USING OBJECT BASED IMAGE ANALYSIS IN EXTRACTING OFFSHORE AQUACULTURE FEATURES IN VICTORIAS CITY, NEGROS OCCIDENTAL

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ABSTRACT: The Philippines' huge coastal area provides a wide array of different fishing mechanisms such as offshore aquaculture and nearshore fish corrals. The latter are very apparent in the coast of Victorias City, Negros Occidental. Fish corrals are stationary fishing structures that are usually constructed in areas that has moderate currents and are known to be rich fishing grounds. The fish corrals in the coast of Victorias City were extracted using Object Oriented Image Analysis. The Digital Terrain Model (DTM) was used in separating water from land while the Digital Surface Model (DSM) from LiDAR was used in creating the derivatives. The LiDAR derivatives used in the classification process were rugosity and slope of slope. Principal Component Analysis (PCA) was performed to reduce the redundancy across the bands. Rugosity which is the measure of surface roughness based from the ratio of surface area to planar area has been used to identify relatively tall structures from the water surface. The slope of slope which is the second derivative of elevation, was used to separate the structures in the water surface. PCA with three output bands was performed on the DSM, slope of slope and rugosity. The portion that was classified as water were segmented using multiresolution segmentation with heavier weights given to the first band of PCA. Since fish corrals are apparent in the PCA, contextual editing was done in order to remove other objects in the water area that are not fish corrals. The workflow used in this study has extracted 100% of the Fish Corrals in the coast of Victorias City. This study can also be the basis in creating suitability maps to guide what area is appropriate for building these structures, including the extraction of other various aquaculture in the Philippines such as Fish Pen, Fish Cages and etc.

1. INTRODUCTION

Aquaculture has played a great role in the development and survival of the coastal communities in the Philippines. In 2013 alone, the Philippine Fishing Industry has produced 4,705,413.29 metric tons of fish products; and 2,373,386.48 or about 50.44% of it is from Aquaculture (BFAR, 2013). Aquaculture in the Philippines is subdivided into two categories, those that are located in inland waters such as fish ponds and those that are located in marine waters such as fish corrals, fish cages and fish pens. The Philippines has 266,000 square kilometers of coastal territorial area where offshore aquaculture features such as Fish Corrals are located.

Fish Corral is a very predominant method of catching fish in the country. Fish Corrals as defined by IIRR (1995) in their book entitled Livelihood Options for Coastal Communities are as follows: Fish Corral or baklad is one popular method of catching fish along tidal flats, in coral reefs and mangrove areas. They are located in bays or near estuaries with moderate currents (not strong waves), affected by tidal fluctuations. This fishing gear is stationary and is constructed in areas known to be rich fishing grounds. The fish corral consists of a guiding barrier or leader made of bamboo slats with nylon nets connected to a 3.0 cm wooden post. The size of the corral varies from 30.0-100.0 m wide. It is shaped like an arrow tip, pointed towards the sea from shoreline. At the back of the leader is the playground, a semi-round shape made of the same materials as the leader. Connected to the playground is the terminal pound or bunt where the fish are trapped. The bunt is usually heart-shaped with a small opening. The nylon net of the leader and playground is fine-meshed with sizes of 1.27-1.9 cm opening. The terminal pound is similarly built as the playground, but with finer mesh nylon nets of 1.27-1.90 cm. This is to prevent small impounded fish to escape. Normally, the movements of fish are guided by tidal currents. At high tide, they travel towards the shore to forage and look for food. During low tide, they follow the current drifting towards the sea. If they happen to enter the fish corral contraption, they are finally trapped. (IIRR, 1995).

Fish corrals which is the focus of this study is very prevalent in the coastal cities and municipalities of Negros Occidental. Numerous quantities of fish corrals can be seen in the municipalities of E.B. Magalona, Manapla, & Toboso and also in some major cities such as Victorias, Cadiz, Sagay, Talisay and many more. In the orthographic photograph, the fish corrals appear like arrows. The leader in the fish corral looks like the shaft of an arrow while the playground and bunt appears to be like the head of an arrow. Here are sample images of the Fish Corrals as seen in the coast of Victorias City.

Figure 1. Aerial view of Fish Corral with visible leader from orthographic photo.

Figure 2. Aerial view of Fish Corral without visible leader from orthographic photo.

Fish corrals in the city of Victorias were extracted using LiDAR data only specifically the Digital Surface Model (DSM) and Digital Terrain Model (DTM). Derivatives such as slope of slope, rugosity and principal component analysis of different layers were also used in extracting the features.

2. MATERIALS AND METHODS

2.1 Workflow

Since fish corrals are huge and tall structures in the coastal area, it is highly possible to extract them using LiDAR data only. The figure below shows the workflow of how the Fish Corrals were extracted in the coast of Victorias City.

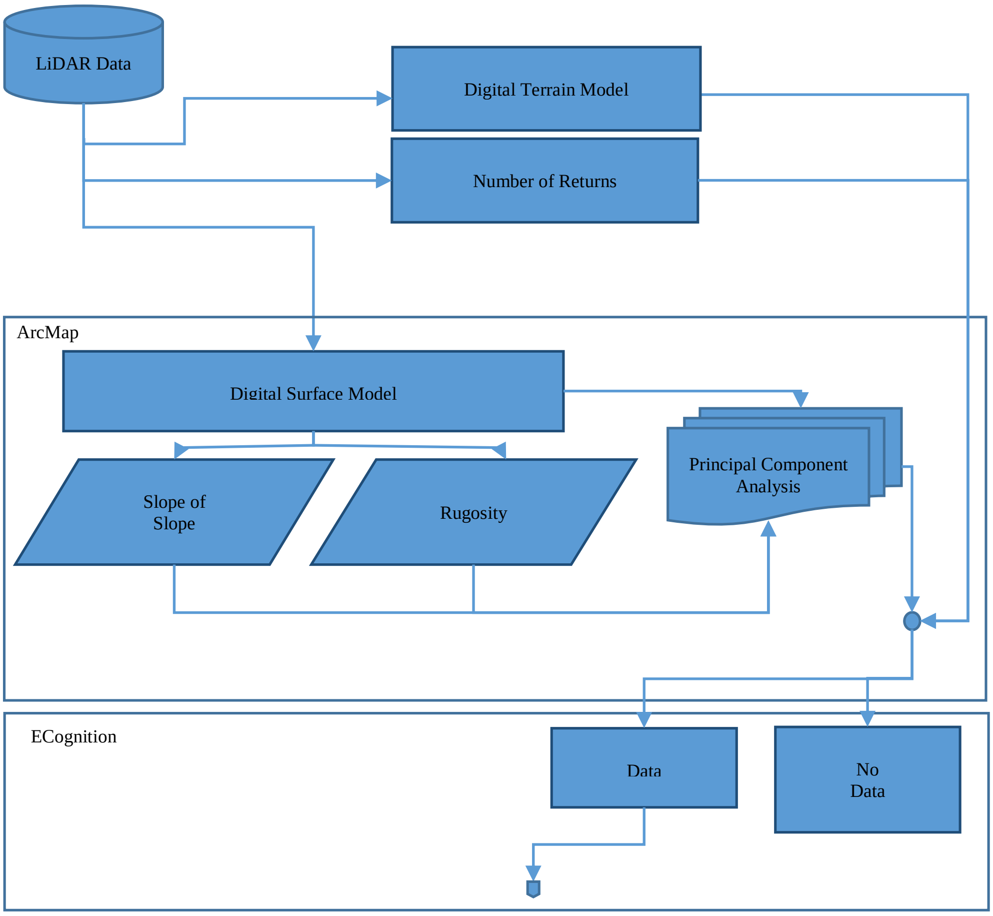

Figure 3a. Fish Corral Extraction Workflow (Part 1, continuation is at the next page)

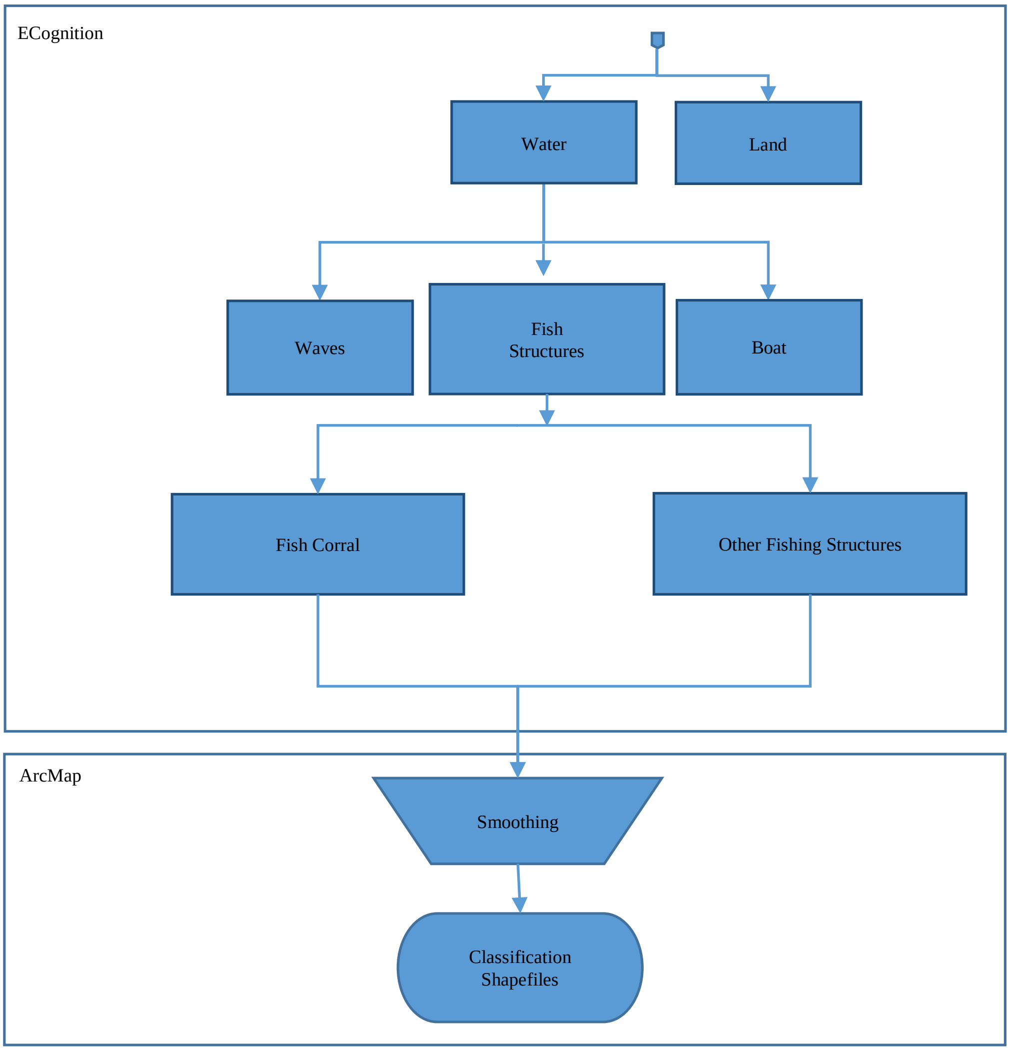

Figure 3b. Fish Corral Extraction Workflow (Part 2, continuation of the previous page)

Fish corrals are classified using LiDAR data alone. The layers used in processing were Digital Surface Model (DSM), Digital Terrain Model (DTM), Number of Returns and Principal Component Analysis (PCA). In order to get the PCA, two LiDAR derivatives namely slope of slope and rugosity were used. The two LiDAR derivatives were processed using ArcGIS.

The following layers: Digital Surface Model (DSM), Digital Terrain Model (DTM), Number of Returns, and Principal Component Analysis (PCA) were loaded in ECognition. The layers were classified according to which areas contain data and which areas do not. The area that contains data were further segmented and was divided between water and land. From the water area, the features that are candidate Fish Corrals were classified and contextual editing was done so as to not include the boats and other tall structures. The classification shapefiles were then smoothen using ArcGIS.

2.2 Pre-processing of Data

The LiDAR data was pre-processed by the UP Training Center for Applied Geodesy and Photogrammetry (UP-TCAGP) which has been conducting a research entitled “Nationwide Disaster Risk and Exposure Assessment for Mitigation” (DREAM) supported by the Department of Science and Technology (DOST) Grants-in-Aid Program wherein the Data Processing Component (DPC) of the DREAM Program produces digital elevation models from the aerial LiDAR surveys conducted by the Data Acquisition Component (DAC) over the assigned areas (UP-TCAGP, 2013).

2.3 LiDAR Derivatives

The Slope of Slope, Rugosity and Principal Component Analysis derivatives used in the extraction of Fish Corral in Victorias City were processed using ArcMAP version 10.1.

2.3.1 Rugosity: Rugosity is a measure of surface roughness and is the ratio of surface area to planar area. According to Jenness (as cited by UP-TCAGP, 2014) in his DEM Surface Tools manual, the surface area can be computed as follows:

(1)

$$Surface\ Area = \frac{Cell\ Size^2}{Cos(\ Slope * \frac{\pi}{180})}$$

The rugosity derivative was calculated using Raster Calculator (Spatial Analyst) in ArcMAP. The raster calculator Builds and executes a single Map Algebra expression using Python syntax in a calculator-like interface (ESRI, 2014). The resulting image can be seen in Figure 5 while the digital surface model can be seen in Figure 4.

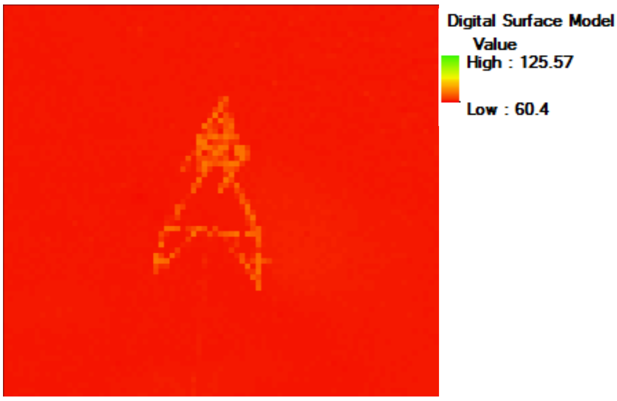

Figure 4. The Digital Surface Model of one Fish Corral

Figure 5. The Rugosity Derivative

2.3.2 Slope of Slope: The Slope of Slope which is in units of degrees of degrees is a second derivative of the bathymetric height (UP-TCAGP, 2014). The Slope (3D Analyst) in ArcMAP identifies the slope (gradient, or rate of maximum change in z-value) from each cell of a raster surface (ESRI, 2012). It calculates the slope of a raster by using its immediate neighborhood or a 3 x 3 window surrounding each cell.

Using the Slope (3D Analyst) function in ArcMAP, a slope derivative of the Digital Surface Model was created. After having the output, another derivative was created using the same method but instead of using the DSM as an input for the Slope function in ArcMAP, the previously processed slope was used instead. The resulting derivative is the slope of slope.

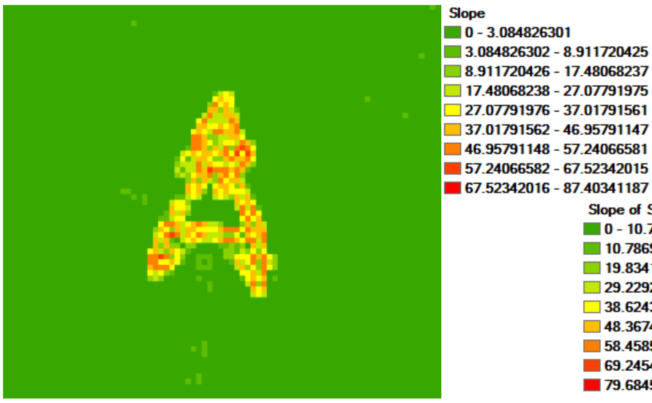

Figure 6. The Slope Derivative

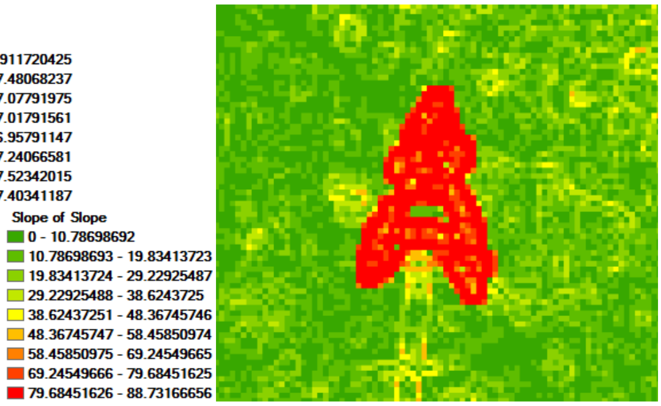

Figure 7. The resulting Slope of Slope derivative

The slope of slope derivative enhances the chances of extracting the Fish Corrals as one object. Based on the definition of slope of slope, each cell in the Digital Surface Model that has a high value has now scattered across the 3 by 3 region of the DSM's 3 by 3 region.

2.3.3 Principal Component Analysis: Principal Component Analysis (PCA) is a mathematical method which reduces the dimensionality of the original dataset by removing redundant information across the different bands (UP-TCAGP, 2014). The Digital Surface Mode, Slope of Slope and Rugosity derivatives were used as input for the Principal Components (Spatial Analyst) in ArcMAP. The said ArcMAP functionality performs Principal Component Analysis (PCA) on a set of raster bands and generates a single multiband raster as output (ESRI, 2014).

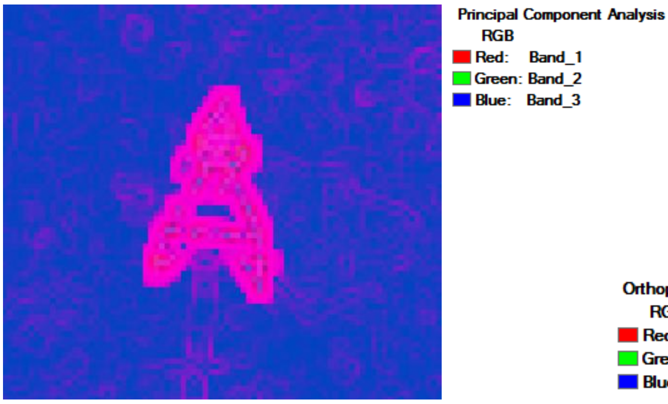

Figure 8. The PCA output layer.

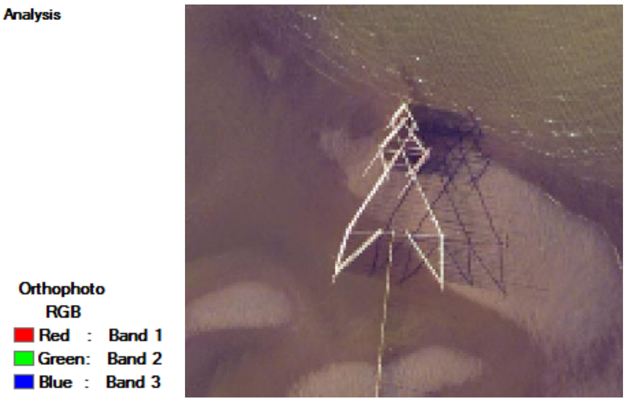

Figure 9. Orthophoto of the Fish Corral

As compared to the Digital Surface Model, the output from Principal Component Analysis shows higher chances of extraction if were are to check it based on the values of its three bands.

2.4 Image Processing

The image processing was done using ECognition Developer 9. The Digital Surface Model (DSM), Digital Terrain Model (DTM), Number of Returns (NR), Orthophoto and Principal Component Analysis. The following images are subsets of the actual data.

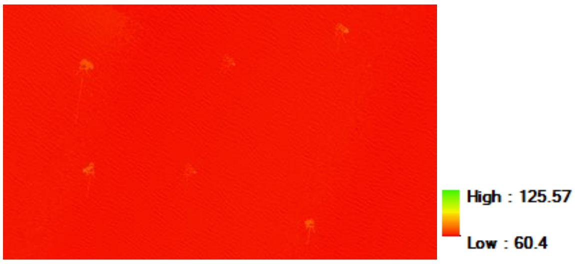

Figure 10A. Digital Surface Model

Figure 10B. Digital Terrain Model

Figure 10C. Number of Returns

Figure 10D. Orthographic Photo

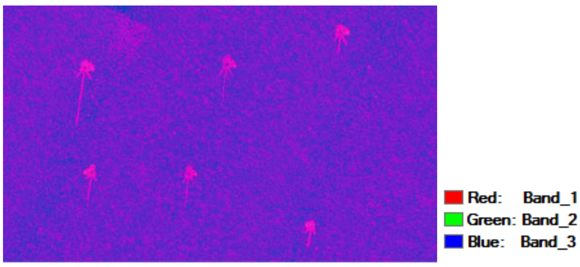

Figure 10E. PCA

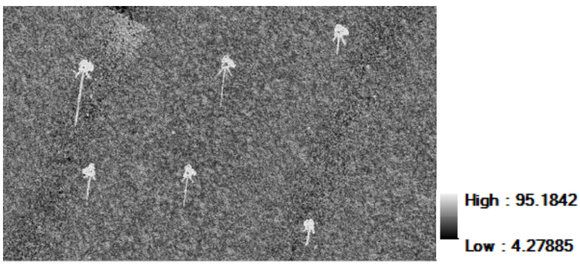

Figure 10F. PCA (First Band)

2.4.1 Segmentation: The first process of segmentation was using Multi-threshold segmentation. Areas with DTM less than or equal 61.6 were classified as water while areas with less than or equal to 0 DTM was classified as No Data. Areas that have DTM which is greater than 61.6 were classified as land. The Water area was further segmented using Multi-resolution segmentation with a scale parameter of 69. Its composition of homogeneity criterion for shape is 0.1 and compactness is 0.5. The image layer weights can be seen in the table below.

Table 1. Image Layer Weights

Image Layer	Weight
Digital Surface Model	2
Number of Returns	1
Principal Component Analysis (Band 1)	2
Principal Component Analysis (Band 2)	1
Principal Component Analysis (Band 3)	1

Since classification was removed after the segmentation, the image was reclassified using the same condition as the Multi-threshold segmentation mentioned above. Since some objects were still too big wherein a Fish Corral was in the same object with a huge portion of water, the image was then re-segmented using the same conditions as the Multi-resolution segmentation stated above but the minimum object size of 10. The image was then reclassified according to water, land and no data. Figure 11 below shows the segmentation of the image.

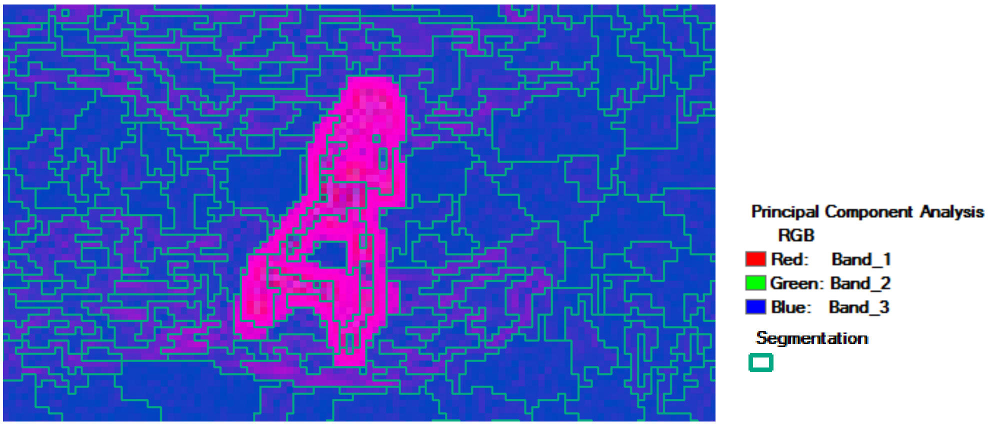

Figure 11. Image Segmentation

We can see that the portions with high values in the first band of PCA show as red were segmented according to its shape. A good segmentation can benefit and help ease the process of classification.

2.4.2 Classification: The Principal Component Analysis played a great role in classifying the Fish Corrals. In order to classify the fish corrals after the segmentation, water with mean first band of PCA which is greater than or equal to 75 were classified as tall.

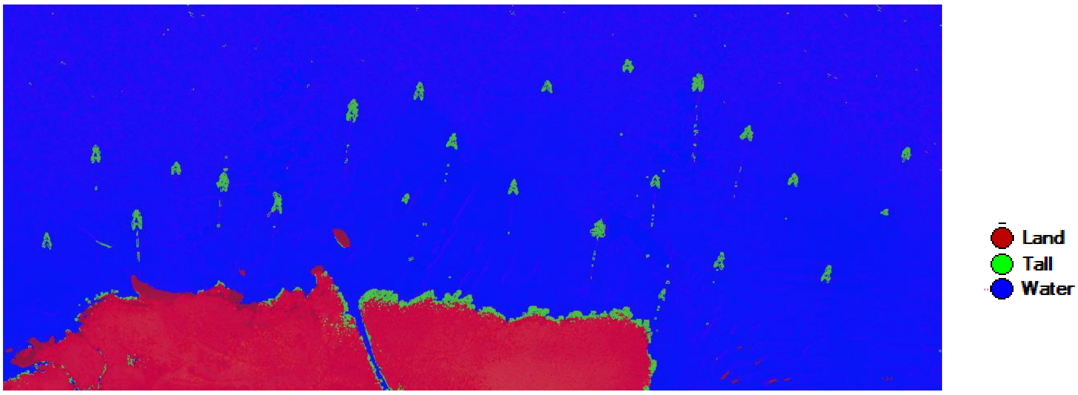

Figure 12A. Tall structures in Fish Corral Classification

Afterwards, all the tall objects were merged and all the water objects were also merged. All water objects with with relative border to tall objects is equal to one was classified as tall also and was merged with the remaining tall objects. All tall objects that are completely surrounded with water were then reclassified as candidates. The candidates class are the literal candidates for Fish Corrals.

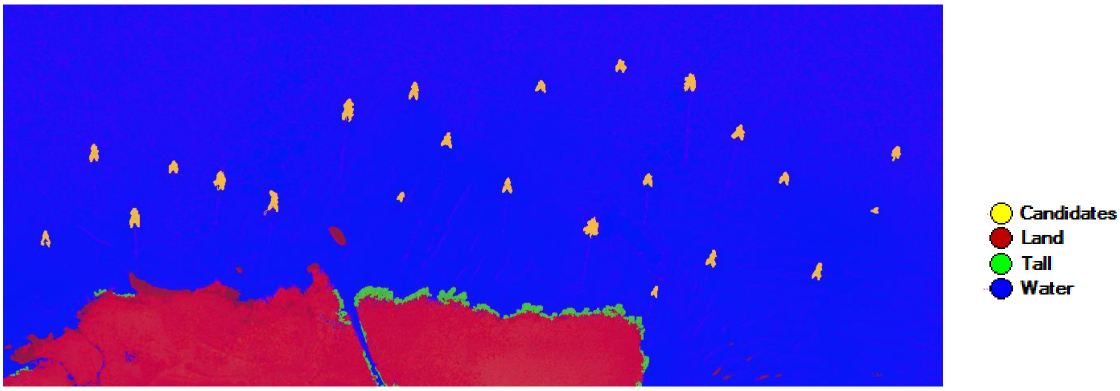

Figure 12B. Candidate Fish Corrals

2.4.2 Contextual Editing: In order to have better accuracy some contextual editing was done. Candidates with Mean DSM which is less than or equal to 61.45 and mean NR which is less than or equal to 1.024 were reclassified as tall. Furthermore, candidates with number of pixels which is equal to 1,628 was reclassified as tall.

3. RESULTS AND DISCUSSION

The fish corrals in the City of Victorias were already extracted with the use of LiDAR data only. Only manual accuracy assessment was done since no classifier was involved in the processing and also the object can easily be checked through visual inspection. Furthermore, there are no other objects other than Fish Corral and water hence, it wouldn't be enough to calculate separability or use machine learning.

3.1 Accuracy Assessment

In order to get a quantifiable accuracy for the map, validation points were made for each individual Fish Corral in the City of Victorias. The accuracy assessment was done manually but ArcMAP was used in selecting the points.

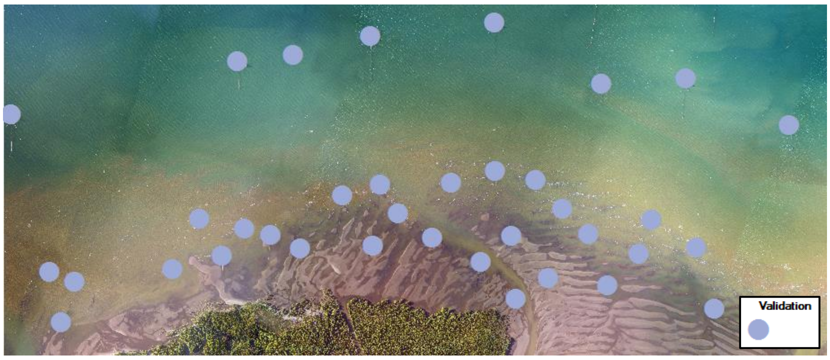

Figure 13. Validation Points

Table 2 below shows the summary of the Accuracy for the Fish Corral classification in Victorias City.

Table 1. Image Layer Weights

	Fish Corral	Others	Sum
Fish Corral	47	0	47
Others	0	0	0
Sum	47	0	47
Accuracy	1		

The overall accuracy is 100%. There were 47 validation points and there were also 47 extracted Fish Corrals in the City of Victorias.

3.2 Ouput Map

The image below shows the Fish Corral Map of Victorias City in Negros Occidental.

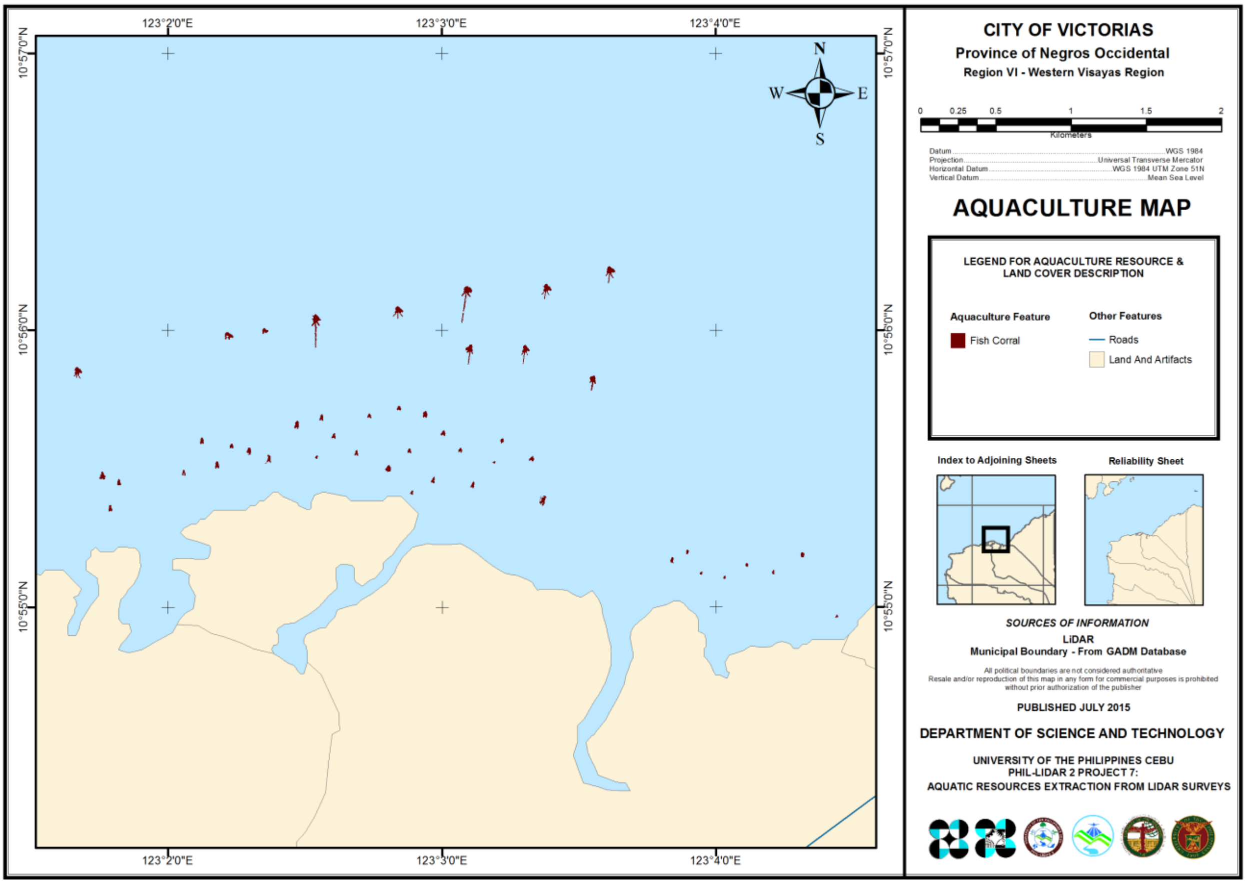

Figure 14. Aquaculture Map of Victorias City (Fish Corral Features Only)

4. CONCLUSIONS

The fish corrals in the City of Victorias were extracted using LiDAR data only with an accuracy of 100%. Furthermore, the Principal Component Analysis of the Digital Surface Model, Slope of Slope, and Rugosity derivatives has helped in making a straightforward approach in the extraction of fish corrals.

This study can greatly help in the extraction of other various aquaculture features in the Philippines such as Tidal Set Net, Fish Pen, Fish Cages and etc. Furthermore, this study can be used by the local government unit in order for them to track the status of these fish corrals and if whether or not they are following the rules and regulations imposed by the law so as to not exhaust and abuse the coastal resources. Identifying the location of the fish corrals can open up possibilities in suitability analysis for possible areas where the coastal communities can build new fish corrals.

5. RECOMMENDATION

In order to promote innovation and continuous research, there are a lot of areas where this research can be improved. First is that the city of Victorias has only one offshore aquaculture feature which is the fish corral and it might be harder to extract them when it comes to other municipalities or cities that has a more diverse set of offshore aquaculture. Second is that the leader part of the Fish Corral was not fully extracted, only the playground and the bunt were extracted. This might be due to the fact that the leader is basically shorter than the playground or the bunt itself since the leader only acts as a guide for the fish.

Lastly, the extraction of the fish corrals are height-based only which means that fish corrals who are submerged will not be detected unless the orthographic photo will be added in the workflow. However, submerged fish corrals might be abandoned already since if they are under the surface of the sea, the fishes can just swim above them and it would beat the idea of fish corral being a fish trap.

6. ACKNOWLEDGEMENTS

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