MAPPING OF SUGAR CANE CROPS USING LIGHT DETECTION AND RANGING (LIDAR) DATA

Marife Kung Villareal [1*], Marlowe Edgar C. Burce [2]

1 Doctor in Engineering Program, University of San Carlos Talamban Campus, Nasipit,Talamban,Cebu and College of Engineering and Design, Silliman University, Dumaguete City, Philippines
mkvillareal27@gmail.com

2 Department of Computer Engineering, University of San Carlos Talamban Campus Nasipit,Talamban,Cebu, Philippines, mcburce@yahoo.com

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ABSTRACT

Sugar cane is one of the major agricultural crops in the Philippines. However, there is a problem in fully identifying areas with sugar cane because the plantation varies in its location and size as well. Large or small areas are scattered in different parts of the region. Sugar cane crops need to be identified so that it would be easier for the Sugar Regulatory Administration (SRA), a government agency that monitors sugar cane crops in the Philippines to identify the areas in case problem occurs especially if there are pest attacks in the plantation. It has been a challenge among agricultural technicians to find an effective means of identifying areas with sugar cane due to its wide range of coverage in a scattered manner. It is important for SRA to have a land cover classification map in order to monitor sugar cane areas in the country. The objective of this study is to develop a methodology to create a land cover classification map for sugar cane crops.

Remote sensing is one of the tools used in resource mapping in which LiDAR's elevation data are valuable to improve identification and delineation of remotely-sensed data. This tool is used to identify sugar cane in a particular area. To determine its extent and coverage in the study area, this study utilized orthophotos and LiDAR derived datasets and applied Object-based Image Analysis (OBIA) using Support Vector Machine algorithm. The classified image was then validated on site and the classification accuracy yielded 98.4%. Through the integration of the LiDAR data paired with orthophoto and the softwares used in the classification process and verification as well as doing the fieldwork using the handheld GPS, this study was able to demonstrate a method and create a land cover classification map in identifying the sugar cane crops and its growth stages.

1. INTRODUCTION

One of the sources of income in the town of Tuburan, Cebu is growing sugar cane crops. Tuburan is located 10°43'38.66" North Latitude and 123° 49'55.39" East Longitude in the province of Cebu, Philippines. It has a total land area of 29316 hectares. Shown in Figure 1 is the location of the study area.

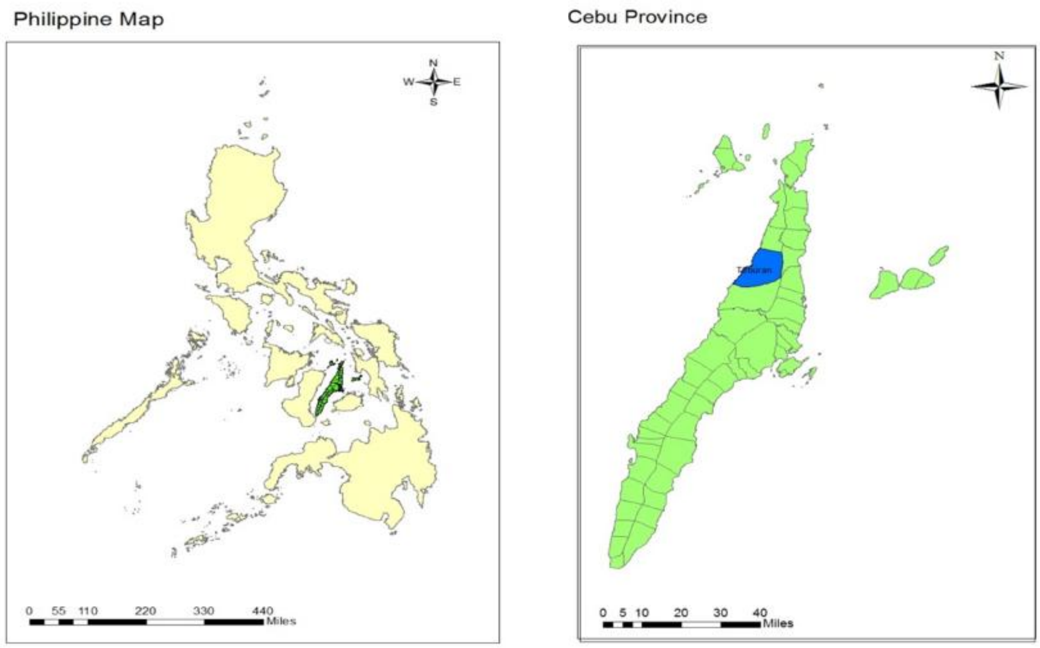


Figure 1: Study area location

Though Tuburan is just a small town, sugar cane is considered as one of the crops that augment the economy of the town. The study area is Barangay Mangga in the municipality of Tuburan. Aside from the study area, other areas and regions in the Philippines with sugar cane crops should be taken into consideration.

It is important to use technology for the agricultural development of a town, city or country. Even if Barangay Mangga is a small part of the Philippine archipelago where this study is conducted, however, it can make a difference for the country as a whole to create a land cover classification map for sugar cane. Studies show, that satellite imagery were used to develop a resource map or land cover classification map for agricultural crops. Moreover, it also shows the use of remote sensing applications and techniques for monitoring sugar cane crops. The application of advanced synthetic aperture radar (ASAR), alternating polarization precision (APP), horizontal transmit and horizontal receive (HH)/(HV) horizontal transmit and vertical receive data in mapping sugar cane growth area and retrieve the Leaf Area Index (LAI) of sugarcane crop use the polarization ratio of ASAR HV/HH data in the Nansha agricultural development area in the southeast part of Guangdong Province (Hui Lin, 2009)**.**

One of the methodologies that are efficient in the classification of sugar cane and other species is using OBIA. The Object-based Image Analysis and Data mining for mapping sugarcane with Landsat Imagery was used in Sao, Paulo Brazil (A. R. Formaggio, 2012.). A methodology was also developed for automatically mapping sugarcane over large areas using object-oriented classification of sugarcane using time-series middle-resolution remote sensing data based on AdaBoost in China where in two major techniques were used, the object-oriented method (OOM) and data mining (DM) which produced a map for the sugar cane planting area (Zhen Zhou, 2015).

A Data mining for sugarcane crop classification using MODIS (Moderate Resolution Imaging Spectroradiometer) sensor data, on board of the orbiting platforms of the International program EOS(Earth Observing System), led by NASA has generated processed data for global studies of vegetation (J.F.G. Antunes, 2011).

An original method for mapping cropping practices: crop type and harvest mode, was used in a sugarcane landscape of western Kenya using remote sensing data. They used ground survey for crop type and harvest (Betty Mulianga, 2015).

This study is also about the classification of cotton *(Gossypium hirsutum L.)* and sugarcane *(Saccharum officinarum L.)* crops based on spectral behavior of their plants. The hand held ground based remote sensing optical Multispectral Radiometer MSR5 was used for this purpose (Muhammad Shahzad shifa, 2011). Therefore remote sensing plays a very important role in the development of resource maps for agricultural crops. Sugar cane is one of the crops shown in the studies presented. This type of technology is not fully implemented in the Philippines. Today, tools such as GIS, LiDAR and other remote sensing applications were used. There are digitized map being used in the Philippines, only in areas where sugar cane production is big. Smaller areas like less than 30 hectares were not properly monitored. An example is the area of Tuburan, Cebu where this study is conducted. Remote sensing techniques especially LiDAR, can help monitor the sugar production in the country, estimate production in specific areas and monitor the sugar cane growth and production. It can also help to lessen the sugar importation of the country in the future. It is shown in this study the process and steps of object-based image analysis (OBIA) using Trimble eCognition version 9 and ArcMap version 10.1 software. The verification of sugar cane area is by ground survey using the Global Positioning System (GPS).

2. METHODOLOGY

The study area for this mapping is Barangay Mangga, Tuburan, Cebu. The Orthophoto image of Barangay Mangga is shown in Figure 2 and Figure 3, the shape file Map of Tuburan. LiDAR derivatives and orthophotos courtesy of Phil-LiDAR Research Center at the University of San Carlos Talamban Campus.

Figure 2 : Orthophoto of Barangy Mangga

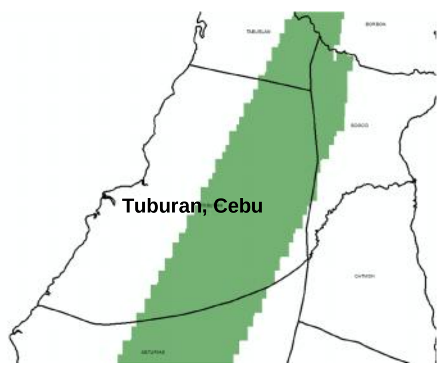


Figure 3 : Map of Tuburan, Cebu

LiDAR data, Global Positioning System (GPS), orthophotos and software like eCognition and ArcGIS were used to create a land cover classification map identifying the sugar cane crops. The LiDAR data shows a high spatial resolution imagery which is effective in accurately mapping crop species by object-based image analysis (OBIA) and has been developed and used in crop species classification (Conrad, Fritsch, Zeidler, Rücker, & Dech, 2010), (Duro, Franklin, & Dubé, 2012), (Peña-Barragán, Ngugi, Plant, & Six, 2011). The Methodological Flow is shown in Figure 4. The LiDAR derivatives and orthophotos have gone through merging process and layer mixing to come up with an image for segmentation.

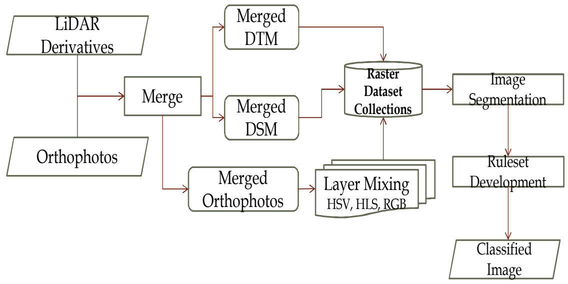


Figure 4: Methodological Flow

This study uses the object-based image analysis (OBIA) for classification. The workflow is shown in Figure 5 using the eCOgnition software. Four image layers were used in the object-based image analysis. These four layers are the following; Normalized digital surface model (nDSM) from LiDAR and LiDAR Red, Green, Blue (RGB orthophoto) for pre-segmentation process. Rule set were developed to classify high, medium and low elevation objects. The pre-segmentation process is done using the eCognition software. The first segmentation process is the quad tree based segmentation using nDSM and having a scale parameter of 2.0 meters. Next is the spectral difference segmentation with maximum spectral difference of 2.0 meters. After the segmentation, is the pre-classification process where high, medium and low objects are assign. High elevation objects have a mean threshold condition of Mean nDSM greater than 2.0 (nDSM (nDSM>2.0). Medium elevation objects have a mean threshold condition of Mean nDSM less than or equal to 2.0 and greater than or equal to 0.25 (nDSM<=2.0, nDSM>=0.25). The remaining objects less than or equal to 0.25 are considered as Low Elevation Objects. The result is shown in Figure 6 classifying the High, Medium and Low Elevation Objects. The verification of areas that have sugar cane crops is by ground survey using the hand held GPS.

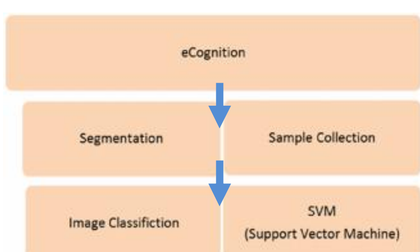


Figure 5: Workflow for Object-based Low Image Analysis

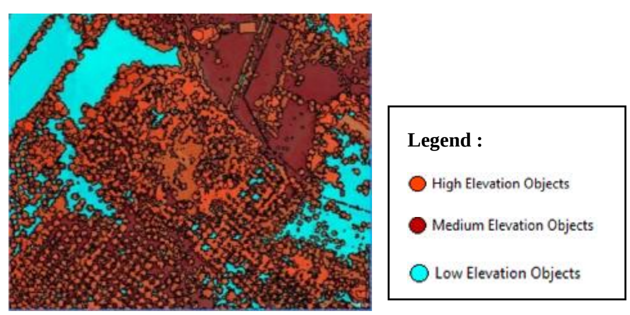


Figure 6: Pre-Segmentation Process classifying the High, Medium and Elevation Objects

A summary of the validation points from ground survey and the sugar cane growth stages are shown in Table 1. The density in the table refers to the population of sugar cane per unit area. An image map and the validation points of the sugar cane areas with the growth stages of Barangay Mangga is shown in Figure 7. The main objective for this study is to identify sugar cane crops.

Table 1: Validation points collected at Barangay Mangga, Tuburan. Cebu

VALIDATION POINTS	Sugar Cane Growth Stages	DENSITY
12	Tillering	Less Dense
8	Establishment	Less Dense
21	Ripening	Dense
21	Vegetative	Less Dense
19	Yield Formation	Less Dense

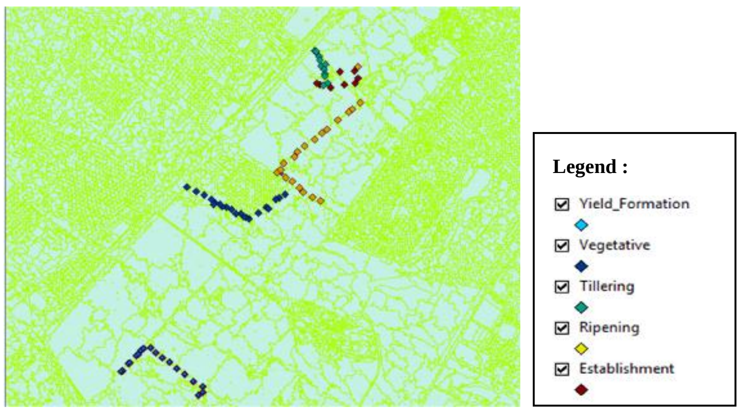


Figure 7: Image Map with the Validation points of Sugar cane Areas in Barangay Mangga,Tuburan Cebu

3. RESULTS AND DISCUSSION

3.1 Segmentation

3.1.1 High Elevation Objects

High elevation objects are segmented using the algorithm multi resolution segmentation with a scale parameter of 17.0 meters, shape is 0.2 and compactness is 0.5. The image layer weight used is the nDSM. End result is shown in Figure 8 the segmentation for High Elevation Objects.

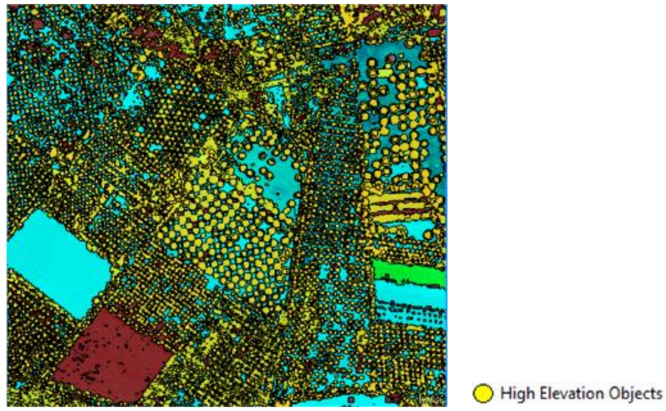


Figure 8: Sample Segmentation of High Elevation Objects.

3.1.2 Medium Elevation Objects

The Medium Elevation Objects are segmented using the same algorithm as in High Elevation but the image layer weights uses the RGB layers. The scale parameter is 40.0 meters, shape is 0.2 and compactness is 0.5. The threshold condition of nDSM<=2.0, nDSM>=0.25 are the Medium Elevation Objects in which sugar cane fall into this group. The other species not within this range are considered as Low Elevation objects. Results of Medium and Low Elevation objects are shown in Figure 9.

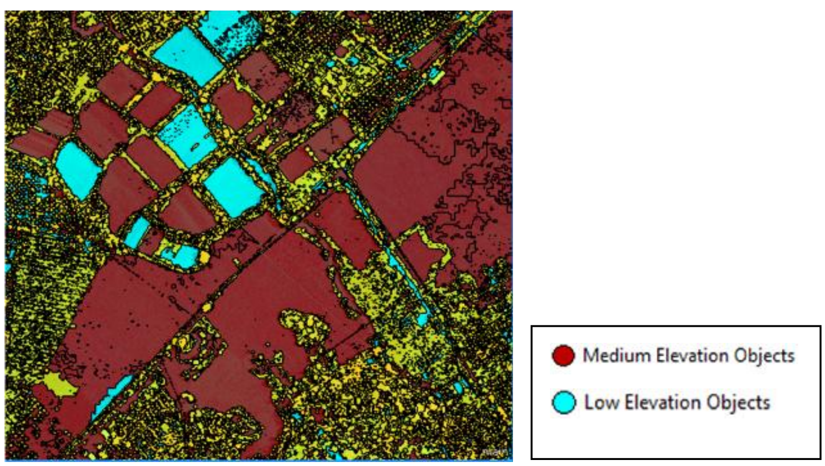


Figure 9: Sample Segmentation of Low and Medium Elevation Objects

3.1.3 Classification of Sugar Cane Crops

Sugar cane is considered as medium elevation objects. In the classification process, the Support Vector Machine (SVM) algorithm is used. The manual classification is needed for the refinement of the classified map. A rule set is established in the classification process using the algorithm, manual classification. The parameters are class: sugar cane and the brush size is 15.0. The orthophoto is shown in Figure 10 and the classified output of sugar cane crops is shown in Figure 11.

Figure 10: Orthophoto

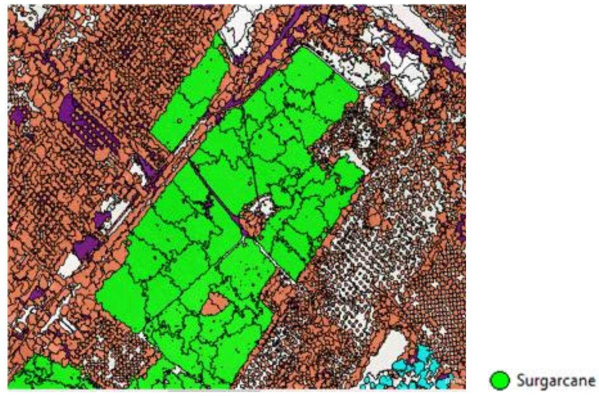


Figure11: Classified Sugar cane Crops

Through the classification process the areas where sugar cane is found are identified in the image with the support data of the ground survey using the GPS. Validation points are identified for the growth stages of sugar cane like establishment, tillering, vegetative, yield formation and ripening. The points were overlayed and merged together with the shape file of Barangay Mangga using ArcGIS to identify areas with sugar cane and their growth stages. The validation points that identify sugar cane and its growth stages are shown in the following figures; Figure 12 is the establishment, Figure 13 is the tillering, Figure 14 is vegetative, Figure 15 is yield formation and Figure 16 is ripening .

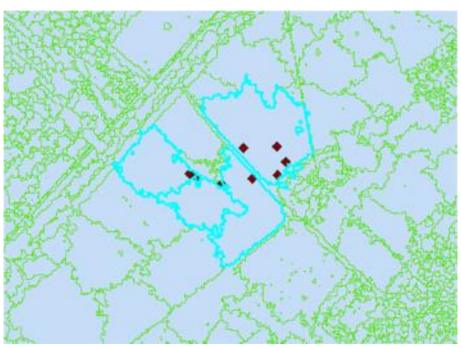


Figure 12: Establishment Growth Stage

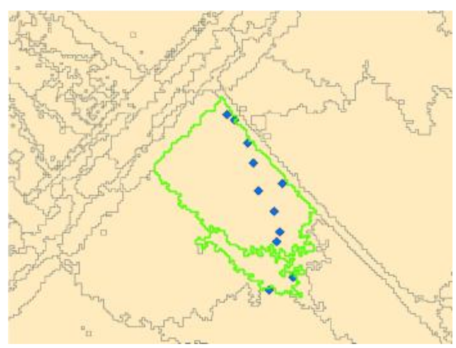


Figure 13 : Tillering Growth Stage

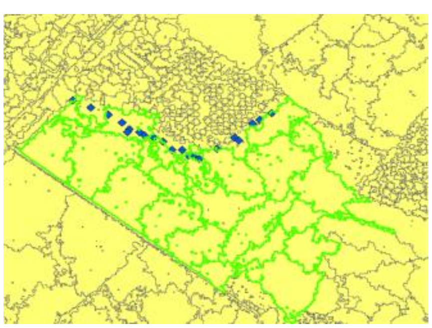


Figure 14: Vegetative Growth Stage

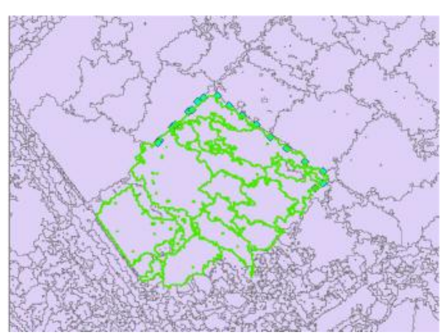


Figure 15: Yield Formation Growth Stage

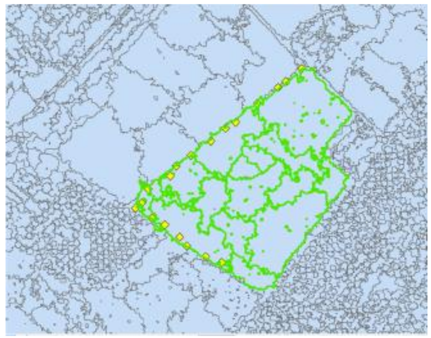
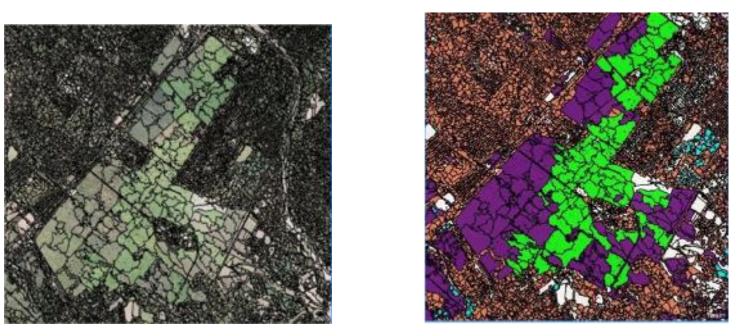


Figure 16: Ripening Growth Stage

3.1.4 Support Vector Machine (SVM)

The Support Vector Machine (SVM) is for classification algorithm. The process is done by sample collection in the rule set in eCognition for sugar cane and shrub. A classified image objects to samples algorithm is used with the class filter shrub and sugar cane. Since sugar cane is identified as medium elevation object, a rule set is made and assign class algorithm is used and the use class, is medium elevation objects. To train the SVM, the algorithm is classifier, operation is train and the configuration is SVM. Train is using the samples only. The Object features used are layer values mean which are RGB and nDSM and the Texture is texture after haralick feature, Gray-Level Co-Occurrence Matrix (GLCM) for Homogeneity and All directions uses the nDSM. For the classifier, the type is SVM, type of SVM kernel is linear and C SVM parameter is 200.0. Train has to be applied, so the algorithm used is classifier and medium elevation objects has to be identified in the class filter. The operation now is applied with the same configuration and the source is object based. With the SVM rule set being developed, it has a high accuracy which is 98.4% and the Kappa Index Analysis (KIA) of 0.12. The SVM end result is shown in Figure 17**,** with the accuracy assessment.



User Class \ Sample	Surgarcane	Shrub	Sum
Surgarcane	134	497	631
Shrub	1312	109771	111083
unclassified	0	0	0
Sum	1446	110268	
Accuracy			
Producer	0.09266943292	0.9954928	
User	0.2123613	0.9881890	
Hellden	0.129	0.9918275	
Short	0.06896551724	0.9837874	
KIA Per Class	0.08751539866	0.202	
Totals			
Overall Accuracy	0.9838069		
KIA	0.1221280		

Figure 17: Results of SVM Process and Table of Accuracy Assessment

3.1.5 Land Cover Classification of Sugar Cane

The mapping or land cover classification of sugar cane is done in ArcGIS software. Data from eCognition is exported to ArcGIS. It is being exported as raster file with content type as classification and the format is Erdas Imagine Images [*img]. In ArcGIS software, the raster file is converted to polygon. Then Dissolve process is performed in ArcGIS and is used for the polygon. The final output is shown in Figure 18.

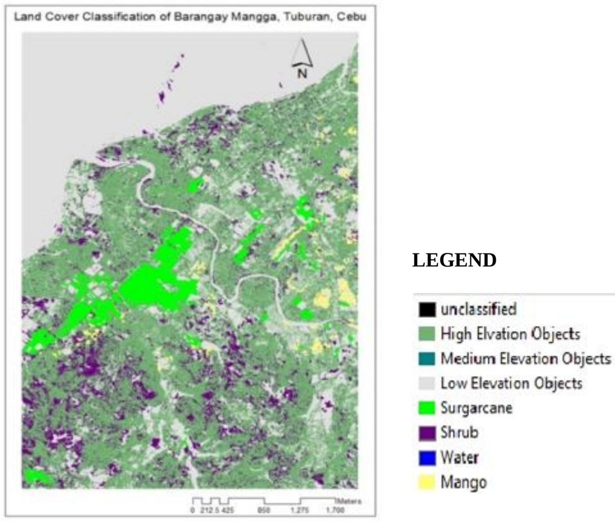


Figure 18: Land Cover Classification of Barangay Mangga, Tuburan Cebu

4. CONCLUSION

The processes used in the eCognition and ArcGIS software with the LiDAR data, orthophotos, field work and ground survey with the handheld GPS shows an output of the land cover classification map that identify the area of sugar cane plants in the study area. Using the SVM, the overall accuracy is 98.4%. Areas with sugar cane plantations in the Philippines can now be identified regardless how small the area is. Developing the skill in using the tools for this study is recommended to be able to produce more accurate results and eventually estimate the crop yield per hectare of plantation to improve the sugar production.

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