USING REMOTE SENSING AND GIS TO PERFORM MONITORING OF FISH CORRALS AND SUITABILITY ANALYSIS ON POSSIBLE AREAS OF ERECTION IN VICTORIAS CITY, NEGROS OCCIDENTAL

Mark Anthony A. Cabanlit[1], Judith R. Silapan[2], Ariadne Victoria S. Pada[1], Florencio P. Campomanes V[1], Julius Jason S. Garcia[1]
[1]University of the Philippines Cebu Phil-LiDAR 2, Cebu City, Cebu, Philippines,
Email: mharkiecabanlit@gmail.com
[2]University of the Philippines Cebu, Cebu City, Cebu, Philippines,
Email: jsilapan@hotmail.com

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

ABSTRACT: This study was conducted to assist local government units a) monitor existing fish corrals within their jurisdictions and b) identify suitable areas for new establishments, in accordance to the standards stated in the Fisheries Act No. 4003. For the monitoring of fish corrals, the closest distance between each fish corral was determined first. The law imposes that each fish corral must be at least 200 meters apart and fish corrals that have the same owner must be at least 60 meters apart unless if they are not deeper than two meters. It was found that 36 out of 47 fish corrals are within 200 meters from each other's edges, while 100 % of all fish corrals are at least 60 meters away from each other. For the suitability analysis, each fish corral was given a 200 meter radius and these areas were removed from possible areas of establishment. The area was then delimited according to the depth of the water and distance from the land. Based on the interpretation of the extracted features from nine different cites/municipalities, it was found out that the fish corrals are located on areas that are at least 14 meters deep and at a distance of at most 2.6 kilometers from the land. Using the aforementioned conditions as basis for the area, random points were then generated that are at least 200 meters away from each other. On the first iteration, 53 points were generated which may represent fish corrals that can be established by the city of Victorias. Theoretically, 53 more fish corrals can be added alongside the 47 already existing in the area. For future studies, the status of marine habitats and the location of marine protected areas should also be considered in positioning the fish corrals.

1. INTRODUCTION

Aquaculture has been one of the main sources of both food and income in the whole Philippines. The fishing industry employed a total of 1,614,368 fishing operators nationwide of which the municipal fisheries sector accounted for more than one million (1,371,676) operators while the commercial and aquaculture sectors added some 16,497 and 226,195 operators, respectively (Census of Fisheries as cited in BFAR, 2013). 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). It is apparent that aquaculture is one of the Philippine fishing industry's most important source of aquatic products.

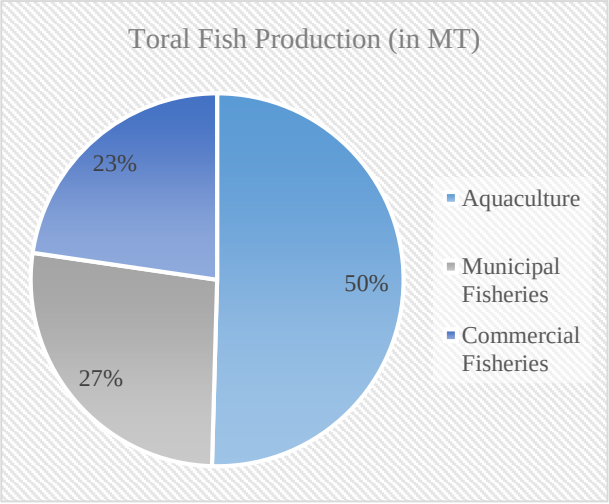

Figure 1. Total Fish Production by Sector in the Philippines

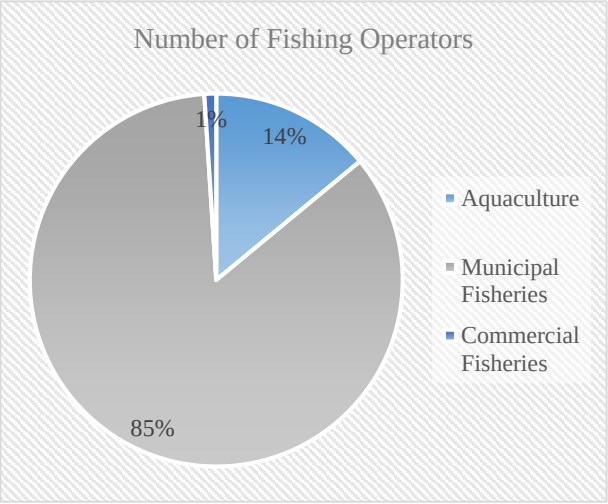

Figure 2. Preliminary data on the number of fishing operators by sector.

Unfortunately, in the past 20 years, the standing of the Philippines in world aquaculture production has dropped down from 4th place in 1985 to 12th place (FAO, 2015). The Philippines now produces only a little over one percent of world aquaculture production. The country's tragic decrease in aquaculture production calls for a need in improving and finding better and more comprehensive ways in sustaining aquaculture in the coastal communities. The advancement of the Philippine aquaculture industry in the future years is likely to be unmanageable unless new markets are established, market competitiveness is enhanced, and farming threats are lessened (Cruz as cited in FAO, 2004).

One way in helping the country create a sustainable aquaculture production is through the use of technology in creating suitability analysis for building aquaculture sites. Aquaculture production must be developed using new ways in areas that shows great potential such as Negros Occidental. According to the Fisheries Profile for the year 2013 published by the Bureau of Fisheries and Aquatic Resources, Region VI (where Negros Occidental is located) has produced 148,053.11 metric tons of fish for marine waters and 7,670.41 metric tons of fish for inland waters. Among the 17 regions in the country, Region VI has ranked second in terms of municipal fisheries production for marine fishing. In terms of Aquaculture production by culture environment Region VI has also ranked second in Aquaculture production in brackish water by producing 84,460 metric tons of fish. However, it is only ranked 9 for Aquacultures in Marine Waters producing only 408 metric tons of fish. With this we can say that Region VI has been one of the major producers of fish in the country.

The vast coast line of Negros Occidental if filled with numerous Aquaculture features but mostly composed of Fish Corrals. This study aims to create a suitability analysis of the Fish Corrals in the City of Victorias in Negros Occidental and at the same time, to perform monitoring of already erected Fish Corral based on their location if whether or not, they have met the specifications and regulations imposed by the law.

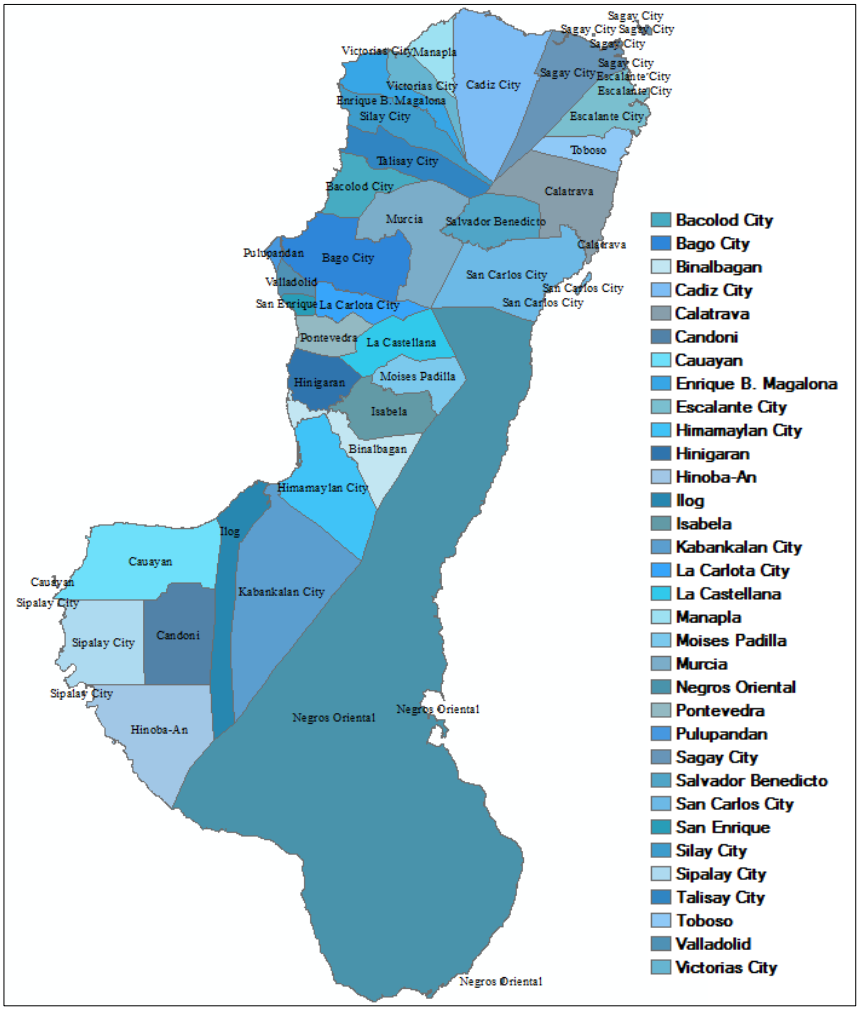

Figure 3. Negros Island

Finding areas suitable for Fish Corrals can help the coastal communities financially since it would give them a new

source of income. Records from the Negros Occidental School of Fisheries at Binalbagan in 1987 showed a return on investment (ROI) of about 200 percent and furthermore, very informal discussions with fishermen reveal rough estimates of about 300-800 percent ROI per year (IIRR, 1995). Finding areas where fishermen can build these structures would be beneficial to both the community and the local government unit.

2. MATERIALS AND METHODS

There are three main processes in the completion of this research, (1) Feature Extraction, (2) Monitoring and (3) Suitability Analysis.

2.1 Workflow

The workflow for creating performing monitoring and suitability analysis for the Fish Corrals in the city of Victorias is shown in Figure 4.

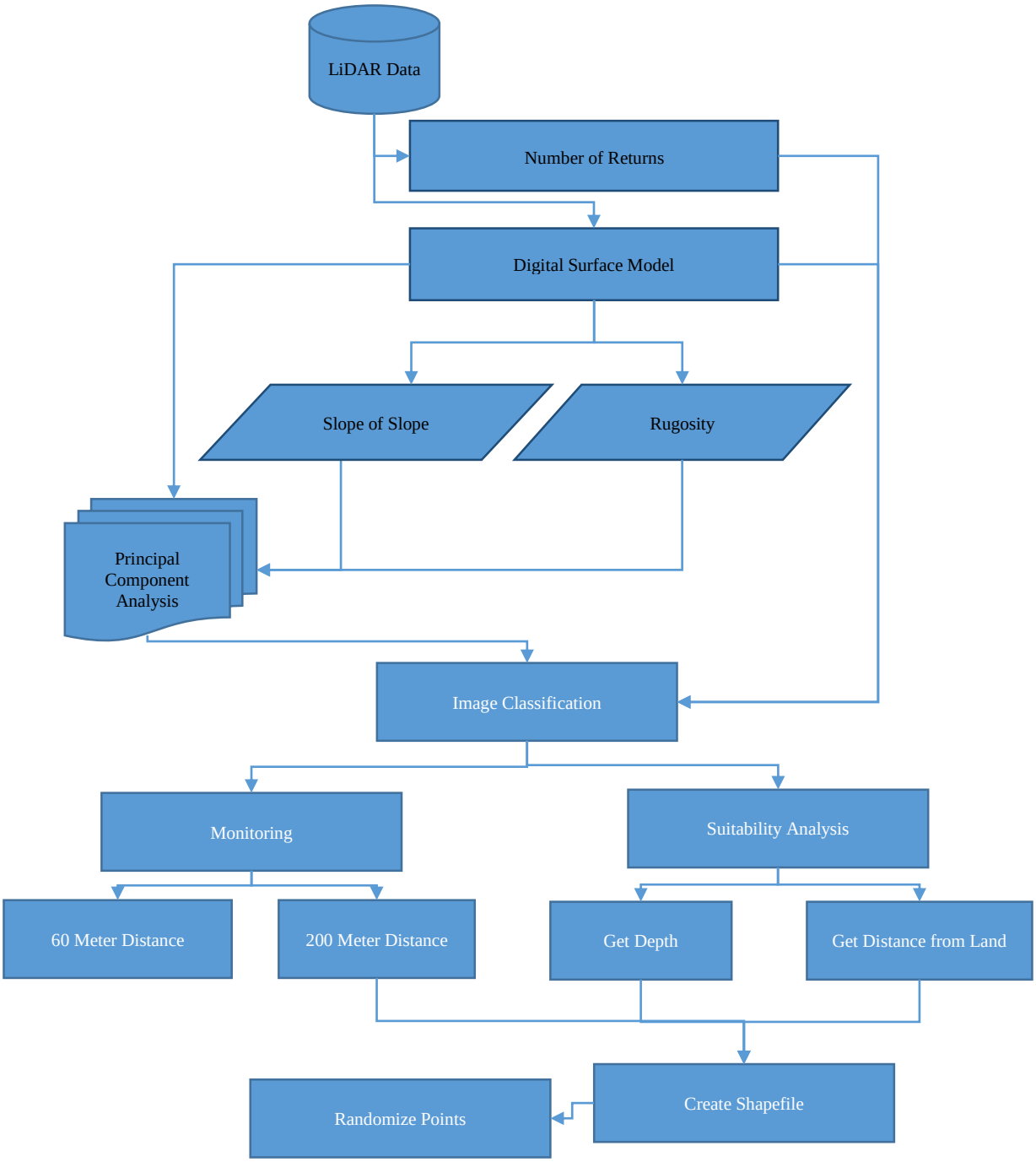

Figure 4. Workflow for Monitoring of Fish Corrals and Suitability Analysis on Possible Areas of Erection

Fish Corrals were extracted from 10 different cities/municipalities that contains the aforementioned aquaculture feature namely: Enrique B. Magalona, Hinigaran, Manapla, Pontevedra, Sagay, San Enrique, Silay, Talisay, Toboso and Victorias. Afterwards, the maximum distance and maximum depth among the fish corrals extracted across Negros Occidental was used in determining were to establish new fish corrals in City of Victorias. The distance between the fish corrals in Victorias City were also calculated to check if they have met the standards imposed by the law. Afterwards, random points were distributed across the suitable area to represent the theoretical fish corrals that can be added based on the analysis.

2.2 Source 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 Feature Extraction

The fish corrals were extracted using ECognition Developer 9. 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.

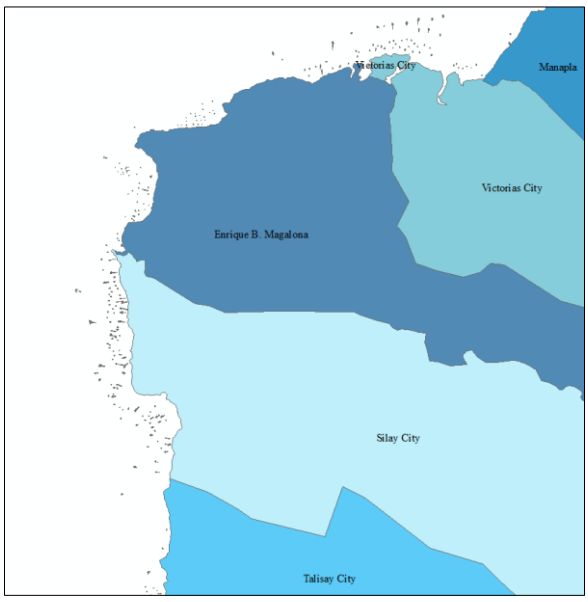

Figure 5. A subset of Negros Occidental with extracted Fish Corral features

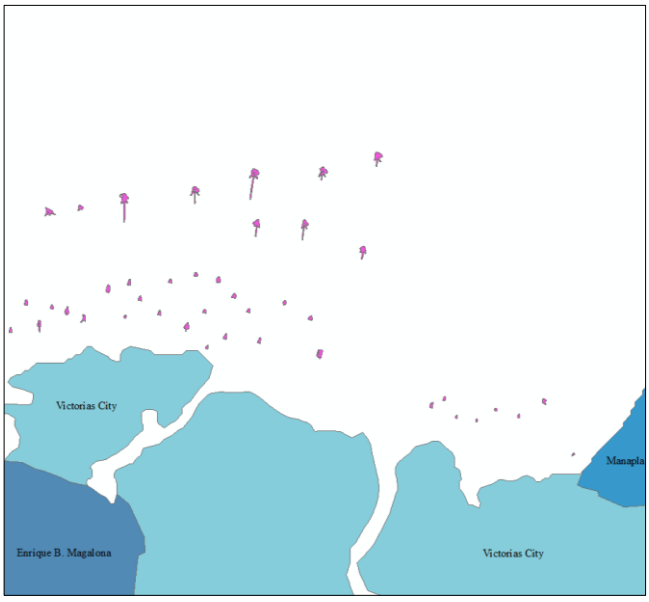

Figure 6. Extracted Fish Corrals in the City of Victorias

There were a total of 444 features extracted from the ten cities/municipalities.

2.4 Monitoring of Fish Corrals

Monitoring fish corrals using modern methods such as using ArcMAP to calculate distance would greatly help the Fisheries Department of the Local Government Unit. Using these modern methods, they can check if the existing Fish Corrals are in suitable distance as recommended by the law.

As stated in Article XI, Chapter III in the Fisheries Act of the Philippines (Act No. 4003, 1932):

> "No fish corral or "baclad" shall be constructed within two hundred meters of another in marine fisheries or one hundred meters in fresh water fisheries, unless they belong to the same license; but in no case shall be less than sixty meters apart except in waters less than two meters deep at low tide or unless previously approved by the Secretary of Agriculture and Commerce or his duly authorized representative."

With this, we calculated the closest distance between a fish corral and its neighboring fish corral in our study site using the Near (Analysis) tool in ArcMap. Afterwards a query was made to check if they have passed the 200 meter or the 60 meter radius.

2.4.1 200M Distance: Since it is required that no fish corrals must be constructed with 200 hundred meter from each other in marine fisheries, a query was made to check from the previously calculated distance if which fish corral has satisfied the condition. It was then found out that 36 out of 47 fish corrals are located within the 200 meter radius of each other.

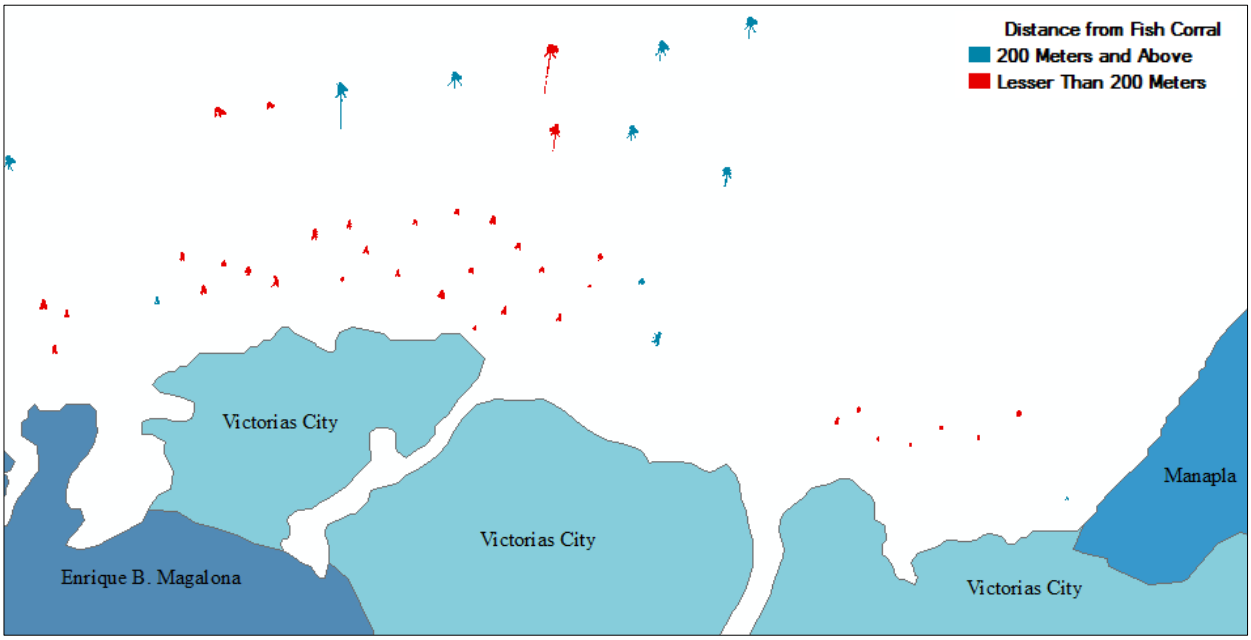

Figure 7. Fish Corrals in Victorias City that has passed/failed the 200-meter check.

2.4.2 60M Distance: Aside from the 200-meter distance check, a fish corral however can be located within 60 meters of each other if they belong to the same owner. Since there is currently no data for the ownership of the extracted features, we assumed in the next test that all fish corrals have the same owner and should at least pass the 60-meter check. As a result, all fish corrals are at least 60-meters apart.

Figure 8. Fish Corrals in Victorias City that has passed/failed the 60-meter check.

2.5 Suitability Analysis

The suitability analysis component of the paper aims to find areas where it is appropriate to erect fish corrals. The newly erected fish corrals must be at least 200 meters apart and must be within the maximum distance from land and maximum depth as based from the results in the extraction of 444 features in the ten municipalities in Negros Occidental.

2.5.1 Distance from Land: There is no law as to what distance can a fish corral be erected. However, using the features that are previously extracted we can calculate their distance from the land. The land shapefiles that were used in the study were from PhilGIS (2011). Using the Near tool in ArcMap, the distance of each of the 444 extracted features were calculated. The maximum distance was then be used to create a buffer from land signifying the possible areas of fish corral erection.

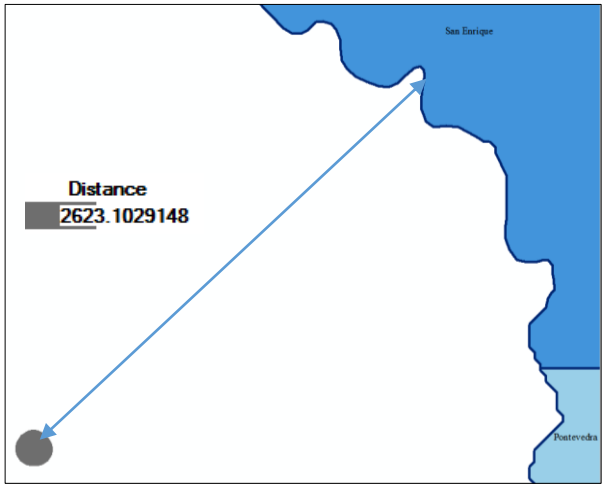

Figure 9. The Fish Corral with the greatest distance from Land

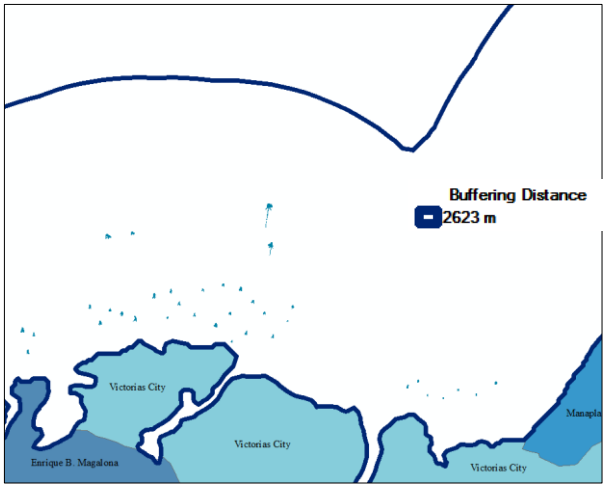

Figure 10. 2,623 m. Buffered Distance from the Coast

The maximum distance was 2,623.10 meters which was based from a fish corral located in between San Enrique and Pontevedra as seen in Figure 9. The resulting distance was then used as a buffer as seen in Figure 10.

2.5.2 Depth: The depth of the location of the 444 extracted fish corrals were also considered. The depth data used was the bathymetry data from GEBCO (2008) which is associated with and can be downloaded in the PhilGIS website. In ArcMAP, each feature was converted into points by using the Feature to Point (Data Management) tool. In order to get the bathymetry values of the data, the Extract Values to Points (Spatial Analyst) function was used. The maximum depth was then determined which is -14. Then the maximum depth was used as a boundary in identifying possible areas of erection. Since the bathymetry data from GEBCO (2008) was a raster, the Contour (3D Analyst) tool in ArcMap was used to convert the -14 depth (deepest location of fish corral) and the 0 depth into contour lines.

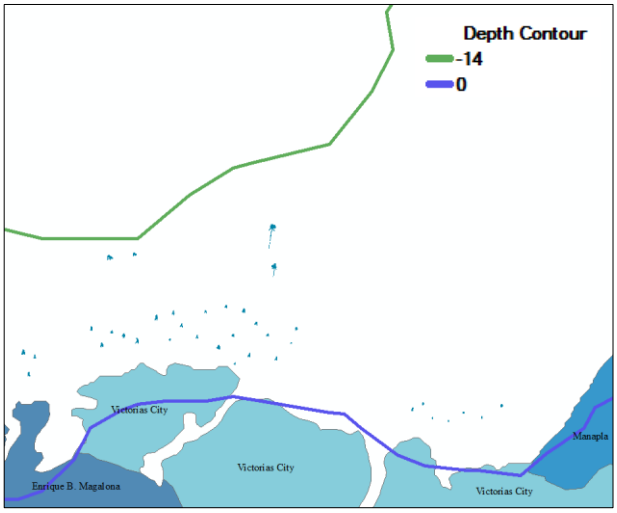

Figure 10. The Depth Boundaries

2.5.3 Determining Suitable Areas: After getting the depth and the distance boundaries, a shapefile was created that encompasses the two factors. The municipal boundaries along the coast was also considered in determining the area.

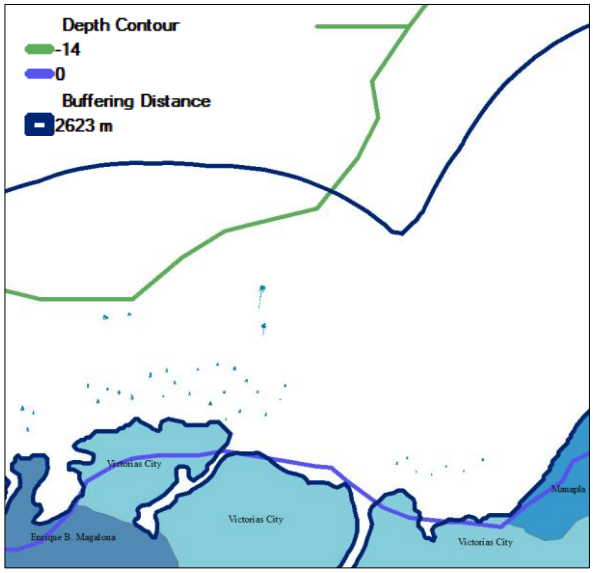

Figure 11. The two factors in determining Fish Corral Erection

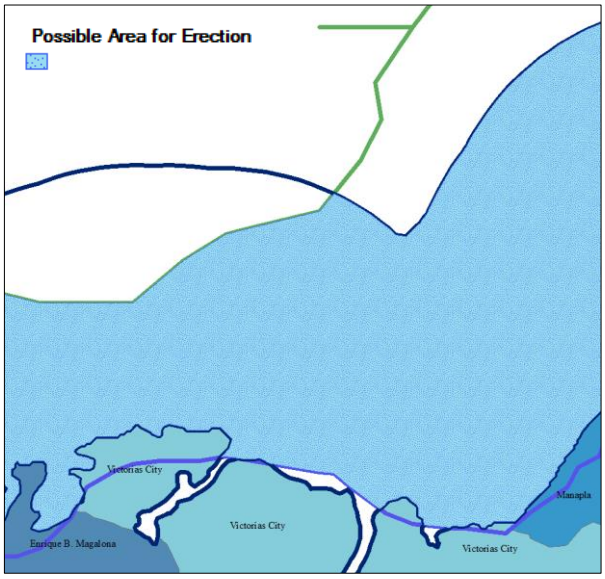

Figure 12. Possible Site for Erection

Since each fish corral must be at least 200 meters away from each other, a buffer was made from each fish corral feature. The buffer was then subtracted from the Possible Site for erection.

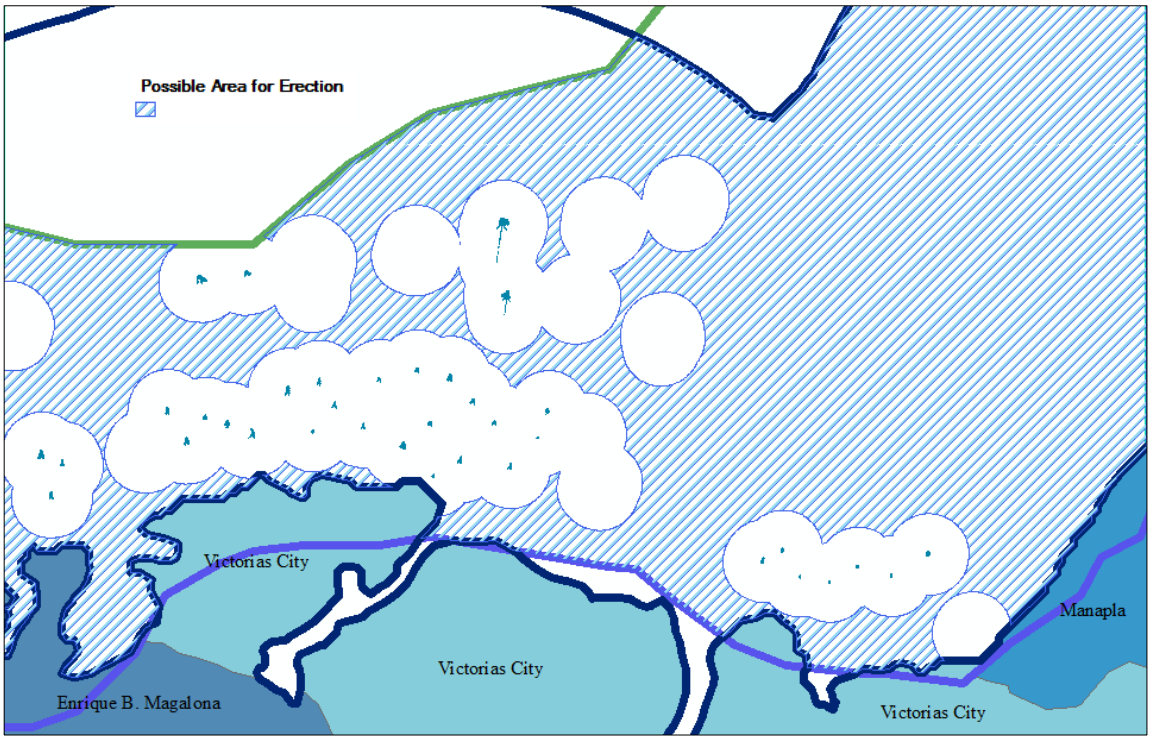

Figure 13. Possible Site for Erection

The area highlighted in Figure 13, will now be the possible site of fish corral erection for Victorias City. This site was determined using the maximum distance of a fish corral and the maximum depth of a fish corral based on the feature extraction in 10 cities/municipalities. This suitable area above was also based on the presence of already built fish corral since a 200 meter buffer was made for each existing fish corral so that no new fish corral will be built within 200 meters of an existing fish corral.

3. RESULTS AND DISCUSSION

In order to create a quantifiable number of Fish Corrals to be erected, random points were generated within the possible area using the Create Random Points (Data Management) tool in ArcMap. By using the same tool, the points were scattered with a minimum allowed distance of 200 meters. These points will represent the new fish corrals in Victorias City. The map in Figure 14 shows the distribution of possible of theoretical fish corrals in the City of Victorias. There were 43 points for theoretical Fish Corrals generated.

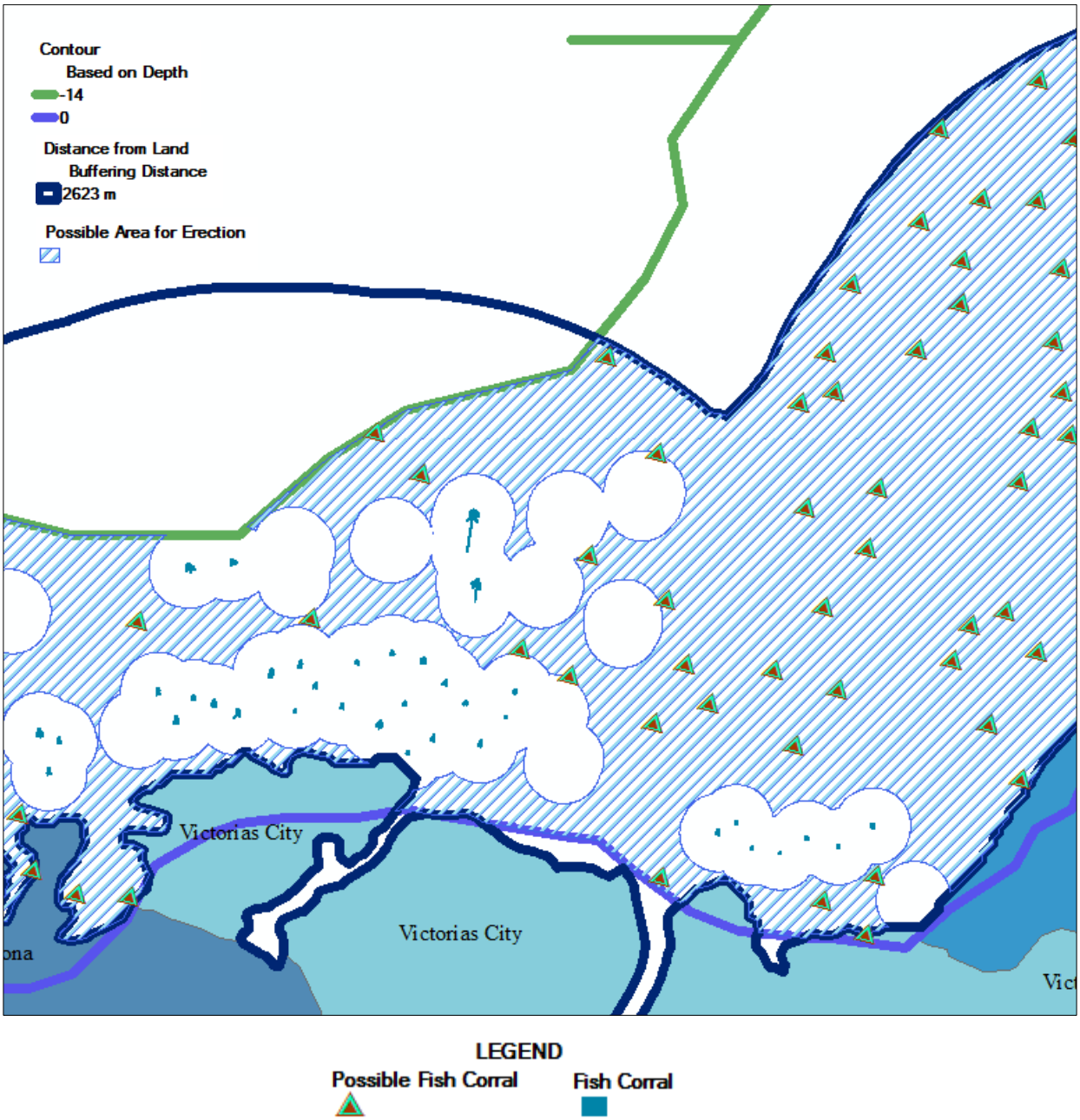

Figure 13. Randomly Generated Points that Represent Fish Corrals in the City of Victorias

The possible area for building fish corrals has a total of 11.68 square kilometers. In this area, the coastal communities of the City of Victorias together with their Local Government Unit could create plans in how to properly use the said area.

As we can see in Figure 13, some Fish Corrals are near the coast of the land feature, however there are some fish corrals in other municipalities that are also located near the shore. Also, in the figure above we can see that one fish corral was randomly positioned in the mouth of the river in Victorias City. The other fish corrals are distributed within the suitable area.

4. CONCLUSIONS

With the help of remote sensing and GIS, the fish corrals in the Victorias City were not only extracted but were also monitored based on the laws specified by the Fisheries Act (Act No. 4003). The distance of a fish corral from land together with its depth was also used to determine possible sites of building a fish corral. In theory, at least 43 new fish corrals can be added alongside the 47 already built fish corrals in the City of Victorias.

5. FURTHER STUDIES

There are still a lot of factors that we should take into consideration in selecting areas for fish corral building such as the biodiversity in the area or presence of marine protected areas. Furthermore, we can also add some weights on an area such as areas near the mouth of the river since it very favorable to place a fish corral near it.

For now, the study only aims to help and show the LGU and the coastal communities that these modern measures can help them in their livelihood and based on the results, it very likely that this study can benefit them.

6. ACKNOWLEDGEMENTS

This paper is an output of the Phil-LiDAR 2 project. We are very grateful for all the project leaders and mentors from UP Diliman especially the CoastMap Team. We are grateful to the Philippine Council for Industry, Energy and Emerging Technology Research and Development of the Department of Science and Technology (PCIEERD-DOST) for the financial support.

7. REFERENCES

BFAR (Bureau of Fisheries and Aquatic Resources), 2013. Philippine Fisheries Profile 2013, Retrieved August 20, 2015, from http://www.bfar.da.gov.ph/publication.jsp?id=2334#post.

FAO (Food and Agriculture Organization of the United Nations), 2015. National Aquaculture Sector Overview: Philippines, Retrieved August 22, 2015 from http://www.fao.org/fishery/countrysector/naso_philippines/en

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

GEBCO (General Bathymetric Chart of the Oceans), 2008. Gridded Bathymetry Data, Retrieved June 1, 2015 from http://philgis.org/freegisdata.htm

PhilGIS (Philippine GIS Data Clearinghouse), 2011. Country Basemaps Dataset, Retrieved June 1, 2015, from http://philgis.org/freegisdata.htm

Philippine Fisheries Act No. 4003, 1932. Fisheries Act, Retrieved August 12, 2015, from http://www.chanrobles.com/actno4003.htm#.VdhDAvmqpBf

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