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Using Remote Sensing technology integrated with the Geographic Information System (GIS) to develop a Plan to save the Egyptian Northern lakes Case study: Lake Burullus

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ABSTRACT

Burullus Lake is one of five coastal lagoons exhibited by the northern Egyptian Mediterranean coast along the Nile Delta coast. The Lake has great economic importance as a wetland, fishery, and resting area for migrating birds, so it is designated a wetland nature reserve under the International Ramsar convention of 1988. It has been declared a nature reserve in Egypt since 1998. It is a shallow brackish lake connected to the Mediterranean by a small outlet (Boughaz) and connected to the western branch of the Nile by a small canal (Brimbal Canal). Because of its central location, the Lake receives most of the drainage water of the Nile Delta region through eight drains. As a result, the lake ecosystem has deteriorated environmentally. An appropriate plan for saving and developing the Northern Lakes of Egypt is urgently required. For this, using Sentiel and Landsat satellite imageries of Lake Burullus in the period 1973-2018, To extract water feature, and vegetation features from imageries, the Normalized Difference Water Index (NDWI) and the Normalized Difference Vegetation Index (NDVI) were applied. The multi-temporal maps of the lake surface area are overlaid to produce a map for the changes in the lake surface area using Geographic Information System (GIS), combined with surface measurements for mapping water quality parameters of Burullus Lake. All of the previous integrated for assessing and managing the threats and problems in the Lake.

INTRODUCTION

The coastal lakes of Egypt are equally important. They represent 25% of the total wetlands of the Mediterranean **(Saad, 2003)**.

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wetlands of the Mediterranean **(Saad, 2003)**. Historically, these lakes contributed to not less than 65% of the total wild fish catch produced in Egypt. Moreover, they are important sites for the passage and breeding of migratory birds.

Burullus lake, Ashtoum El-Gamil in Manzala, and the Zaranik area in Lake Bardawil are protected by law and designed as Ramsar sites. Fishing is the main economic activity and source of livelihood for tens of thousands of fishermen and their families settled around these lakes **(PAP/RAC)**: 2002. Remote sensing, the science of obtaining information about an object without physical contact, has been widely used with GIS in developing the Lake. Multi-dated satellite images have been used in this study to detect the trends of environmental changes in El Brullus Lakes (from 1973 to 2019). The growing increase in population and urbanization expansion; led to a corresponding increase in industrial, agricultural, and urban effluents that were discharged into the aquatic environment. The northern region of Egypt hosts coastal lakes with distinguished characteristics. Particular environmental importance was earned when northern lakes were acknowledged as nature reserves with rich aquatic biota and critical roles as hosts to migratory birds. Also, with growing concerns about climate change impact, northern lakes are considered the front-line defense to Egypt against possible Mediterranean Sea level rise. However, the deteriorating condition has been noticed and triggered several studies to reach sustainability **(Abayazid and Al-Shinnawy, 2012)**. Water is one of the most important natural resources available to humanity. The need to conserve water bodies, especially fresh ones, is being realized everywhere in the world **(Gupta *et al.,* 2011).** Industrial and agricultural wastewater causes surface water pollution (rivers and lakes) with chemicals and excess nutrients **(USEPA, 2000).** Water quality is a description of water's physical, chemical, and biological characteristics **(El Gohary, 2015).** With growing concerns about climate change and its possible impact on environmental systems, human intrusion and progressive development processes have had undeniable adverse fingerprints on maintaining a healthy environment in the coastal lakes of Egypt **(Abayazid and Al-Shinnawy, 2012)**.

STUDY AREA

Burullus is one of four shallow coastal lagoons in the Nile Delta of Egypt: Manzala, Burullus, Edku, and Maryout (Fig. 1). Burullus lagoon is located between the two Nile branches Rosetta to the west and Damietta to the east. It extends between longitudes 30°31` and 31°05` E and latitudes 31°25` and 31°35`. It occupies an area of 420 km², of which 370 km² are open water **(Guirguis *et al.,* 1996).** The rest of the area comprises a group of islands distributed within the water body. The length of the lagoon is about 53 km, its width is about 13 km, and it has water depths ranging from 0.5 to 2.5 m **(Frihy and Dewidar, 1993).** It connects to the sea through a narrow strait called Al-burg inlet or Boughaz El-Burullus at its northeast side. The lagoon is separated from the sea by a narrow coastal strip covered by sand sheets and dunes. The Burullus lagoon receives drainage water at its southern boundary through seven drains. It also receives fresh water from Brimbal Canal at its southwestern corner **(Okbah and Hussein, 2006)**. Agricultural lands encompass the southern and eastern fringes of the lagoon. The environment of Burullus Lagoon has witnessed significant change during the last three decades as many drains were constructed to convey agricultural wastes into the lagoon. In addition, a substantial area has been dried up to agricultural land.

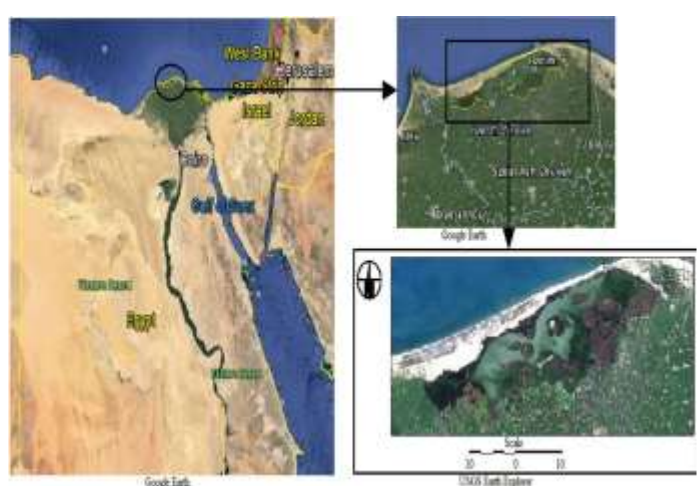


Fig. 1. Details of the study satellite images

The aim of this work is to deal with the importance of the ecosystem for man, showing man's role as a geomorphic agent, affecting all the environmental systems: physical and human. This study aims to evaluate the characteristics of water in Brullus to appraise to what extent water quality variables have been affected by different pollutant discharges in these regions—monitoring the damage and erosion of lakes boundaries. The use of high-resolution space visualizations in the classification and identification of the most common plant species within the water level of Lake El Brullus determines the possibility of exploiting them economically. Sound and sustainable management of aquatic plants within the lake.

The main objectives are: Using the fusion of all data available to manage El Brullus Lake properly.

Tools of the study

A- Field studies: The researchers visited the study:

Hydrologic field measurements like water levels

DATA AND SOFTWARE USED

Landsat images

Satellite data required accomplishing the objectives of remote sensing activities and consequently achieving the current study objectives surveyed from NARSS archived scenes. The current study's remote sensing data sets are as follows: (1) Land sat Thematic Mapper ™ 1973, 1985, 1990, 2003, 2015, and 2018. All images were geometrically rectified to the Universal Transverse Mercator projection (WGS-84) zone 36. The satellite images that covered the study area were collected and used to establish a comprehensive GIS database. Satellite data required fulfilling the study objectives acquired from NARSS archived scenes. A group of Landsat satellite scenes was selected, illustrated in the following figures.

Table 1 Details of the study satellite images

Satellite Data	Date of acquisition	Resolution (m)
Landsat1	1973	60m
Landsat5	1985	30m
Landsat 5	1990	30m
Landsat 5	2003	30m
Landsat 7 ETM+	2009	30m
Landsat 7 ETM+	2015	30m
Landsat 8 OLI	2018	30m
Blanet lab	2018	3.7m

METHODOLOGY OF THE STUDY

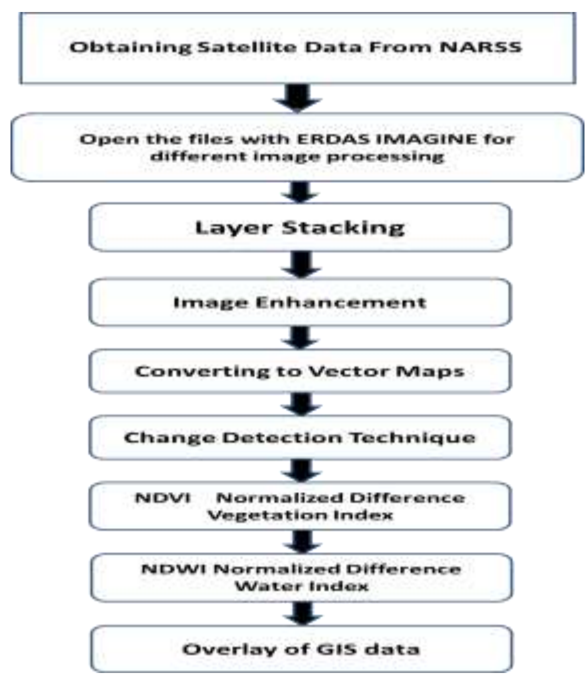


Fig.2. Steps of the images

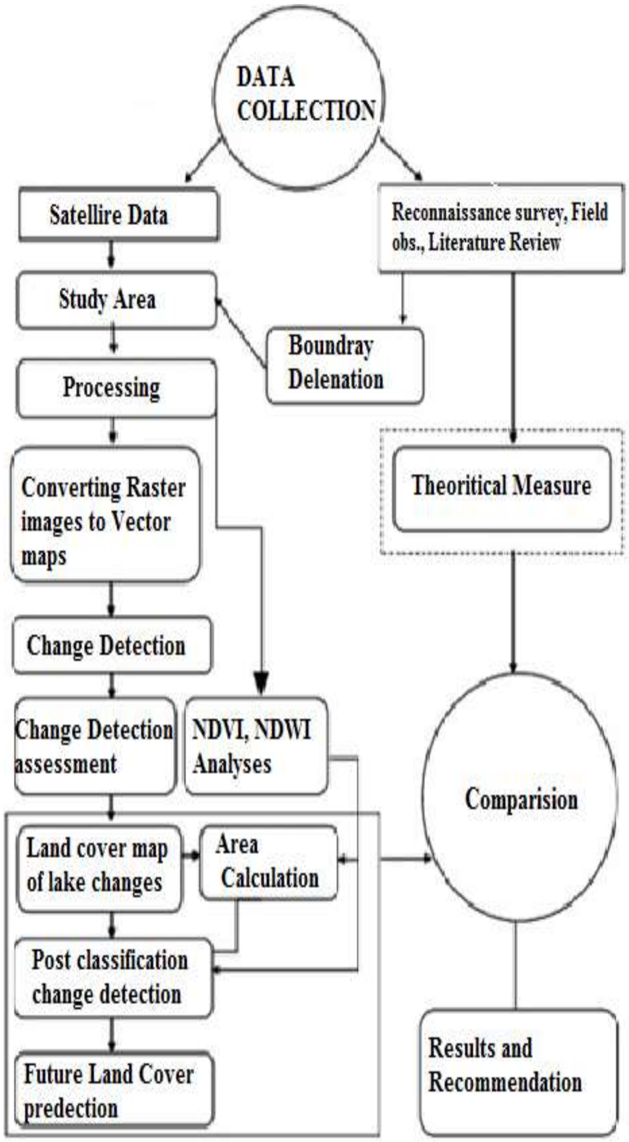


Fig.3. Methodology of the work

MATERIALS AND METHODS

Remote sensing analysis: Data of this study were derived from two main sources; satellite acquisition and field survey. Standard remote sensing techniques were applied to each image to enhance the visual interpretability of remotely sensed elements and better discriminate between lake features and surroundings. The GIS analysis: The analysis was carried out using ArcGIS software to make spatial distribution maps of the parameters not correlated with the satellite data. The boundary of the lake was digitized using the polygon shapefile.

The lake's shoreline was delineated by careful manual digitization of each date. Lake features, such as islands, and agricultural drains, were also mapped following the same method. Next, each image was classified separately by employing an unsupervised classifier, and results were compared following the post-classification method to estimate temporal and spatial changes (1985 – 2018). Information on prevailing aquatic vegetation, the main morphologic features of land-use activities and fish farms, measurement of depth ranges, salinity, and collection of water and bottom samples. Moreover, other coverage patterns in the lake were also collected.

RESULTS AND DISCUSSION

According to the change detection results and measuring the area of the lake in 1973, 1985, 1990, 2003, 2015, 2017, and 2018, the results showed a great degradation in the total area of the lake during the period where the total area of the lake in 1973 was 578.39 km2 and decreased to 529.80 km2 in 1985, then continued it's decreasing to 482.28 km2 in 1990, to follow its area degradation to 464197335.48 km2 in 2003, and also recorded 455.33 km2 in 2009, reaching the area of 453.60 km2 in 2015, to have a great shrinking in 2018 recording 454.10 km2. It is worth pointing out the fact that the results recorded 578166.455 km2 from 1973 to 1985, where the area of the lake increased from 1985 to 1990 by 482049.02 km2, where the scenario of losing areas from the lake continued to be 18077.90 km2 in 2003, down to be 1732.15 till the year of 2009 km2, while area lost in 2015 by 498.59 km2 to reach 2018. The total area lost from 1973 to 2018 was 124,291.11 km2

Fig.4. Satellite image of El Brullus Lake 2018

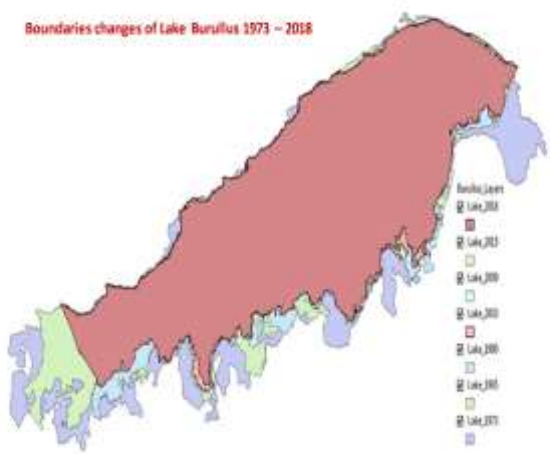


Fig.5. Boundaries changes of Burullus 1973 – 2018

Table 2 Changes in the total area of Burullus Lake

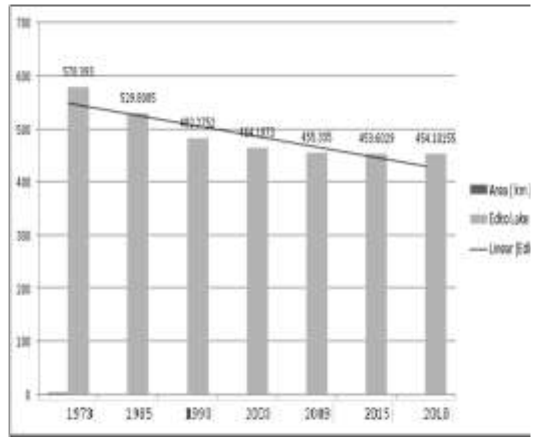
Date of Burullus Lake	Area of Burullus Lake
El Brullus 1973	578.393 km2
El Brullus 1985	529.8085 km2
El Brullus 1990	482.2752 km2
El Brullus 2003	464.1973 km2
El Brullus 2009	455.335 km2
El Brullus 2015	453.6029 km2
El Brullus 2018	454.10155 km2

The decrease in the open water surface area is attributed mainly to many factors, including:

1- Drying of the southern and southwestern fringes for reclamation activities either for agriculture or for aquaculture.

2- The landward movement of dunes and drifted sand from the coastal sand bar, which would potentially reduce the lake area from the north.

Graph 1 Changes in the total area of Burullus Lake



The total area lost from 1973 to 2018 was 124,291.11258608 km2

The Vegetation area changes of El Brullus Lake:

El Brullus Lake NDVI

The results of the NDVI of El Brullus Lake during 1973 – 2018 showed that the total vegetation area of the lake increased from 1973 to 1985, jumping up to its highest level in 1990, which decreased again in 2003, estimating these decreasing due to the awareness of its aquatic life importance, on the contrary in 2015 showed slight vegetation increase, to be reduced slightly again in 2018.

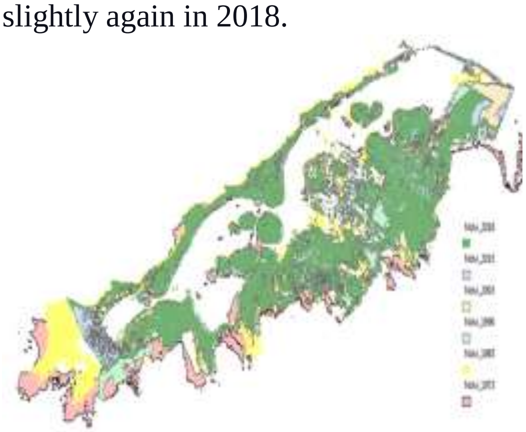


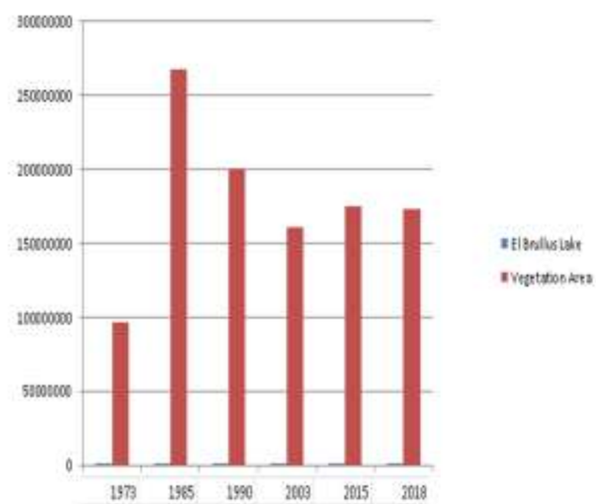
Fig.6. Vegetation changes of Burullus 1973 – 2018

Table 3 Changes in the Total vegetation area of El Brullus Lake

Date of El Brullus Lake	Total Vegetation area (NDVI)
El Brullus 1973	96638363.834925 m
El Brullus 1985	267062016.416163 m
El Brullus 1990	200312931.154928 m
El Brullus 2003	160415194.822385 m
El Brullus 2015	175011327.139388 m
El Brullus 2018	173025009.084714 m

The total vegetation area increased from 1973 to 2018 was 76386645.24978 m

Graph 2 Changes in the Total vegetation area of El Brullus Lake



CONCLUSION

The study concludes that Lake Burullus is threatened by environmental degradation due to continuous human-induced shrinking. Another threat arises from removing the coastal dunes bordering its coastal face. This delicate coastal ecosystem requires appropriate management and protection as the country is moving toward sustainable use of its natural recourses.

They exposed to gross negligence that both Lakes El Brullus have suffered from the spread of weeds, forests, and wolves, which has caused the shrinking of the area suitable for fishing by the lake. The analysis indicated that the water body of El Brullus lake has a decreasing trend. In contrast, the floating vegetation has an increasing trend due to the discharging of agricultural and municipal wastes into the lake without adequate treatment. Over the entire period of the analysis (from 1973 to 2018), the floating vegetation and island area increased, and the water body decreased. The floating vegetation continues over the next 15 years, which makes the water body of the lake unsustainable. This may lead to a variety of adverse environmental impacts and may endanger the ecosystems in the area of the lake. Finally, With remote sensing, we can gather information on the relative variation of water quantity and quality parameters and make some qualitative comparisons. Multisensor satellite data such as LANDSAT, Satellite data are effective in generating GIS database information required for hydrological studies and the application of models. Remotely sensed data contribute to a lake water quality assessment project through its ability to show spatial patterns of various environmental parameters.

RECOMMENDATIONS

1. To eliminate the problems of infringements and drying, it is necessary to dig a bank that separates the fish farms from the water surface of the lake to prevent any new encroachments on the part of the owners of the farms. Also, the work of the civil dredges must be under the Fisheries Authority's supervision because the farms' owners use these rigs to encroach on the lake's water surface.
2. The lake has a great wealth that one does not notice. It is the existence of five million meters of mud deposits, according to the 1984 report. These sediments must be studied for use, either by transferring them to the desert lands to mix them with yellow sand

to increase their fertility or sell them to brick factories.

3. Establish a purification plant for industrial, agricultural, and agricultural wastewater in the lake, and obligate the companies, factories, and villages that have drainage outlets on the sea and the lake to make drainage networks and connect them to the purification plant to be constructed.

4. To take practical measures against the violators of the owners of the farms or the aggressors on the water surface by breaking their contract and removing the infringements at their own expense.

5. The purification of the port of the fishing port, the treatment of the water pollution tank with the laundries by providing pumps for oil suction instead of dumping it in the port, providing a fire line at the port, and providing all means of civil protection to secure the port from the fire.

6. Removal of aquatic plants will increase the movement of water and fish and increase the diversity of organisms.

7. The method of removal of aquatic plants in a studied manner and not random by each species significantly lead to growth, such as the mosquito, and thus the sustainability of economic exploitation.

8. Removal without prejudice to the environmental balance of the aquatic organisms within the lake's water surface.

9. Non-treatment of untreated water in the lake. Plant treatment plants (biological treatment) can be used as an easy and low-cost way to treat wastewater before discharge in the lake to reduce contaminants.

10. Save the fish farms' water in the lake before treatment.

11. Preserving the percentage of plants to play their role in the gas balance in the lake area and contribute to solving the problem of global warming.

12. It is prohibited to use lake plants as livestock feed because they contain high concentrations of heavy elements.

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