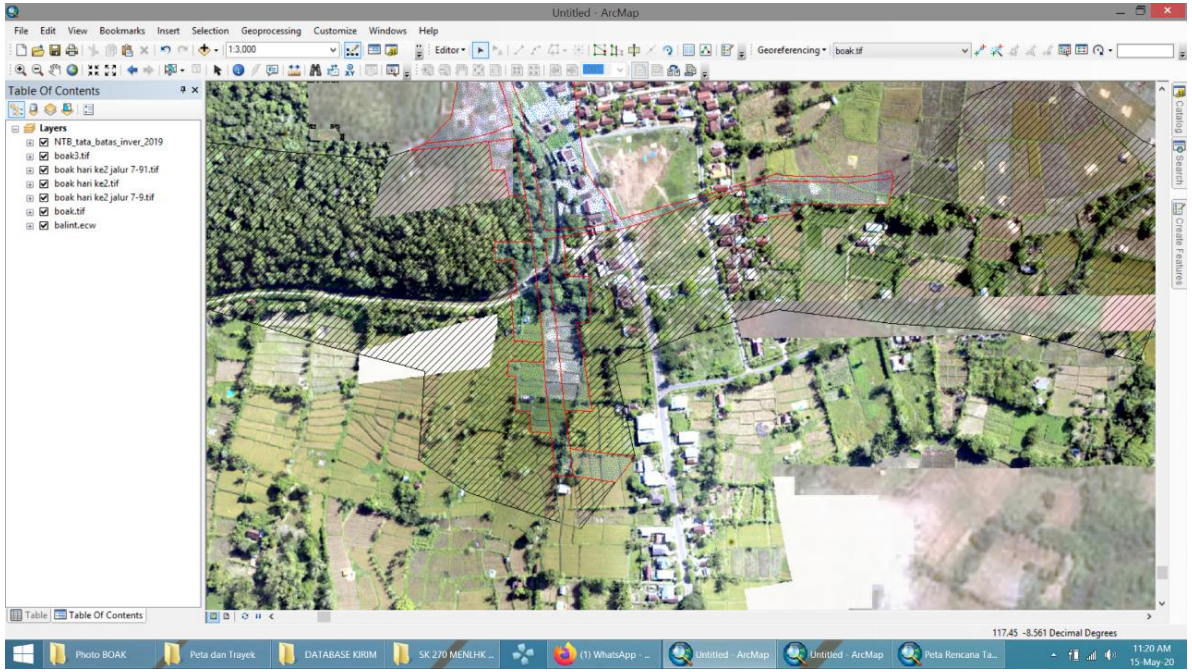
Forest encroachment

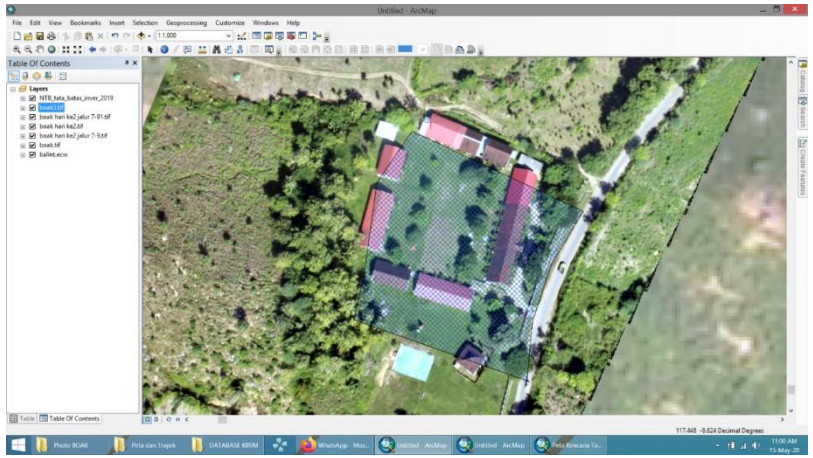
Illegal mining (PETI, Ind.)

Image analysis

Land Redistribution assessment (TORA, Ind.)



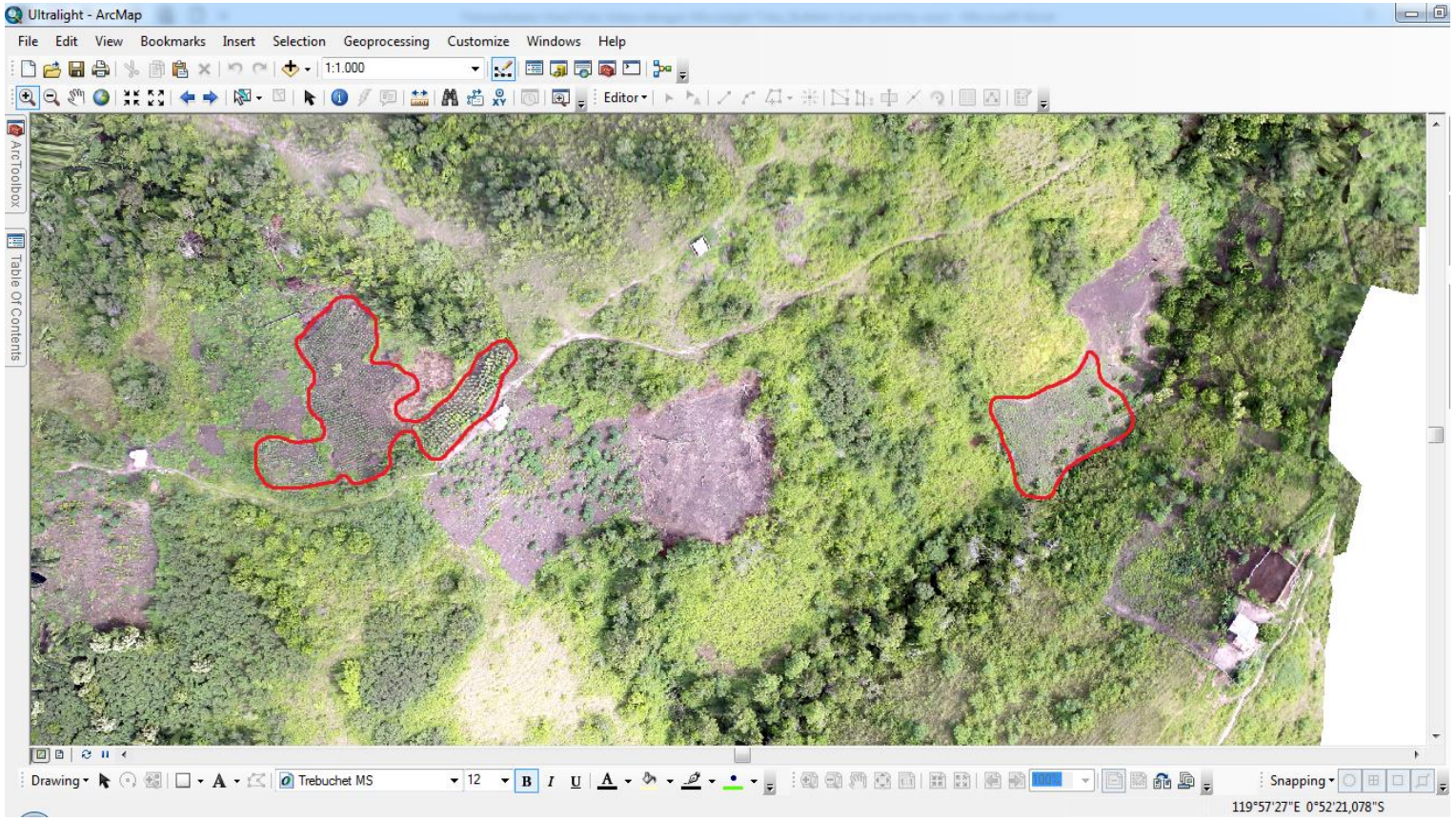




Loc.: Nusa Tenggara Barat Province, 2018

Doc. : Forestry Planning Agency Region Denpasar

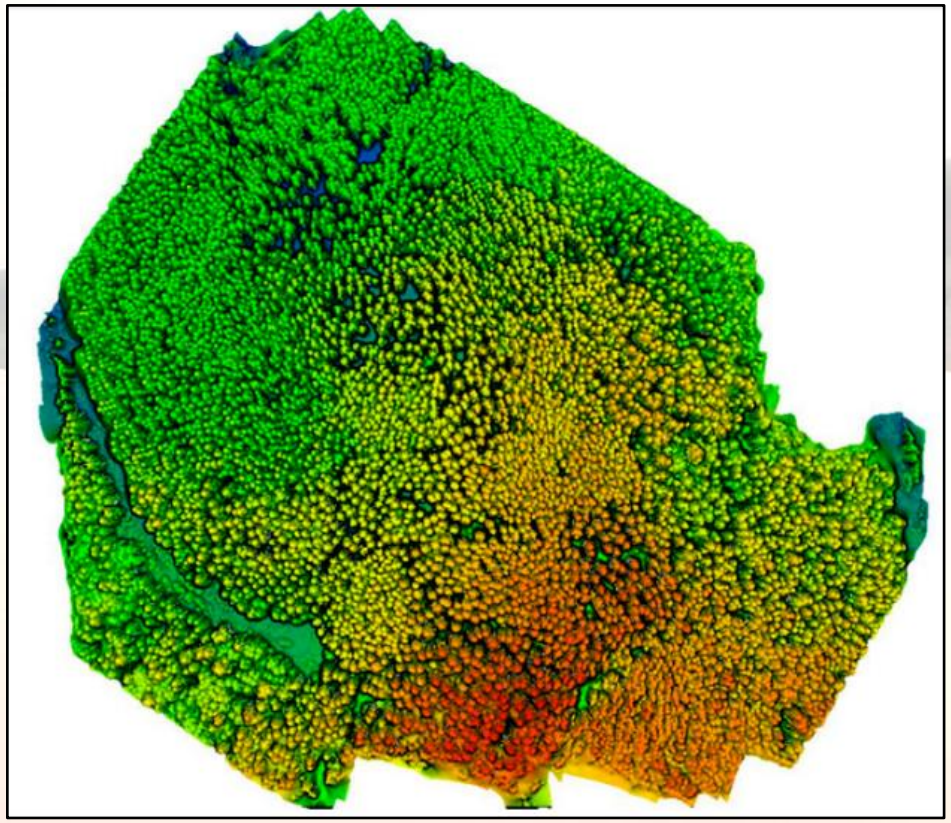
Image analysis (add. analysis)



Crop mapping

Cornfield

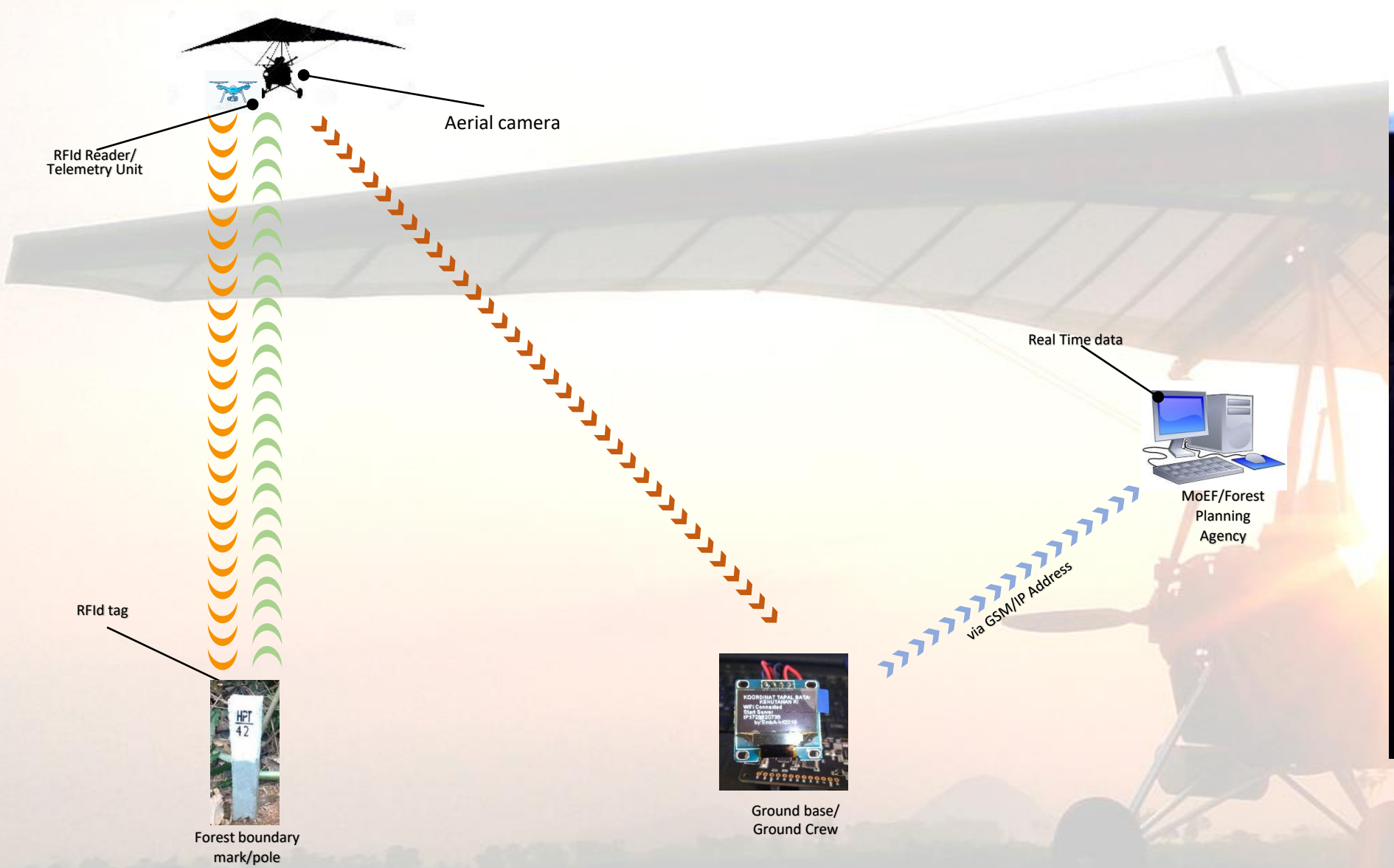
Image analysis *(further/possible elaboration)*

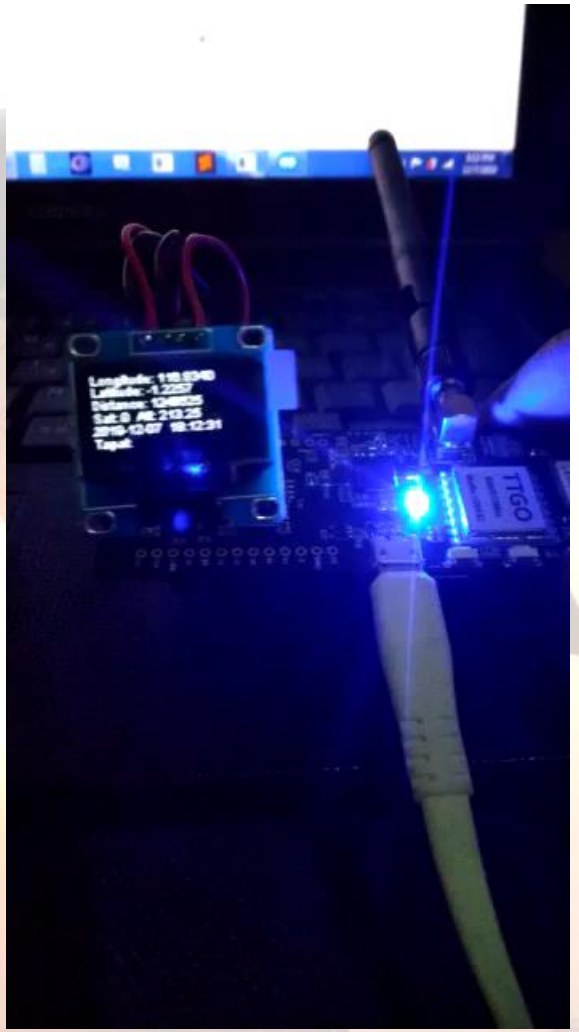


Point cloud extracted from aerial photo, colored according to tree height; green lower tier, red higher tier trees. (Nevalainen *et al.*, 2017)

Forest boundary monitoring *(further/possible elaboration)*

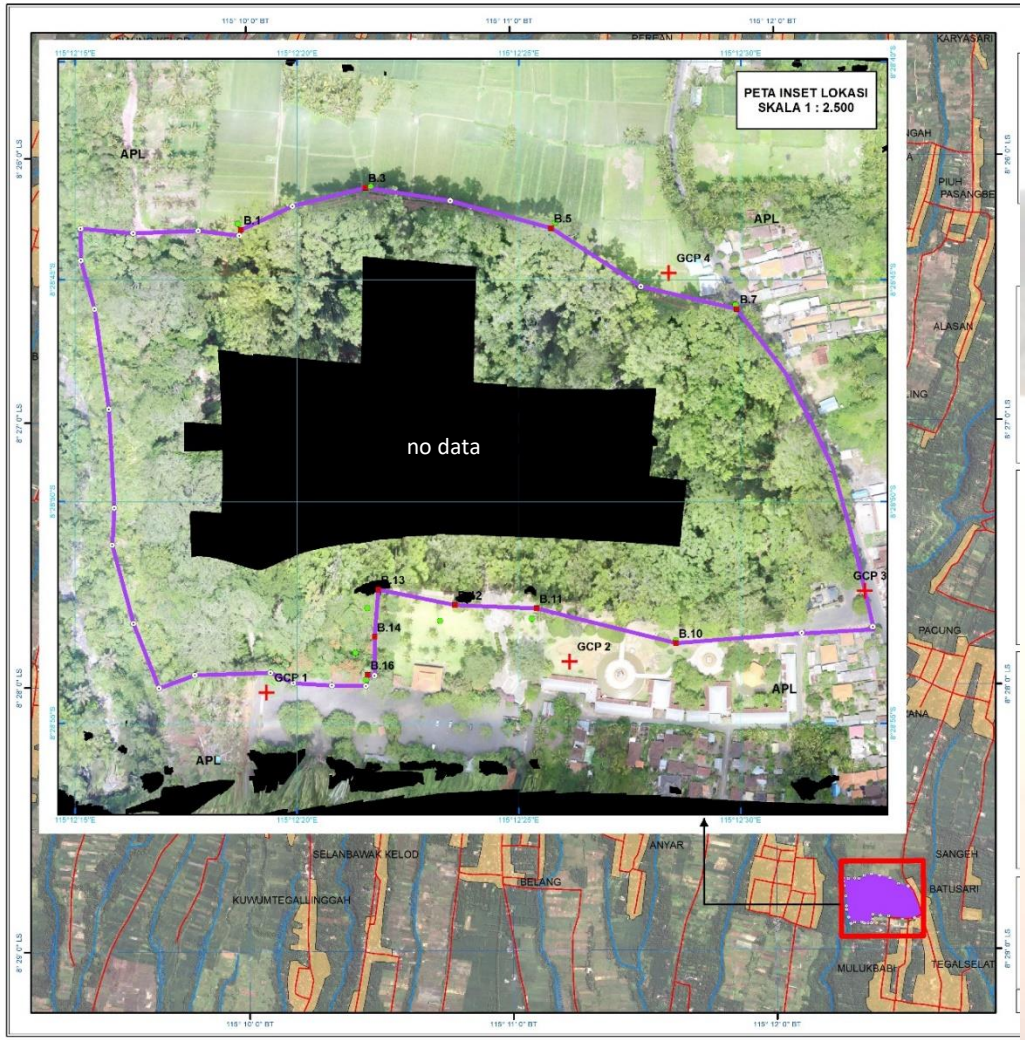
Telemetry Method (Prototype, on going improvement)





Forest boundary monitoring

Telemetry Method (Prototype)



Loc: Sangeh Nature Park, Tabanan - Bali

Coordinate comparison

No.	Pal	X_{Awal}	$X_{Telemetri}$	Δ_X (m)	Y_{Awal}	$Y_{Telemetri}$	Δ_Y (m)
1.	B.1	302421.44	302419.57	1.87	9062307.02	9062311.24	4.22
2.	B.3	302507.21	302510.87	3.66	9062336.72	9062337.73	1.01
3.	B.6	302635.57	302638.16	2.59	9062309.32	9062313.10	3.78
4.	B.7	302763.75	302762.77	0.98	9062253.99	9062256.67	2.68
5.	B.10	302722.85	302722.79	0.06	9062022.32	9062024.43	2.11
6.	B.11	302626.72	302623.38	3.34	9062045.88	9062038.73	7.15
7.	B.12	302570.58	302559.99	10.59	9062047.93	9062037.00	10.93
8.	B.13	302517.40	302509.92	7.48	9062058.55	9062045.53	13.02
9.	B.14	302514.94	302501.95	12.99	9062025.54	9062014.65	10.89
10	B.16	302510.43	302509.41	1.02	9061999.16	9061995.86	3.30

Avg difference: abscissa (X) 4,46 m; ordinate (Y) 5,91 m

- X_{Awal}, Y_{awal} recorded using Differential GPS
- Telemetry unit mounted on Quadcopter Drone at around 10 m flight height

...the end...

Thank you ☺