

# Data Science in Forestry:

## THE FORESTRY SITUATIONER



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**2018 SFFI National Conference**  
**PPC Coliseum, Puerto Princesa City**  
**October 26, 2018**



## **Outline**

- ❑ **Introduction**
- ❑ **Past Initiatives**
  - **National Forest Resources Inventories**
    - **1969 Forest Resources Condition Maps**
    - **1988 Forest Cover and Stand & Stock**
  - **Land Cover Mapping Projects**
    - **2003, 2010 and 2015 Land Cover Data**  
(Objectives, Data sources, Methodology, Results)
- ❑ **Current Initiative**
- ❑ **Issues and Concerns**
- ❑ **Way Forward**

# Introduction

**land cover relates to the type of features present on the earth's surface**



# Introduction

## land cover data:

- Identify locations, assess extent and distribution of features of interest like remaining forest, built-up or open areas
- monitor and detect changes of these features over time
- more accurately estimate deforestation and biomass in various locations for GHG inventory reporting
- develop strategies to reduce carbon emissions
- thematic information in climate change studies
- input in physical & development planning from national down to local levels in the formulation of CLUPs



# Past Initiatives

## National Forest Resources Inventories (NFRIs):

### 1<sup>st</sup> NFRI Project (1965-1969)

- aerial photographs (1962-1968)
- supported with forest inventory/ground measurement
- Bureau of Forestry and CERTEZA Surveying Inc.
- **Output: 1969 Forest Resources Condition Maps (FRCM)**

### RP-German FRI Project (1978-1988)

- satellite imageries (Landsat 1982-85)
- aerial photographs for NE Mindanao taken in 1979
- supported with ground measurement
- Forest Management Bureau with assistance from GTZ and FAO
- **Output: 1988 Forest Cover Maps, and Stand & Stock Tables**

# Past Initiatives

## Land Cover Mapping Project (2002-2004):

- **Objective:** to generate a national forest cover data based on a classification scheme consistent with international standards for global reporting and integration
- **data source:** Landsat7 ETM, 30m res.; CY 2000-2003
- **21 categories, detailed classification of forest areas**
- **visual interpretation**
- **started in the last quarter of 2002**
- **preliminary maps were completed within a year**
- **no ground validation**
- **NAMRIA & FMB collaboration**
- **Output:** 2003 Land Cover Maps



# STANDARD CLASSIFICATION

based on  
FAO-FRA Project  
Field Inventory Manual

	<i>Classification</i>
1	Closed forest, broadleaved
2	Closed forest, mixed
3	Closed forest, coniferous
4	Open forest, broadleaved
5	Open forest, mixed
6	Open forest, coniferous
7	Mangrove forest
8	Forest plantation, broadleaved
9	Forest plantation, coniferous
10	Other wooded land, shrubs
11	Other wooded land, fallow
12	Other wooded land, wooded grassland
13	Other land, natural, barren land
14	Other land, natural, grassland
15	Other land, natural, marshland
16	Other land, cultivated, annual crop
17	Other land, cultivated, perennial crop
18	Other land, cultivated, pastures
19	Other land, fishpond
20	Other land, built-up area
21	Inland water



2003 LAND COVER MAP



PHILIPPINE FORESTLAND COVER STATISTICS	
2003 LANDCOVER	AREA (Hekt.)
Closed forest, broadleaved	2,404,905
Closed forest, mixed	70,185
Closed forest, coniferous	87,301
Open forest, broadleaved	3,849,541
Open forest, mixed	21,195
Open forest, coniferous	113,889
Mangrove forest	249,156
Forest plantation, broadleaved	375,000
Forest plantation, coniferous	3,479
Other wooded land, shrubs	3,052,269
Other wooded land, fallow	80,214
Other wooded land, wooded grassland	3,870,906
Other land, natural, barren land	147,190
Other land, natural, grassland	1,841,081
Other land, natural, marshland	181,087
Other land, cultivated, annual crop	6,671,116
Other land, cultivated, perennial crop	4,807,150
Other land, cultivated, pastures	1,900
Other land, fishpond	279,496
Other land, built-up area	267,996
Inland water	298,747
TOTAL AREA	29,622,896
Note:	
1. The Philippines has been a total island on the National Statistics Office (NSO) 2003 and 2008 censuses, resulting from the 2003 and 2008 National Statistical Survey of Agriculture, Forestry and Fisheries (NSA) in 2003 and 2008.	
2. Projection: Universal Transverse Mercator (UTM) Zone 51P	
Datum: Clark 1986	
Datum Shift: East 100	
Vertical Datum: Mean Sea Level	

LEGEND

- Closed forest, broadleaved

Closed forest, mixed

Closed forest, coniferous

Open forest, broadleaved

Open forest, mixed

Open forest, coniferous

Mangrove forest

Forest plantation, broadleaved

Forest plantation, coniferous

Other wooded land, shrubs

Other wooded land, fallow
- Other wooded land, wooded grassland

Other land, natural, barren land

Other land, natural, grassland

Other land, natural, marshland

Other land, cultivated, annual crop

Other land, cultivated, perennial crop

Other land, natural, pastures

Other land, fishpond

Other land, built-up area

Inland water



# PHILIPPINE FORESTLAND COVER STATISTICS

2000 LANDCOVER	AREA (Hect.)
Closed forest, broadleaved	2,404,905
Closed forest, mixed	70,135
Closed forest, coniferous	87,301
Open forest, broadleaved	3,849,340
Open forest, mixed	11,795
Open forest, coniferous	113,869
Mangrove forest	249,156
Forest plantation, broadleaved	311,002
Forest plantation, coniferous	3,478
Other wooded land, shrubs	3,051,269
Other wooded land, trees	80,754
Other wooded land, wooded grassland	3,875,808
Other land, natural, barren land	547,490
Other land, natural, grassland	1,841,081
Other land, natural, meadow	181,087
Other land, cultivated, annual crop	6,671,116
Other land, cultivated, perennial crop	4,301,155
Other land, cultivated, pasture	1,908
Other land, irrigated	219,496
Other land, built-up area	281,996
Water body	294,144

**TOTAL AREA**

**29,433,894**

Note:

1. The Philippines has a total area of 300,000,000 hectares (300,000,000 ha) or 300,000,000,000,000 sqm (300,000,000,000,000 sqm) according to the 1988/1990 Survey of the National Bureau of Statistics. Simple conversion gives a 300,000,000 ha.

2. The area of the Philippines is 300,000,000 ha (300,000,000 ha) or 300,000,000,000,000 sqm (300,000,000,000,000 sqm) according to the 1988/1990 Survey of the National Bureau of Statistics. Simple conversion gives a 300,000,000 ha.

# Past Initiatives

## Land Cover Mapping Project (2009-2013)

- data sources:
  - ALOS AVNIR-2 (10m) : 116 scenes (62%)
  - SPOT 5 (10m) : 40 scenes (22%)
  - LANDSAT (30m) : 29 scenes (16%)
- 14 aggregated categories
- visual interpretation
- with ground validation and accuracy assessment
- Output: 2010 Land Cover Maps

## LAND COVER CATEGORIES

ID	2003	2010
	21 categories	Aggregated to 14
1	Closed forest, broadleaved	Closed Forest
2	Closed forest, mixed	
3	Closed forest, coniferous	
4	Open forest, broadleaved	Open Forest
5	Open forest, mixed	
6	Open forest, coniferous	
8	Forest plantation, broadleaved	Closed / Open Forest, other classes
9	Forest plantation, coniferous	
7	Mangrove Forest	Mangrove Forest
10	Other wooded land, shrubs	Shrubs
11	Other wooded land, fallow	Fallow
12	Other wooded land, wooded grassland	Wooded Grassland
14	Other land, natural, grassland	Grassland
18	Other land, cultivated, pastures	
16	Other land, cultivated, annual crop	Annual Crop
17	Other land, cultivated, perennial crop	Perennial Crop
13	Other land, natural, barren land	Open/Barren
20	Other land, built-up area	Built-up
15	Other land, natural, marshland	Marshland/Swamp
19	Other land, fishpond	Fishpond
21	Inland water	Inland Water

# 2010 LAND COVER MAP



2010 LAND COVER STATISTICS\*  
PHILIPPINES

LAND COVER CLASSIFICATION	AREA IN HECTARES	PERCENTAGE (%)
Closed Forest	1,934,048	6.54
Open Forest	4,595,191	15.55
Sub-Total	6,529,239	22.09
Mangrove Forest	310,593	1.05
Fallow	7,185	0.02
Shrubs	3,355,816	11.35
Wooded Grassland	3,820,562	12.93
Grassland	1,431,254	4.84
Annual Crop	6,276,605	21.24
Perennial Crop	6,177,929	20.90
Open/Barren	97,770	0.33
Built-up	692,389	2.34
Marshland/Swamp	131,499	0.44
Fishpond	245,212	0.83
Inland Water	480,023	1.62
TOTAL	29,556,076	100.00

\* Adjusted to incorporate slight increase resulting from stakeholders' feedback and availability of higher resolution imageries. The increase in total land area is attributed to the inclusion of some small islands in Northern Samar and additional mangrove and built-up areas in Bohol. Forest plantations depending on age and height may have been classified under Closed/Open forest or other categories.

LEGEND

- Closed Forest

Open Forest

Shrubs

Wooded Grassland

Grassland

Fallow

Perennial Crop
- Annual Crop

Built-up

Open/Barren

Mangrove Forest

Marshland/Swamp

Fishpond

Inland Water

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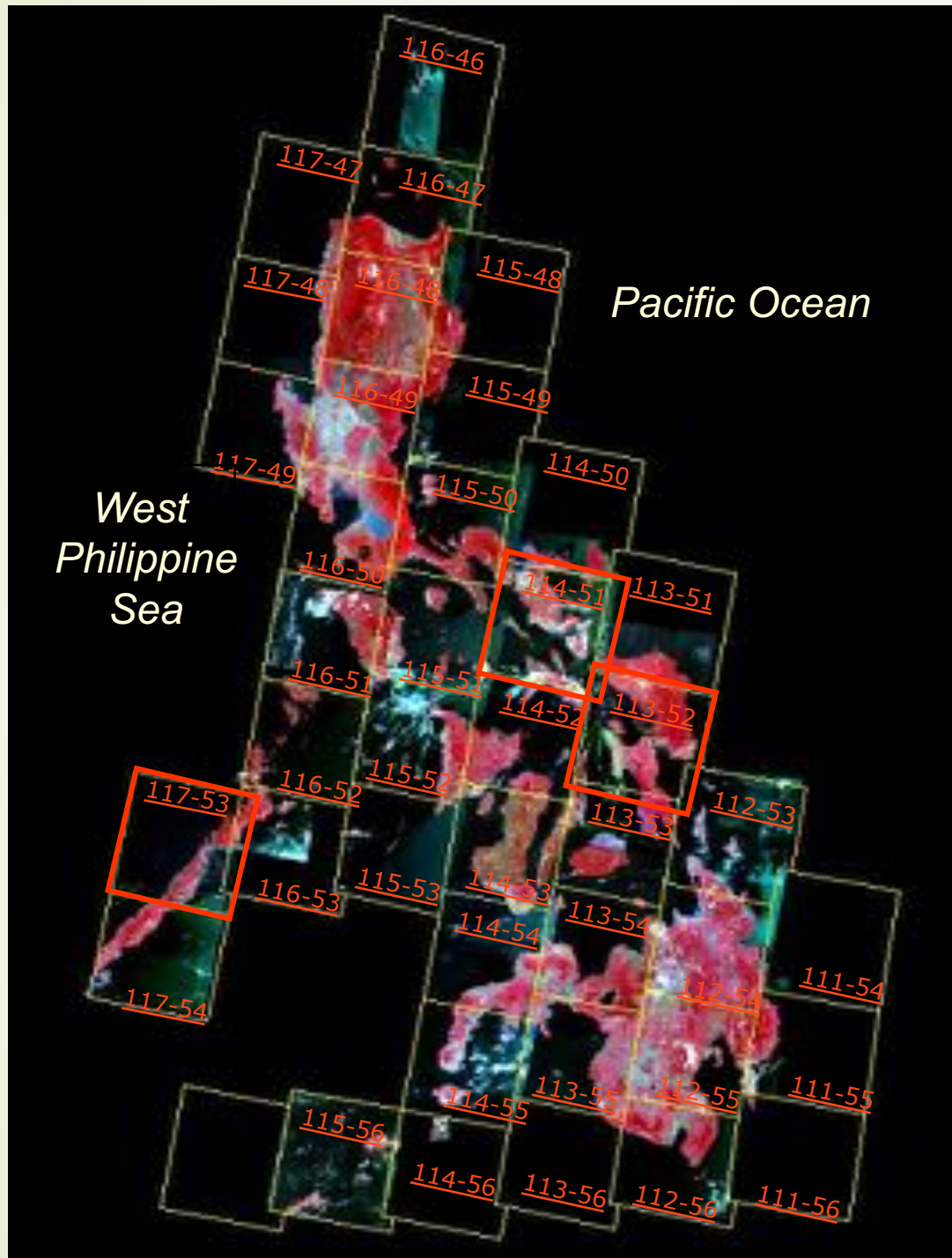


# Past Initiatives

## Land Cover Mapping Project (2013-2017)

- **Objectives:**
  - to update existing nationwide land cover data using latest satellite imageries
  - to determine land cover change
- **data source: Landsat 8, 30m res., CY 2014-2016**
- **reference data: Google maps, topo maps, ground truth data**
- **12 aggregated categories**
- **digital image classification (OBIA)**
- **with ground validation and accuracy assessment**
- **Output: 2015 Land Cover Maps**





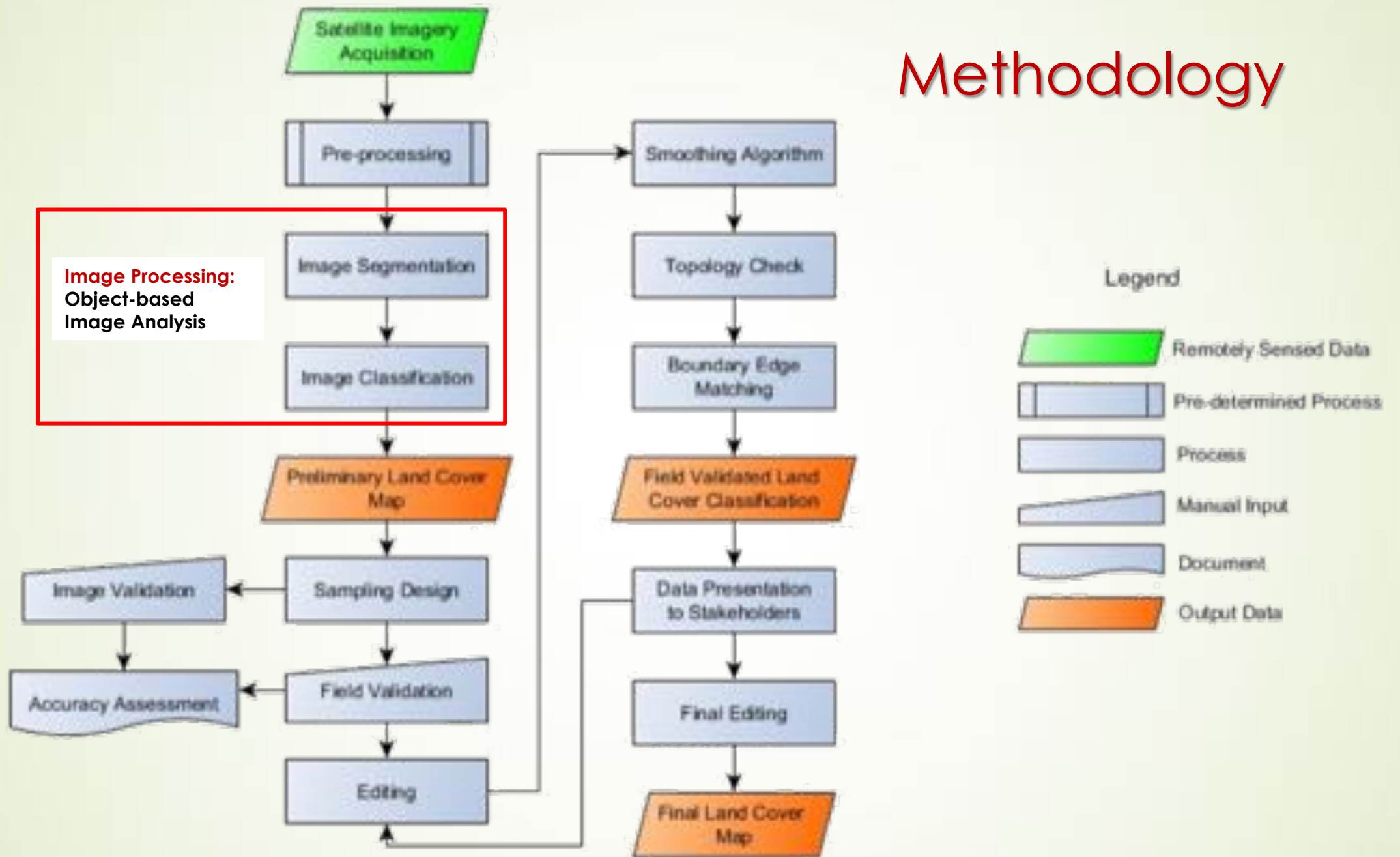
## INDEX OF LANDSAT

**44 SCENES**  
(CY 2014 onwards)

# 12 Land Cover Categories

- Closed Forest
- Open Forest
- Mangrove Forest
- Shrubs / Brushland
- Grassland
- Annual Crop
- Perennial Crop
- Built-up
- Open / Barren
- Marshland
- Fishpond
- Inland Water

# Methodology

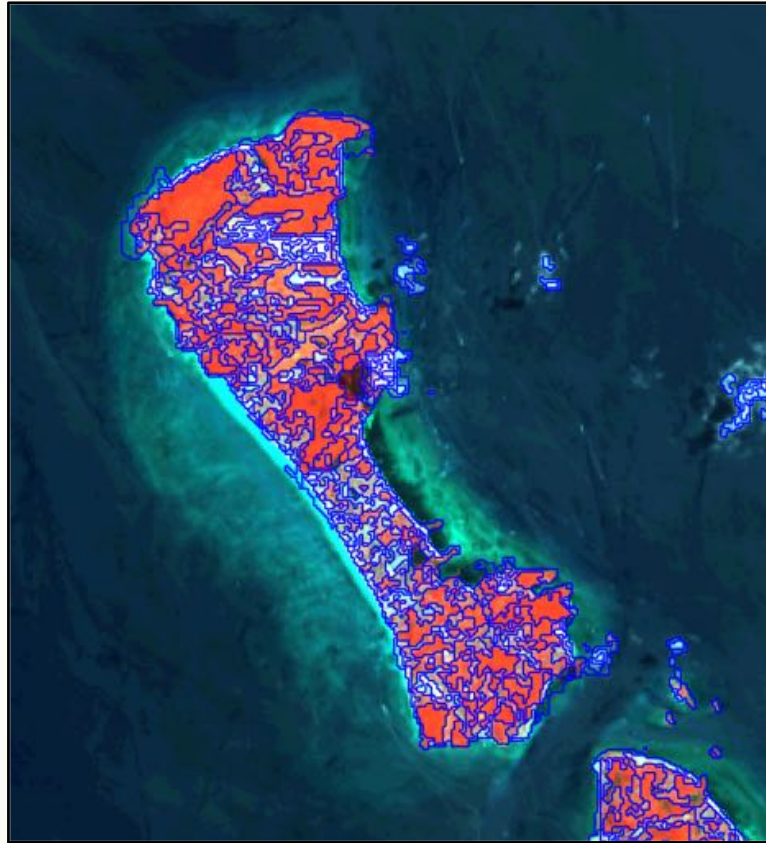




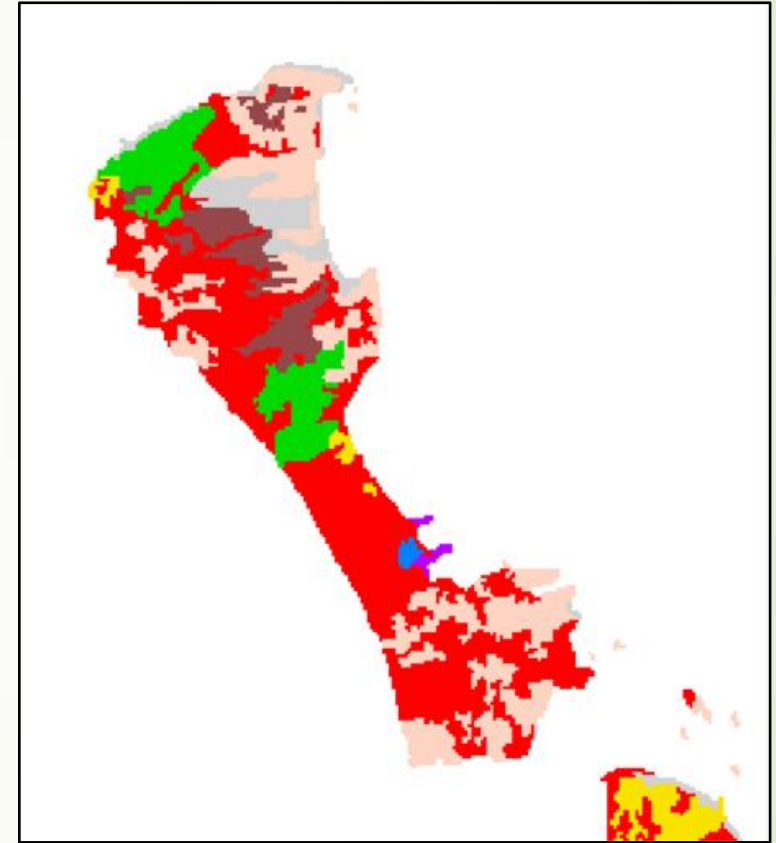
# Image Processing



**LandSat 8  
Image**

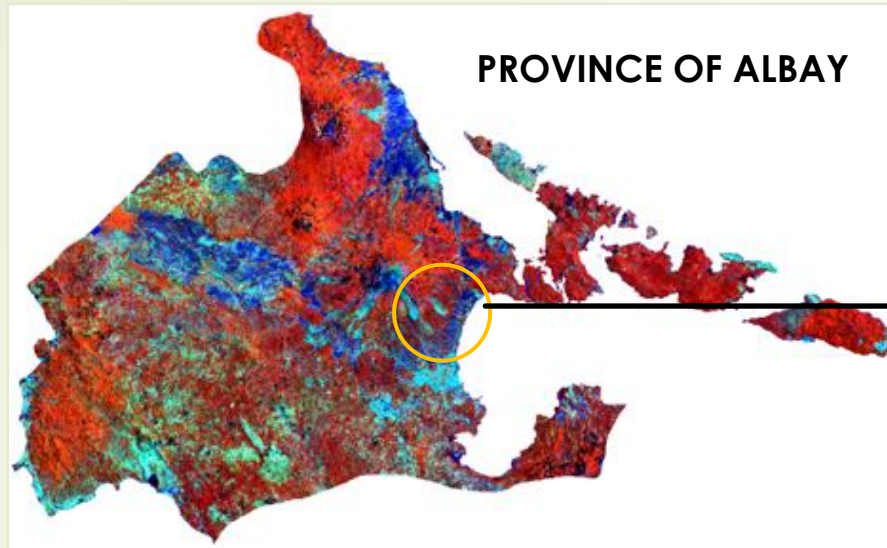


**Image  
Segmentation**



**Preliminary Image  
Classification**





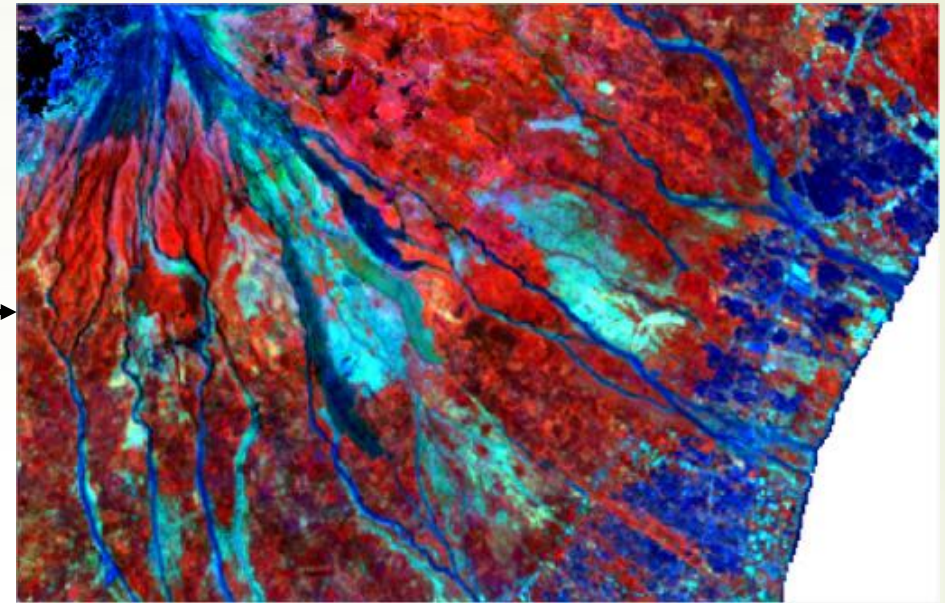
**Landsat 8 Path 114 Row 051 Mosaic**

Dates taken:

April 1, 2015

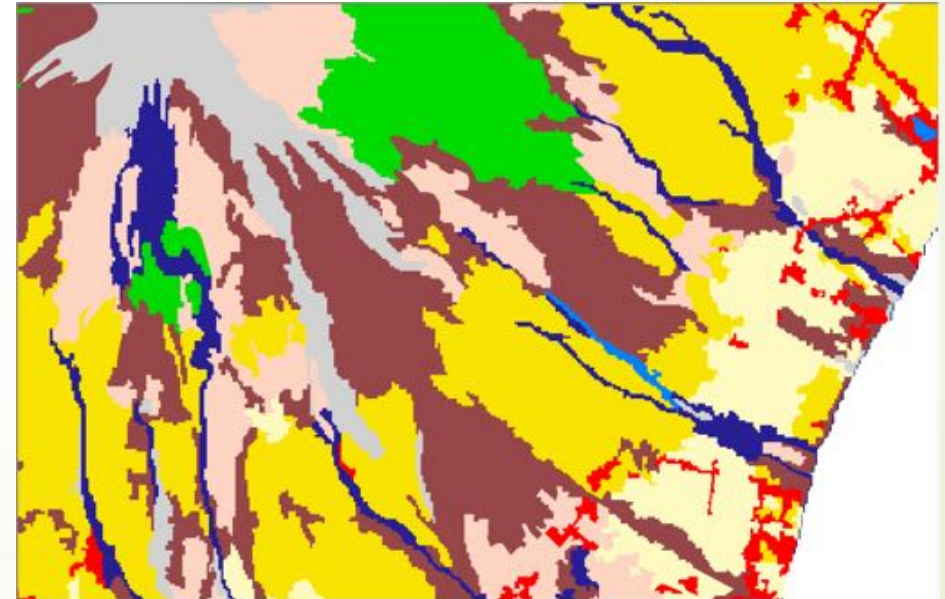
April 17, 2015

May 19, 2015



**Legend:**

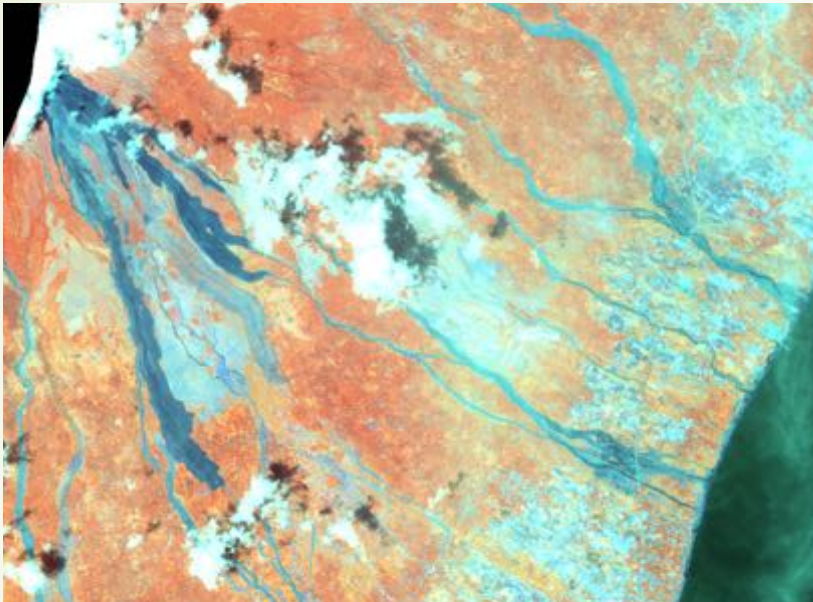
- Closed Forest
- Open Forest
- Brush/Shrubs
- Grassland
- Perennial Crop
- Annual Crop
- Built-up
- Open/Barren
- Mangrove
- Marshland
- Fishpond
- Inland Water



**RESULT OF DIGITAL CLASSIFICATION**



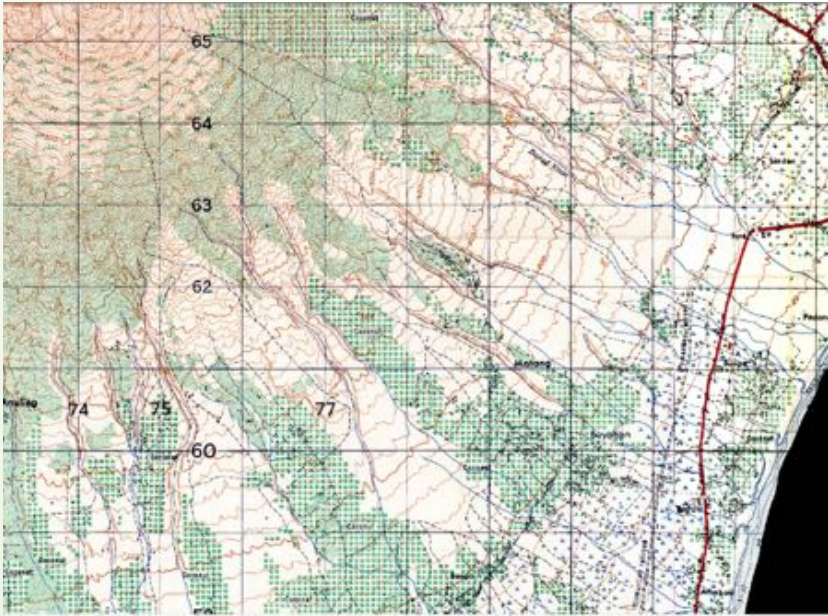
Other  
References:



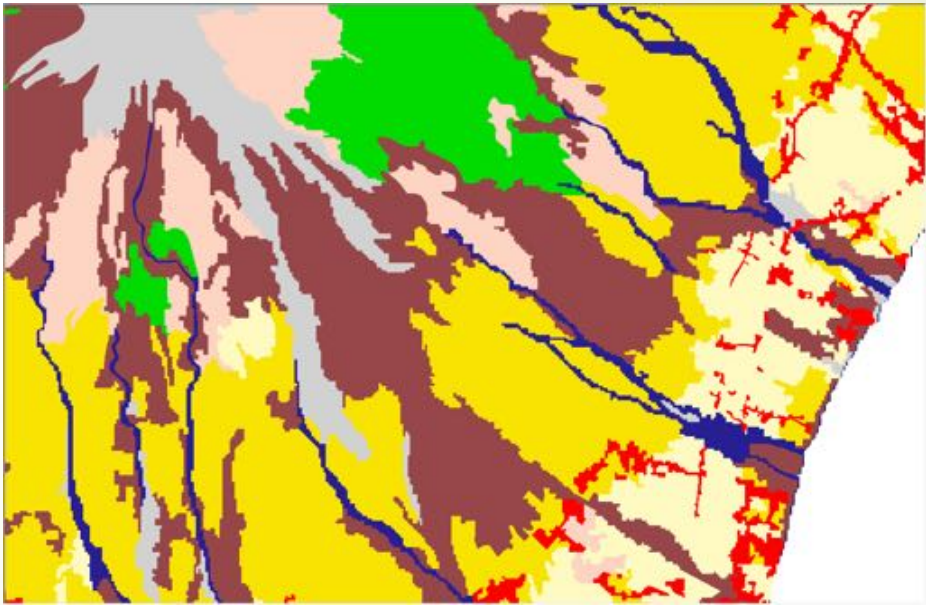
WorldView 2



Google Earth Image



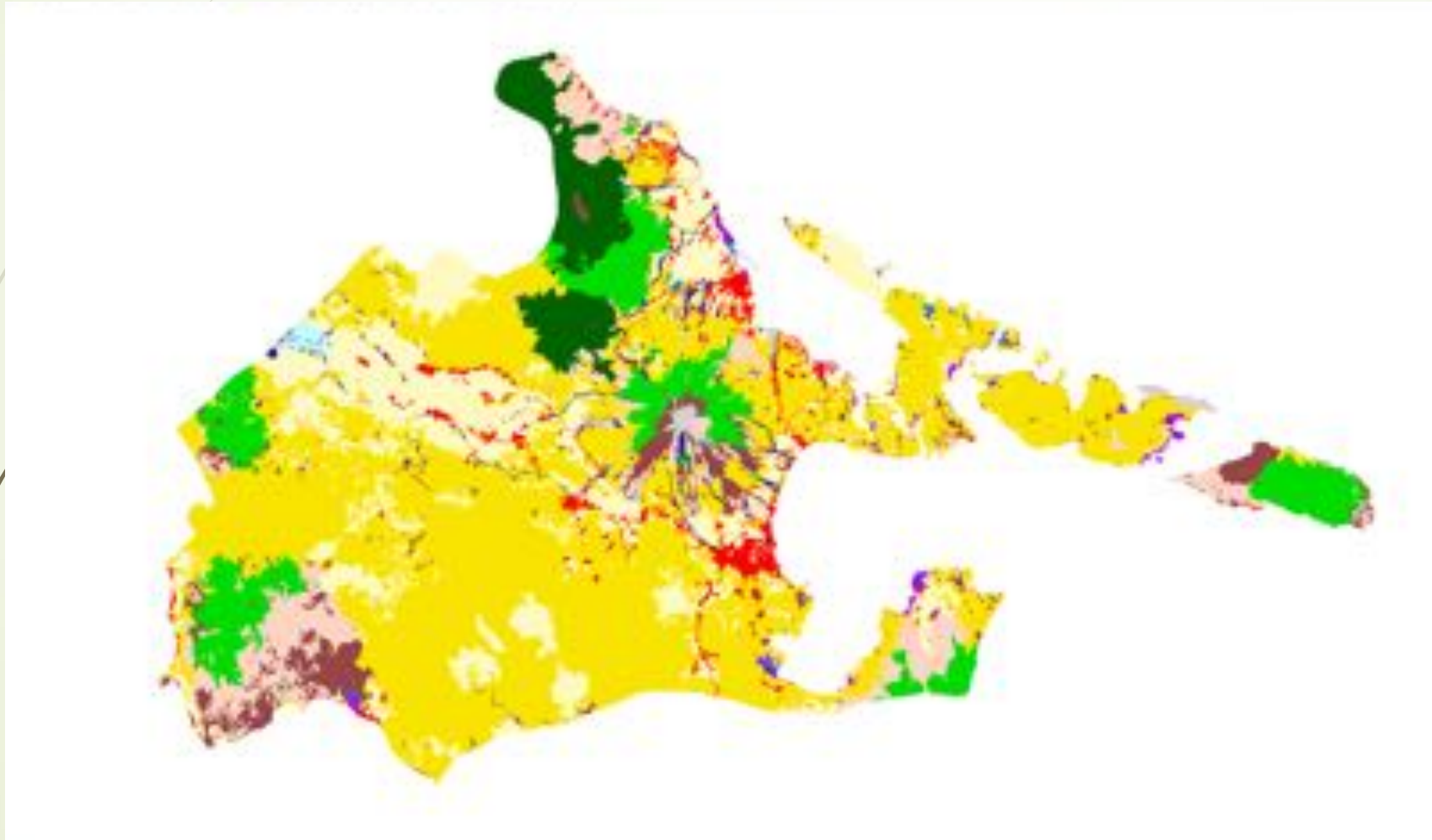
NAMRIA Topographic Map



PRELIMINARY CLASSIFICATION

# Preliminary Land Cover Map

## Province of Albay

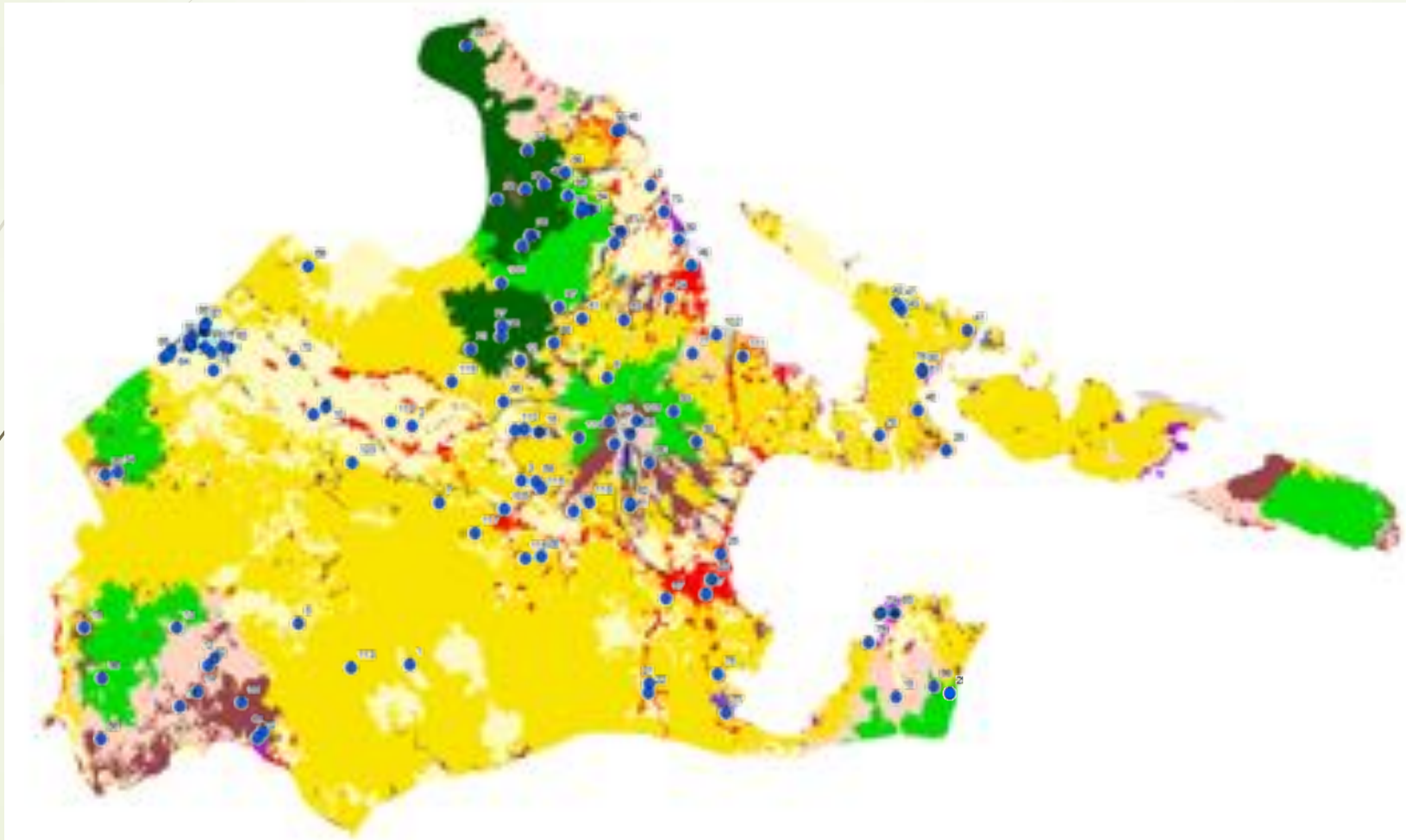


Legend:

- Closed Forest
- Open Forest
- Brush/Shrubs
- Grassland
- Perennial Crop
- Annual Crop
- Built-up
- Open/Barren
- Mangrove
- Marshland
- Fishpond
- Inland Water



# Validation of Sampling Points



Legend:

- Closed Forest
- Open Forest
- Brush/Shrubs
- Grassland
- Perennial Crop
- Annual Crop
- Built-up
- Open/Barren
- Mangrove
- Marshland
- Fishpond
- Inland Water
- Sample Point

# Sample Validation Form

LAND COVER MAPPING PROJECT									
FIELD VERIFICATION SAMPLING POINTS									
PROVINCE OF ALBAY									
POINTS	BARANGAY	MUNICIPALITY	TOPO MAP NO.	PRELIMINARY CLASSIFICATION	COORDINATES (UTM)				ACTUAL CLASSIFICATION
					PREDETERMINED		ACTUAL		
					EASTING	NORTHING	EASTING	NORTHING	
1	Batila	Suwaybatan	1778 IV	Annual Crop	558202.37	1467488.23	557762.39	146717.77	Annual Crop
2	Batila	Ligao	1778 IV	Annual Crop	558338.81	1467504.55	558732.8	1467500.27	Annual Crop
3	Malabang	Suwaybatan	1778 IV	Annual Crop	560736.85	1467375.22	560776.7	1467707.82	Annual Crop
4	Buga	Ligao	1878 I	Annual Crop	559585.25	1470885.17	55985.8	1470215.34	Annual Crop
5	Batila	Ligao	1878 I	Annual Crop	545767.82	1470811.55	545698.05	1470885.82	Annual Crop
6	Bugang	Palawan	1778 IV	Annual Crop	555176.85	1467054.88	555181.71	1467054.8	Annual Crop
7	Agila	Ligao	1778 IV	Annual Crop	540475.17	1467181.85	540775.17	1467094.24	Annual Crop
8	Umag	Malabon	1780 IV	Annual Crop	579371.89	1467115.78	579378.21	1467024.24	Annual Crop
9	Batila	Ligao	1878 I	Annual Crop	543385.25	1467778.43	543870.88	1467879.22	Annual Crop
10	Batila	On	1878 I	Annual Crop	551787.58	1466984.84	551882.88	1467000.88	Annual Crop
11	Batila	Ligao	1778 IV	Brush/Woods	560212.87	1470882.88	560882.38	1469872	Brush/Woods
12	Malabon	Ligao	1878 I	Brush/Woods	543885.88	1467972.72	543888.88	1468855.77	Brush/Woods
13	San Antonio	On	1878 I	Brush/Woods	540005.36	1467087.88	540084.36	1467085.87	Brush/Woods
14	Malabon	Ligao	1878 I	Brush/Woods	543785.15	1467428.78	543888.88	1467488.24	Brush/Woods
15	Malabon	Ligao	1878 I	Brush/Woods	540747.88	1467111.88	540811.88	1467054.71	Brush/Woods
16	Malabang	Suwaybatan	1778 IV	Brush/Woods	547007.84	1467052.88	547011.72	1467122.84	Brush/Woods
17	Batila	Malabon	1778 IV	Brush/Woods	579371.72	1467085.87	579382.88	1467285.84	Annual Crop
18	Batila	Malabon	1778 IV	Brush/Woods	540005.32	1467087.78	540088.38	1467052.88	Brush/Woods
19	Malabon	On	1878 I	Brush/Woods	551887.22	1467112.38	551882.88	1467128.38	Brush/Woods
20	Palawan	Ligao	1878 I	Brush/Woods	555176.35	1467087.88	555181.88	1467022.87	Annual Crop
21	Bugang	Palawan	1778 IV	Built-up	555176.85	1467054.88	555181.88	1467054.88	Built-up
22	Bugang	Palawan	1778 IV	Built-up	555176.28	1467054.88	555181.88	1467054.88	Built-up



# Accuracy Assessment

**LAND COVER MAPPING PROJECT  
ACCURACY ASSESSMENT  
PROVINCE OF ALBERTA  
CONFIDENTIAL**

Reference Classification	Mapping Results													Total
	Correct Class	Other Forest	Non-Forest Forest	Other	Open Forest	Non-Forest	Non-Forest Forest	Other Forest	Non-Forest Forest	Other Forest	Non-Forest Forest	Other Forest	Non-Forest Forest	
Forest	10													10
Open Forest	1	10												11
Non-Forest Forest			10											10
Other		1		10										11
Open Forest					10									10
Non-Forest Forest						10								10
Other							10							10
Open Forest								10						10
Non-Forest Forest									10					10
Other										10				10
Open Forest											10			10
Non-Forest Forest												10		10
Other													10	10
Total	10	1	10	1	10	1	10	1	10	1	10	1	10	100

CLASSIFICATION  
100%

# Presentation of Results



Validated Land Cover Maps are presented to various stakeholders for their comments.  
(local DENR, LGUs, NGOs and SUCs)



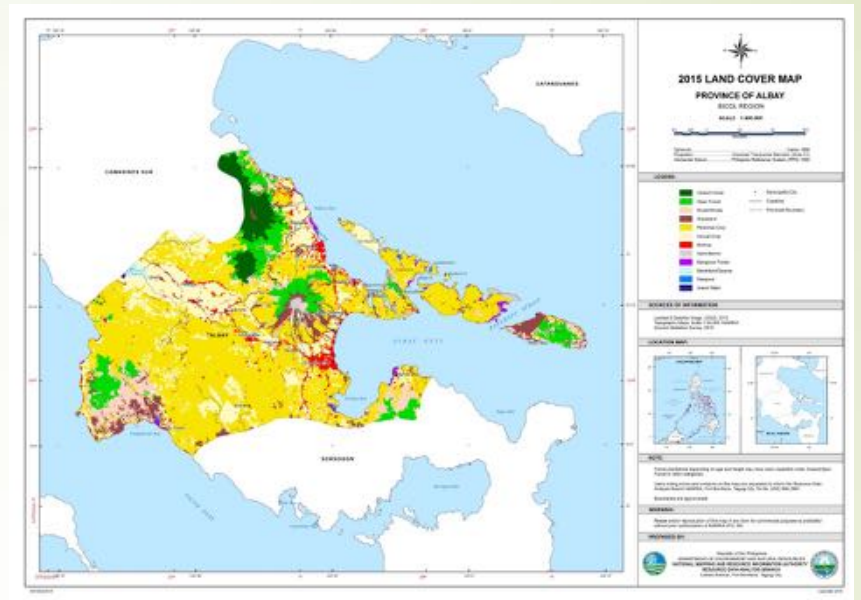
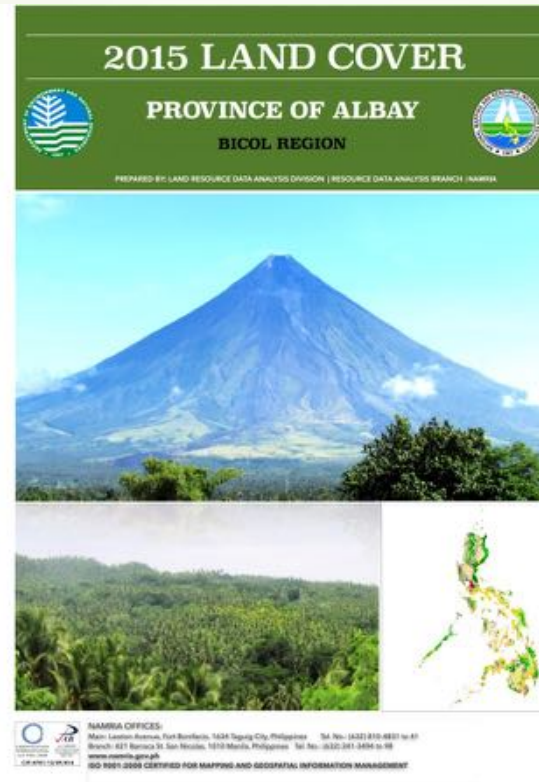
## 2015 LAND COVER STATISTICS PROVINCE OF ALBAY

LAND COVER CLASSIFICATION	AREA (Ha)	(%)
Closed Forest	9,144	3.79
Open Forest	20,326	8.43
Sub-total	<b>29,470</b>	<b>12.22</b>
Mangrove Forest	1,325	0.55
Brush/Shrubs	15,962	6.62
Grassland	12,239	5.08
Annual Crop	48,618	20.16
Perennial Crop	118,646	49.20
Open/Barren	2,530	1.05
Built-up	9,158	3.80
Marshland/Swamp	690	0.29
Fishpond	346	0.14
Inland Water	2,160	0.90
<b>TOTAL</b>	<b>241,145</b>	<b>100.00</b>



# Project Output

- Provincial Report
- 2015 Land Cover Shapefile, Map and Statistics



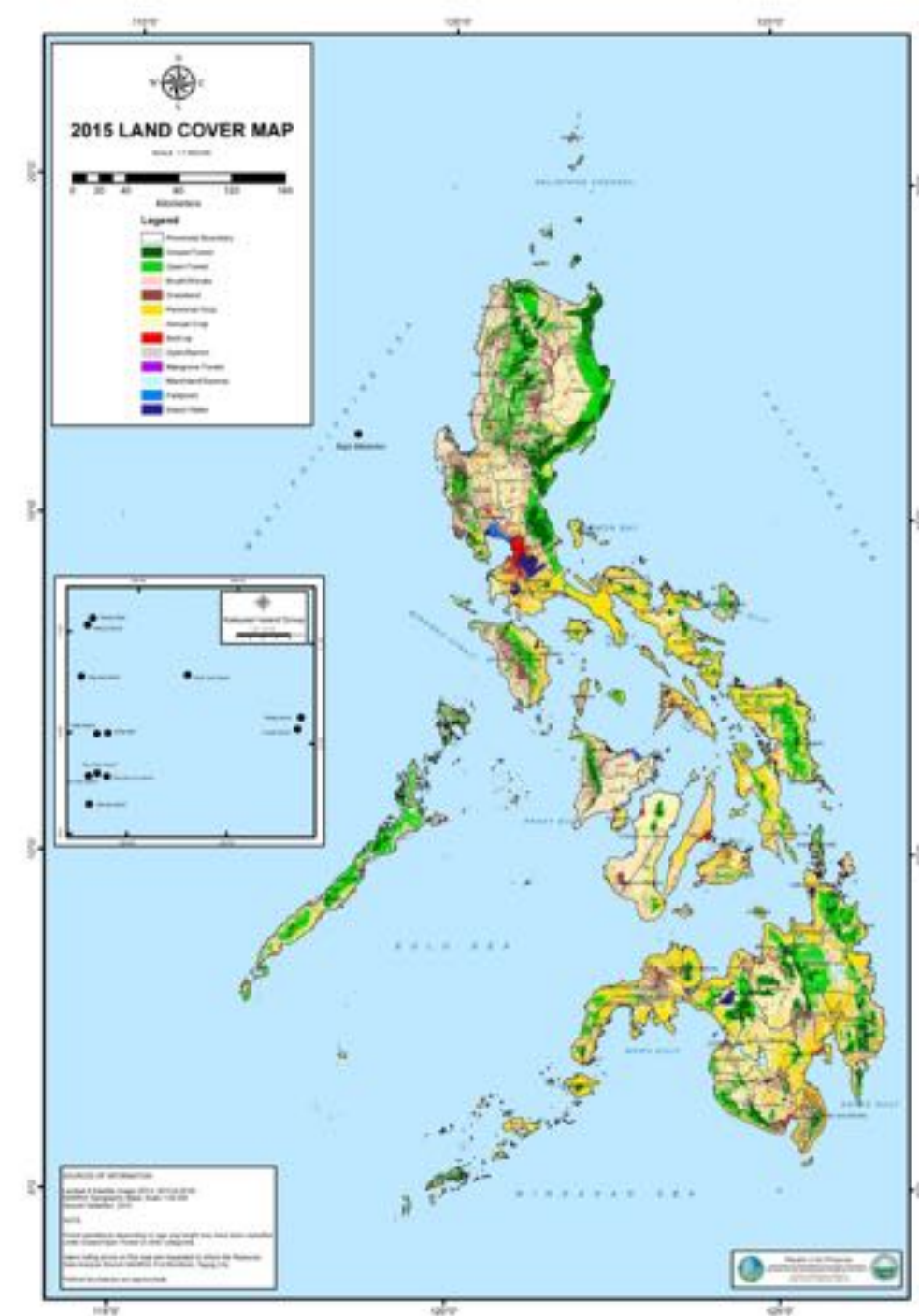
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Inland Water	2,160	0.90
<b>TOTAL</b>	<b>241,145</b>	<b>100.00</b>





# 2015 Land Cover Data

Land Cover Classification	Area (Ha.)	%
Closed Forest	2,028,015	6.86
Open Forest	4,682,764	15.84
<b>Sub-total</b>	<b>6,710,779</b>	<b>22.70</b>
Mangrove Forest	303,373	1.03
Brush/Shrubs	6,034,586	20.41
Grassland	1,961,817	6.64
Annual Crop	6,117,428	20.69
Perennial Crop	6,574,386	22.24
Open/Barren	121,730	0.41
Built-up	852,148	2.88
Marshland/Swamp	140,135	0.47
Fishpond	235,824	0.80
Inland Water	511,136	1.73
<b>TOTAL</b>	<b>29,563,341</b>	<b>100.00</b>



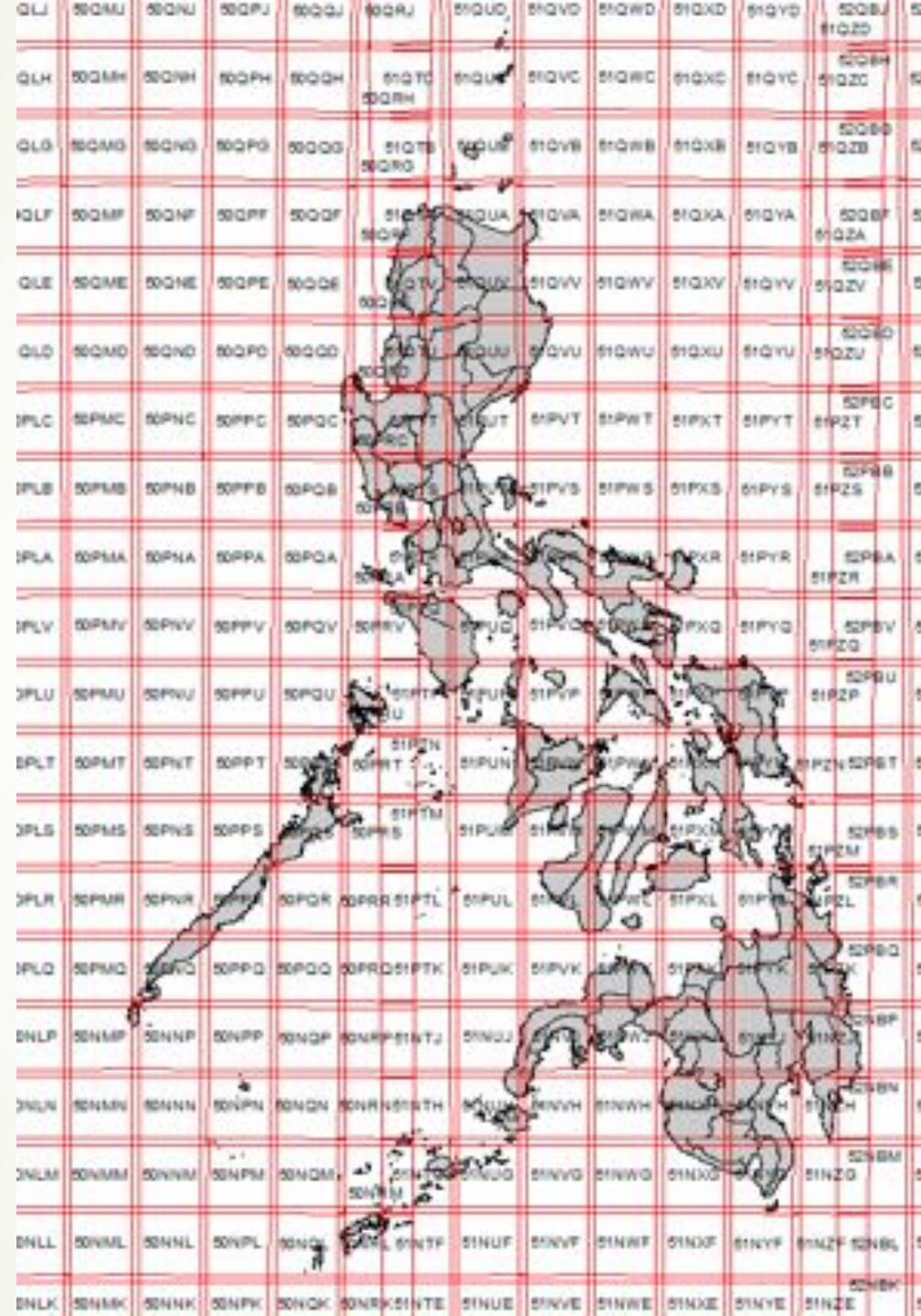
# Current Initiative

## Land Cover Mapping Project (2017-2020)

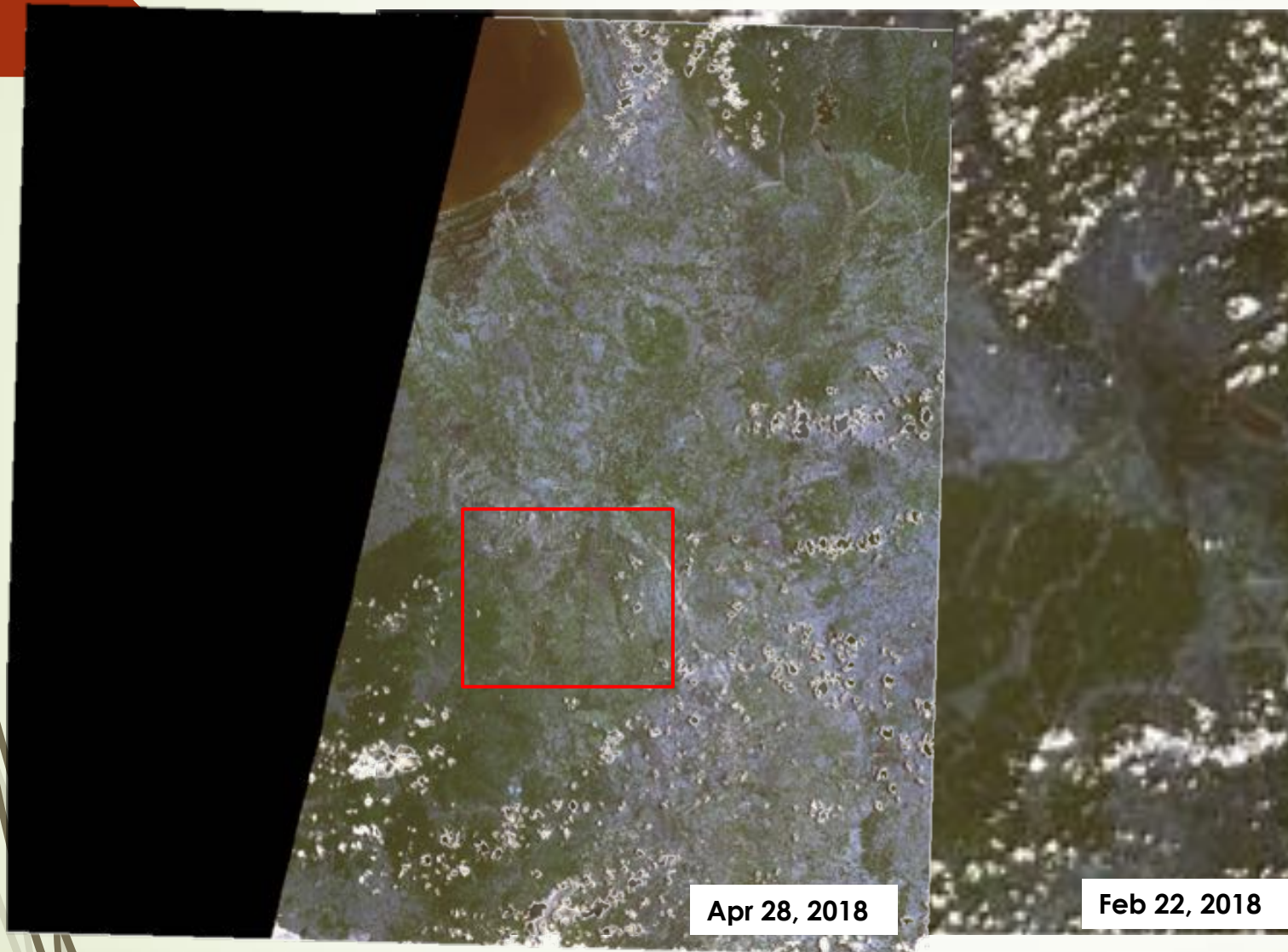
- **Data source: Sentinel-2, 10m res., CY 2017 onwards**
- **12 aggregated categories**
- **digital image classification (OBIA)**
  - **Additional validation points using VHR  
(50-75 sample points per land cover class/cluster)**
- **with ground validation and accuracy assessment**

# INDEX OF SENTINEL 2

126 scenes







## Cloud Cover Requirements

- not more than 10%
- if there is no available image with  $\leq 10\%$  cloud cover, a higher percentage of up to  $\leq 20\%$  will be accepted/ downloaded, provided that there is a series of images wherein clouds are in different positions. Note: patch images should be within the year.



Feb 22, 2018 with patched Apr 28, 2018



# Status

**38 provinces with preliminary mapping  
and field validation completed**

## 2017 Accomplishment

- Ilocos Norte
- Ilocos Sur
- Pangasinan
- La Union
- Benguet
- Mt. Province
- Ifugao
- Apayao
- Kalinga
- Batanes
- Cagayan
- Isabela
- Quirino
- Nueva Vizcaya
- Cavite
- Laguna
- Batangas
- Quezon
- Rizal
- Aurora



# Status

## 2018 Accomplishment

- Bataan
- Nueva Ecija
- Tarlac
- Zambales
- Bulacan
- Pampanga
- Marinduque
- Mindoro Occidental
- Romblon
- Mindoro Oriental
- Albay
- Sorsogon
- Catanduanes
- Camarines Norte
- Camarines Sur
- Masbate
- Bohol
- Siquijor

# Issues and Concerns

- High acquisition cost of high resolution satellite imageries, hardware and RS/GIS processing software
- Persistent cloud cover in some areas
- Integration of different data sources with various resolutions, date of observation, optical and radar, to fill gaps
- Effect of different data sources/resolutions and methodologies on the over-all map accuracy and land cover change analysis
- Absence of official data on administrative boundaries, total areas



# Issues and Concerns

- **Limitations of available data to meet mapping requirements**
- **Peace and order, security and accessibility concerns**
- **Transfer of trained staff to other agencies**
- **Sustainability of data sources and funding support over time**

# Way Forward

- Acquisition of higher resolution imageries such as Planet (3m res) at regular/semestral intervals
- Enhance land cover mapping procedures including accuracy assessment and land cover change analysis based on previous cycle learnings
- Regular updating of <sup>National</sup> land cover data on a 4-5 years cycle or less (ie. every 2 years cycle) with bigger funding support
- Capacity building for technical staff on digital classification, accuracy assessment and land cover change analysis
- Use of drones for field validation



# Conclusion

- Science and technology continue to innovate the way we collect, process and analyze data within the forestry sector.
- This is in the form of availability of higher resolution satellite imageries with shorter revisit time, employment of OBIA and artificial intelligence in digital image classification, and the increasing use of drones in mapping applications.
- These advancements enable us to monitor and detect significant changes in the environment and resources over time on a regular or on-demand basis.
- Updated forest information is vital in developing plans and formulating policies to ensure protection and sustainability of resources at the national and local levels.



# Thank You



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