Mangrove Forest mapping Using Landsat 8 Images

Engr. Homer Pagkalinawan
Department of Geodetic Engineering, College of Engineering
University of the Philippines, Diliman, Quezon City

I. INTRODUCTION

Remote sensing is the practice of deriving information about the earth's land and water surfaces using images acquired from an overhead perspective, using electromagnetic radiation in one or more regions of the electromagnetic spectrum, reflected or emitted from the earth's surface (Campbell 1966). Remote sensing data can be derived from the different regions of the electromagnetic spectrum. Examples are middle resolution Landsat and high resolution WorldView satellite images that utilize the visible to infrared region, RadarSat from radio waves and Light Detection and Ranging (LIDAR) which employs ultraviolet light.

Landsat Data Continuity Mission (LDCM), commonly called Landsat is among the publicly accessible remote sensing database. Starting operation in 1972, LDCM is the world's longest continuously acquired collection of space-based, moderate-resolution (15/30m), land remote sensing data. LDCM was a joint initiative between the US Geological Survey (USGS) and National Aeronautics and Space Administration (NASA). In 2013, they launched their latest satellite platform called Landsat 8. Data acquired by the mission are accessible through public domain in the web pages of Global Visualisation Viewer (www.glovis.usgs.gov) and EarthExplorer (www.earthexplorer.usgs.gov).

Using Landsat imageries, Long et al. (2014) mapped and assessed the condition of mangrove forest in the Philippines from 1990 to 2010. Their study found out that from 268,996 ha in 1990, mangrove areas decreased to 256,185 ha in 2000 and further down to 240,864 ha in 2010. Shown below (**Fig. 11**) is the mangrove forest map for 2010 based on Long's findings.

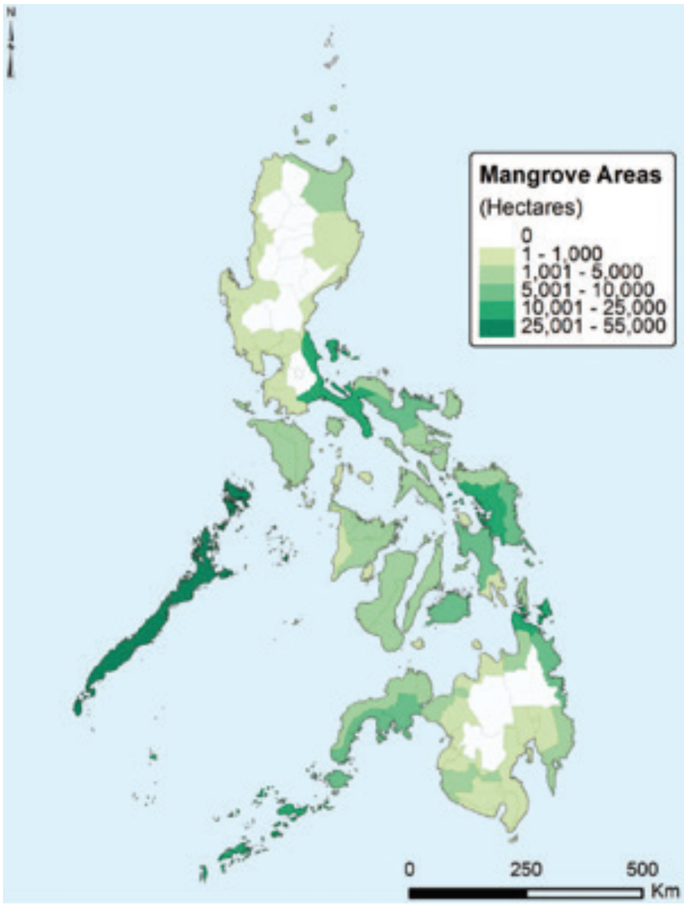
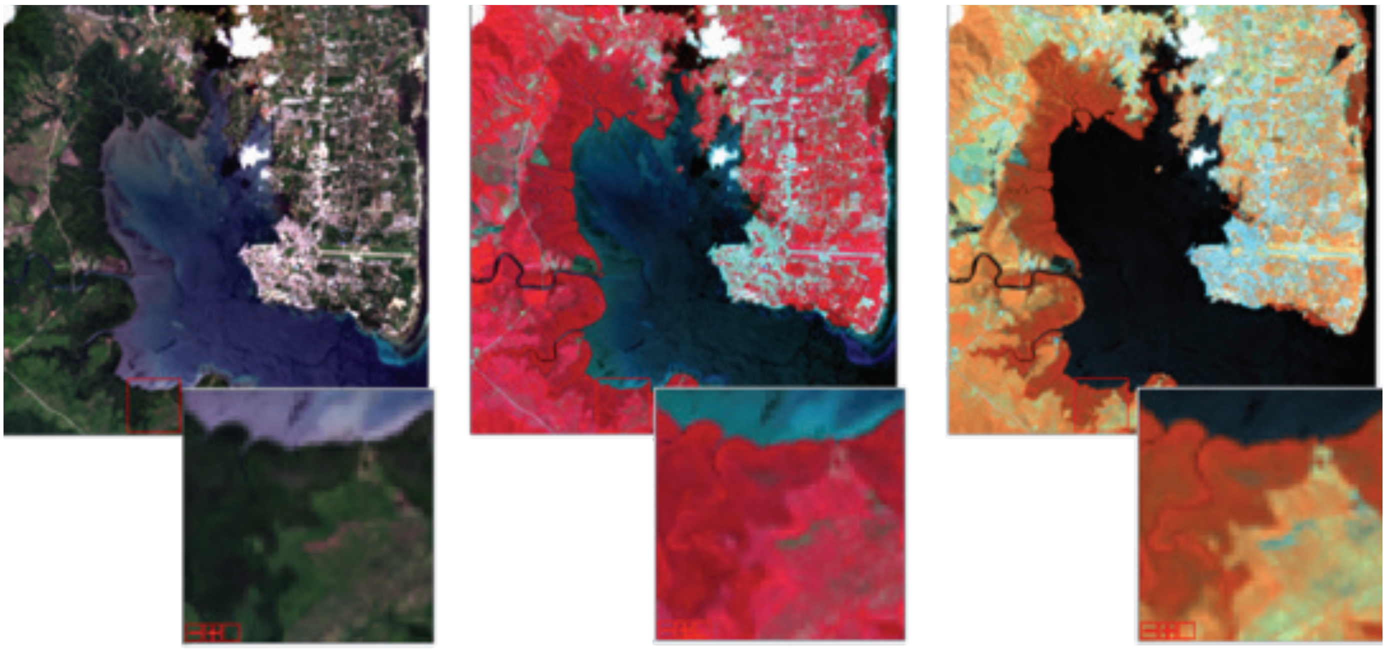


Figure 11. Mangrove forest cover 2010 by Long et al.

II. MAPPING OF MANGROVES

Using Landsat 8 imageries, mangroves can be characterized visually through combinations of bands. In **Figure 12**, a true color combination of bands 4-3-2 (red, green and blue) shows that mangroves appear to have a darker green color than other vegetation. On the other hand, a false color combination of 5-4-3 (infrared-red-green) displays mangroves as darker red compared to other vegetation. Another false color combination of bands 5-6-7 (infrared-midinfrared1-midinfrared2) represents mangroves in a striking orange hue compared to other vegetation. Among these combinations, bands 5-6-7 was deemed to be the most useful in identifying mangroves.

Also, mangroves, just like other objects, have their own spectral signature which can be used for their classification. Spectral signature refers to the unique response of object when subjected to varying wavelengths of the electromagnetic spectrum. The value of spectral response of mangroves in mid-infrared is lower compared to other vegetation (see **Fig. 13**).



True Color Composite Landsat 8 Bands 432 | False Color Composite Landsat 8 Bands 543 | True Color Composite Landsat 8 Bands 567

Figure 12. Characterization of mangrove forests from different band combinations

Mangrove | Non-mangrove vegetation

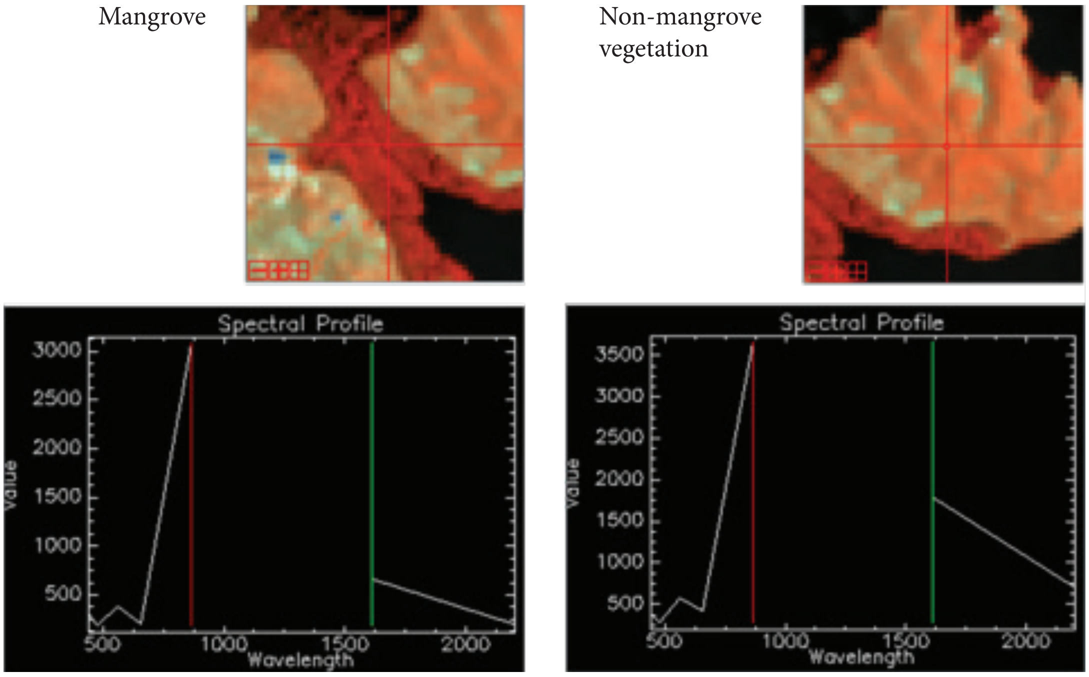


Figure 13. Comparison of spectral response between mangroves and other vegetation

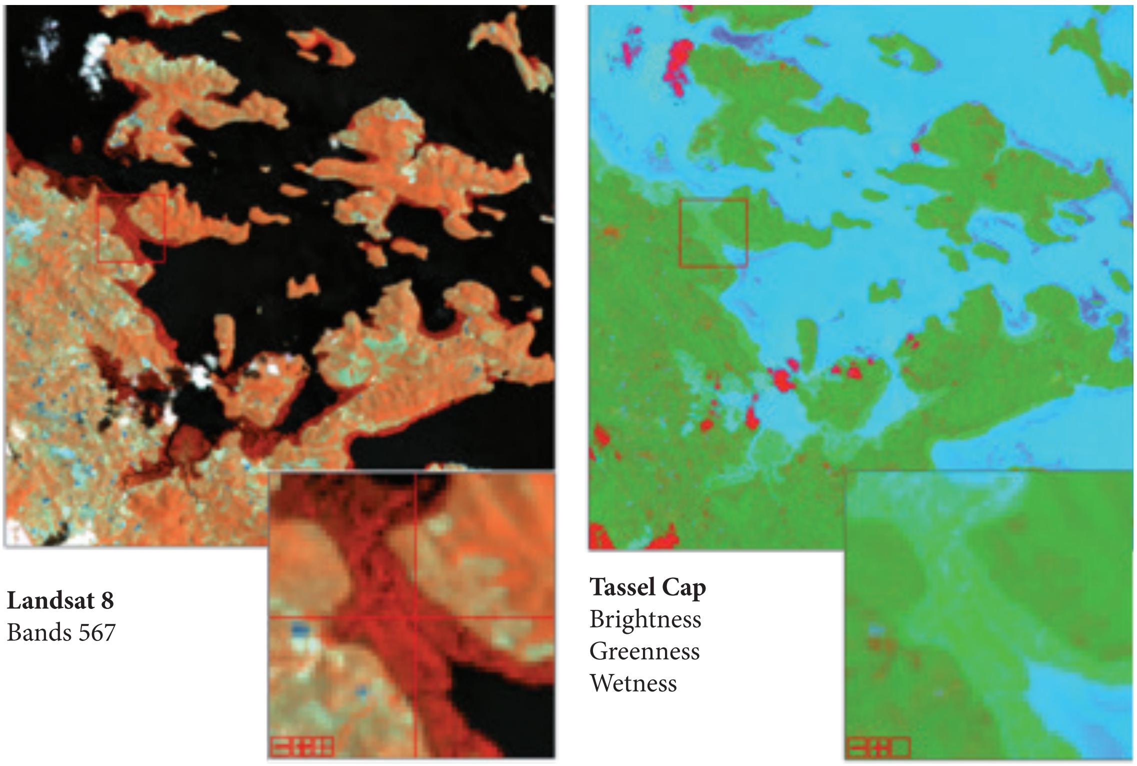


Figure 14. Comparison of a false color combination and tasselled cap transformation

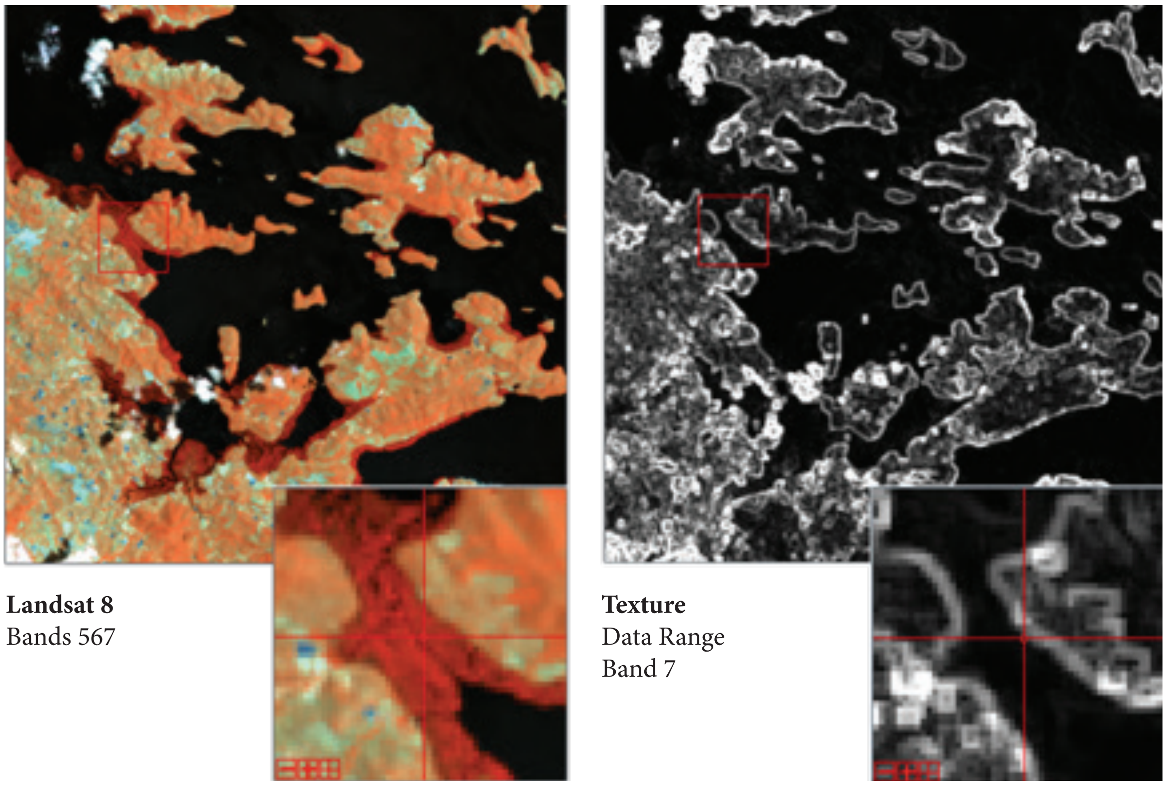


Figure 15. Comparison of a false color combination and texture Filtering

Tools in remote sensing such as tasseled cap transformation and texture filtering were also used to identify mangroves. Tasseled cap transformation refers to orthogonal transformation of the original data into index bands. These indices are called brightness, greenness, wetness, fourth (haze), fifth and sixth. A combination of brightness, greenness and wetness indices can be useful in differentiating mangroves from other vegetation as shown in **Figure 14**.

On the other hand, texture filtering smoothens the spatial variation of image brightness and was found to be helpful in differentiating mangroves from rainforest. Band 7 (mid-infrared 2) was applied with texture filtering for this study.

Infrared, mid-infrareds (1 and 2), brightness, greenness, wetness and texture filtered mid-infrared 2 bands were used as input for classification. Method used was Iterative Self Organizing Data Analysis Technique Algorithm (ISODATA), an unsupervised classification wherein classes/clusters are iteratively splitted and merged based on user defined threshold. No fieldwork was conducted for the study, thus ISODATA was appropriate for this study since it does require a training class for classification.

III. RESULTS

Five Landsat 8 images dated 2013 were used for the classification of mangroves. User accuracy, which refers to the probability that a pixel labelled as a certain class is really the said class, ranges from 64% to 88%. On the other hand, producer's accuracy, or the probability that a certain object on the ground is classified as such, had values from 68% to 96%. Kappa coefficient, which measures the degree of agreement from 0 (no agreement) to 1 (complete agreement), ranges from 0.769 to 0.792. **Table 22** shows a summary of these accuracy parameters.

A total of 2,159 ha of mangroves were estimated to be within the provinces of Bataan, Bulacan, Cagayan, Ilocos Norte, La Union, Pampanga and Pangasinan. This is lower compared to the 2010 mangrove forests identified by Long et al. (2014) as well as those declared by LGUs.

Table 22. Accuracy Parameters

Path	Row	User's Accuracy	Producer's Accuracy	Kappa Coefficient
116	50	81.91%	80.70%	0.79
116	49	64.93%	96.39%	0.77
116	48	70.36%	70.02%	0.70
116	47	68.55%	82.77%	0.71
117	49	88.83%	68.83%	0.77

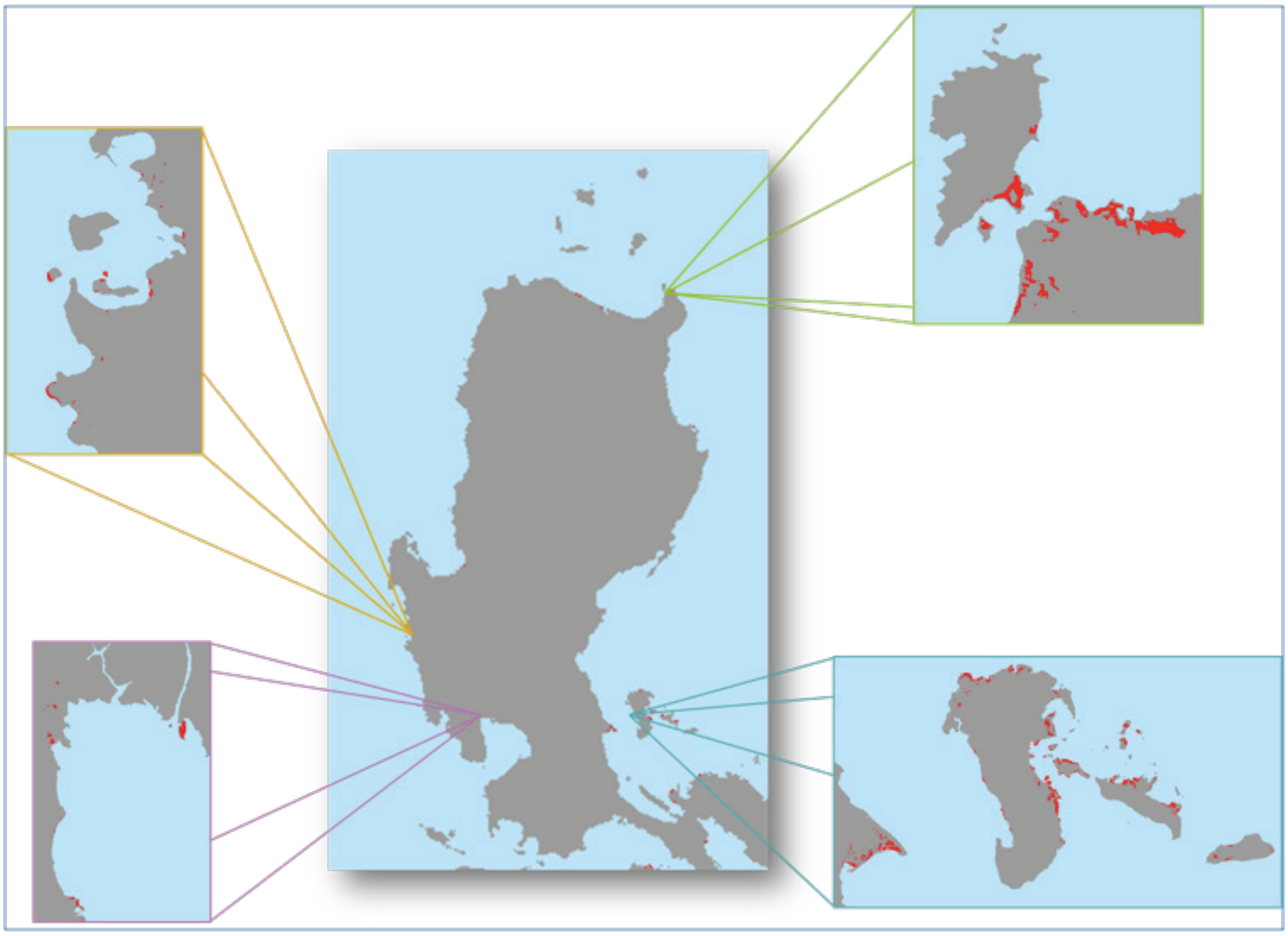


Figure 6. Mangrove areas with areas of concentration zoomed in

Among the areas with mangrove forests, Palaui Island (Cagayan), San Narciso (Zambales), Bataan and Polilio Island (Quezon) are areas of concentration.

Table 23. Mangrove Forest Area per Province

Province	2013 (in ha)	2010 Long et al (in ha)	As per LGU (in ha)
Bataan	42	172	282
Bulacan	33	265	294
Cagayan	1,655	4,737	5,336
Ilocos Norte	1	58	38
Ilocos Sur	0	40	169
La Union	78	44	79
Pampanga	56	132	159
Pangasinan	205	207	470
Zambales	89	217	604
Total	**2,159**	**5,872**	**7,431**

IV. SUMMARY AND RECOMMENDATIONS

The study showed preliminary results of mangrove mapping using remote sensing data. Different tools were explored to come up with accurate classification results. Compared to results of another study, which employed more complex rules in identifying mangrove forest, the study yielded lower results. However, the said study lacks field validation for their results. Similarly, figures declared by the LGUs are also higher. This can be attributed to newly planted areas included in their total mangrove areas.

For more accurate results, the use of higher resolution satellite images, other remote sensing data or combination of both are recommended. However, it should be noted that higher resolution images will require more processing time, thus more experts and manpower. Other classification techniques can also be explored. In collecting field data, the actual data on the location of the mangroves is encouraged. This can be done in collaboration with the concerned LGU.

V. REFERENCES

Campbell J, Wynne R. 2011. Introduction to Remote Sensing 5th edition. The Guilford Press

Long JB, Giri C. 2011. Mapping the Philippines' Mangrove Forests Using Landsat Imagery. Sensors 11: 2972–2981. doi: 10.3390/s110302972

Long JB, Napton D, Giri C, Graesser J. 2014. A Mapping and Monitoring Assessment of the Philippines' Mangrove Forests from 1990 to 2010. Journal of Coastal Research 30(2): 260–271. doi: 10.3390/s110302972

USGS Global Visualization Viewer. 2013. Retrieved from http://glovis.usgs.gov