Integration of 3S Technologies for Mangrove Destruction and Reforestation Monitoring - After the 2004 Indian Ocean Tsunami in Phang Nga, Thailand

[1]Daroonwan KAMTHONKIAT , [2]Wutthichai BOONPOOK
[3]Chakree RODFAI , [4]Aneak SAIWANRUNRKUL,
[5]Shunichi KOSHIMURA, [6]Masashi MATSUOKA

[1&2]Department of Geography, Faculty of Liberal Arts, Thammasat University. THAILAND
[3&4]Mangrove Administrative Division 2. Krabi Province, THAILAND
[5]Disaster Control Research Center, Graduate School of Engineering, Tohoku University, JAPAN
[6]GEO Grid Research Group, Information Technology Research Institute, National Institute of Advanced Industrial Science and Technology (AIST), JAPAN

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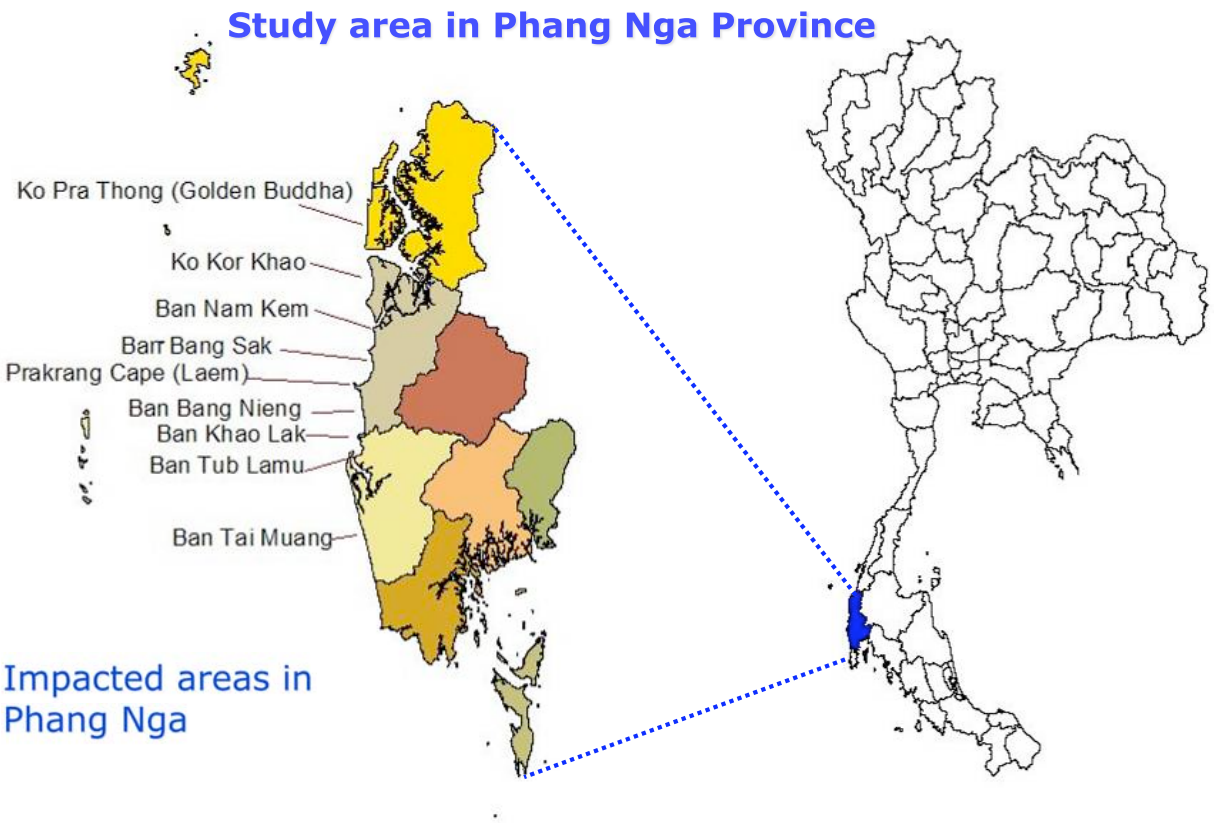
1. Introduction

- In the aftermath of the 2004 Indian Ocean tsunami, **mangrove has been reported as a good protector against coastal disasters.**
- Information of mangrove damaged area is very necessary for estimating the Tsunami affected area and planning of mangrove reforestation/recovery.
- In Thailand, most of the mangrove damaged areas were located in Phang Nga Province (the Department of Marine and Coastal Resources, Ministry of Natural Resources and Environment - MONRE, Thailand, 2005).
- In this study, **3S technologies;** Remote Sensing (RS), Geographic Information System (GIS) and Global Position Systems (GPS) are integrated for monitoring the changes of mangrove (before tsunami/ – after tsunami/damaged – Present/Recovery).

2. Objective

- **To monitor mangrove destruction and reforestation in Phang Nga, Thailand using 3S technologies**
  - to apply Multi-temporal RS for mangrove area mapping in the Pre and Post 2004 Tsunami Periods
  - to locate the observed site and update mangrove status using GIS and GPS.

3. Study Area, Materials and Methodology



3. Study Area, Materials and Methodology (2)

Materials

❖ **Satellite data** – ASTER (15 meter resolution) from GEOGrid, ASIT as listed below

No.	Date
1	07 Mar 2003 [Before]
2	31 Dec 2004 [After]*
3	8 Feb 2005 [After]
4	4 Jun 2009 [Recovery]*
5	6 Feb 2010 [Recovery]

* Cloudy images, only some small fractions in the images can be used to compare the changes.

3. Study Area, Materials and Methodology (3)

ASTER Bands

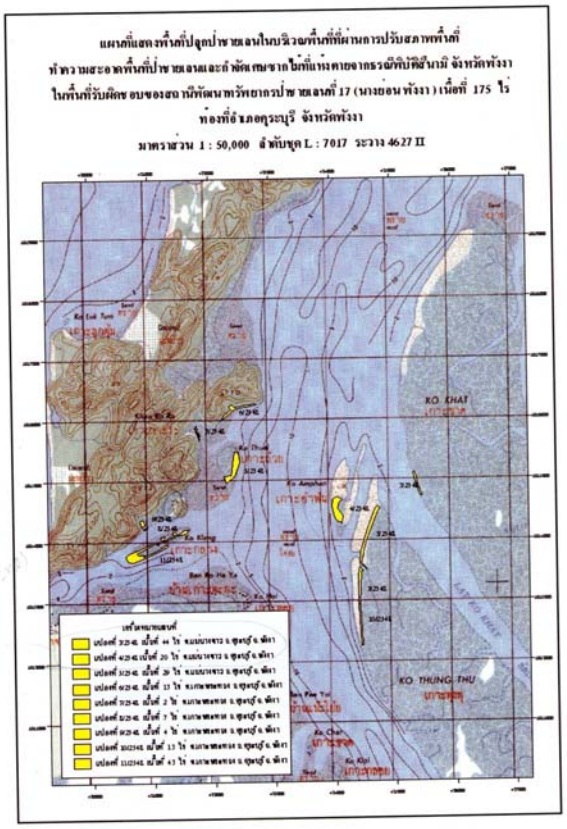
Band	Label	Wavelength (μm)	Resolution (m)	Nadir or Backward	Description
B1	VNIR_Band1	0.520–0.600	15	Nadir	Visible Green/Yellow
B2	VNIR_Band2	0.630–0.690	15	Nadir	Visible Red
B3	VNIR_Band3N	0.760–0.860	15	Nadir	Near Infrared
B4	VNIR_Band3B	0.760–0.860	15	Backward	
B5	SWIR_Band4	1.600–1.700	30	Nadir	Short-wave Infrared
B6	SWIR_Band5	2.145–2.185	30	Nadir	
B7	SWIR_Band6	2.185–2.225	30	Nadir	
B8	SWIR_Band7	2.235–2.285	30	Nadir	
B9	SWIR_Band8	2.295–2.365	30	Nadir	
B10	SWIR_Band9	2.360–2.430	30	Nadir	
B11	TIR_Band10	8.125–8.475	90	Nadir	Long-wave Infrared or Thermal IR
B12	TIR_Band11	8.475–8.825	90	Nadir	
B13	TIR_Band12	8.925–9.275	90	Nadir	
B14	TIR_Band13	10.250–10.950	90	Nadir	
B15	TIR_Band14	10.950–11.650	90	Nadir	

3. Study Area, Materials and Methodology (4)

- **Landuse Map 2000 (1:50,000) and 2007** (1:25,000) **of Phang Nga** from the Land Development Department (LDD), Ministry of Agriculture and cooperatives
- **Landuse (Base Map) 1999 of Phang Nga, 1:50,000** from the Pollution Control Department, Ministry of Natural Resources and Environment
- **Landuse and road maps 2006 of Phang Nga Province**, 1:50,000 from The Royal Thai Survey
- **Mangrove Plantation Sites in Phang Nga**, 1:50,000 from Mangrove Administrative Division 2. Krabi Province, THAILAND
- **GPS / ground truth data,** interview local people, etc.,

3. Study Area, Materials and Methodology (5)

❖ **Mangrove Reforestation Sites in 2005** from Mangrove Administrative Division 2. Krabi Province, THAILAND → created as GIS layer.



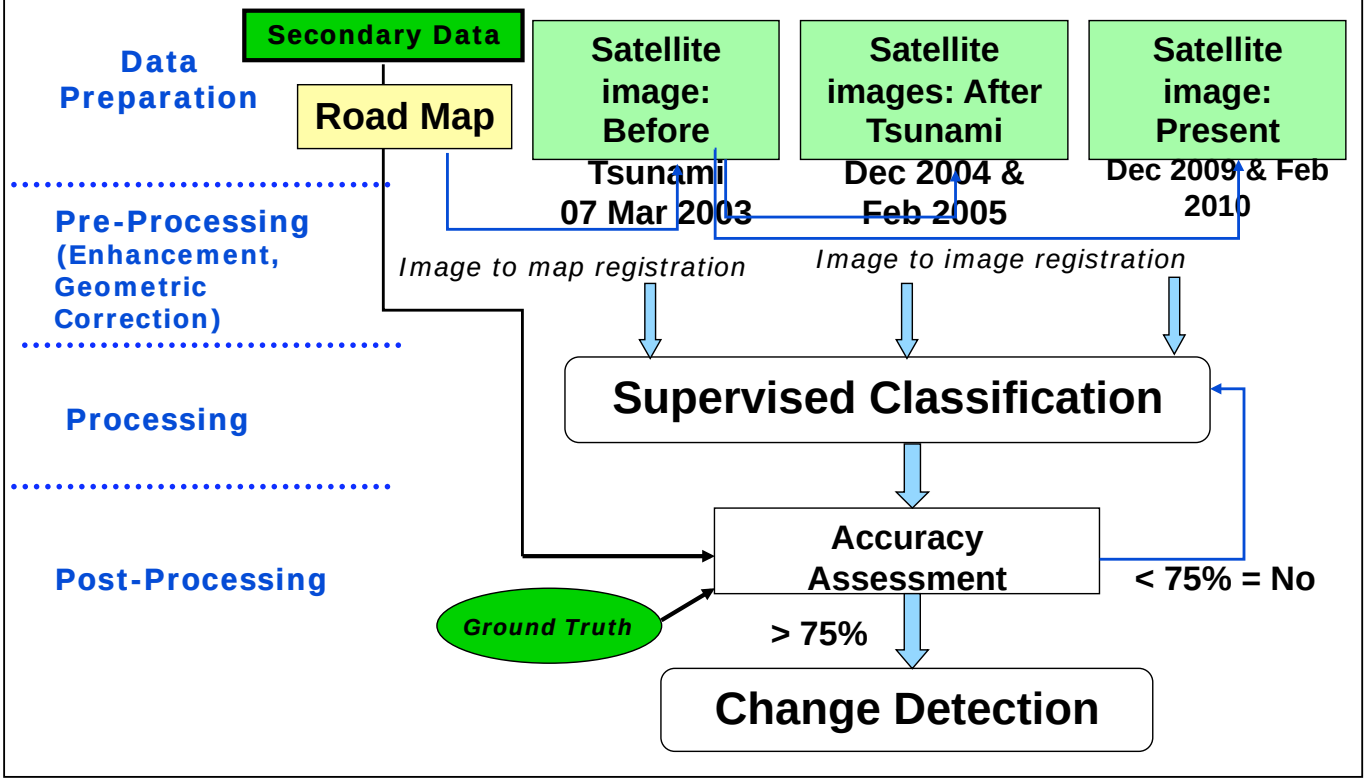
3. Study Area, Materials and Methodology (6)

❖ **Software**

- ENVI 4.6
- ARC GIS 9.3
- GPS Utilities

3. Study Area, Materials and Methodology (7)

Overall Methodology

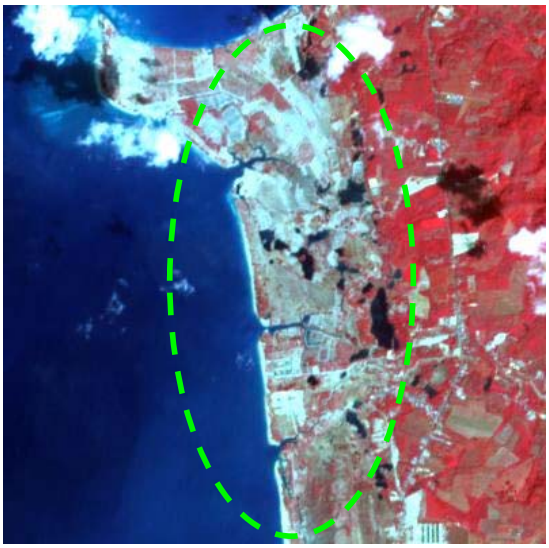


3. Study Area, Materials and Methodology (8)

Multi-temporal ASTER images of Prakarang Cape, Phang Nga, Thailand

ASTER: 7 Mar 2003 (Before Tsunami)

ASTER: 8 Feb 2005 (After Tsunami)



3. Study Area, Materials and Methodology (9)

- Change Detection **provides a way to compare imagery collected over the same area at different times** and highlight features that have changed.
- There are two forms of change detection: absolute and relative.
  - **Absolute change detection highlights specifically what has changed (e.g. forest to grassland).**
  - **Relative change detection shows that something has changed but does not specify what that change is. Relative change detection provides a faster method for quickly comparing images.**

3. Study Area, Materials and Methodology (9)

ASTER: 8 Feb 2005
(After Tsunami)

GPS (Global Positioning System), for updating the topographic coordinate (compare the affected locations or areas - before and after Tsunami)

Survey Mangrove Recovery/reforestation after the 2004 Tsunami – Phang Nga

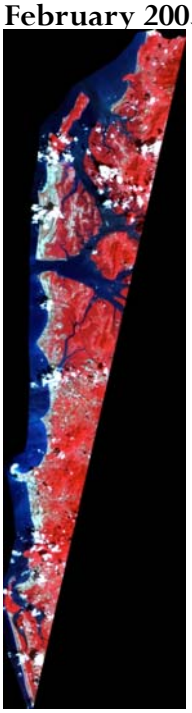
Survey Beach Recovering after Tsunami 2004 – Phang Nga

Survey – Rebuilt village, interview their tsunami's understanding, information of mangrove area and their activities…

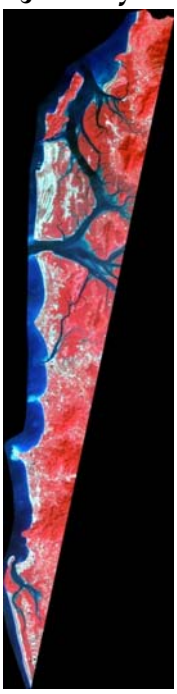
4. Results – Pre-processed images

7 March 2003

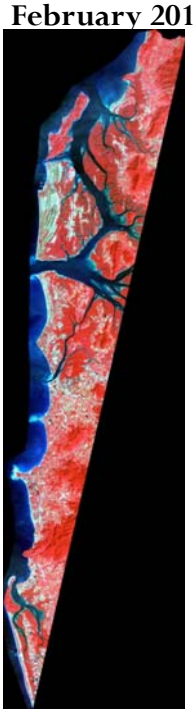
8 February 2005



26 January 2006

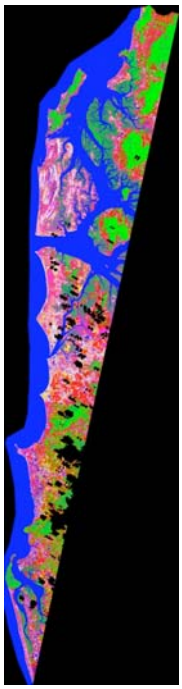


6 February 2010

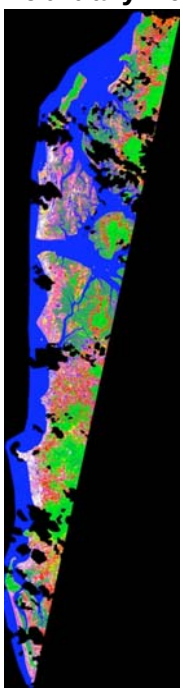


4. Results – Processed/Classified images

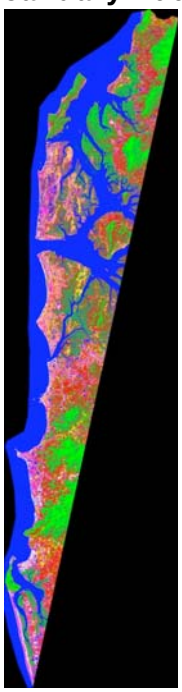
7 March 2003



8 February 2005



26 January 2006



6 February 2010

10 classes of Land uses in Phang Nga – western part/coastal area

4. Results – Post Processed / Accuracy Assessment

Classified Image	Source of Referenced Data	Overall Accuracy (%)
7 March 2003	Landuse 2000,Land Development Department	83.13%
8 February 2005	Landuse 2006, Royal Thai Survey Department	82.08%
26 January 2006	Landuse 2007, 2000,Land Development Department	89.91%
6 February 2010	Ground truth data (field survey in 2009-2010)	78.86%

Although the accuracy of each classified image is high, confusion among vegetation; mangrove, forest and agriculture should be minimized.

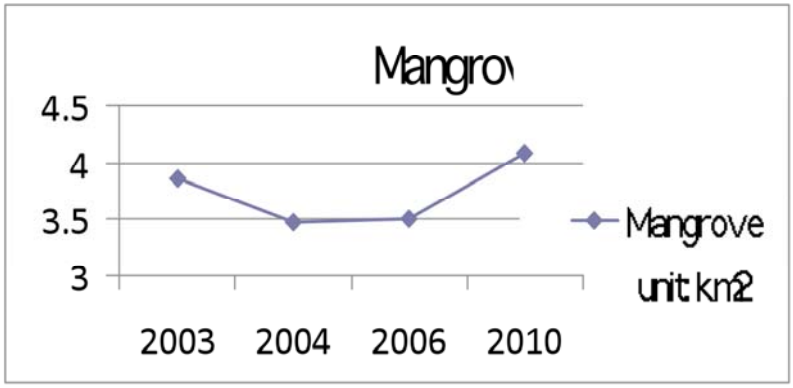
Framed on the area of Laem Pom, Koh Kho Khao, Takua Pa, Phang Nga

7 March 2003

31 December 2004

26 January 2006

6 February 2010



2003 = Before Tsunami

2004 = Damaged just after the Dec 2004 Tsunami

2005-2006 = Reforestation

2010 = Recovered in same area + beyond

26 January 2006

6 February 2010

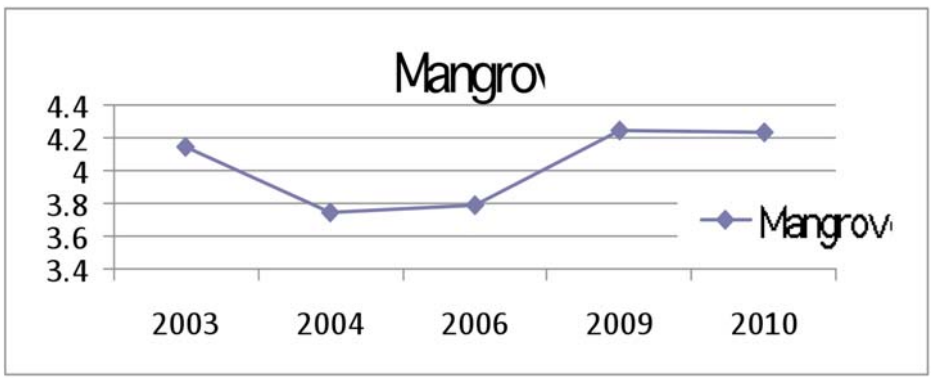
Framed on the area of Klong Thap Lamu, Tai Mueng, Phang Nga

7 March 2003

31 December 2004

26 January 2006

4 Juan 2009



6 February 2010

In 2010, mangrove is a bit reducing because of human activities.

Survive after the Dec2004 Tsunami

Reforestation in 2005-2006

After reforestation, mangrove trees in some locations have very slow progress and some are dead (poor soil conditions and strong waves).

4. Results – Change Detection

- In the classified images and changed detection; mangrove, beach forest and beach are focused and summarized here

	2003 (Square Km.)	2005 (Square Km.)	Changed area (Square Km.)
Mangrove	165.73	148.73	-17.23
Beach Forest	88.95	72.41	-16.54
Beach	10.71	16.90	6.19

4. Results – Change Detection (2)

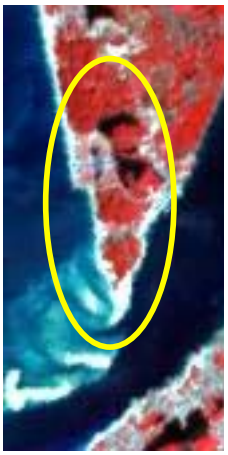
	2005 (Square Km.)	2006 (Square Km.)	Changed area (Square Km.)
Mangrove	165.73	211.44	45.71
Beach Forest	72.41	62.03	-10.38
Beach	16.90	13.89	-3.02

4. Results – Change Detection (3)

	2006 (Square Km.)	2010 (Square Km.)	Changed area (Square Km.)
Mangrove	211.44	174.44	-38.99
Beach Forest	62.03	72.13	11.44
Beach	13.89	25.32	10.10

26 January 2006

6 February 2010



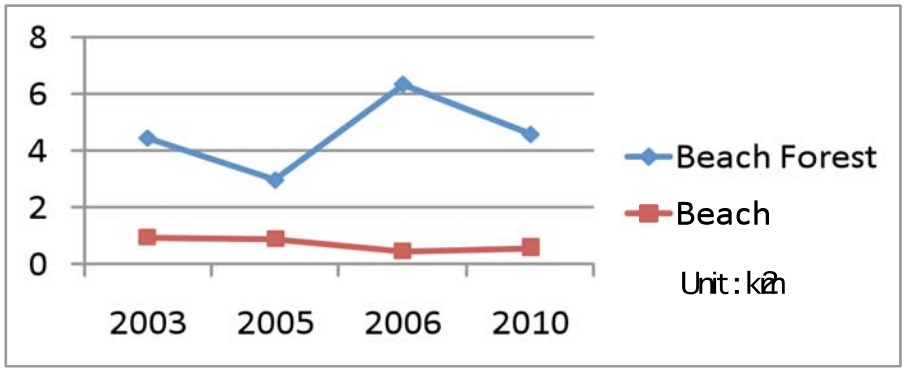
Studying area the Cape Tubkaak , Koh Kho Khao, Takua Pa, Phang Nga.

7 March 2003

8 February 2005

26 January 2006

6 February 2010



Loss the beach in this area – after Tsunami, the waves become stronger hit to the shore here.

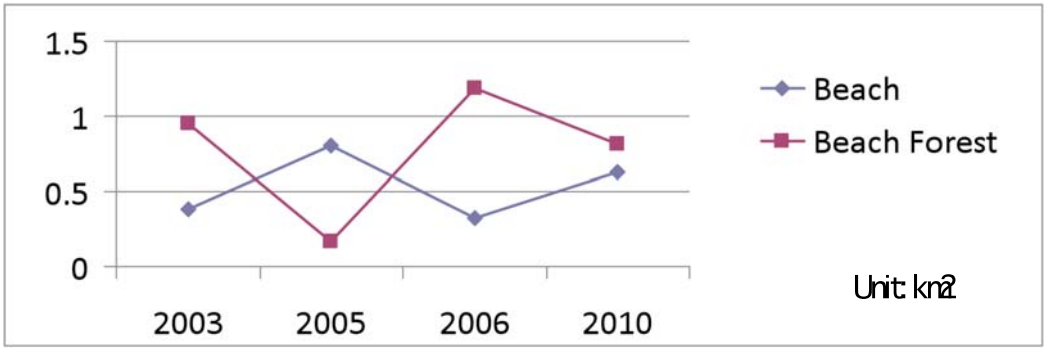
Framed on Laem Hua Krang Yai (Laem Pakarung), Takua Pa,Phang Nga

7 March 2003

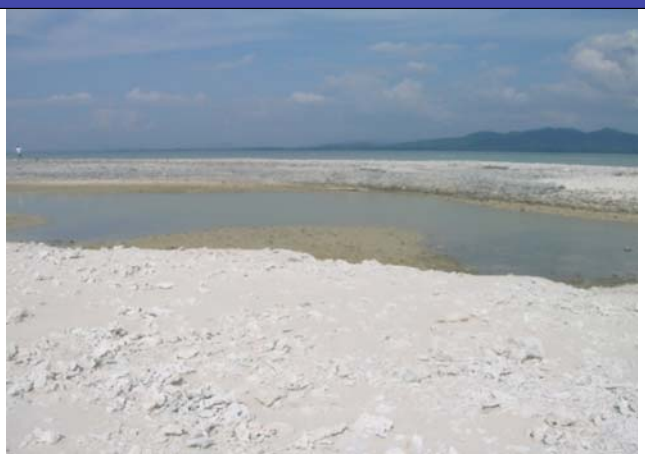
8 February 2005

26 January 2006

6 February 2010

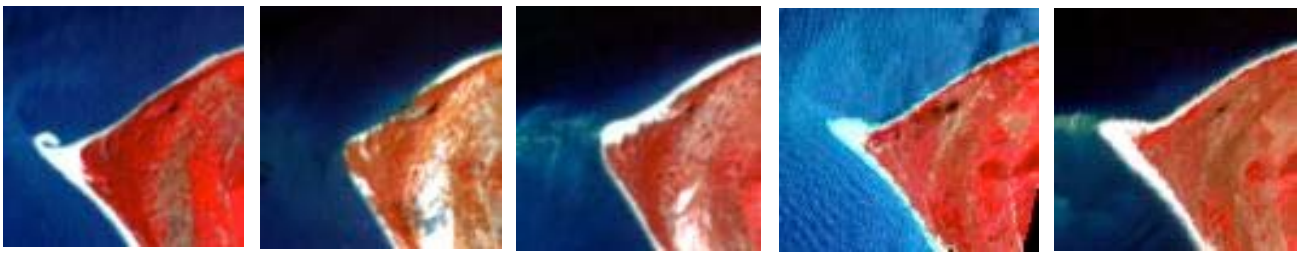


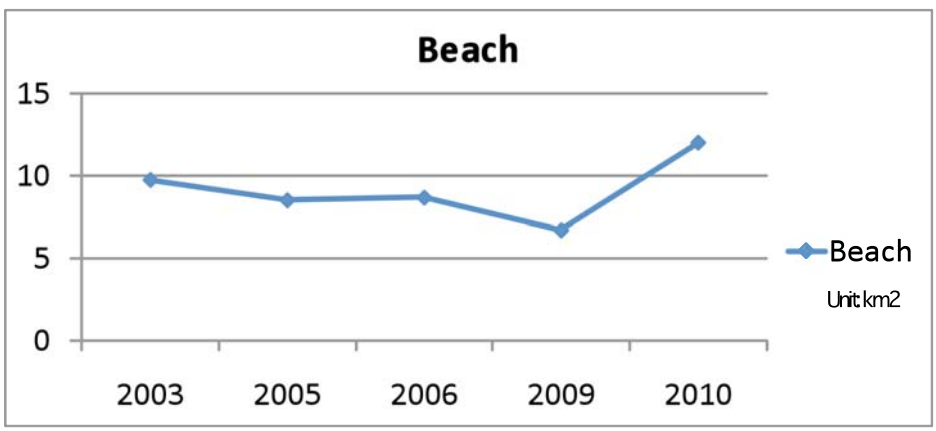
Pakarung = Coral reef



Framed on Ban Nok Na Takua Pa, Phang Nga

7 March 2003 | 8 February 2005 | 26 January 2006 | 4 Juan 2009 | 6 February 2010





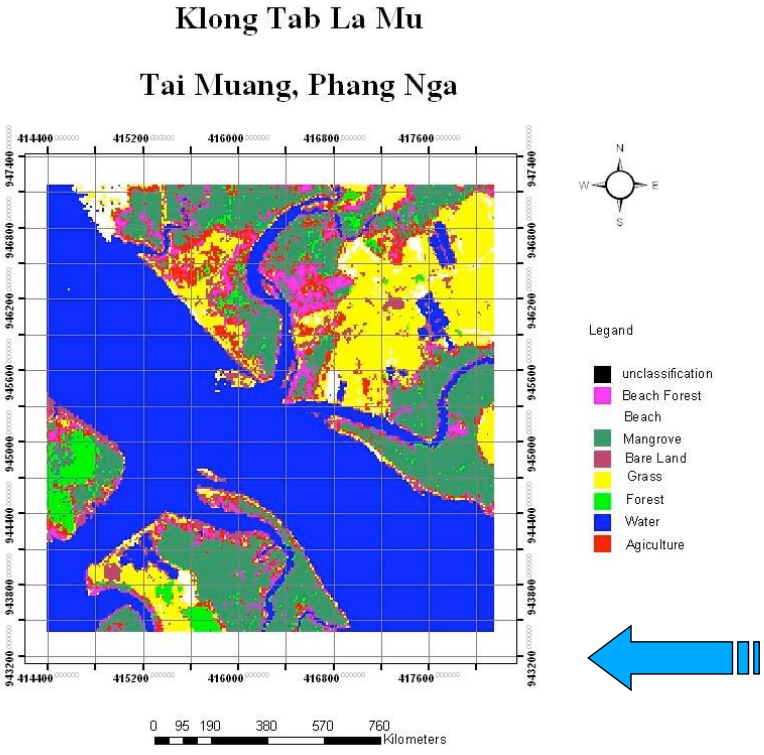
5. Conclusions

- **Although the accuracy of the classified images in this study are acceptable, but**
  - targeting only western part of Phang Nga **might be biased the accuracy**
  - confusing among vegetations; mangrove has confused in the classes of agriculture (rubber/orchard) and inland forest → **should be minimized.**
- **It is difficult to analyze the changes at the same location using multi-temporal of satellite images;**
  - atmospheric affects/under **cloud covered** → loss information or **non-reliable spectral** → too bright/dark in the same area
  - **Close spectral ranges** of different land uses (agriculture – forest -mangrove), make it difficult to separate these classes → **spectral index (besides NDVI) or other satellite products might to a good assist the classification.**

5. Conclusions (2)

- **Integration of 3S technologies are very useful for supporting the area/location information of mangrove destruction and reforestation in the aftermath of the 2004 Indian Ocean Tsunami in Phang Nga, Thailand**
- **The information of mangrove damaged and recovered areas will be very much useful for government planning - prepare and mitigate the future disasters.**

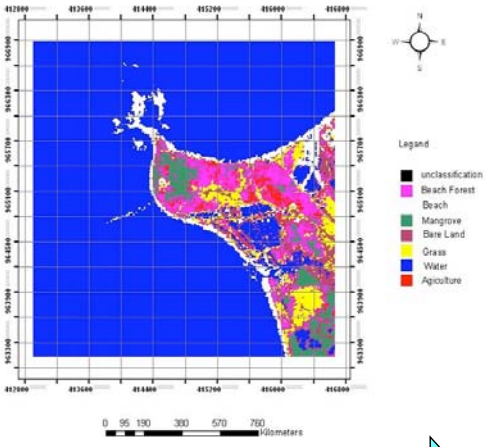
Map Making & Further Analysis in GIS



The classified image can be used in the form of raster or convert to GIS vector – more friendly to use with other layers and more attractive map production in GIS.

Map Making & Further Analysis in GIS (2)

ASTER: 8 Feb 2005 (After Tsunami)



By extracting the inundated or damaged area from RS and creating a map.

Evacuation Route Maps

Tsunami Evacuation Building – on going construction in many places

Thanks……to

- **Dr.Koshimura, Tohoku University, JAPAN → PI of a research project** titled the "Development of real-time tsunami damage detection technology for expeditious disaster response of Japan and ASEAN countries (Project ID : 08E52010a)".
- the New Energy and Industrial Technology Development Organization **(NEDO), JAPAN → supporting the project**
- **Dr.Matsuoka,** the Global Earth Observation Grid **(GEO Grid),** the National Institute of Advanced Industrial Science and Technology **(AIST), JAPAN**
- **Local officers/collaborators** under Mangrove Administrative Division 2. Krabi Province, the Department of Marine and Coastal Resources, **Ministry of Natural Resources and Environment, THAILAND**
- **Etc.,**

Thank you for your attention ;--)