

NEARSHORE FISHERIES ZONING ANALYSIS IN THE NEGROS ISLAND REGION

Mark Anthony A. Cabanlit¹, Judith R. Silapan², Brisneve Edullantes², Ariadne Victoria S. Pada¹, Julius Jason S. Garcia¹, Roxanne Marie S. Albon¹, Rembrandt Cenit¹, John Jaasiel S. Juanich¹, Wilfredo C. Mangaporo¹, Jerard Vincent M. Leyva¹, Deo Jan D. Regalado¹

¹University of the Philippines Cebu Phil-LiDAR 2, Cebu City, Cebu, Philippines,

Email: mharkiecabanlit@gmail.com

²University of the Philippines Cebu, Cebu City, Cebu, Philippines,

Email: jsilapan@hotmail.com

KEY WORDS: LiDAR, Aquaculture, Fishing Structures, Coastal Resource

ABSTRACT: The Negros Island in Western Philippines is one of the regions in the Philippines that are rich in both land-based aquaculture and nearshore fish corrals. Negros Island is composed of Negros Occidental and Negros Oriental with 548.95 km² and 323.63 km², respectively of coastal area. The first part of this study was the extraction of the nearshore fish corrals in Negros Occidental using Object Based Image Analysis. The Digital Terrain Model (DTM) was used in separating water bodies from land while the Digital Surface Model (DSM) from LiDAR was used in creating the derivatives for classification which include rugosity and slope of slope. Principal Component Analysis (PCA) was performed to reduce the redundancy across DSM, slope of slope and rugosity. The feature extraction was followed by an initial suitability analysis based on weighted attributes of the extracted features in Negros Occidental. The attributes were used to reclassify the distance and depth. Euclidean distance was conducted around the surrounding area of ports, marine protected areas, reef locations and other monitored sites. The carrying capacity of the bodies of water was also considered by using the chlorophyll-a data. Each of the datasets was then reclassified with higher weights assigned to more suitable conditions depending on the criterion. A weighted overlay analysis was then applied to the different rasters in order to arrive at a suitability raster. The values contained in the raster are directly proportional to the suitability of the area in hosting the fish corrals. The whole process was then applied to the whole coastal area of Negros Island, successfully classifying suitable sites. The feature extraction component has implication on the monitoring of fish corrals when it comes to checking the correct positioning and distancing from other nearshore fisheries features and services like navigation while the site selection component will be used for determining suitable areas for the nearshore fisheries.

1. INTRODUCTION

The small-scale fisheries in the Philippines provides livelihood for much of the archipelago's coastal cities and municipalities and is also a significant supplier of the country's protein requirement (Pelayo & delos Angeles, 1993). Unfortunately, due to the inequitable commercialization of coastal resources and great deficiencies in parallel management, unsustainable fishing practices have now surfaced, with coastal fisheries now characterized by excess harvest and unethical and destructive fishing methods (Rhodes et al., 2011).

Negros Island is home to a lot of marine protected areas and two marine reservations: Sagay Marine Reserve and Danjungan Island Marine Sanctuary that are home to various species of fish and very abundant marine life. Due to its abundance, it is also very much prone to exploitation. One very prevalent form of nearshore fisheries in Negros Island are the fish corral or locally called 'payaw' or 'baclad'. These fishing mechanisms as defined by IIRR (1995): 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).

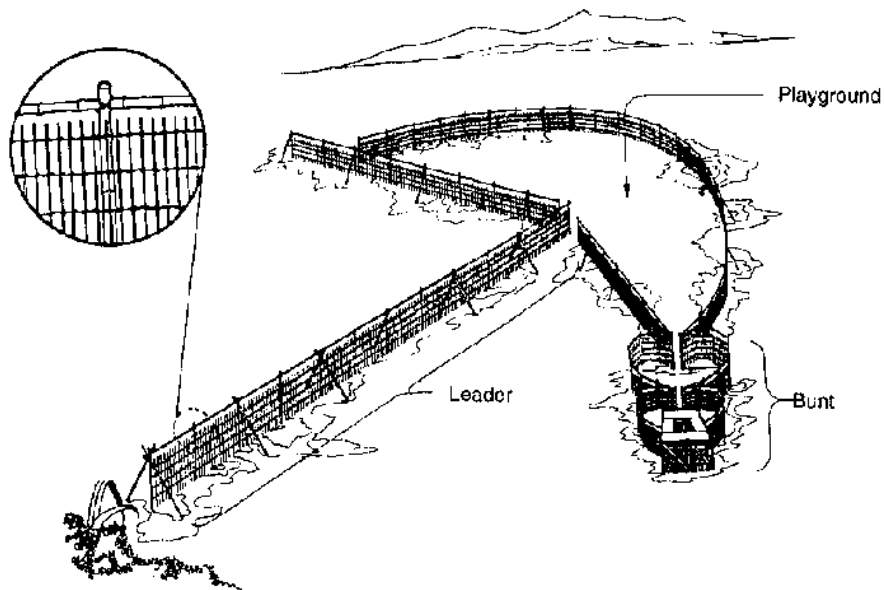


Figure 1. Parts of a Fish Corral (IIRR, 1995)

This fishing method is mostly popular in the Visayas Region of the Philippines and predominantly used in Negros Island and in Panay Island, unfortunately there are not that much studies relating to the suitability, basis for structure and guidelines in building of the said structures.



Figure 2. Orthographic Photo with Shapefiles of Fish Corrals in Victorias City, Negros Occidental

According to Travaglia, Profeti, Aguilar-Manjarrez, & Lopez (2004), the most common target species of fish corrals are the rabbit fishes (*Siganus* spp.) at sizes ranging from 6.8 to 19.4 cm with a modal length of 11.2 cm, this size range is considered too small as this species can potentially reached lengths of 40 cm. Other commercial species which are caught in fish traps and fish corrals are varieties of *Leiognathus*, *Penaeus* spp., *Scatophagus*, *Carangoides*, *Mugil*, *Rastrilleger* and crustaceans.

Records from the Negros Occidental School of Fisheries at Binalbagan showed a return on investment (ROI) of about 200 percent for fish corrals (IIRR, 1995). Possible exhaustion of marine resources using these fishing mechanism is not far off. With the current problem at hand, it is very timely to have a suitability analysis for nearshore fisheries in the country. Performing suitability analysis along the coast of Negros Island would not only be very beneficial to the fisher folks but it will also help in protecting the coastal resources by checking the chlorophyll values and using it as basis for the carrying capacity of the marine ecosystem. The suitability analysis should also take into consideration the preservation and protection of our marine protected areas, and reef locations. Furthermore, learning from the characteristics of existing fish corrals will also be very beneficial in creating criterions for suitable sites.

2. MATERIALS AND METHODS

2.1 Workflow

The diagram below shows the flow of the methodology of this study.

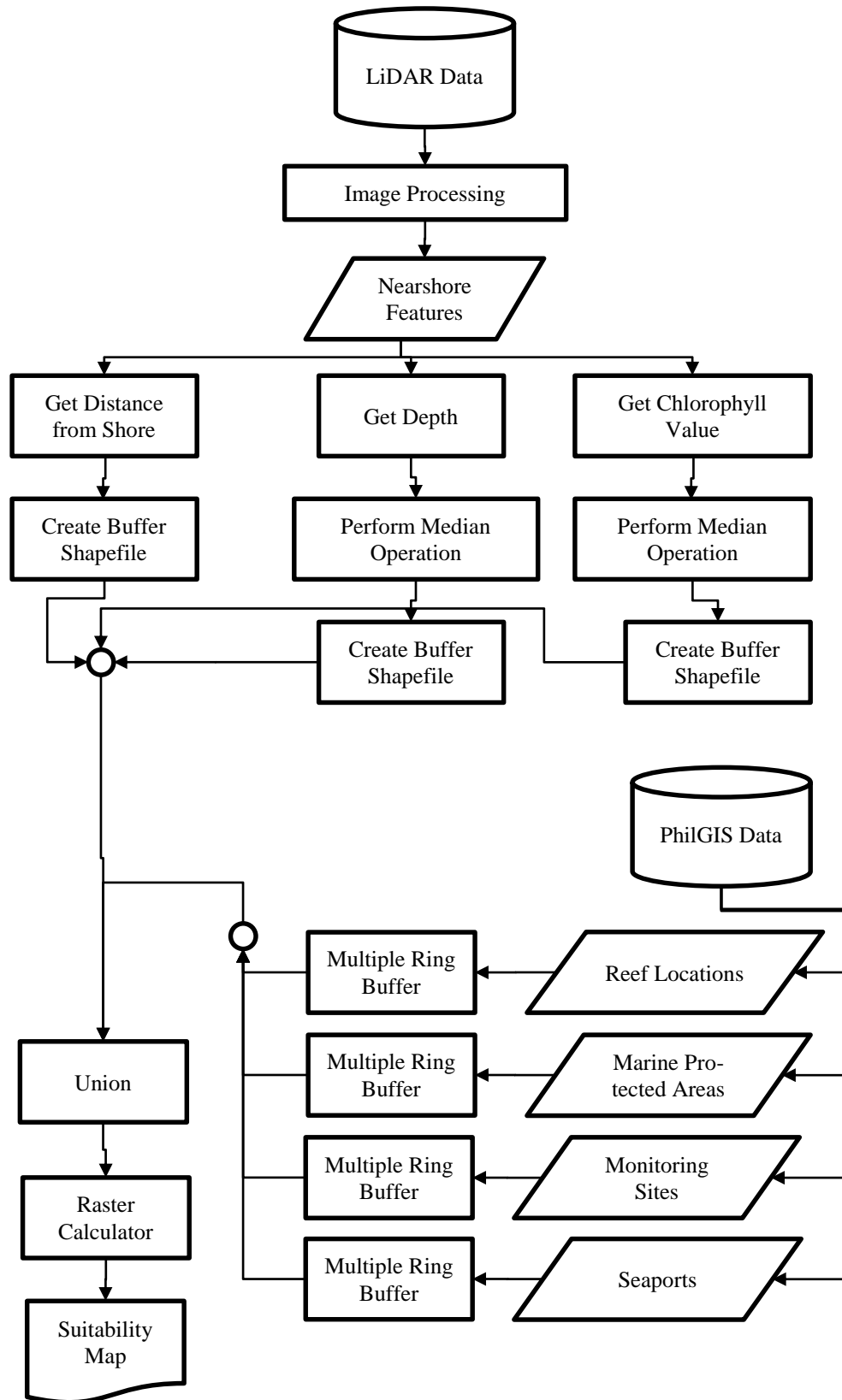


Figure 3. Workflow for Nearshore fisheries zoning in the Negros Island Region

The main process of this study was to use the extracted features from Negros Occidental as basis for creating a suitability map for the whole island including Negros Oriental. The fish corrals from Negros Occidental were analyzed and their attributes will be used as basis for the site selection.

2.2 Data Pre-processing

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 Study Site

The study was conducted in Negros Island. Negros Island is divided into two provinces: Negros Occidental and Negros Oriental.

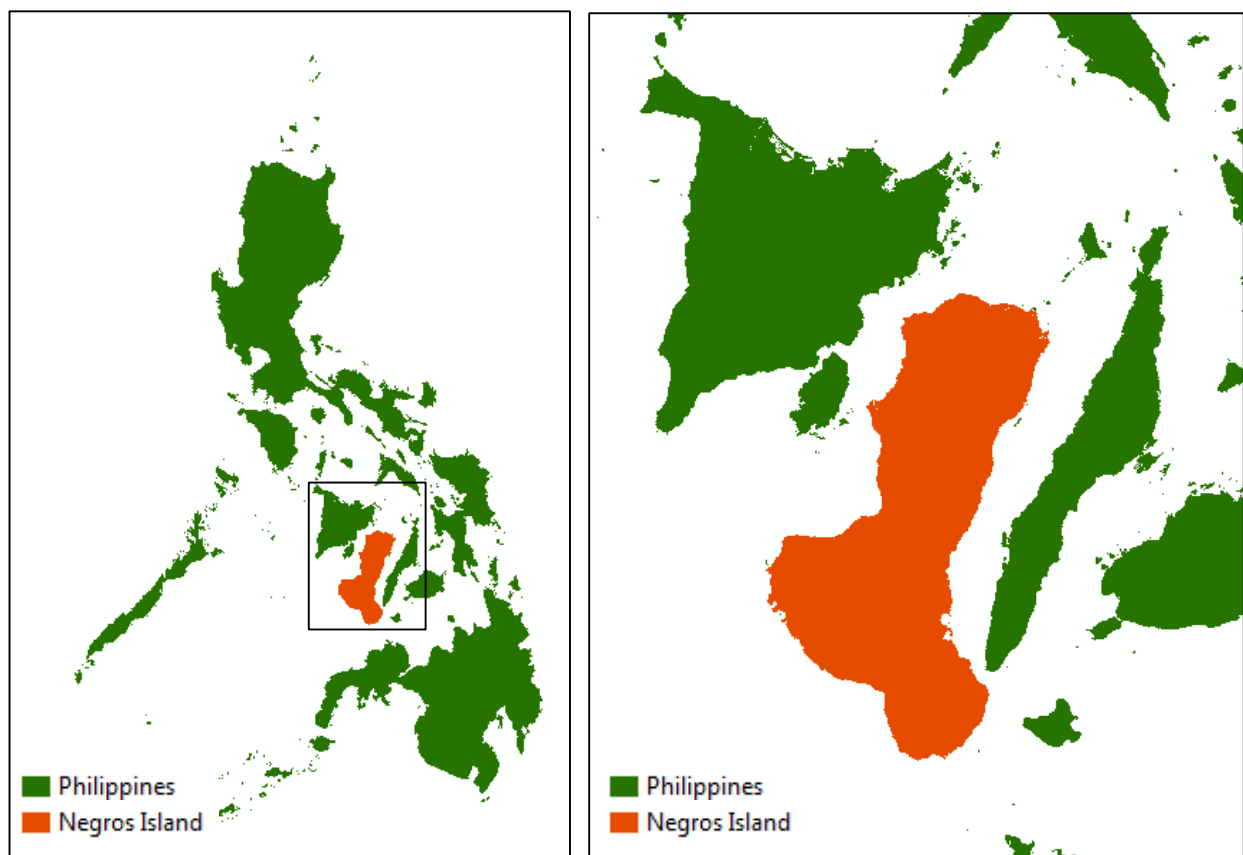


Figure 4. Negros Island

2.4 Fish Corral

There are a lot of Nearshore fishing methods in the Philippines but this study only focuses on fish corrals since they are widely used in the coastal cities and municipalities of Negros Occidental.

The fish corral shapefiles that were used in this study were extracted using the methodology of Cabanlit et.al. (2015). Fish corrals were extracted using Object Based Image Analysis. Cabanlit et.al. (2015) used Digital Terrain Model (DSM), Digital Terrain Model (DTM). Layers such as slope, slope of slope, and rugosity were also used. Principal Component Analysis (PCA) was performed on the DSM, slope of slope and rugosity. After segmentation the resulting raster was used to classify the fish corrals from the surface water. The values from the PCA have highly distinguish the fish corral in the Nearshore area. There were 622 fish corrals extracted in the province of Negros Occidental.

2.5 Distance

The distance from the fish corral object to the nearest land mass calculated using the Near function in ArcMap. The near function calculates distance and additional proximity information between the input features and the closest feature in another layer or feature class (ESRI, 2012). The feature with the largest value was then used to create a buffer for the Negros Island shapefile. The resulting distance was 2022.68 meters and was rounded off to 2025 meters. A 50 meter inward buffer was created in island's shapefile in order to eliminate some inaccuracies of the coastline. The output shapefile will then be used as a layer for the analysis. The area within the buffer are given a value of 5 while those that are not in the buffer were given 1.

2.6 Depth

There are no studies yet that has stated an exact suitable depth for fish corrals but by using the extracted features we can analyze as to which depth most of these fish corrals were built.

By using the feature to point function in ArcMap, each fish corral polygon was converted into a centroid point and then their bathymetry values were extracted. These values were then analyzed in excel and their medians were calculated in order to find the appropriate ranges for their suitability.

The median between all the fish corrals were first calculated then the medians of the upper and lower half of the data which was sorted from lowest to highest in depth was calculated. Then then upper and lower half of the upper half were then calculated for their medians and so as the upper and lower half of the lower half of the data. These were done up to 4 iterations to create ranges for the buffer with weights.

Table 1. Weights for Depth from Bathymetry

Weight	Lower Range	Upper Range
5 – Most suitable	-5 to -2	-2 to -5
4	-9 to -5	1 to 3
3	-12 to -9	3 to 6
2	-15 to -12	6 to 11
1 – Least suitable	-15 and below	11 to 12

The bathymetric data from PhilGIS (2016) was then converted into contour lines using Contour function in ArcMap. Each contour line from the ranges above was converted into polygons and weights were added. After completing all of the weights, all the polygons were merged into one shapefile.



Figure 5. Distance Layer

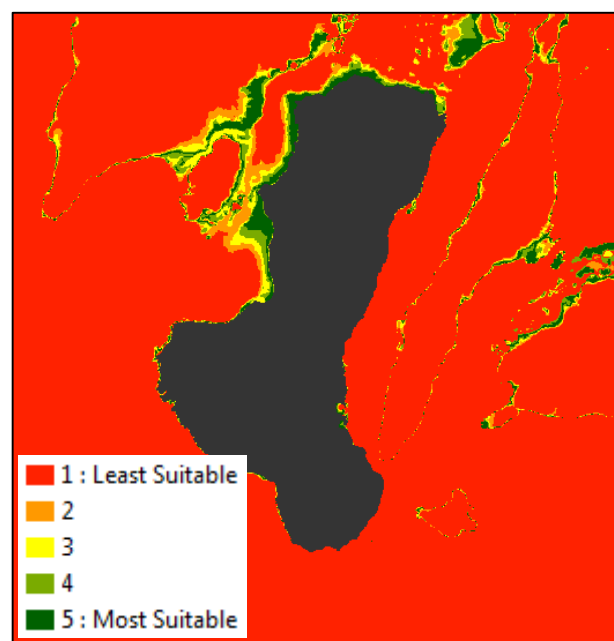


Figure 6. Depth Layer

2.7 Chlorophyll Concentration

The same median process were used to calculate the ranges for the chlorophyll value but the upper half of the chlorophyll concentration was directly considered as suitable. The table below shows the calculated values:

Table 2. Weights for Chlorophyll Concentration

Weight	Lower Range	Weight	Lower Range
5 – Most suitable	0.858147 and above	2	0.04599 – 0.50762
4	0.530837 – 0.858147	1 – Least suitable	0.046 and below
3	0.50762 - 0.530837		

After finalizing the weights the raster was then converted into a polygon, using the select by attributes in ArcMap, each polygon in the shapefile was assigned with their corresponding weights.

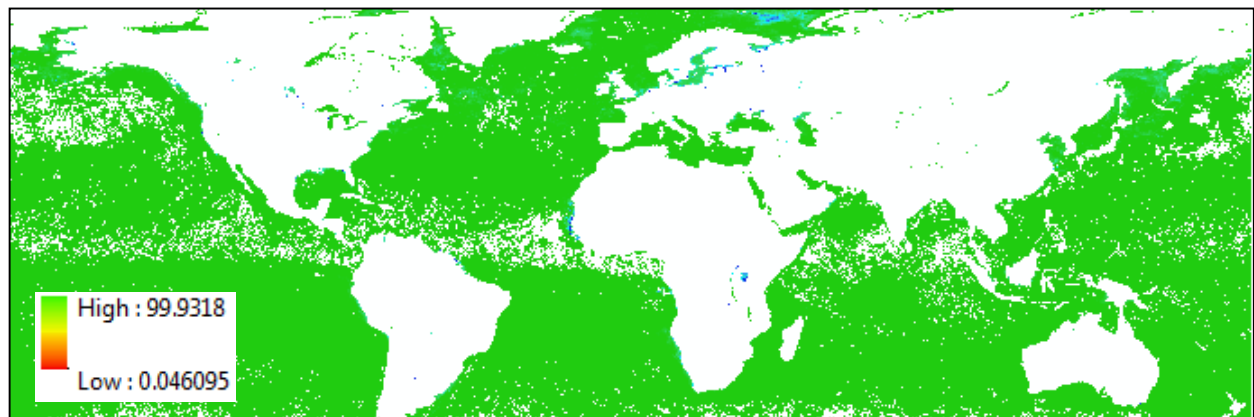


Figure 7. Chlorophyll Concentration in the World

According to NASA Earth Observations (2015), the chlorophyll concentration map shows where tiny, floating plants live in the ocean. These plants, called phytoplankton, are an important part of the ocean's food chain because many animals (such as small fish and whales) feed on them. Phytoplankton contain a photosynthetic pigment called chlorophyll that lends them a greenish color. When phytoplankton grow in large numbers they make the ocean appear greenish (NASA Earth Observations, 2015).

2.8 Reef Locations, Marine Protected Areas, and Monitoring Sites

The shapefiles for reef locations, marine protected areas and monitoring sites were acquired from PhilGIS (2016). Each site is represented by a point. In order to represent them as actual sites, a 1000-meter buffer was created around the point representing the feature. This buffer will have a weight of 1 which means that it would not be suitable to create a fish corral in the spot. Although it is very rich in aquatic resources, these areas are mostly restricted. The table below shows the weights and their buffer distances from the point.

Table 3. Weights for Buffered Distances from Protected Areas

Weight	Buffered Distance	Weight	Buffered Distance
5	10000	2	150000
4	25000	1	1000
3	75000		

This was implemented by using multiple ring buffer function in ArcMap. The buffered distances was used as input for the function and then the resulting shapefile was then reclassified into their corresponding weights.

2.9 Seaports

The seaports shapefile was acquired from PhilGIS (2016). Each port is also represented by a point. Each point is given a 10 kilometer buffer with weight is equal to 1 and 5 for the rest of the area. The weight are lowest on seaports since it wouldn't be good site for nearshore fisheries.

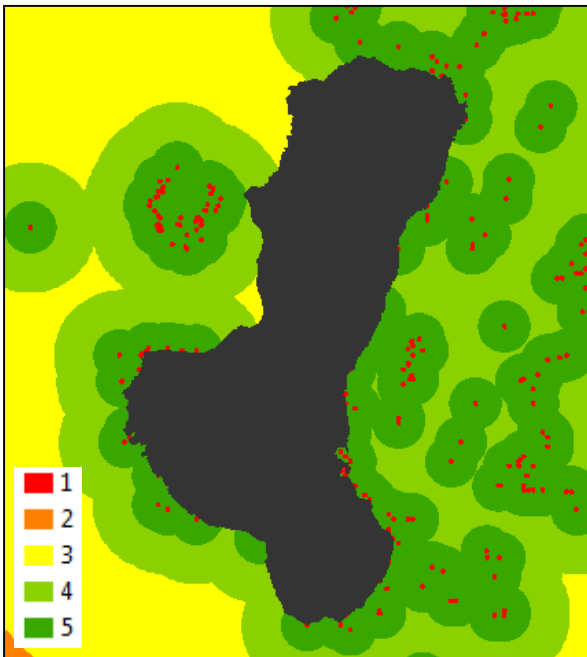


Figure 8. Reef Locations Layer

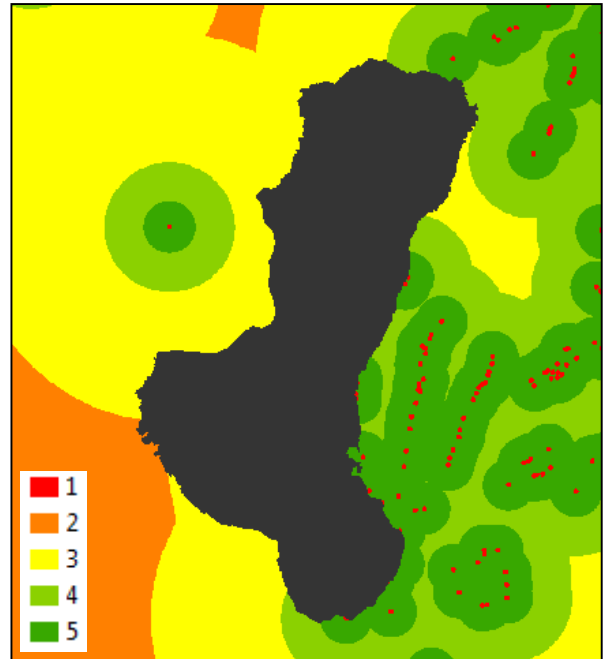


Figure 9. MPA Layer

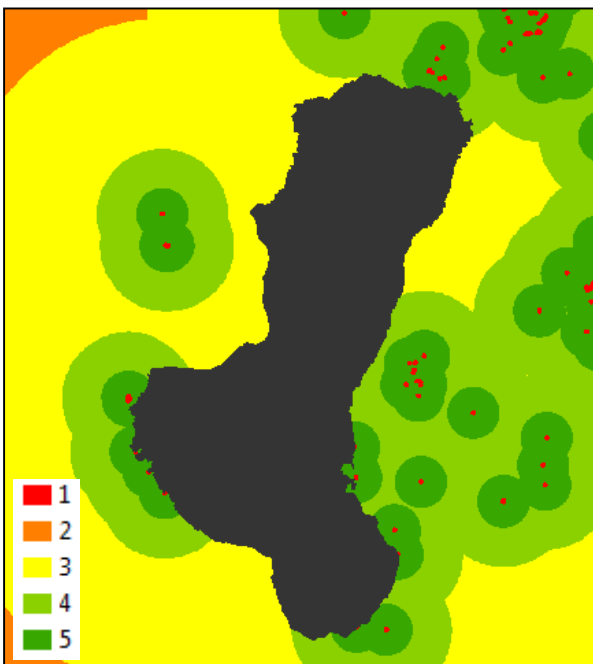


Figure 10. Monitoring Sites Layer

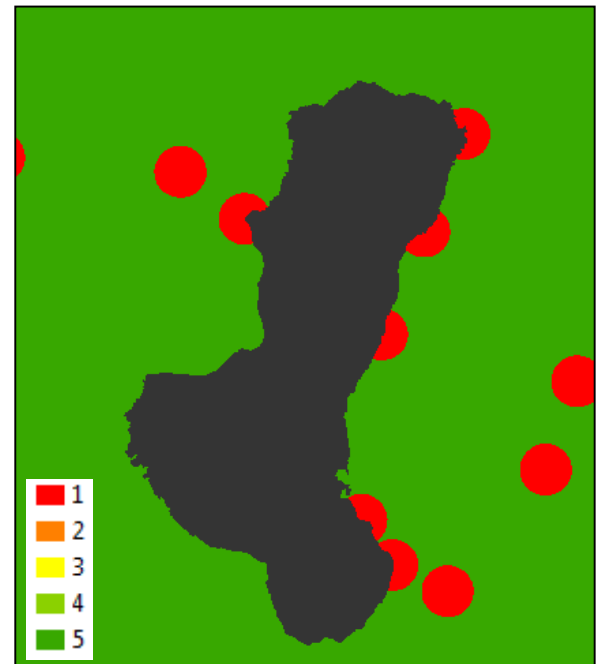


Figure 11. Seaports Layer

2.10 Union

After gathering all the necessary layers, a Union was performed among all the shapefiles. Raster calculator was then performed to get the suitability value for each polygon. The suitability was calculated by:

$$\text{Suitability}_x = \frac{\text{Distance}_x}{\text{Distance}_{max}} + \frac{\text{Depth}_x}{\text{Depth}_{max}} + \frac{\text{Chlorophyll}_x}{\text{Chlorophyll}_{max}} + \frac{\text{Seaports}_x}{\text{Seaports}_{max}} + \frac{\text{Reefs}_x}{\text{Reefs}_{max}} + \frac{\text{MPA}_x}{\text{MPA}_{max}} + \frac{\text{Monitoring Sites}_x}{\text{Monitoring Sites}_{max}}$$

7

The resulting shapefile will have a value ranging from 1 to 5, with 5 as the most suitable while 1 as the least suitable. These values will be used for our analysis of the suitable sites.

3. RESULTS AND DISCUSSION

3.1 Suitability Map

The resulting map shows a 2-kilometer buffer of Negros Island with polygons containing suitability values for each particular section of the coastal area.

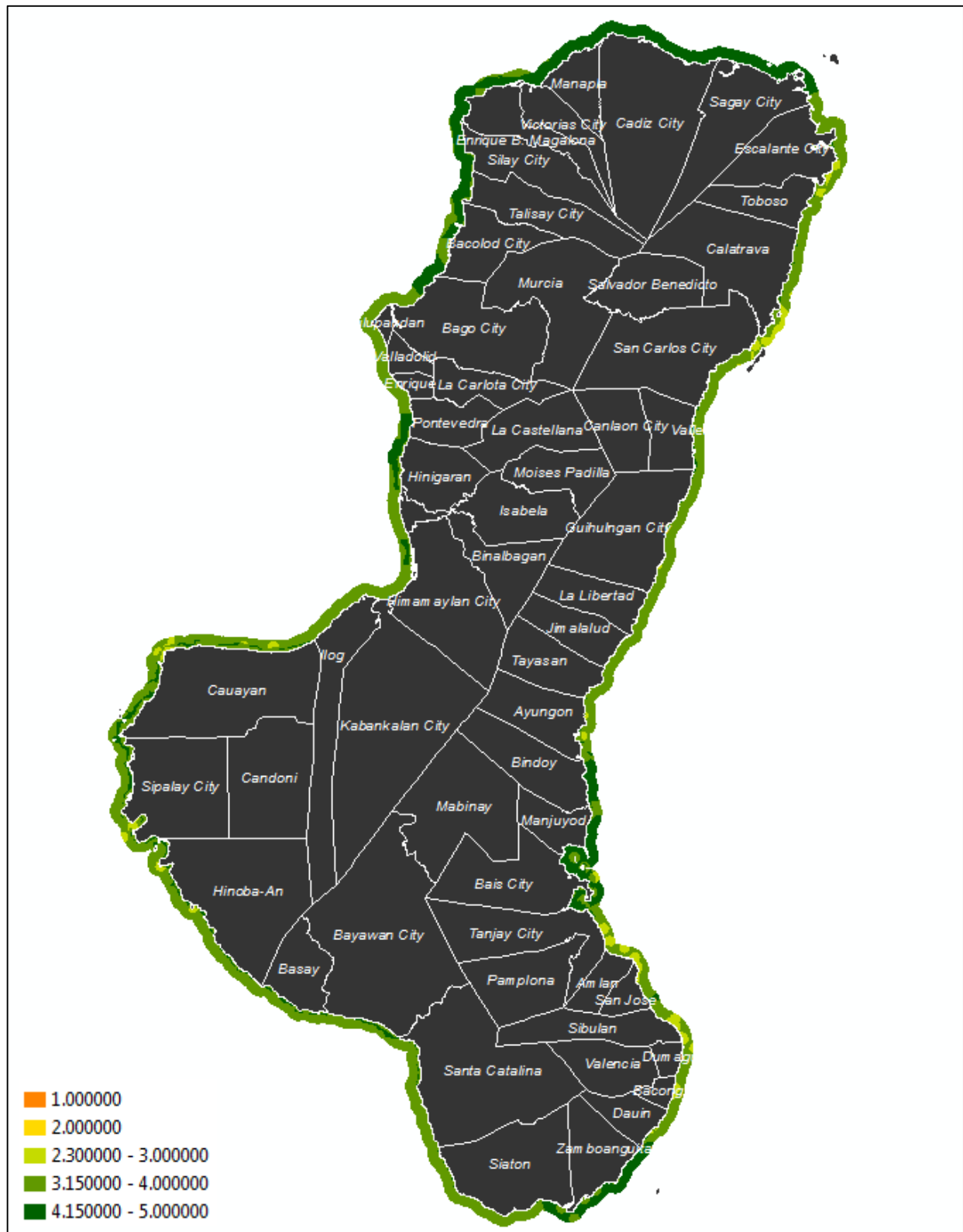


Figure 12. Nearshore Fisheries Suitability Map in Negros Island

3.2 Satellite Imagery

Here are some areas (specifically three municipalities) from the Suitability Map that yielded high suitability values. All images are courtesy of Google Earth (2016)



Figure 13. Coastal Features along Sagay City

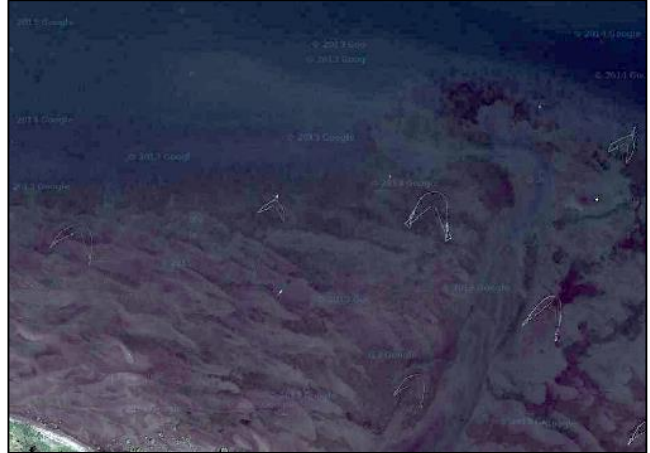


Figure 14. Coastal Features along E.B. Magalona

As we can observe in suitability map, the highly suitable coastal areas in the province of Negros Occidental has already a lot of pre-existing fish corral. These municipalities/cities include Sagay, Cadiz, Manapla, Victorias, E.B. Magalona, Silay, Talisay, Bago, Pontevedra and Hinigaran.



Figure 15. Coastal Section of Bais City

The municipalities/cities with higher suitability values in Negros Oriental were Manjuyod, Bais, Bindoy, Zamboanguita, Tanjay and a portion of Sison. The figure above shows the coastal area of Bais City. The city also has the largest fish pond area in the whole province of Negros Oriental.

4. CONCLUSIONS

The extracted fish corrals from Negros Occidental has been successfully used to create a suitability map for the whole Negros Island. The distance and depth analyzed from the extracted fish corrals, paired with the chlorophyll concentration was utilized to create the map. Furthermore, the monitoring sites, reef locations, marine protected areas and seaports were also beneficial in producing the suitability map. Along the coastal area of the Negros Island Region, there is 430.61 km² of nearshore area that highly suitable for fish corrals.

5. FURTHER STUDIES

For further studies, an interview with experts regarding the distribution of weights will be conducted. Furthermore, a chlorophyll raster with a higher resolution would be more helpful for the study. Actual areas for the monitoring sites, reef locations and marine protected areas would be more accurate as compared to the point shapefiles. There are a lot more factors that we can consider in the suitability analysis but at least for now, the methodology is already laid out and adding additional layers wouldn't be that complex to incorporate in the study.

6. ACKNOWLEDGEMENTS

This paper is an output of the Phil-LiDAR 2 project. We are grateful to the Department of Science and Technology (DOST) our funding agency and the Philippine Council for Industry, Energy and Emerging Technology Research and Development of the Department of Science and Technology (DOST- PCIEERD) our monitoring agency. We are also very grateful to the University of the Philippines Cebu for their support. We are also very much thankful to the local government units and the provincial offices in Negros Occidental for their assistance and support.

7. REFERENCES

Cabanlit, M.A., Silapan, J., Pada, A. V., and Garcia, J. J., 2015. Using Object Based Image Analysis In Extracting Nearshore Aquaculture Features In Victorias City, Negros Occidental. Retrieved September 13, 2016, from http://www.a-a-r-s.org/acrs/administrator/components/com_jresearch/files/publications/TU2-2-6.pdf.

ESRI (Environmental Systems Resource Institute), 2012. ArcMap 10.1. ESRI, Redlands, California.

IIRR, 1995. Livelihood Options for Coastal Communities, Retrieved August 20, 2015, from <http://www.nzdl.org/gsdImod?e=d-00000-00---off-0fnl2.2--00-0---0-10-0---0---0direct-10---4-----0-11--11-ky-50--20-preferences---00-0-1-00-0--4----0-0-11-10-OutfZz-8-00&cl=CL1.3&d=HASHad92f71605f7c1b3c2d988.6.2.1>=1>

Travaglia, C., Profeti, G., Aguilar-Manjarrez, J., & Lopez, N. ,2004. Mapping Coastal Aquaculture and Fisheries Structures by Satellite Imaging Radar. Retrieved September 1, 2016, from <http://www.fao.org/docrep/007/y5319e/y5319e.pdf>

Pelayo, R., & delos Angeles, M.S., 1993. The Nearshore Fisheries in Central Visayas, Philippines: An Impact Evaluation Report of CVRP-I. Retrieved September 1, 2016 from <http://dlc.dlib.indiana.edu/dlc/bitstream/handle/10535/5428/The%20Nearshore%20Fisheries%20in%20Central%20Visayas,%20Philippines%20An%20Impact%20Evaluation%20Report%20of%20CVRP-I.pdf?sequence=1>.

NASA Earth Observations , 2015. Chlorophyll Concentration (1 Month-AQUA/MODIS). Retrieved June 2016, from http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MY1DMM_CHLORA

PhilGIS, 2016. Country Basemaps. Retrieved September 1, 2016 from <http://philgis.org/general-country-datasets/country-basemaps>.

Provincial Government of Negros , 2016. Natural Resources Management. Retrieved September 1, 2016, from <http://www.negros-occ.gov.ph/development-agenda/negros-first-development-agenda/negros-first-natural-resources-management>

Rhodes, K.L., Warren-Rhodes, K., Houk, P., Cuetos-Bueno, J., Fong, Q. and Hoot, W., 2011. An Interdisciplinary Study of Market Forces and Nearshore Fisheries Management in Micronesia. A Report of the Marine Program of the Asia Pacific Conservation Region, The Nature Conservancy. Report No.6/11. 120 pp.

UP-TCAGP (University of the Philippines – Training Center for Applied Geodesy and Photogrammetry), 2013, Report on LiDAR Data Acquisition and Data Processing in the Cagayan de Oro and Iponan Floodplain, Disaster Risk and Exposure Assessment for Mitigation (DREAM), DOST-Grant-In-Aid Program, 47pp