

Data Science in Forestry:

THE FORESTRY SITUATIONER



Usec. Peter N. Tiangco, PhD
Administrator, NAMRIA

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□ **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):

1st 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



2003 LANDCOVER	AREA (Hect.)
Closed forest, broadleaved	2,400,900
Closed forest, mixed	70,180
Closed forest, coniferous	87,701
Open forest, broadleaved	3,849,841
Open forest, mixed	11,790
Open forest, coniferous	113,889
Mangrove forest	249,156
Forest plantation, broadleaved	370,000
Forest plantation, coniferous	3,473
Other wooded land, shrubs	3,002,269
Other wooded land, fallow	80,214
Other wooded land, wooded grassland	3,870,806
Other land, natural, barren land	147,190
Other land, natural, grassland	1,841,081
Other land, natural, marshland	180,087
Other land, cultivated, annual crop	6,671,116
Other land, cultivated, perennial crop	4,867,150
Other land, cultivated, pasture	1,900
Other land, fishpond	279,496
Other land, built-up area	267,996
Inland water	290,749
TOTAL AREA	29,622,886

Note:
 1. The Philippines joined a total forest area National Inventory (FAN) 2003 and national mapping from the AAS/DTI/Department of Environment and Natural Resources, Manila, Philippines under a 2003-2005
 2. Projection: Universal Transverse Mercator (UTM) Zone 51E
 General: UTM 51E
 Horizontal Datum: UTM 51E
 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	2,404,900
Closed forest, mixed	70,130
Closed forest, coniferous	87,301
Open forest, broadleaved	3,849,340
Open forest, mixed	11,190
Open forest, coniferous	113,869
Mangrove forest	249,156
Forest plantation, broadleaved	375,000
Forest plantation, coniferous	3,478
Other wooded land, shrubs	3,052,269
Other wooded land, trees	80,754
Other wooded land, wooded grassland	2,870,808
Other land, natural, barren land	547,190
Other land, natural, grassland	1,841,000
Other land, natural, meadow	181,087
Other land, cultivated, annual crop	6,671,116
Other land, cultivated, perennial crop	4,307,150
Other land, cultivated, pasture	1,900
Other land, irrigated	279,496
Other land, built-up area	291,996
Water body	294,749

TOTAL AREA **29,432,894**

Note:

1. The Philippines uses a two-level system for forest land cover. The 2000 land cover statistics were derived from the LANDSAT 2000 Survey of Forest Land Cover (SFLC) conducted in 2000.

2. The term "Other land, cultivated, annual crop" includes:

- Annual Crop (AC)
- Annual Crop (AC) (AC)
- Annual Crop (AC) (AC)

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		Annual Crop
	Open Forest		Built-up
	Shrubs		Open/Barren
	Wooded Grassland		Mangrove Forest
	Grassland		Marshland/Swamp
	Fallow		Fishpond
	Perennial Crop		Inland Water

2010 LAND COVER STATISTICS* PHILIPPINES

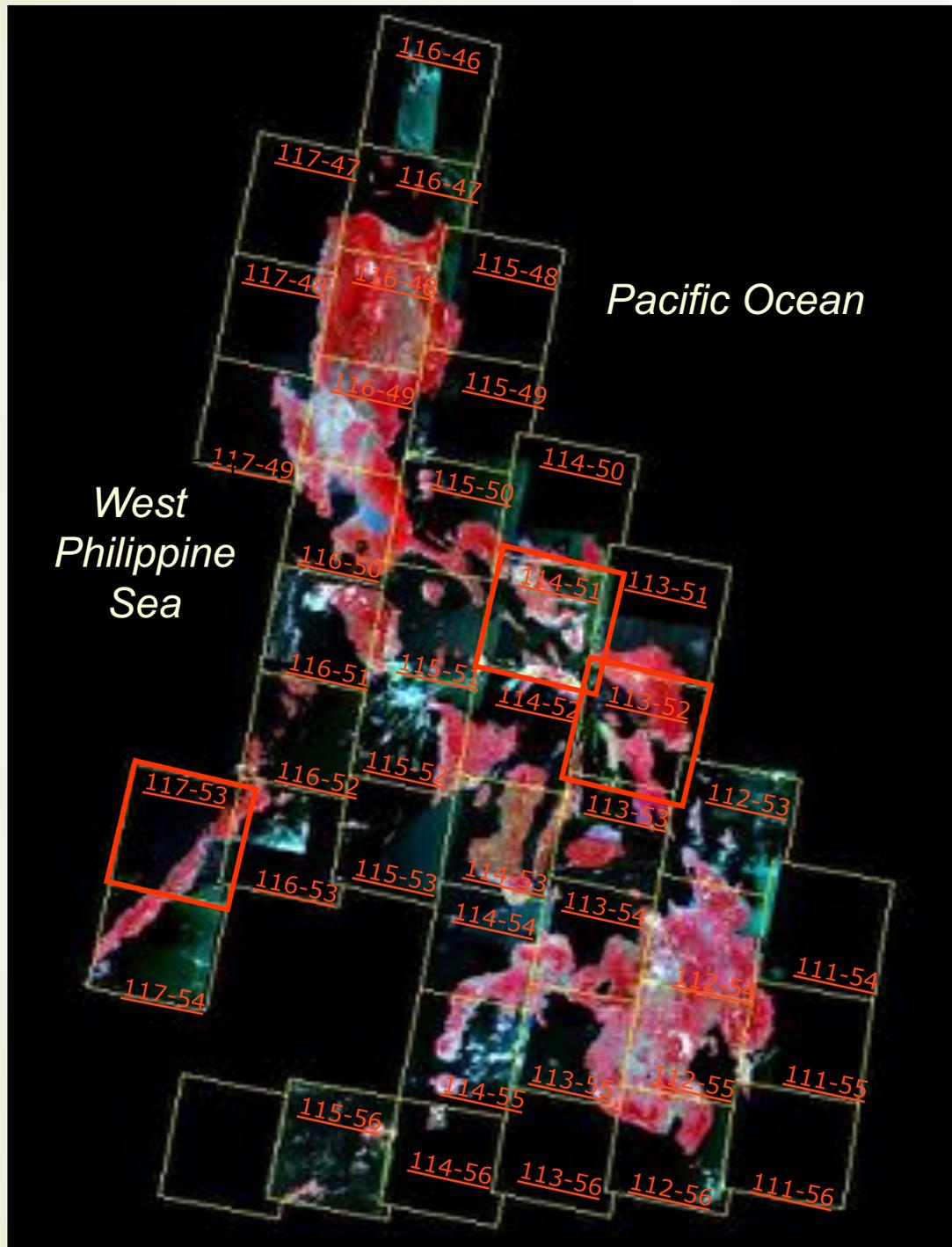
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Past Initiatives

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

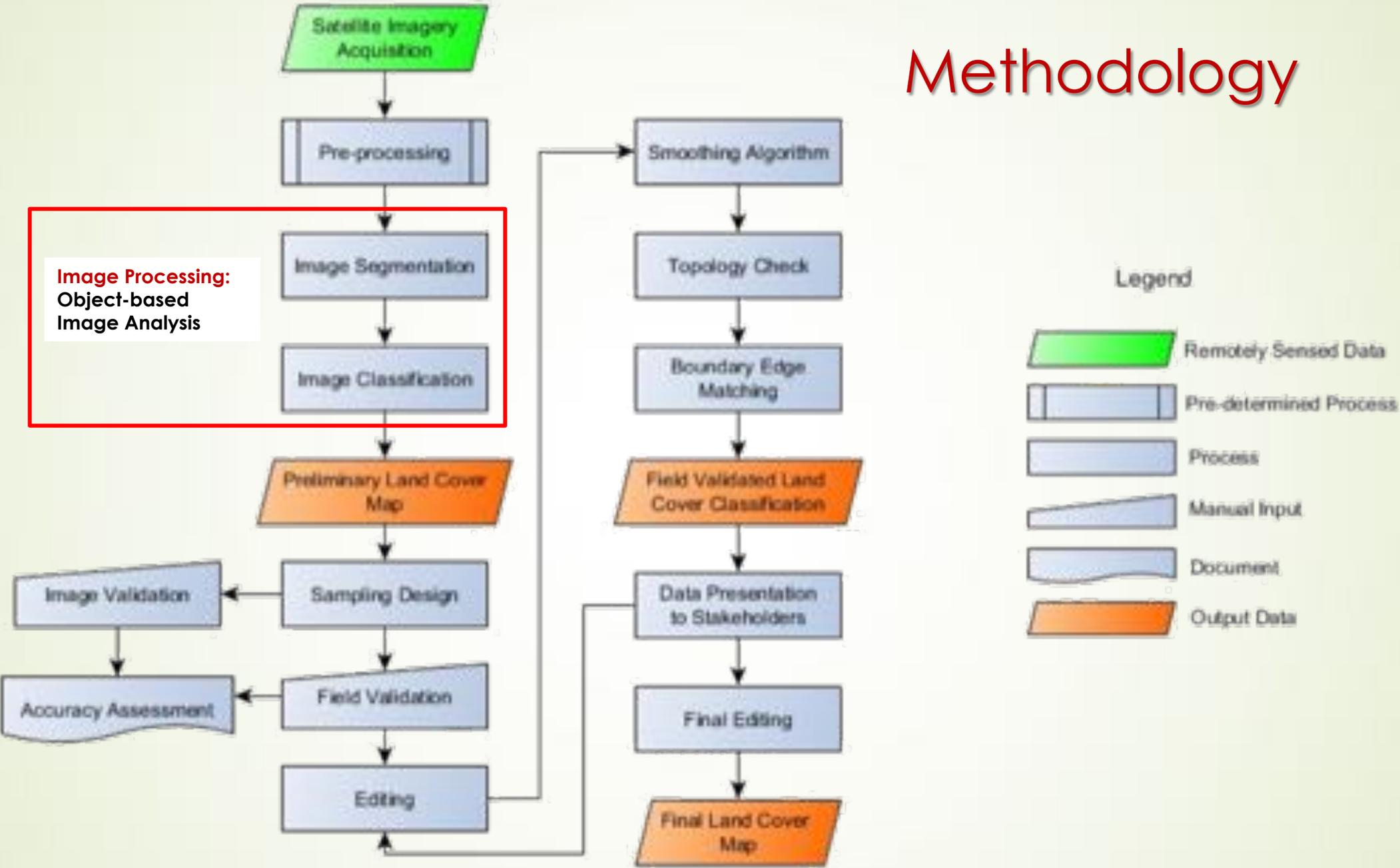
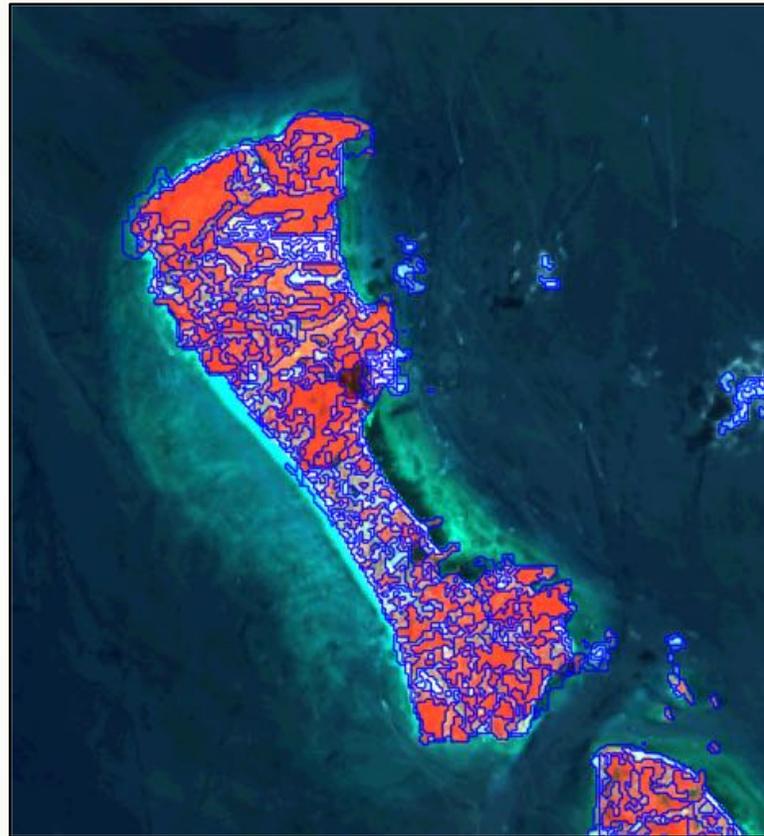


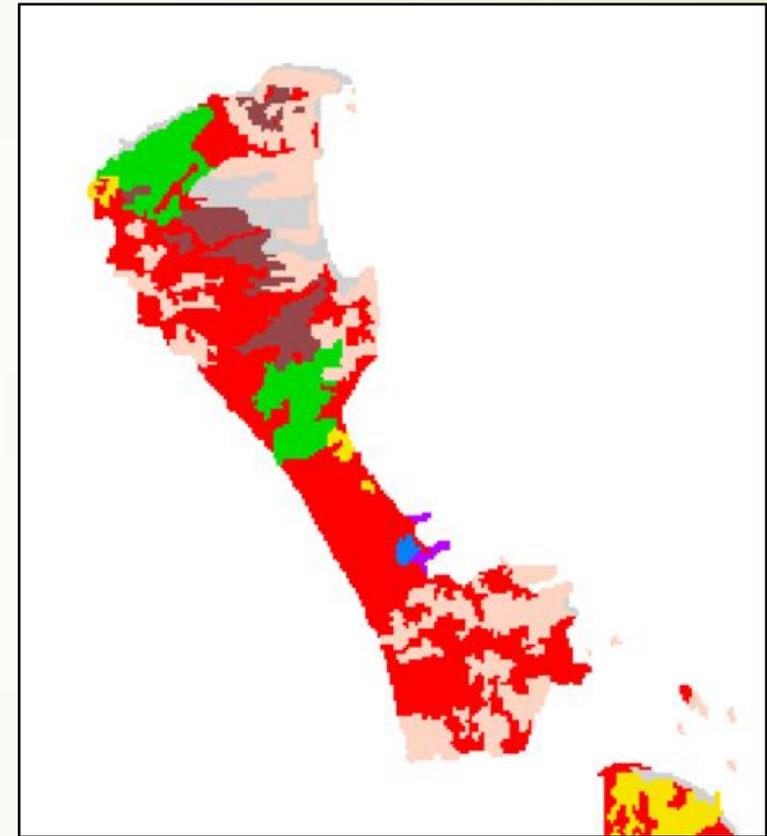
Image Processing



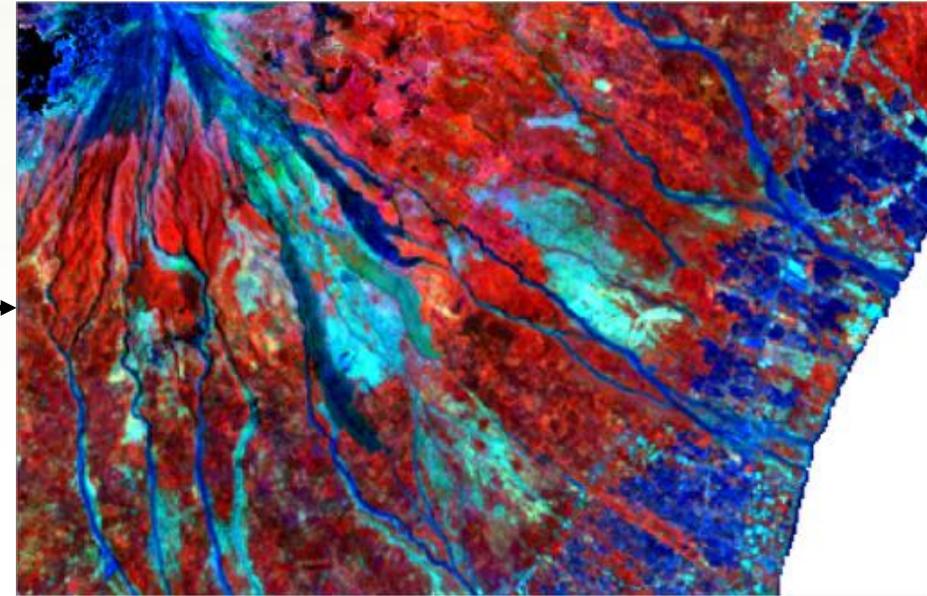
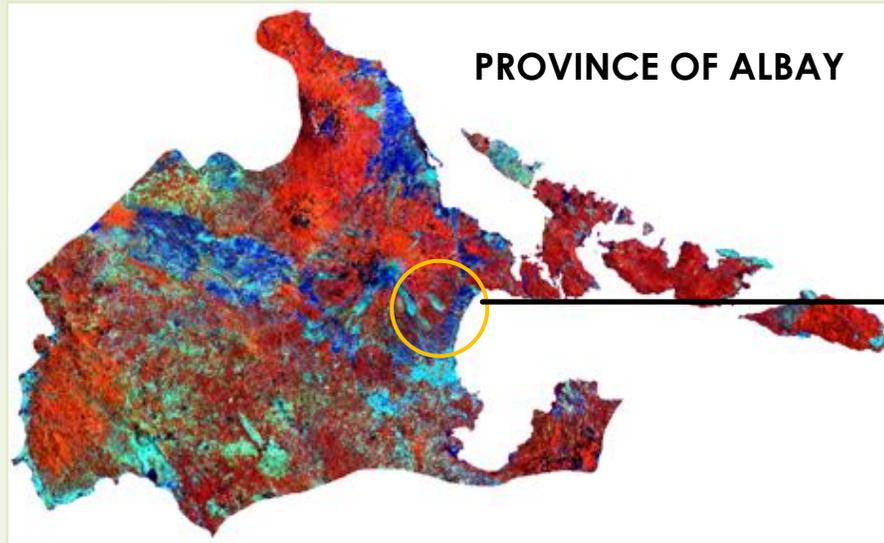
**LandSat 8
Image**



**Image
Segmentation**



**Preliminary Image
Classification**

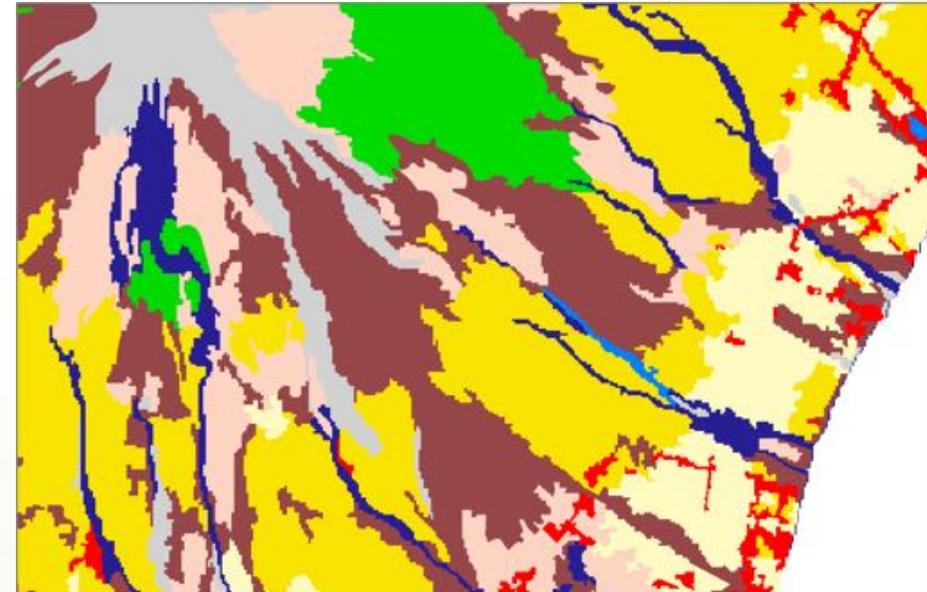


Landsat 8 Path 114 Row 051 Mosaic

Dates taken:
 April 1, 2015
 April 17, 2015
 May 19, 2015

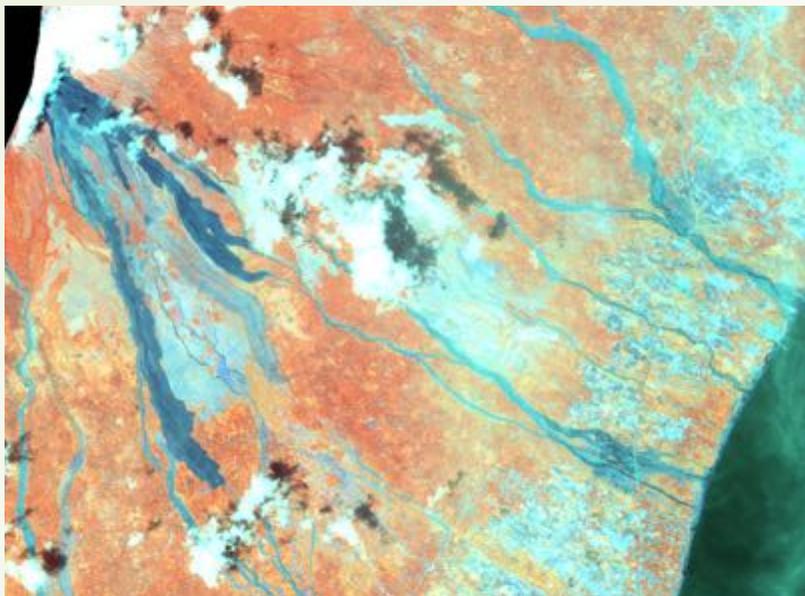
Legend:

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



RESULT OF DIGITAL CLASSIFICATION

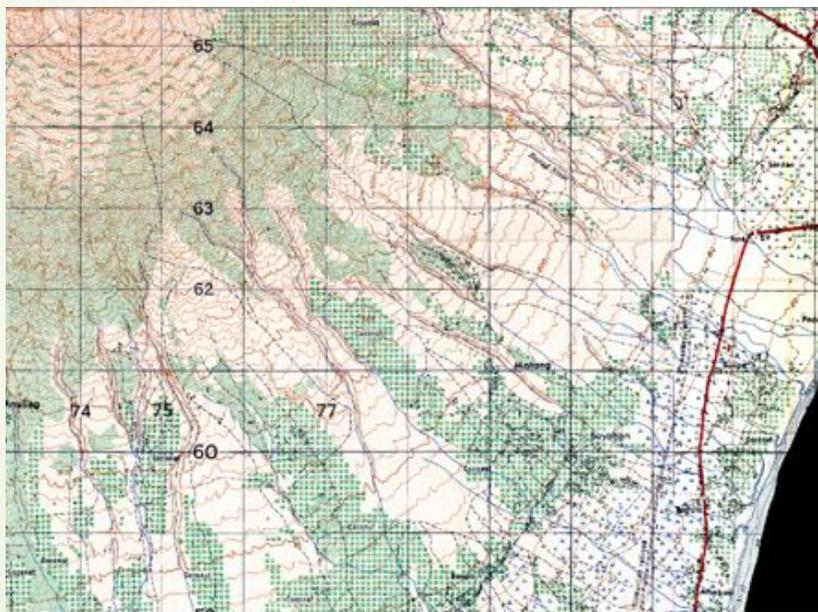
Other References:



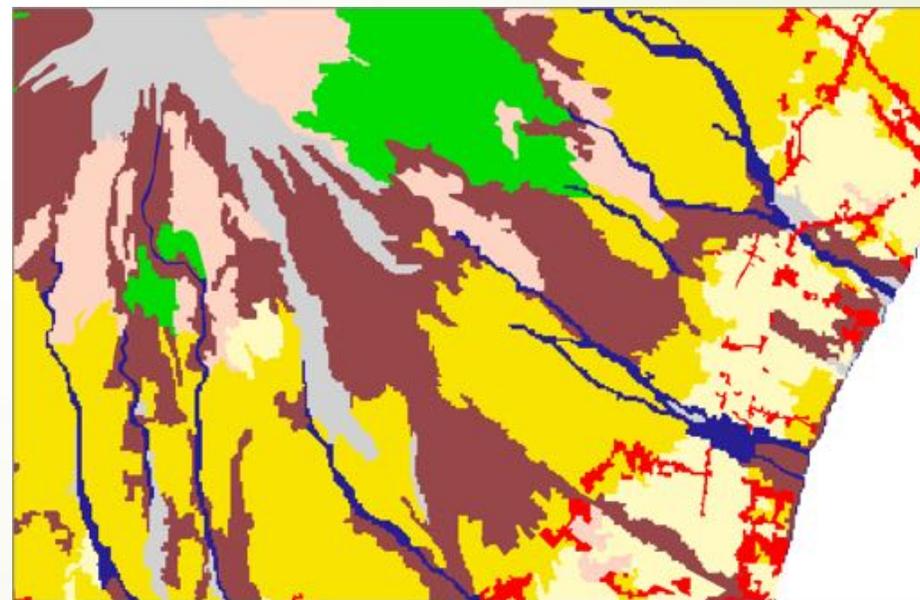
WorldView 2



Google Earth Image

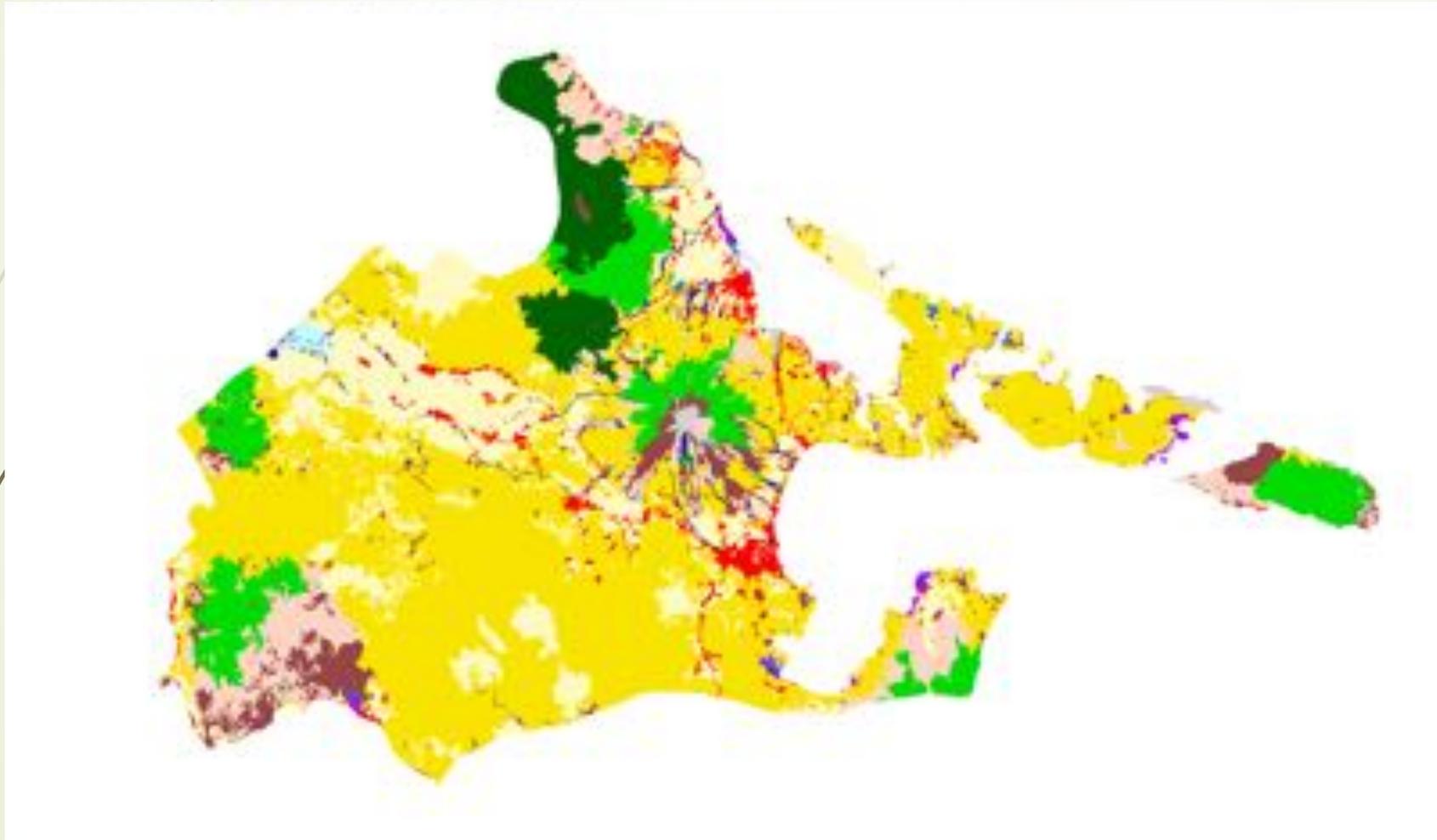


NAMRIA Topographic Map



PRELIMINARY CLASSIFICATION

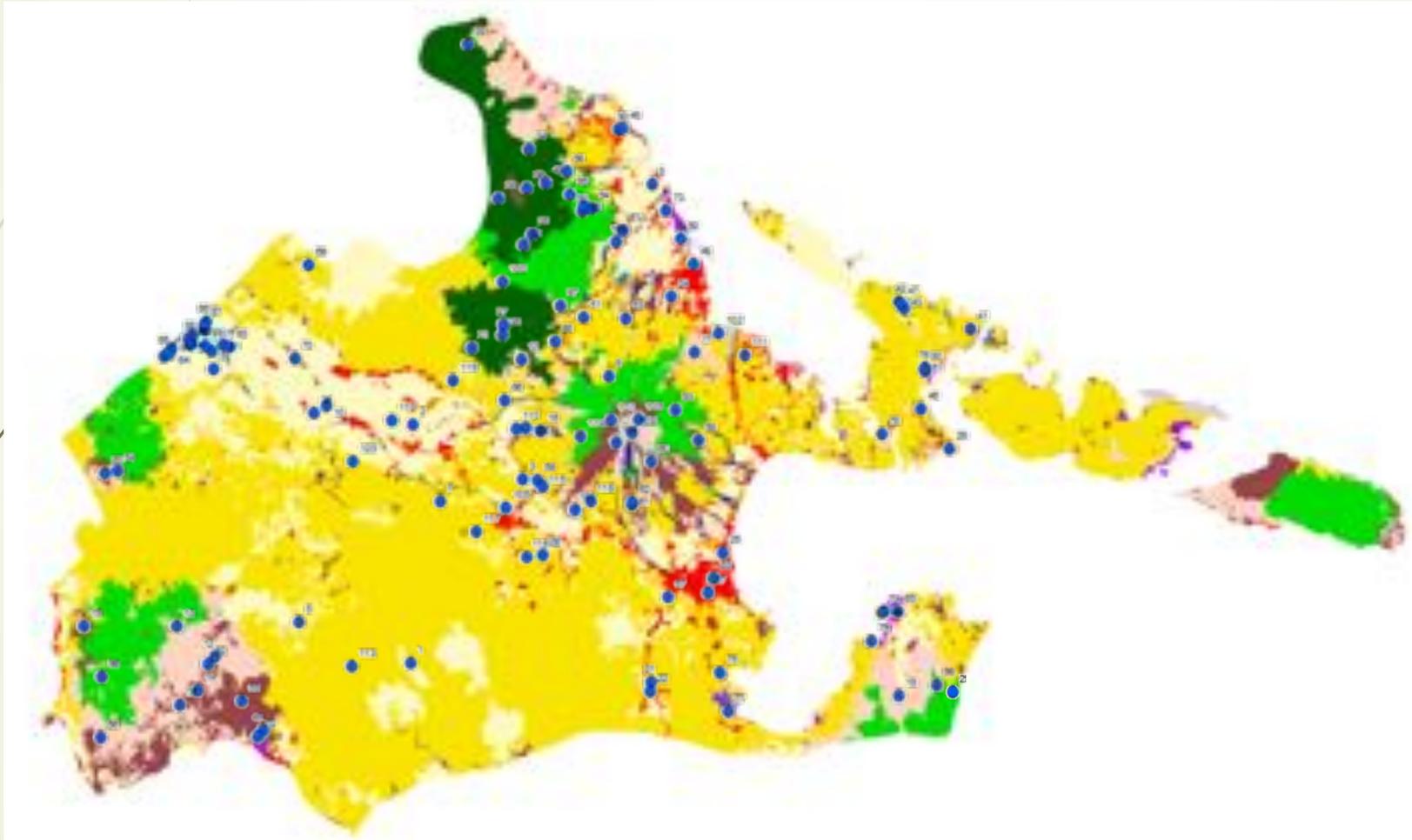
Preliminary Land Cover Map Province of Albay



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	Katib	Sumbatitan	1719 IV	Annual Crop	188200.27	1467488.23	187762.39	1467177	Annual Crop
2	Katib	Ligay	1719 IV	Annual Crop	188339.81	1467504.99	188792.8	1467500.27	Annual Crop
3	Makawing	Sumbatitan	1719 IV	Annual Crop	188376.81	1467375.31	188776.7	1467397.82	Annual Crop
4	Boyo	Libon	1818 I	Annual Crop	143580.25	1473885.17	143885.8	1473715.34	Annual Crop
5	Libon	Ligay	1818 I	Annual Crop	144767.82	1473811.98	144898.09	1473885.81	Annual Crop
6	Boyo	Pulape	1719 IV	Annual Crop	171176.85	1469094.88	171181.71	1469094.8	Annual Crop
7	Boyo	Ligay	1719 IV	Annual Crop	180475.17	1467141.81	180375.17	1467094.34	Annual Crop
8	Boyo	Malinao	1719 IV	Annual Crop	179171.89	1467115.78	179078.21	1467035.34	Annual Crop
9	Boyo	Libon	1818 I	Annual Crop	143385.25	1473778.81	143870.88	1473879.21	Annual Crop
10	San Isid	Can	1818 I	Annual Crop	151787.18	1468984.88	151882.88	1469000.88	Annual Crop
11	Boyo	Ligay	1719 IV	Brush/Woods	188012.87	1467481.88	187882.38	1467473	Brush/Woods
12	Malinao	Ligay	1818 I	Brush/Woods	143882.88	1473771.71	143888.81	1473885.77	Brush/Woods
13	San Isidoro	Can	1818 I	Brush/Woods	148985.18	1469081.88	148984.38	1469081.87	Brush/Woods
14	Malinao	Ligay	1818 I	Brush/Woods	143785.18	1473828.78	143888.88	1473885.28	Brush/Woods
15	Malinao	Ligay	1818 I	Brush/Woods	143781.88	1473811.88	143881.88	1473874.71	Brush/Woods
16	Makawing	Sumbatitan	1719 IV	Brush/Woods	187307.88	1467012.89	187391.71	1467100.38	Brush/Woods
17	San Isidoro	Malinao	1719 IV	Brush/Woods	179125.71	1467085.87	179082.88	1467185.38	Brush/Woods
18	San Isidoro	Malinao	1719 IV	Brush/Woods	184882.10	1467041.78	184888.28	1467050.88	Brush/Woods
19	Malinao	Can	1818 I	Brush/Woods	143887.18	1473811.38	143881.88	1473878.28	Brush/Woods
20	Malinao	Libon	1818 I	Brush/Woods	143178.18	1473887.88	143188.88	1473821.81	Annual Crop
21	San Isidoro	Can	1719 IV	Build-up	178228.88	1469088.88	178238.88	1469081.88	Build-up
22	San Isidoro	Can	1719 IV	Build-up	178210.28	1469088.88	178238.88	1469087.28	Build-up



Accuracy Assessment

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

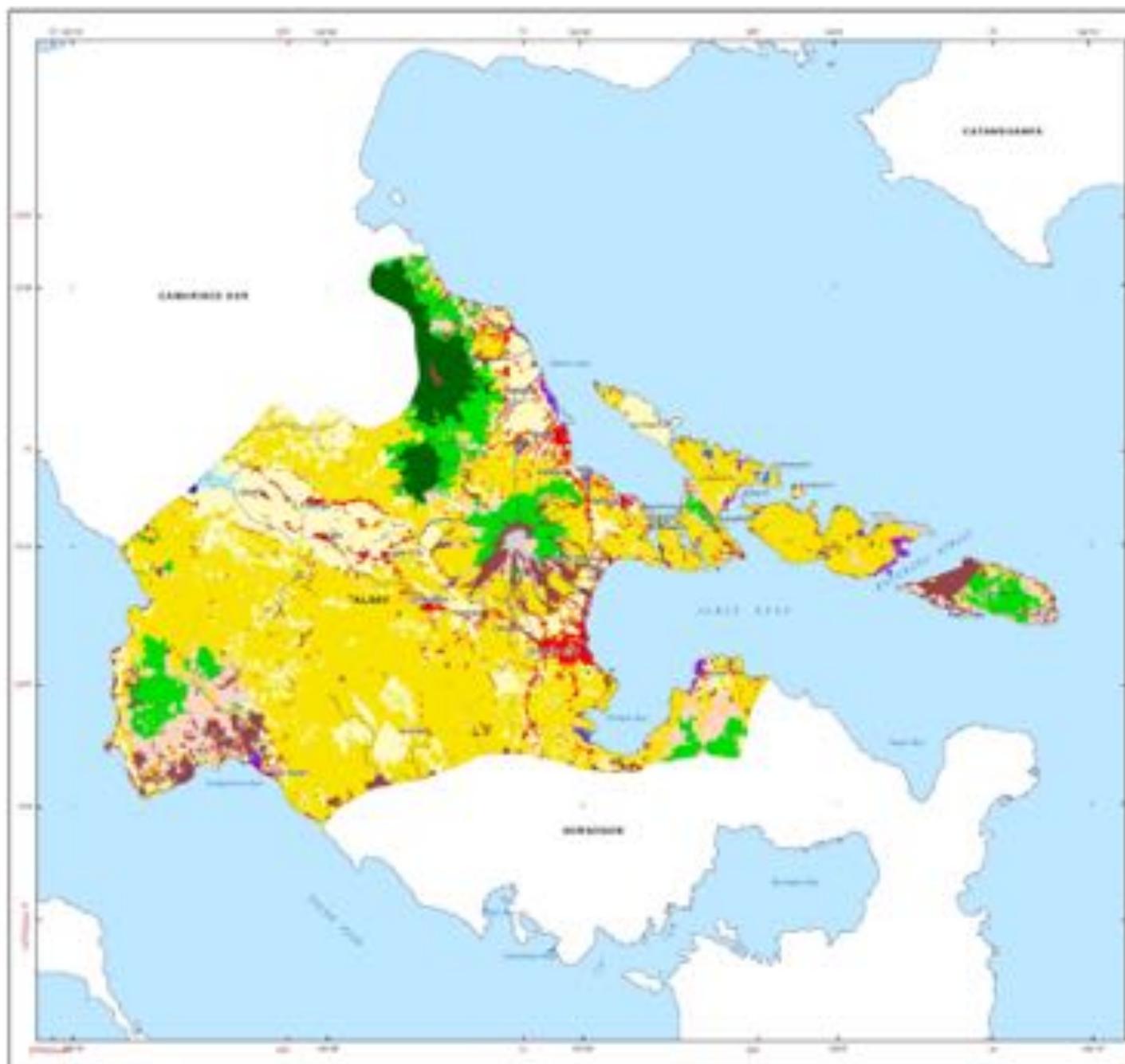
Reference Classification	Mapping Results												Total
	Correct Class	Water	Wetland	Forest	Open	Urban	Barren	Barren/Agg	Agg	Forest	Water	Wetland	
Water	100	0	0	0	0	0	0	0	0	0	0	0	100
Wetland	0	100	0	0	0	0	0	0	0	0	0	0	100
Forest	0	0	100	0	0	0	0	0	0	0	0	0	100
Open	0	0	0	100	0	0	0	0	0	0	0	0	100
Urban	0	0	0	0	100	0	0	0	0	0	0	0	100
Barren	0	0	0	0	0	100	0	0	0	0	0	0	100
Barren/Agg	0	0	0	0	0	0	100	0	0	0	0	0	100
Agg	0	0	0	0	0	0	0	100	0	0	0	0	100
Forest	0	0	0	0	0	0	0	0	100	0	0	0	100
Water	0	0	0	0	0	0	0	0	0	100	0	0	100
Wetland	0	0	0	0	0	0	0	0	0	0	100	0	100
Barren	0	0	0	0	0	0	0	0	0	0	0	100	100
Barren/Agg	0	0	0	0	0	0	0	0	0	0	0	0	100
Agg	0	0	0	0	0	0	0	0	0	0	0	0	100
Total	100	100	100	100	100	100	100	100	100	100	100	100	1000

Classification Count

Presentation of Results



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




2015 LAND COVER MAP
PROVINCE OF ALBAY
 BICOL REGION
 SCALE 1:60,000


 0 1 2 3 4 5 6 7 8 9 10 Kilometers

Source: Data: 2015
 Project: Project: National Land Use Classification System
 Date: Project: National Land Use Classification System

LEGEND

■ Forestland	— Municipality
■ Non-Forestland	— Province
■ Waterbody	— Provincial Boundary
■ Water	
■ Agricultural	
■ Residential	
■ Industrial	
■ Unclassified	
■ Waterbody	
■ Water	
■ Land Use	

SOURCE OF INFORMATION

Department of Environment and Natural Resources
 National Land Use Classification System
 National Land Use Classification System



NOTE

*This land cover map is for informational purposes only and does not constitute a legal document.
 Land cover data and maps are subject to change without notice.
 Department of Environment and Natural Resources

DISCLAIMER

The data and information contained herein are for informational purposes only and do not constitute a legal document.

PREPARED BY


 Republic of the Philippines
 Department of Environment and Natural Resources
 National Land Use Classification System
 National Land Use Classification System
 National Land Use Classification System



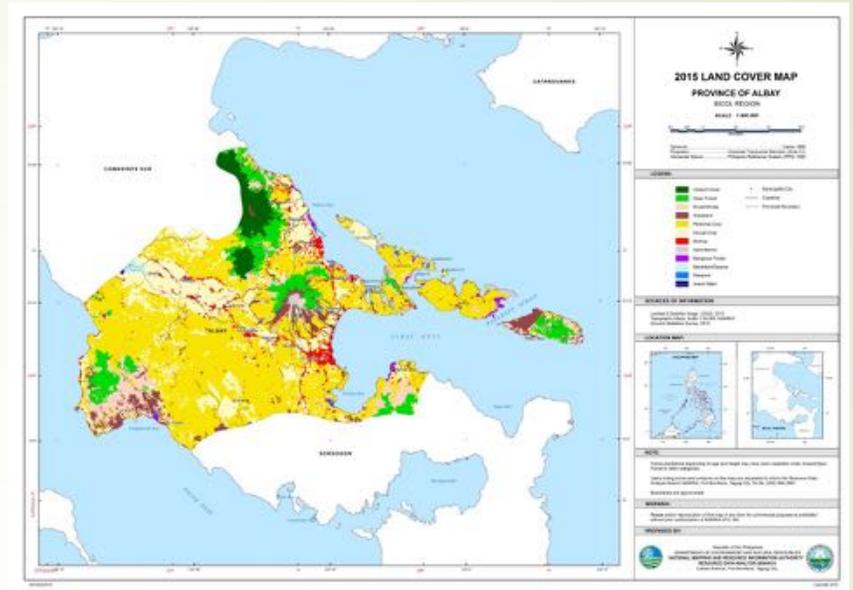
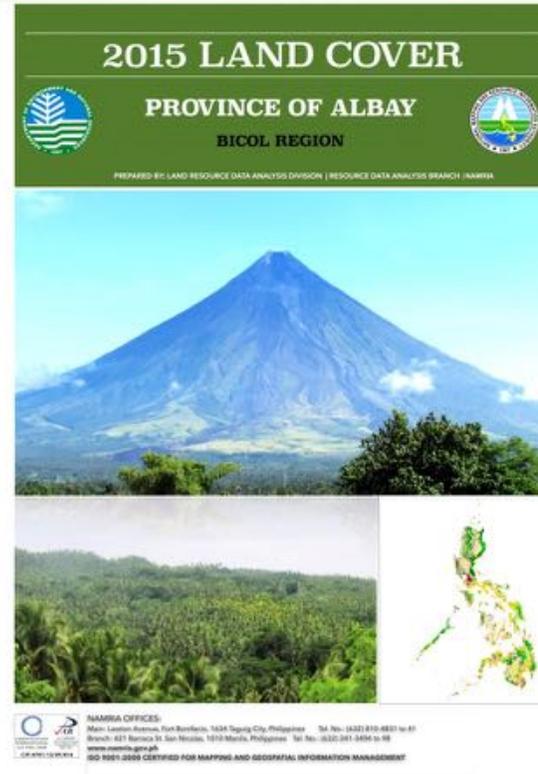
2015 LAND COVER STATISTICS PROVINCE OF ALBAY

LAND COVER CLASSIFICATION	AREA (Ha)	(%)
Closed Forest	9,144	3.79
Open Forest	20,326	8.43
Sub-total	29,470	12.22
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
TOTAL	241,145	100.00



Project Output

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



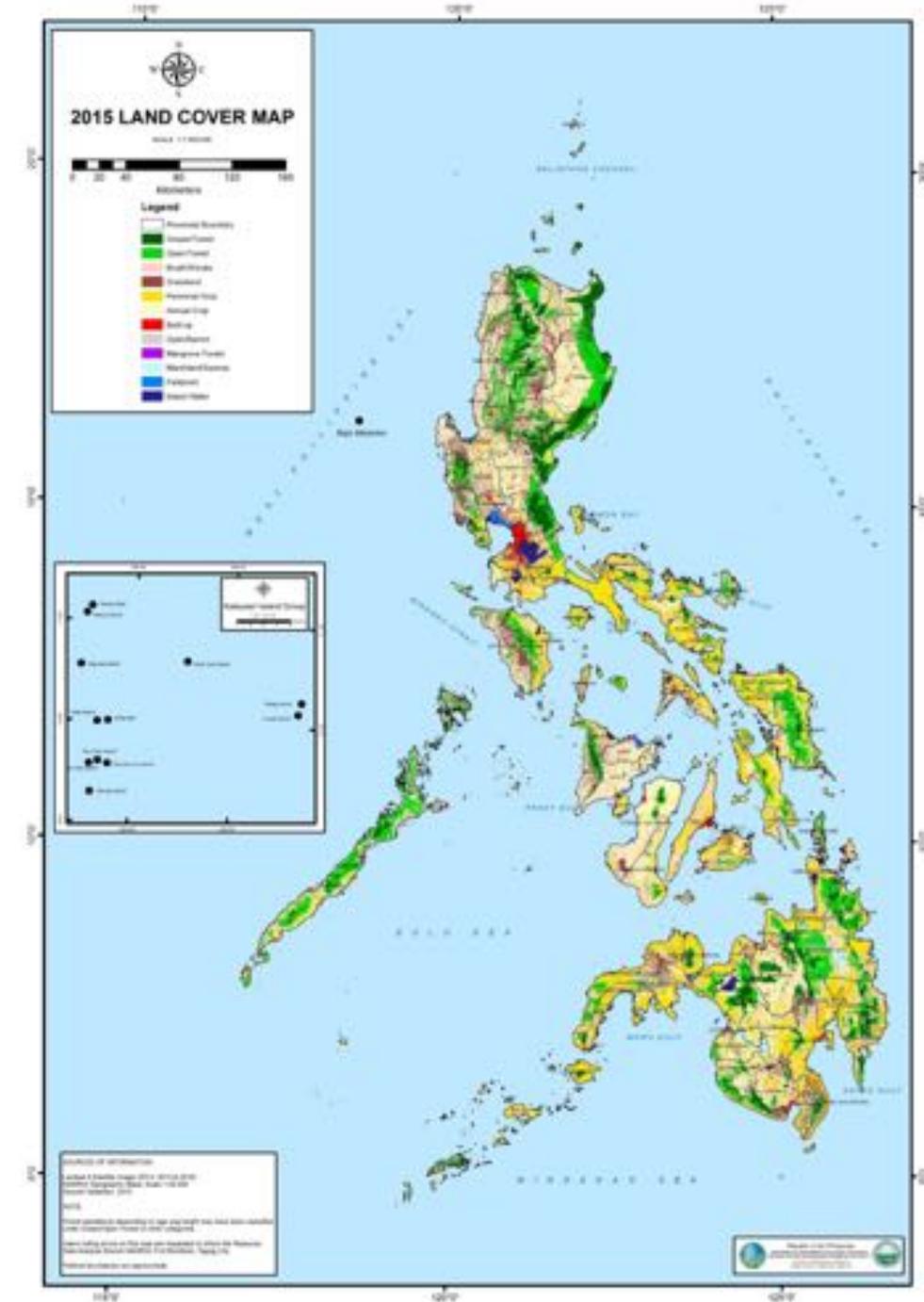
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2015 Land Cover Data

Land Cover Classification	Area (Ha.)	%
Closed Forest	2,028,015	6.86
Open Forest	4,682,764	15.84
Sub-total	6,710,779	22.70
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
TOTAL	29,563,341	100.00



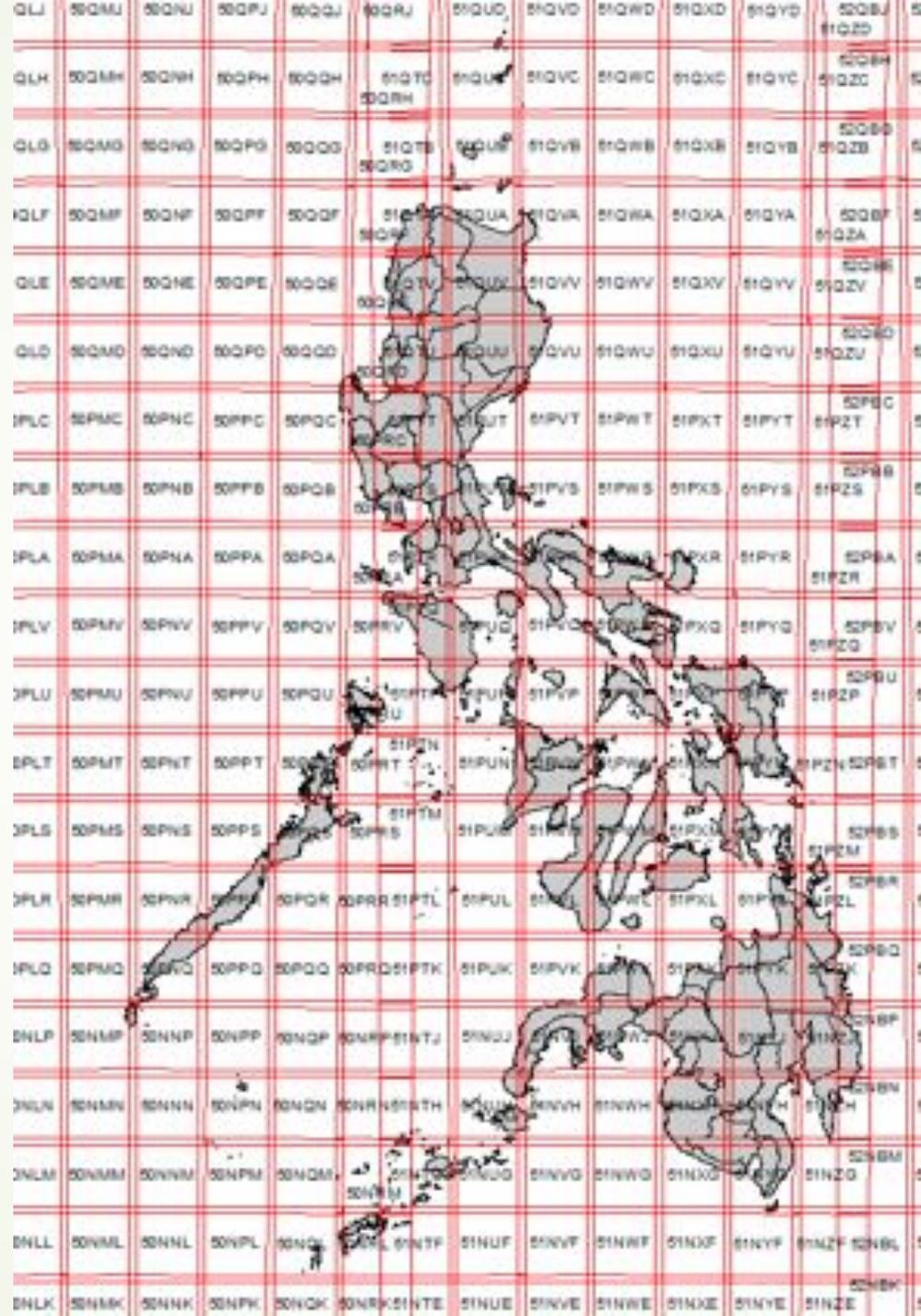
Current Initiative

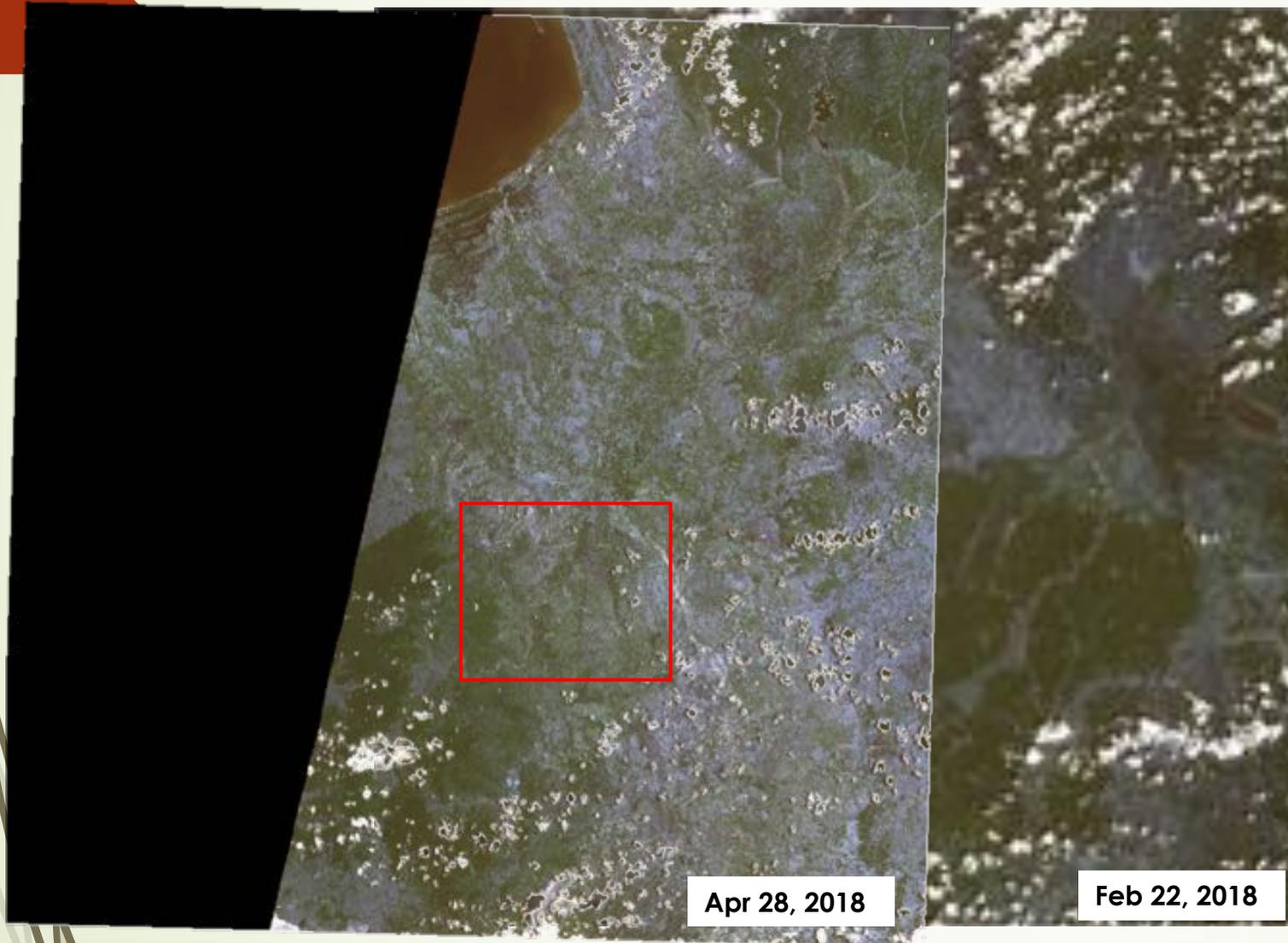
Land Cover Mapping Project (2017-2020)

- **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 ^{National} 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



Department of Environment and Natural Resources
National Mapping and Resource Information Authority
Lawton avenue, Fort Bonifacio, Taguig City, Philippines
Website: <http://www.namria.gov.ph>

