Estimation of Tree Canopy Cover in Central Luzon State University Using Satellite Imageries and GIS

Edmark Bulaong (1), Annie Melinda Paz-Alberto (1)

1 Institute for Climate Change and Environmental Management
Email: epbulaong@gmail.com, melindapaz@gmail.com

KEY WORDS: tree, canopy cover, GIS, crown cover

ABSTRACT: This paper investigates tree canopy cover mapping of Central Luzon State University in Science City of Muñoz, Nueva Ecija, Philippines using satellite imageries. Object-Based Image Analysis (OBIA) was used to extract tree canopy cover. Multi-resolution segmentation and a series of assign-class algorithm in eCognition software was also performed to extract different land features. Contextual features of tree canopies such as height, area, roundness, slope, length-width and elliptic fit were also evaluated. The results showed that at the time the imagery data was collected (November 2019), the tree cover was around 143.4082 (21.79% of CLSU Area) was extracted from the satellite imagery. The computed crown cover using GIS included forest patches and individual trees. The overall accuracy of the analysis was 98.4 % when compared from digital crown cover to field validation.

1. MANUSCRIPT

1.1 Introduction

Canopy cover is a major biophysical attribute used to understand the ecology and spatiotemporal changes which are home to diverse flora and fauna. The canopy can be affected by the health of a tree, which in turn is affected by nutrition, water access, disease, pest infestations, and stress. In Central Luzon State University (CLSU), tree crowns give shade abundantly to every pathway and contribute to meeting the university's regulatory clean air requirements. Access to trees, green spaces, and parks promotes greater physical activity, and reduces stress, while improving the quality of life in the university and neighboring areas. Traditional methods have been used to quantify canopy cover via field measurements. With the use of remotely sensed imagery from satellites and airborne platforms classified by appropriate approaches are now preferred to assess canopy cover in different areas by many researchers.

1.2 Objectives of the Study

The general objective of the study is to generate tree crown cover in the study area.
Specifically, This Study Aimed To:

1. Estimate Percent Canopy Cover (PCC) in CLSU
2. Project an optimal map for tree crown cover in CLSU.

1.3 Significance of the Study

Thus, canopy cover acts as an indicator of these factors for both natural as well as cultivated groves and forests. Due to its ecological importance, canopy cover estimation has recently become a major part of forest inventories in the Philippines. This study projected the estimated tree crown cover in Central Luzon State University. Also, the study mapped the entire tree cover in the area and projected area estimates of land cover. It give awareness on the residents of the ecological importance and health status of trees in the campus.

1.4 Scope and Limitation

The study focused only in surveying tree crown cover of CLSU, Science City of Muñoz, Nueva Ecija. Satellite acquired imageries of crown top cover were analyzed to create an optimal map of the university. Tree species located in different areas were not identified. Two land cover classes were specifically identified to project only the tree crown cover in the area (the other class was composed of combined land cover classes such as buildings, water bodies, pavements, soil, agriculture, etc.).

The study was conducted in Central Luzon State University (CLSU) from October to November 2019.

2. METHODOLOGY

2.1 Acquired Data Sources

3. Year	Satellite	Res	Season	Cloud Area	Acquisition
2019	Worldview 3	31cm	Dry Season/Harvest Time/Land-prep	0 %	2019-02-18

Table 1. Description of the satellite imagery used in the study

Figure 1. Satellite Imagery of CLSU, Science City of Muñoz, Nueva Ecija

The satellite imagery was acquired on February 18, 2019 during the dry season wherein most of the crops were harvested leaving the area with bare lands and reflecting mostly brown color. The imagery has a 31cm resolution with 8 composite images available upon processing. Cloud cover was found in some areas outside the University but does not cover any parts of the study area.

3.1 Preprocessing

The images were geometric/atmospheric correction done after download. The images then undergo compositing wherein band indices were selected to fully project land elements for the red-blue-green (RGB) combination which will clearly identify the land cover classes. Clouds observed were very small and does not cover the study area..

3.2 Image Segmentation and Classification

Multi-threshold segmentation algorithm was applied to the DSM layer to distinguish reflective surface of different features such as trees, crops, buildings, pavement, water. The threshold value of 1.25m–1.75m was used and offered 2% to 12% error rate in determining trees and shrub cover. Refinement of crown cover was carried out using “Relative Border” algorithm to classify the unclassified points embedded in each class and to delineate shadows from trees and shrubs. Further, each class was merged together using “Merged Region” algorithm. Each was assigned with its corresponding class color.

3.3 Accuracy Assessment

After processing using the algorithm, the accuracies of the extracted tree canopies were evaluated. Validation points were classified into different classes which include Bare Land, Built-ups, and Trees. Some of the validation points were taken from the field by taking a GPS coordinates on the actual features. After the initial classification, the first two classes were merged into one: the non-tree class.

3.4 Map Refinement

Areas classified as trees were exported as object shapefiles and was loaded to ArcGIS 10.2.2 software for editing and refinement. Additional information was added to the object shapefiles such as shape length and shape area. Final refinement of the object shapefiles was carried out by digitizing visual tree crown cover and eliminating further shadows and dark areas. Calculation of tree canopy area was carried out using the Calculate Geometry Tool of ArcGIS.

4. RESULTS

The normalized difference vegetation index (NDVI) is a simple graphical indicator that can be used to analyze and assess whether the target being observed contains live green vegetation or not.

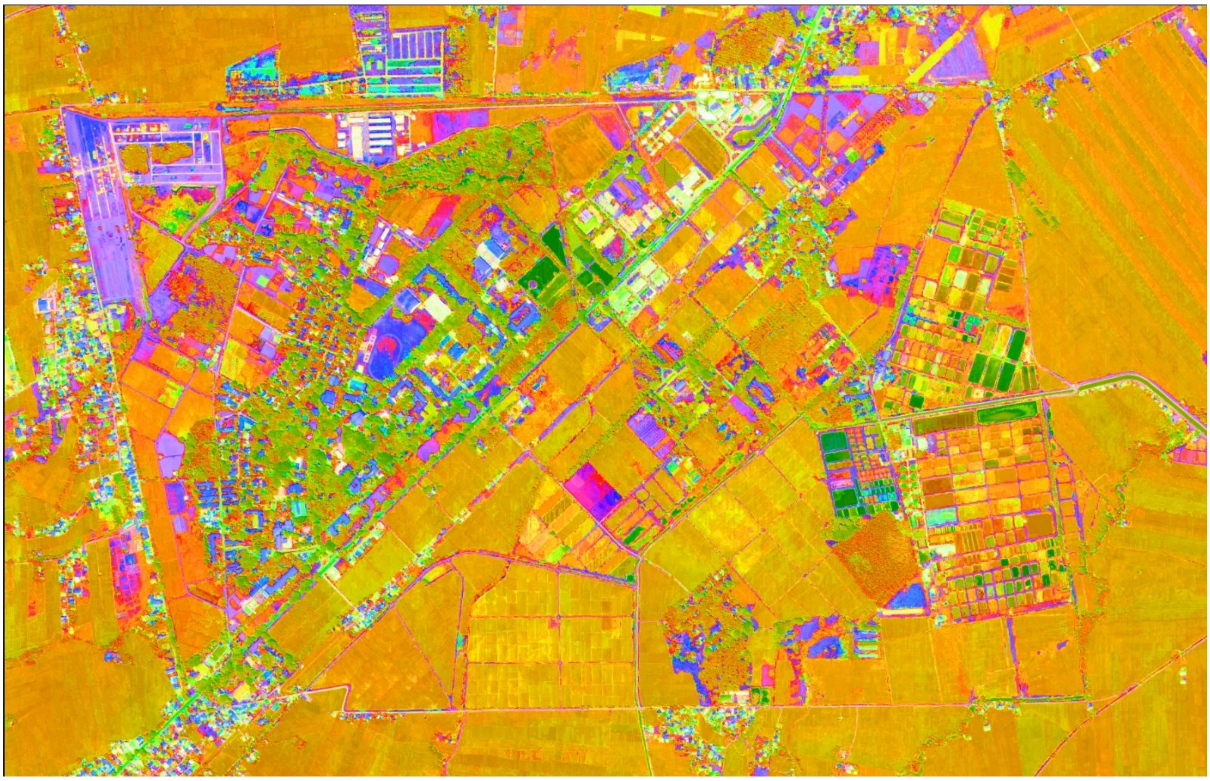

Figure 2. NDVI of the study area projecting the tree cover and some vegetation into bright green color

4.1 Delineating Trees from other Green Structures

NDVI of different features may come close or more likely to have almost the same values but it will always have different reflection. This will enable us to delineate tree features from other features by assigning classifications to different surface. Supervised classification helped assigned different class with the same visual reflection.

Figure 3. Delineating features overlapping or with close reflection ID with the tree canopy.

The roof top of the CHSI matching the visual reflection of the trees in CLSU thus undergo manual supervised and manual classification. Also, with the Sunflower and other crops which were not harvested and were overlapping with the tree canopy can be delineated.

4.2 Refinement of Tree Patches

Figure 4. Delineating features overlapping or with close reflection ID with the tree canopy.

Shadow and dark patches which is not included as tree crown will be refined using the ArcGIS refinement and shadow delineation to remove excess areas and project tree crown cover accurately.

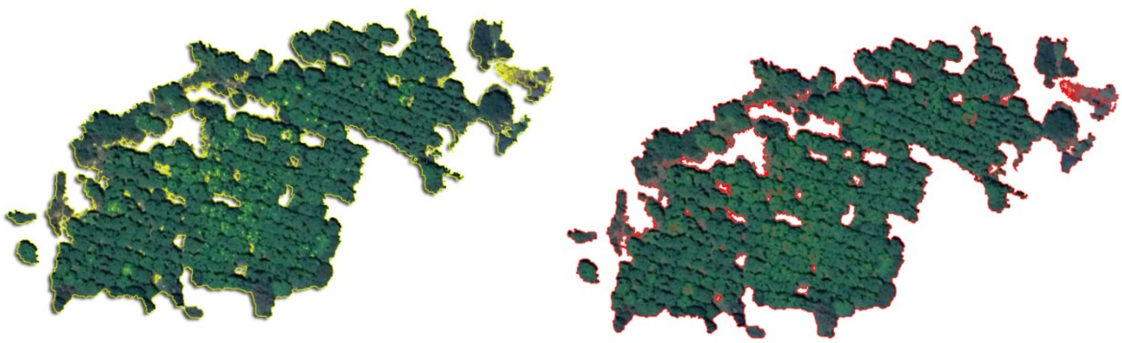

Figure 5. Delineating tree crown cover.

These patches were segmented and converted to polygons to project the measurement and area in total. After refinement and post-processing, the tree crown cover produced sharp-edges and sharp corners projecting a more accurate tree crown cover.

4.3 Final Crown Cover of CLSU

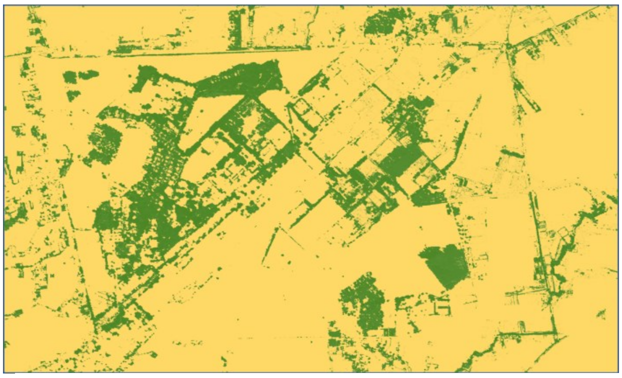

Figure 6. Total tree crown cover.

Square meters	Square kilometers	hectares
1,434,082 m^2	1.434 km^2	143.4082 ha
CLSU	Tree Crown cover	Percentage
658 ha	143.4082 ha	21.79%

A total of 143.4082 ha of tree crown cover (21.79% of CLSU Area) was extracted from the satellite imagery. The computed crown cover using GIS included forest patches and individual trees.

4.4 Accuracy Assessment

The points gathered were validated using GPS, Trees present in the map were checked on the road which will provide efficient data and accuracy of the trees classified in the application. A total of 492 points from the field data were considered trees and shrubs and offered a 98.4 % accuracy of data.

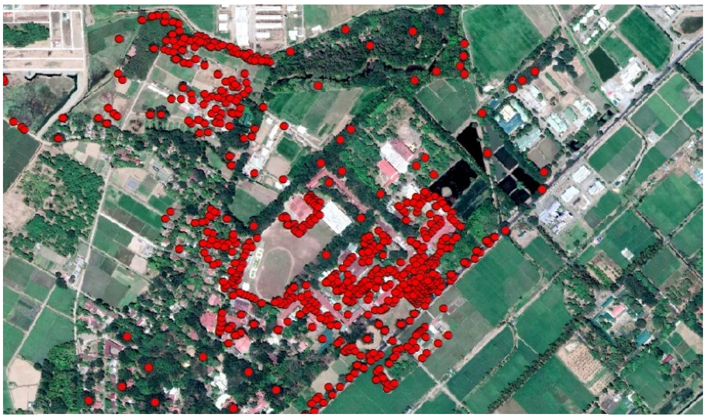

Figure 7. Ground survey of trees

Generated	Field validated
500 points	492
8 points	Shrubs and tall crops
Tree crown observed	Underlying covers
Shadow area computed by GIS	225,249 sqm
Tree shyness spacing	Added to the generated crown cover
Tall crops and other shrubs/plants	Unknown percentage or area which can be added as crown cover

Crown cover of the pine tree became larger in surface area covered due to the leaning effect of the tree. Tree shyness as limiting factor for accuracy due to spacing of individual trees and this area covered were included to the total area of tree canopy cover. Overall, the tree crown cover will be lesser in total in reality because of the additional area added to the crown cover.

4.5 References and/or Selected Bibliography

References should be cited in the text, thus (Smith, 1987b), and listed in alphabetical order in the reference section. The following arrangements should be used:

4.6 Future use of generated data

- Can be used to assess plant/tree health using crown cover area/diameter
- Can be used for estimating carbon storage/sequestration potential in the area
- Assessment of ecological importance of the area (CLSU)
- Land cover and land use map
- Biomass estimation

4.7 GIS and Remote Sensing Tech

- Satellite remote sensing and GIS technology are useful for fast and efficient data acquisition
- The temporal and spatial resolution of the satellite imagery and ground truth information helped project and obtain better result.
- Further analysis of tree condition can be assessed

5. REFERENCES

1. Ke, Y., Quackenbush. L.J., 2011. A review of methods for automatic individual tree-crown detection and delineation from passive remote sensing. International Journal of Remote Sensing. 32(17): 4725-4747.
2. Lim, K., Treitz, P., Wulder, M., St-Onge, B., Flood, M., 2003. LiDAR remote sensing of forest structure. Progress in Physical Geography. 27: 88-106.
3. McPherson, E.G., Scott, K.I., Simpson, J.R., 1998. Estimating cost effectiveness of residential yard trees for improving air quality in Sacramento, California, using existing models. Atmos. Environ. 32, 75–84.
4. McPherson, E.G., Simpson, J.R., Peper, P.J., Xiao, Q., Wu, C., 2008. Los Angeles 1-Million tree Canopy Cover Assessment (No. PSW-207). USDA Forest Service Pacific Southwest Research Station, Albany, CA.
5. McPherson, E.G., Simpson, J.R., Xiao, Q., Wu, C., 2011. Million trees Los Angeles canopy cover and benefit assessment. Landsc. Urban Plan. 99, 40–50.
6. McPherson, G., Simpson, J.R., Peper, P.J., Maco, S.E., Xiao, Q., 2005. Municipal forest benefits and costs in five US cities. J. Forest. 103, 411–416.
7. National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center. 2012. "Lidar 101: An Introduction to Lidar Technology, Data, and Applications." Revised. Charleston, SC: NOAA Coastal Services Center.
8. Vaze, J., Teng, J., 2007. High resolution LiDAR DEM – How good is it? In Oxley, L. and Kulasiri, D. (eds) MODSIM 2007 International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2007. http://www.mssanz.org.au/MODSIM07/papers/12_s27/HighResolution_s27_Vaze_.pdf
9. Walton, J.T., Nowak, D.J., Greenfield, E.J., 2008. Assessing urban forest canopy cover using airborne or satellite imagery. Arboriculture and Urban Forestry. 34(6): 334-340.
10. Wang, K., Franklin, S.E., Guo, X., Cattet, M., 2010. Remote sensing of ecology, biodiversity and conservation: a review from the perspective of remote sensing specialists. Sensors. 10: 9647-9667.