Mapping of Aquaculture in River Nile Using Google Earth Images and GIS Procedures - Rosetta Branch, Egypt

Hala M. Ebaid[1] and Salwa M. Abou El Ella[2]

[1]Associate professor, Survey Research Institute, National Water Research Center, Delta Barrage, P.O. Box 13621, Egypt.
[2]Professor, Channel Maintenance Research Institute, National Water Research Center, Delta Barrage, P.O. Box 13621, Egypt.
hala_srif@yahoo.com, salwaabouelella@yahoo.com

Abstract: Negative impact of fish cages on the environment, water quality, bio-deposits on sediment, and hydraulic efficiency were the main reason for monitoring fish farms in Nile River. Due to hard traditional field work and long time consumption to monitor illegal fish cages, a technique was developed for monitoring fish cages in Rosetta branch of River Nile in Egypt. Eighty, high resolution satellite images were extracted from Google Earth in 10/2/2016 using "Map Window GIS". These images were first preprocessed as: they were georeferenced, sorted, mosaiced, and the entire branch was subseted. A sequential of GIS procedures under Arc GIS environment were applied on the branch for fish cages polygons determination. These procedures comprise:1-Statistical filter, 2- Iso classification for fish farms class discrimination,3- Extraction of polygons of fish cages in raster format,4-Some generalization tools were applied on the resulted fish cages raster data, 5-Conversation from raster to vector and Enhancing tools were also applied, which produce final accurate fish cages layer in polygons vector format. Hence the numbers and the positions of all fish cages across the entire study area can be easily detected. The resulted total number of fish cages were 9857, with approximated total area about 600,000 m^2, for about 20 km length. This technique provides decision maker with information about illegal fish cages areas in fast, accurate manner and cost effective instead of costly traditional field work. Hence a proper actions can be applied for environment protection.
[Hala M. Ebaid and Salwa M. Abou El Ella. **Mapping of Aquaculture in River Nile Using Google Earth Images and GIS Procedures - Rosetta Branch, Egypt.** *J Am Sci* 2017;13(6):57-63]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org. 7. doi:10.7537/marsjas130617.07.

Keywords: Google Earth; Satellite Images; Fish cages; GIS; Rosetta Branch; Egypt

1. Introduction

Monitoring fish cages development is very important due to the negative impacts of fish cages on water quality. Impact of aquaculture is well studied due to its expansion in developed countries or with the financial investment of developed countries in developing countries. Number of reports on environmental impact assessment of cage farming in several countries are available, among them studies in Australia, Canada, Chile, Norway, United Kingdom and the United State (EAO 1996, Winsby *et al.,*1996, ASI 1999, Heining 2000, Nash 2001, Buschmann 2002, Crawford *et al.,*2002, SECRU 2002, Brooks and Mahnken 2003 a Carroll *et al.,*2003, Weber 2003). Although the risks and degree of effects are site specific and may vary from place to place, all of these studies have pointed out similar risks and impacts.

The impact of fish cages to the environment varies depending on the type of culture systems (including the type of fish being reared, feeding mode and type of feed), site selection, characteristics of the location and size of the cage. The environmental impacts of aquaculture are seen in a variety of ways and includes user conflicts, alteration of hydrological regimes, introduction of exotic species to the wild, pollution of water resources, etc.

Nash (2001) has listed the risks of cage culture in three major categories: High, Low, and little. High risk with impacts of: bio- deposition sediment, therapeutic compounds on non-target organisms, and accumulation of heavy metals in the sediment on benthic communities. Low risk as physiological effect of low dissolved oxygen levels in the water column, toxic effect of H_2S and ammonia from bio-deposit, Proliferation of human pathogens in the aquatic environment, Proliferation of fish and shellfish pathogens in the aquatic environment, and Increase in incidences of disease among wild fish. Little risk as: Escape of non-native species, Impact of antibiotic resistance bacteria on native fish, and Impact on human health and safety. ASI (1999) in a short review on cage farming elicited general impacts of cage aquaculture on environment with emphasize on water pollution [eutrophication] and living organisms in the water column. The field survey of environmental impact of fish farming in lakes and coastal water ecosystems, has underlined the impacts on water and sediment chemistry and benthic community (Buschmann, 2002).

The procedure of cage culture is almost similar all around the world. The major inputs directly involved in farming process are feed, juvenile, chemicals and drugs. Dead fish, residuals of chemicals, uneaten feed and fish faeces are various types of waste coming from farms, which enter the ecosystem in solid and/or dissolved form.

The government of Egypt is taking important actions toward increasing and support aquaculture activities, as a source of animal protein, while keeping close and careful attention to the aquatic environment safety.

Remote sensing (RS) coupled with geographic information system (GIS) can be used as important tools for rapid monitoring aquatic environments that respond to changes in the hydrologic regime with a cost effective manner. Remotely sensed data can fill the gap by providing essentially uniform coverage over large areas at reasonably high positional accuracy, spatial and temporal resolution (Ehlers et al., 1991). A number of studies have been published on the application of GIS and remote sensing in aquaculture (Kapetsky *et al.,*1988; Salam *et al.,*2003; Carlo Travaglia *et al.,*2004; Diwedi and Kandrika, 2005; Jayanthi *et al.,*2006; Trevor Platt *et al.,*2015; Wagdy,2015).

Permanent monitoring of illegal fish farms in the Nile River, especially in Rosetta branch is very important, for its bad impacts on the water quality and the environment. Continuous change in the numbers and sites of fish farms along the Rosetta branch during the seasons of the year, makes it difficult to quantitatively monitor on an ongoing basis due to Hard traditional field work and time consumption for accurate monitoring fish cages. The objective of this study is determination the numbers, positions, and the areas of fish cages along the Rosetta branch effectively using Google earth satellite images and effective GIS procedures for environment protection purpose.

2. Study Area

Rosetta branch of the River Nile is about 225 km in length, with an average width of 180 m, and depth varies between 1.5 - 16.0 m. Rosetta estuary is delimited by a barrage for controlling water discharge at Edfina City, 30 km before its connection with the sea. It was estimated that Rosetta Branch receives more than 0.5 million m^3 daily of untreated or partially treated domestic and industrial wastes and huge amount of agricultural drain water (Awad and Yousef, 2002). The study area of this research extend from Kanater Edfina at south till the entrance to the international coastal road at north with about 20 km length. The extent of this study area are between 30.408940N to 30.516921 N Decimal Degrees (DD), and between 31.304788 E to 31.409596 E in DD (figure 1).

3. Methodology

3.1 Data set

Eighty satellite images of the Digital Globe constellation from the Google earth pro, which contain the most comprehensive and up-to-date high-resolution imagery: Geo Eye-1, World View- 2, Worldview-3, with spatial reference GCS_WGS_1984 were used in this work. The study area of Rosetta branch was divided to small parts to maintain high resolution of the images (about 0.6 m). Dividing the branch was carried out by using polygons boundaries of the mask layer in KML format, which cover the entire branch on Google Earth pro."Get Image from GE" tool under Map Window GIS software was used to capture images (Georeferenced) from Google Earth (figure 2).

The extracted images which cover Rosetta branch were sorted then mosaiced together (figure3).

3.2 Fish cages determination procedures

The flowchart below describe all applied procedures for accurately delineation of fish farms.

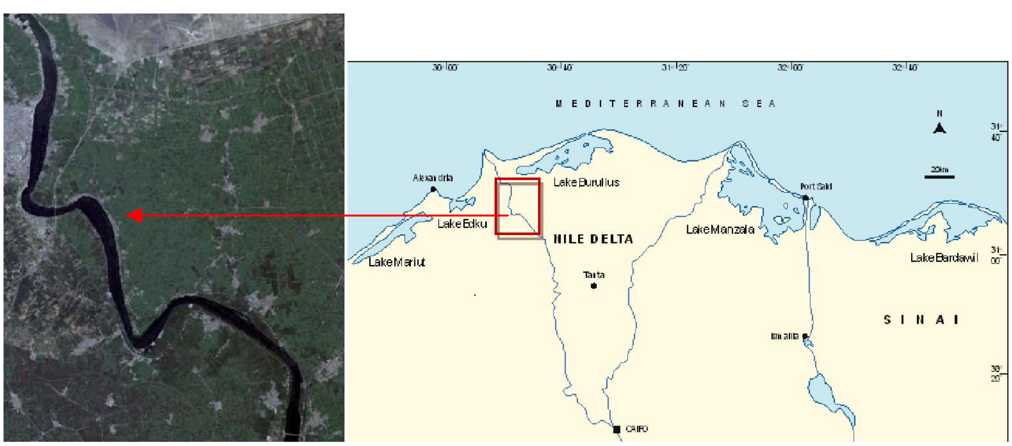


Figure 1: Rosetta branch study area

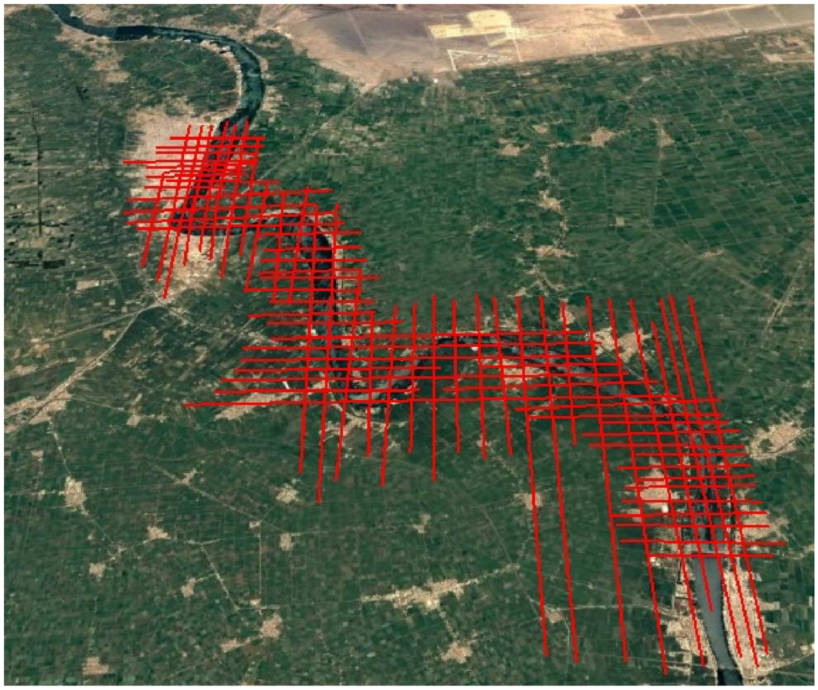


Figure 2: The KML layer overlay Rosetta branch on Google Earth pro

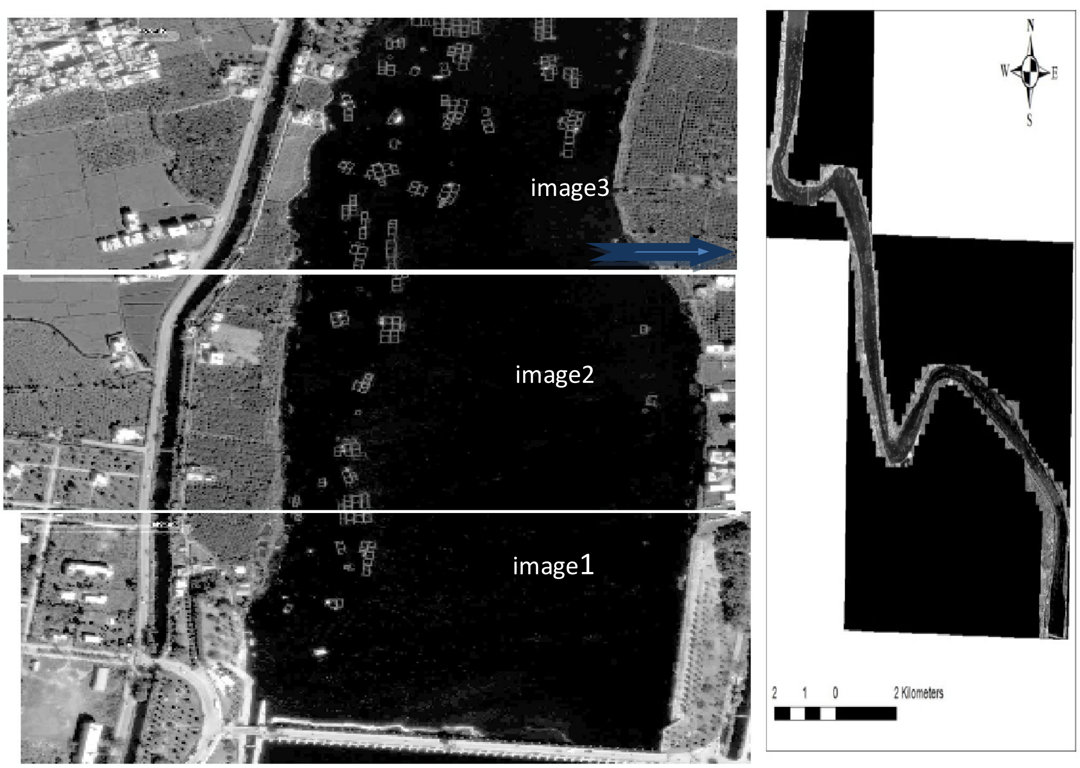
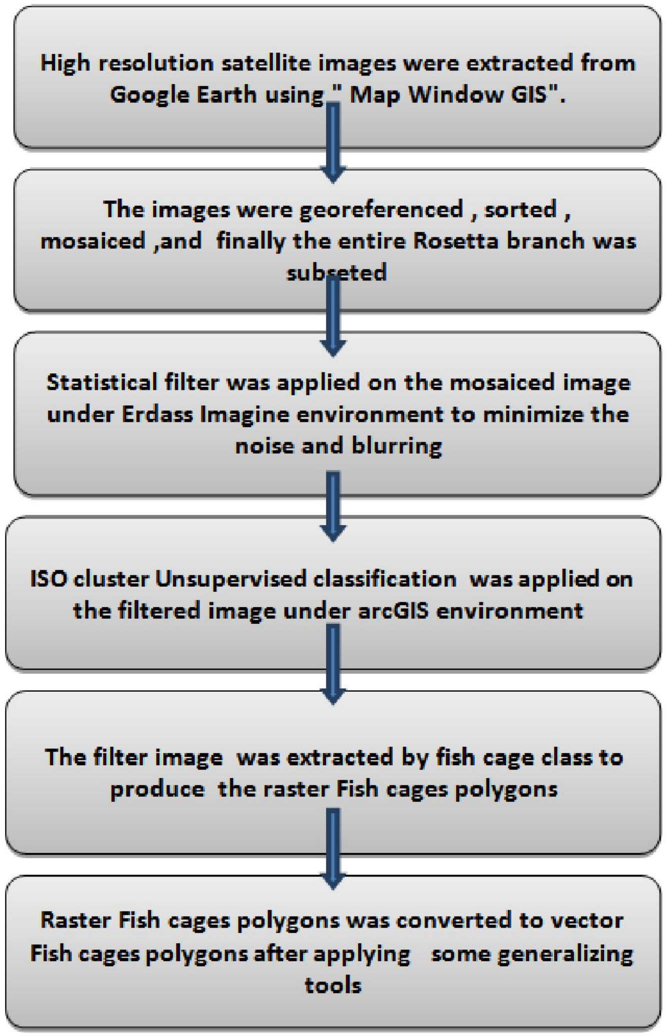


Figure 3: Mosaiced satellite image (from Google Earth) for Rosetta branch



4. Results and Discussions

The Mosaiced image for the study area was first subset to the boundary of the water body by feature class (figure 4). This mosaiced satellite image need to be enhanced before applying classification procedure to discriminate the fish farms, this can be achieved by applying statistical filter (SF) to minimize the noise and blurring (as demonstrated inside the circle) of the original raster image under Erdass Imagine environment.

In the statistical filter, the center pixel is replaced by the average of all pixels within the moving window (5 x 5) that fall within a defined range about the center pixel, that is, DN = [center pixel DN] sigma. Sigma is statistically one standard deviation. Here it is assume:

$$\text{sigma} = \text{coefficient of variation} = \frac{\sqrt{Variance}}{Mean}$$

For this SF, sigma is set to 0.15, an average value. The resulted image after applying SF was demonstrated below in figure 5.

Many trials related to the numbers of classes were applyed on the imag, the most approprate number of classes to apply was four. ISO cluster Unsupervised classification was applied on the filtered image under arc GIS environment (figure 6).

Extract the statistically filtered image by fish cage class was carried out produce the raster Fish cages polygons which demonstrated in figure 7. Thin tool was applied on the extracted fish farm raster data to Thins rasterized fish cages features by reducing the number of cells representing the width of the features (figure 8).

Thin raster features of fish cages was converted to features lines in vector format using Raster to Polyline tool under Arc GIS environment, which Converts a raster dataset to polyline features. Feature lines describe fish cages were converted to polygons using features to polygons tool under Arc GIS environment. Then Multipart To Single part tool was applied on the resulted polygons feature class in the previous step, this is very important tool, to separate all fish cages polygons with unique IDs. Minor boundary clean for resulted polygons were performed producing final fish cages polygons (figure 9).

Fish cages were determined at February 2015. It was found that they were Spread over a distance of approximately 27 km from Kantaret Motobas until the area before the end of the Rosetta Branch with about 3 Km (CMRI. 2015). Fish cages density was about 350 cage per 1 km length of the branch. Total numbers of fish cages were about 9493 (CMRI, 2015). Most of them take the form box ranging between 2 meters and 10 meters (figure 10). The fish cages at this date were investigated and counted from the computer screen using world view-2 images. Using these types of satellite images is very expensive, and counting the fish cages in this way is time consuming. Applying the procedures which described in this paper is time consuming in the stage of gathering and mosaicing the satellite image for Rosetta branch (80 small images) from Google earth, it take about 4 hours, while other remaining GIS procedures were accurate automated technique. The resulted total number of fish cages were 9857 with approximated total area about 600,000 m^2, for about 20 km length. This new technique can provide decision maker with information about illegal fish cages areas in fast, accurate manner and cost effective instead of costly traditional field work.

Figure 4: Satellite image for Rosetta branch (before applying statistical filter)

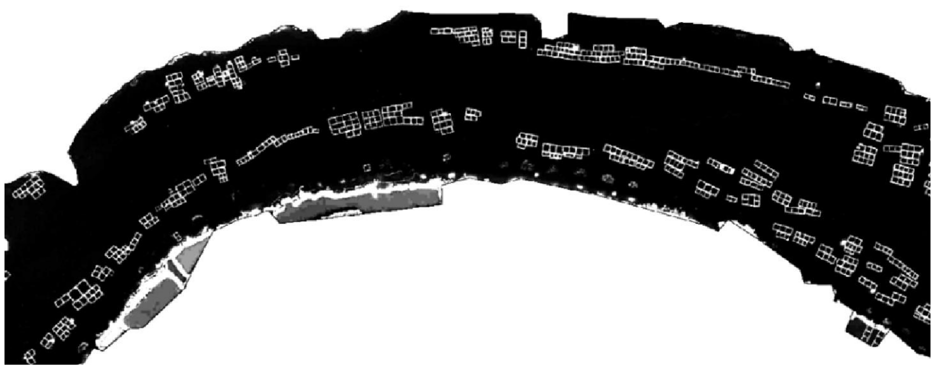


Figure 5: Satellite image for Rosetta branch after applying SF

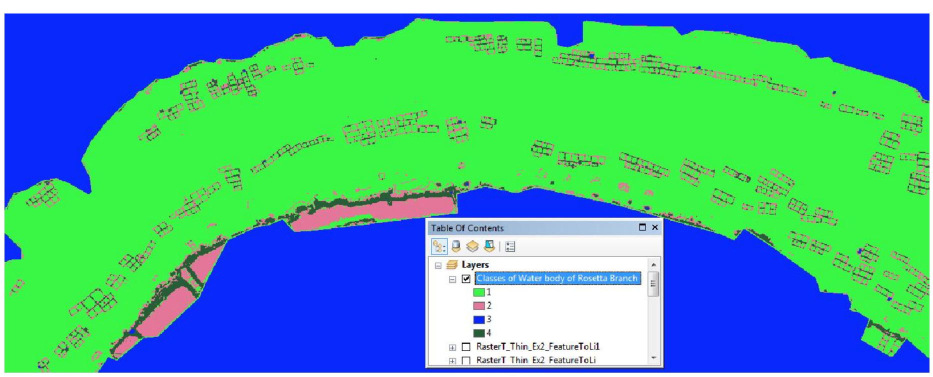


Figure 6: Classified Satellite image for Rosetta branch

Figure 7: Extracted Fish cages of Rosetta branch in raster format

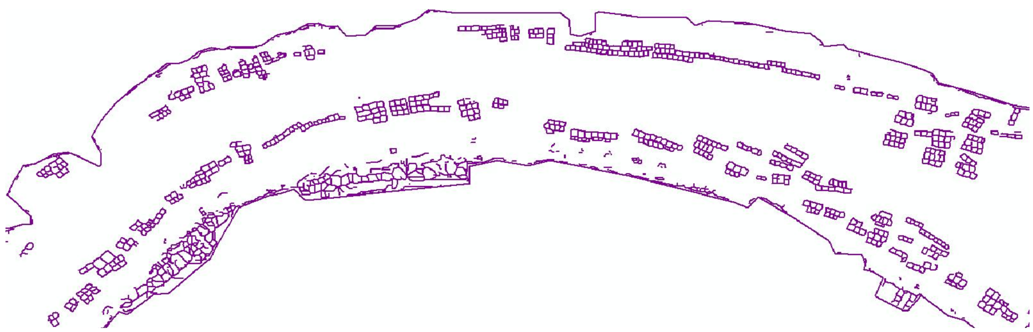


Figure 8: Thin extracted Fish cages of Rosetta branch in raster format

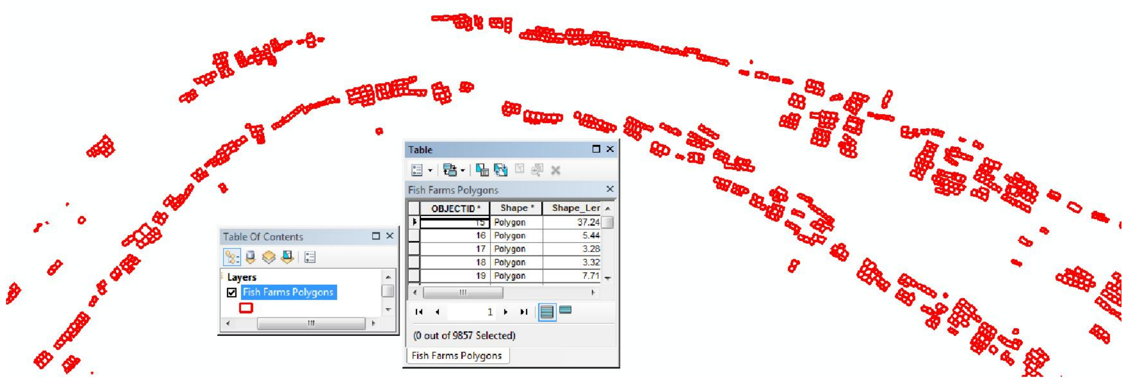


Figure 9: Final resulted fish cages polygons after boundary clean

Figure 10: Cages in Rosetta branch.

5. Conclusions

In this study Gathering and mosaicing the satellite image for Rosetta branch (80 small images) from Google earth were carried out to produce one image for the entire Rosetta branch, The image produced has a resolution of 0.6 m, which is considered as an excellent resolution to clearly discriminate fish cages. A sequential procedures were carried out to determine numbers, areas, and positions of these fish cages polygons in the Rosetta branch. The resulted total number of fish cages were 9857, for total area about 600,000 m^2, and about 20 km length. This new technique can provide decision maker within formation about numbers, positions, and areas of illegal fish cages in fast, automatic, accurate manner, and economically effective instead of traditional field work.

References

1. ASI (Aquatic Science Inc) (1999. Literature review of the environmental impacts of caged aquaculture, ASI project E9708. G.B.A. Foundation. 22p.
2. Awad, Hasan and Nabiha Yousef; (2002). Nile River delta: Rosetta branch and Edku Lagoon. Biogeochemical modeling node of the land–ocean interactions in the coastal zone (LOICZ).
3. Berntssen, M.H.G., Hylland, K., Bonga, S.E.W. and Maage, A. (1999). Toxic level of dietary copper in Atlantic salmon (Salmon salar L.) parr. Aquatic Toxicology46: 87-99.
4. Brooks, K.M. and Mahnken C.V.W. (2003a). Interaction of Atlantic salmon in the Pacific Northwest environment, II. Organic wastes. Fisheries Research 62: 255-293.
5. Brooks, M.K. and Mahnken, C.V.W. (2003b). Interaction of Atlantic pacific salmon in the Pacific Northwest environment, III. Accumulation of zinc and copper. Fisheries Research 62: 295-305.
6. Buschmann, A. (2002). Environmental impact of Chilean salmon farming: The situation in the Tenth region of the lakes. Terram. www.terram.ch/publication
7. Burford, M.A. and Rothlisberg, P.C. (1999). factors limiting phytoplankton production in tropical continental shelf ecosystem. Estuarine, Coastal and shelf Science 48: 541-549.
8. Crawford, C., Macdonald, C. and Mitchell, I. (2002). Evaluation of techniques for environmental monitoring of salmon farms in Tasmania. Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Australia.
9. Carlo Travaglia et al., (2004) Mapping coastal aquaculture and fisheries structures by satellite imaging radar, Case study of the Lingayen Gulf, the Philippines FAO fisheries technical paper.
10. Carroll, M.L., Cochrane, S., Fieler, R. Velvin, R. and White, P. (2003). Organicenrichment of sediments from salmon farming in Norway: Environmental management practices and monitoring techniques. Aquaculture 226: 165-180.
11. Channel Maintenance Research Institute (CMRI) (2015). Fish cage detection in River Nile. report, 38.2015, published by CMRI.
12. Dwivedi, R.S. and Kandrika, S. (2004). Delineation and monitoring of aquacultureareas using multi-temporal space borne multispectral data. Current Science, 89: 1414-1421.
13. EAO (Environmental Assessment Office of the British Colombia, Canada) (1996). Thesalmon aquaculture review, final report http://www.interafish.com/laws-and-regulations/report_bc14.11.2003.
14. Ehlers, M., Greenlee, D., Smith, T. and Star, J. (1991). Integration of remote sensing and GIS data access. Photogrammetric Engineering and Remote Sensing,57: 669-675.
15. Heinig, C.S. (2000). The impact of salmon aquaculture: The difficulties of establishing acceptability limits and standards. Report presented to Aquaculture/Environment Workshop. University of Massachusetts, Boston, USA. Jan. 11-13,2001.
16. Jayanthi, M., Rekha, P.N., Kavitha, N. and Ravichandran, P. (2006). Assessment of impact of aquaculture on Kolleru Lake (India) using remote sensing and geographical information system. Aquaculture Research, 37: 1617-1626.
17. Kapetsky, J.M., Hill, J.M. and Worthy, L.D. (1988).A geographical information system for catfish farming development. Aquaculture, 68: 311-320.
18. Nash, C.E. (editor). (2001). The net-pen salmon farming industry in the Pacific Northwest. U.S. Dept. of Commer., NOAATech. Memo. NMFS-NWFSC-46.
19. Salam, M.A., Ross, L.G. and Beveridge, C.M.M. (2003). A comparison of development opportunities for crab and shrimp aquaculture in southwestern Bangaladesh using GIS modeling. Aquaculture, 220: 477-494.
20. SECRU, (2002). Review and synthesis of the environmental impacts of aquaculture. Scottish Executive Central Research Unit, Edinburgh, Scotland.
21. Trevor Platt et al. (2015)."Use of remote sensing in the context of cage aquaculture",5th International Symposium on Cage Aquaculture in Asia (CAA5).
22. Wagdy A. Kawi Ashry, 2015 "Using Remote Sensing and GIS Application for the Development of Aquaculture in Nasser Lake conference: 2015 IARIW-CAPMAS" Experiences and Challenges in Measuring Income, Wealth, Poverty and In equality in the Middle East and North Africa, November 2015.
23. Winsby, M., Sander, B., Archibald, D., Daykin, M., Nix, P., Taylor, F.J.R. and Mundy, D. (1996). The environmental effects of salmon net-cage culture in British Colombia. Ministry of Environment, Lands and Parks, Environmental Protection Dept. Industrial Waste /Hazardous Contaminants Branch, Victoria, BC. Canada.

5/31/2017