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EIA FOR LAKE MARYUT SUSTAINABLE DEVELOPMENT ALTERNATIVES USING GIS, RS, AND RIAM SOFTWARE

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ABSTRACT:

Exploitation of land and water resources has increased rapidly in Alexandria Governorate, paralleling regional population and industrial growth. Encroachment of urban areas and increase pollution sources are typically considered to have detrimental effects on Lake Maryut ecosystems. Lake Maryut suffering from different effects including nutrient loading, chemical substances, contaminated sediment, invasive aquatic plants, and wholesale hydrologic alterations, eutrophication is the most widespread pressure impacting on the lake. In general, its need to be restored using different sustainable development alternatives, by active integration and partnership between all stakeholders, regarding a balance between resources prosperity, social development, cultural values, and ecological integrity, to improve the life quality of human community. This paper aims to propose three restoration alternatives strategies for Lake Maryut based on the information derived from Remote Sensing, GIS, and field survey, each proposed alternatives are Mechanical, Biological, and Bio-Manipulation Alternatives. The result obtained by RAPID IMPACT ASSESSMENT MATRIX (RIAM Software) indicates that the most suitable alternatives for Lake Maryut restoration plan are the mechanical alternative, and biological alternative. On the other hand the "bio-manipulation alternatives" has some significant positive impact on the surrounding environment, and with some negative impacts especially on biological and ecological component.

Keywords: ***Lake Maryut, Sustainable Development alternatives, EIA, R.S, GIS, RIAM.***

1. INTRODUCTION:

Improving water quality in lakes suffering from eutrophication is one of the biggest challenges facing water managers across the world (Smith and Schindler, 2009). The implementation of wide reaching legislation (e.g. European Urban Waste Water Treatment Directive "UWWTD; 91/271/EEC"), the European Water Framework Directive (WFD; 2000/60/EC), and the U.S. Federal Water Pollution Control Act (US Statutes at Large, 1987), has resulted in the introduction of restoration targets and strategies for impacted freshwater ecosystems. As countries attempt to meet their obligations under these legislations, the cost of lake remediation is likely to increase dramatically (Pretty et al., 2003; Vinten et al., 2012). In addition, the general public is becoming less tolerant of the undesirable symptoms of eutrophication, such as algal blooms (Yardley, 2008) and large scale fish kills (Sweeney, 2009). The most common approach to eutrophication management is the reduction of external and internal phosphorus (P) loads with the aim of reducing phytoplankton biomass (Sas, 1989;

Søndergaard et al., 2005; Jeppesen et al., 2005).

2. STUDY AREA

Wetland lakes can be defined as any enclosed body of water, fresh or saline, that is 6 m or less in depth (Davis, 1994), lake Maryut fall within this definition. The shallow coastal lakes on the Nile Delta have been subjected to major disturbance since ancient times (Butzer, 1976). The hydrological regime of all these lakes results from a balance of freshwater runoff from the agricultural regions in the south and seawater input from the north, where undisturbed by land reclamation and development (Ramdani et al, 2001). Lake Maryut is one of the five Northern lakes of Egypt, located on the Mediterranean to the north of the delta. The lake proper and valley of Maryut extend for 80 km along the North Western coast and 30 km south and is divided into five basins by highways and railroads. The average depth of the lake ranges between 0.55 and 1.2 m. The level of water surface is -2.8 m compared to average Sea Level (Bakr and Saadallah, 2007). It is a shallow water body that lies near Alexandria (Abaza, et al, 2009) between Longitudes $29^{o}\ 51^{/}\ 00^{//}$ - $29^{o}\ 56^{/}\ 15^{//}$ E, and Latitudes $31^{o}\ 04^{/}\ 15^{//}$ - $31^{o}10^{/}\ 45^{//}$ N (Abd El-Malek and Halim, 2009; Ghoraba, 2012) as illustrated in figure (1).

Lake Maryut is a brackish water lake, which differs from other Delta lakes. It is a closed basin isolated from the open sea, with no natural connection to the Mediterranean Sea (Louizeau and Stanley, 1994; Abdel Aziz and Aboul Ezz, 2004; Ahmed and Kaiser, 2014). The lake five basins are somewhat interconnected to each other by several breaches in the dykes of El-Umum Drain and Nubaria Canal. The lake since 1892 has been fed by drainage canals. In order to keep the lake at level -2.8 m, excess water is pumped into the sea by El-Max Pumping Station, created for this purpose. The Lake is used to be one of the major lakes in Northern Egypt with vast biodiversity and vital source of fish and salt production. "Maryut valley" with high aesthetic value as well (El Din and Ayoub, 2013).

3. MATERIALS AND METHODS

The data used in this paper are Topographic Maps for the date 2007 with the scale 1:25000 the map projection type is universal transverse Mercator (UTM) Zone 35N, Satellite Image of Quick Bird for the dates 2014 with the spatial resolution 0.5 meter. Image was geometrically corrected and registered to the UTM coordinate system, Zone 35N, Datum Name WGS84, and; Field survey of ground truth. The methods utilized in this study can be explained as the following:

- Image pre-processing (band combination, image mosaic, and resolution merge).
- Image processing (image classification) the unsupervised classification in this work is carried out using (ISODATA Algorithm) to classify the image into 50 clusters. In addition the supervised classification (MAXIMUM LIKELIHOOD Algorithm) was carried out using training sites of the study area.

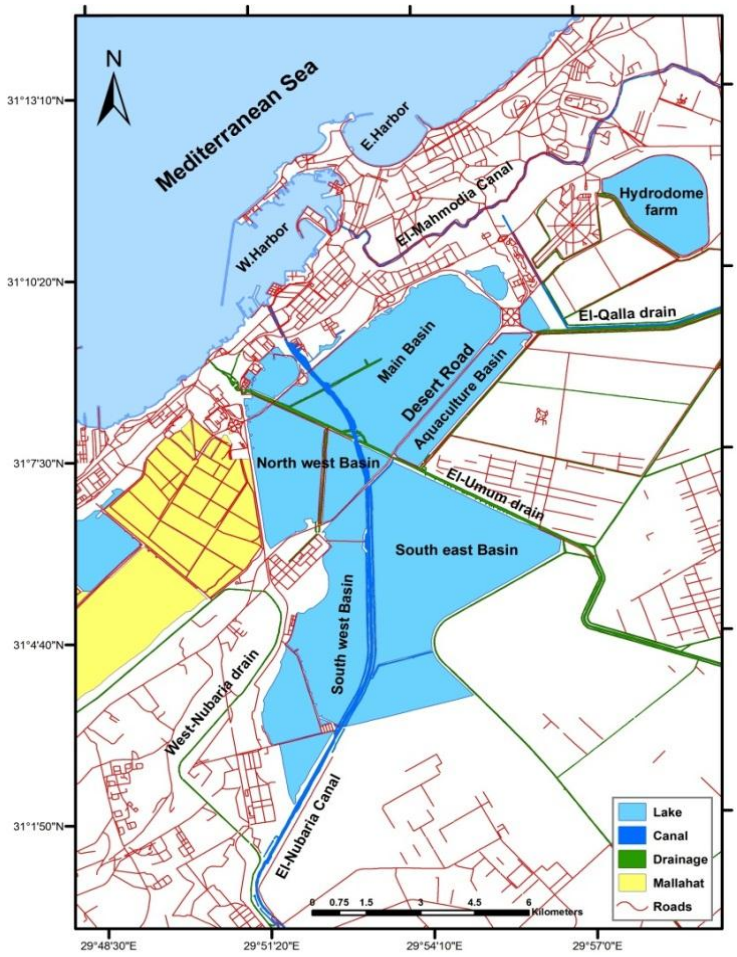

Figure (1): location of the study area "Lake Maryut"

- **As a final step the signatures created from both supervised and unsupervised training are merged and appended together to perform hybrid classification.**
- **Assessing the Accuracy for hybrid classified images by ERDAS IMAGINE Software 2014, while processing the accuracy assessment module an equalized number of random points was tested is 200 point.**
- **Finally Creating Geographic Information System For the study area that ready for various GIS analysis, and putting many alternatives for study area sustainable management, furthermore using (RIAM) application for assessing the environmental impact for these alternatives, for choosing the best alternative for managing the study area. (RIAM) application assessing proposed scenario according to four environmental categories, this includes (1) Physical/Chemical components (PC) Covering the physical and chemical aspects of the lake, (2) Biological/Ecological components (BE) Covering the biological and ecological aspects of lake (3) Social/Cultural components (SC) Covering all human and cultural aspects of lake, (4) Economic/Operational components (EO), Covering all economic consequences of the lake, both temporary and permanent. Each parameter is estimated according to**

the magnitude, duration, reversibility, and cumulative effects and is given a score based on the author's knowledge of the study area. The scales used to evaluate different impacts for various environmental parameters are completely different; it ranges from 0 to 4 in importance, -3 to +3 in magnitude, and 1 to 3 in permanence, reversibility, and cumulative components. The positive sign indicates positive beneficial impact, the negative sign indicates negative adverse impact and zero indicates an insignificant impact.

4. RESULTS AND DISCUSSION

Deterioration of Lake Maryut and its surrounding can be restored, but this task is difficult, and may be expensive to apply. Further, the results of lake rehabilitation alternatives may not be apparent for some years. In this paper a number of alternatives could be proposed for lake management based on the information derived from remote sensing, GIS, and field survey, each proposed alternatives would discuss separately as the following.

4.1 MECHANICAL ALTERNATIVE

Six scenarios were selected as potential mechanical solutions for many problems of the lake:

4.1.1 SECONDARY TREATMENTS OF (WTP) AND SUGGESTED CANAL

Applying Secondary treatments of wastewater in all water treatment plant of Alexandria Governorate before disposal its water into the lake directly or indirectly through Canal and Drain connecting with the lake. In this alternative we suggest converting the path of El-Qalaa drain from Lake Maryut main basin to reach of Ikingi Maryut districts through Suggested Canal, and reusing its water For Reclaim desert land, and cultivated this area with some plant such as wooden trees, cotton, and flax that enter into some industries. But not use this water for cultivated edible plant at the same time. By using Interpolation function, we can use the elevation points on the Topographic Maps and ASTER Image to generate the elevation layer that necessary for define the best path of its Canal, figure (2) illustrate the output study area elevation map, and suggested Canal with about 24.5 km length from started point "El-Qalaa drain" to ended point "Ikingi Maryut districts", but when the land elevation changed, we suggest creating pump station to raising the water from lower elevation to higher elevation. The main advantage of this alternative is reusing wastewater for reclaimed new areas that helping to increase production of suggested plants (due to the shortage of water resources in the future in Egypt) instead of disposal of this water into the lake without any benefits. The main disadvantage its expensive cost for digging its Canal, and may be the Canal path inconsistent with other infrastructure in the study area.

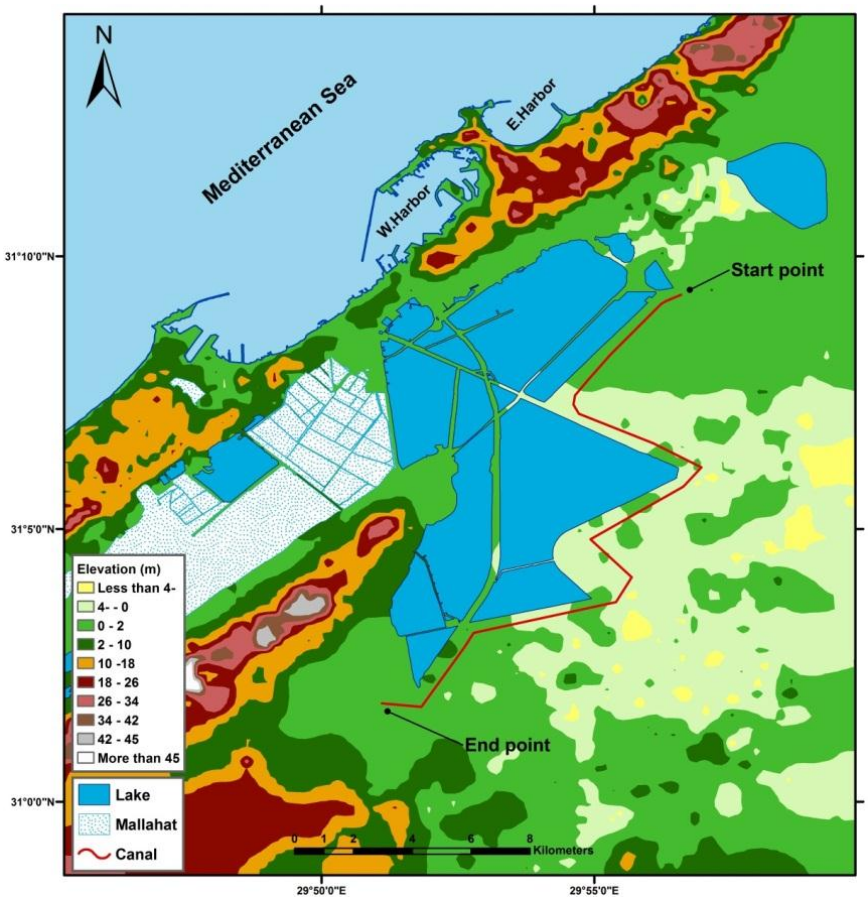

Figure (2): Study Area Digital Elevation Map and Suggested Canal

4.1.2 DREDGING

Surface and core sediments from Lake Maryut, Egypt, one of the most polluted lakes sediment in Egypt (Omar, et al., 2011), it has been stated that the nature of the bottom of Lake Maryut has been altered markedly from its original condition, due to the continuous supply of sewage and industrial wastes. Sediment type in Lake Maryut is saline sand-clay, grayish to blackish gray with a smell of Hydrogen Sulphide (Mostafa, 1994). Dredging process is used to remove sediment, which can be a major source of different pollutant in the water like phosphorus, heavy metals, sludge, chemical substances, nutrient, and pesticides that dissolved in the polluted water and accumulated in the lake sediment for long time, killing many plants, animals in the lake as well as the algae and birds. Dredging can accomplish several goals: removal of chemical substances, macrophyte, phosphorus, and contour alteration for navigational purposes.

Removal of sediments is an expensive method for removing pollutants, but it is introduce some advantages. The main advantage that dredging has over other techniques is that it does not introduce foreign substances into the water body, the lake becomes deeper than before, and the oxygen demand, nutrient, phosphorus, chemical substances, heavy metals load are lower. The main disadvantage is that the extracted sediments have to be put somewhere, and treatment of these deposit sites is still impossible because this

sediments containing large amount of sludge mixing with hazardous pollutants from urban, agricultural, and industrial regions. In such cases the separation of the mostly non-polluted sand and mechanical drying and the very expensive special deposition of the contaminated fine-grained materials is necessary. So that, we suggest constructing number of huge hollow cylinders made of armed cements or concrete, placed with its top open in the lake basins for disposal of sediments from the lake pumped by a powerful pump.

Several of these cylinders are placed inside the lake and sediments inside are allowed to settle down after evaporation by the sun. When the cylinders are filled by polluted sediment the top is closed by 1m of sand and cultivated trees are allowed to grow. These cylinders are then connected by bridges and used as recreational areas in the lake for the local people around the lake like small café in the big center cylinder, and small garden on other small cylinder, as illustrate in figure (3). The best layer of cleaning the bottom sediments of Lake Maryut, varying according to the sludge thickness in the Lake that differs from site to another site in the whole lake. The sludge thickness in the Lake Maryut was 0.0 cm at Northern and Southern part of Aquaculture Basin, Southern part of South Basin and at the Northern part of the Main Basin, and varied between 5cm at different parts in the lake and reached to maximum thickness 50 cm in front of the mouth of El-Qalaa drain Figure (4). To define which suitable sites for constructing each cylinder, how many cylinders needed the height, the width and diameter of this cylinder to accommodate all sediment layer of the lake? We needed engineering, environmental, and feasibility study to give the excellent results in a relatively short time.

4.1.3 REMOVE COMMON REED

Satellite image for lake Maryut year 2014 illustrate a large area that covered by Common Reed especially in the main basin and South- East basin, so the system is designed to remove these plants from many places inside the lake as shown in figure (5), removing this plant is a successful way, but there is no benefit, when we remove the upper part (above the water surface) of that plant because, these plants growth quickly with wide spread area. Then we need to remove these plants as whole. The successful way is divided the rooted plant area into small areas, isolate this area from the main lake body, we have two choices to dry this area. First one by pumping and the second leaves it naturally dried by evaporation. The next step is to dredge this area until we reach the plants root (completely removed). After that the dredged soils were leaved for some time to be completely dry. Then let the lake water released to the cleaning area (Hussain, 2004). The main advantage of this alternative cleaning the Lake water and open ways for fishing activity. The main disadvantage is isolating some parts of the lake through implementing steps of this alternative, leads to stop the fishing activity that effect adversely on the fishermen community that based only the fishing as the main source of income.

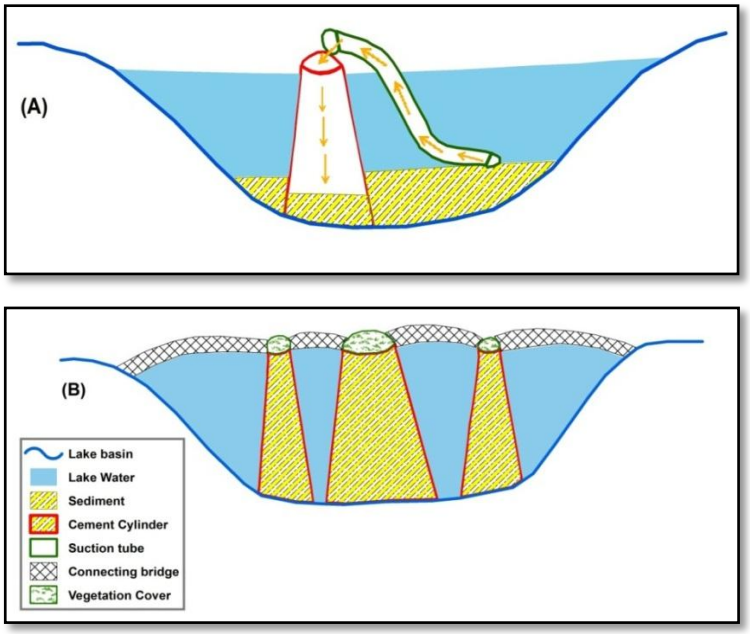

Figure (3): Suggested Cylinders in Lake Maryut

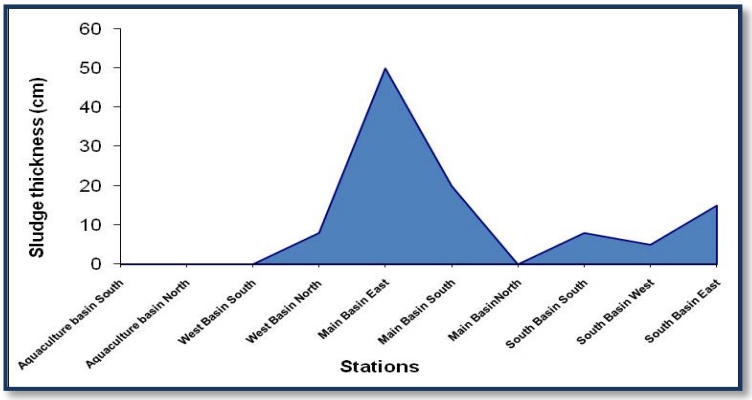

Figure (4): Sludge Thickness at each site (Fishar, 2008)

4.1.4 REMOVE WATER HYACINTHS

Satellite Image for Lake Maryut year 2014 illustrate a large area that covered by Water Hyacinths especially in the main basin as presented in figure (6).

Two ways to fight the Water Hyacinths, the first is harvesting the Water Hyacinths and could be using as a source of biogas production and Papers industry. The second is aquaculture the specific species of fish called El-Mabrouk "Grass Carp", this type of fish feeding on Water Hyacinths. The main advantage of that alternative, increasing the fish production of El-Mabrouk, decreases the spread of Water Hyacinths, Papers and biogas production. The main disadvantage is the spread of El-Mabrouk fish "low economic value" may be leads to decrease the production of Tilapia fish due to don't find suitable environment to lay eggs.

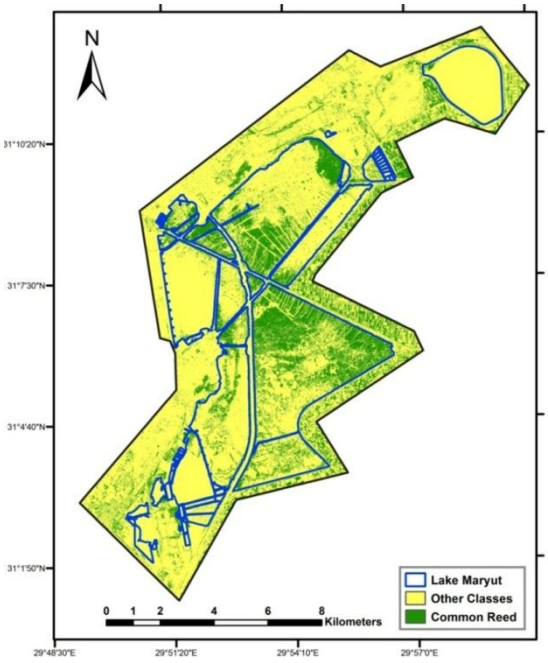

Figure (5): Location of Common Reed, 2014

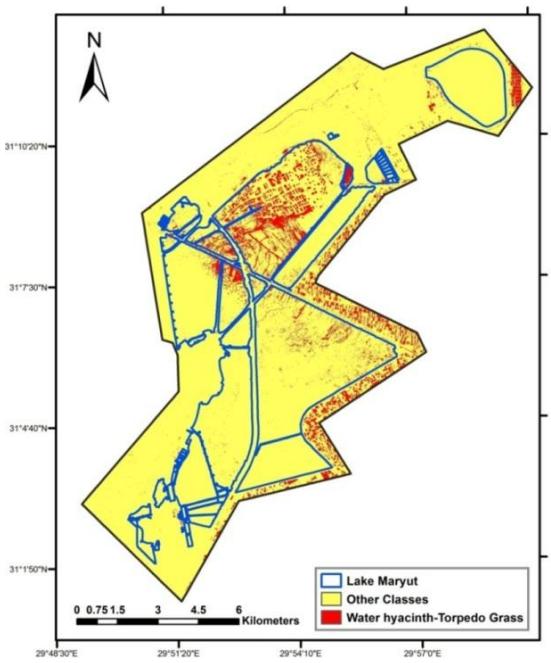

Figure (6): Location of Water Hyacinths, 2014

4.1.5 ARTIFICIAL RE-AERATION

Artificial re-aeration system is a device (like Air Compressor) sucks oxygen from the air and re-pumping it into lake deep water using air diffuser, figure (7).We need this solution only when the bottom dissolved oxygen (DO) concentration decreased under the 5 mg/l to prevent the conversion of aerobic conditions to anaerobic. Artificial aeration and circulation increase dissolved oxygen levels that prevent killing fish and create a larger zone of habitation for fish and microscopic animal communities. Aeration can also slow the tapping of phosphorus from bottom sediments.

4.1.6 ARTIFICIAL CIRCULATION

Artificial circulation system is a device (like a fan) putting in each cell to push water mass, figure (8). This device must be contact with meteorological device to define wind speed and direction. During calm or low wind speed the rotated device must be start to run with suitable speed and direction. On the other hand , the negative effects of this alternatives on lakes water, may be water temperature increase, release phosphors from sediment, increase in Do concentration. So that we suggest apply this alternative after removing the lake sediment.

4.2 BIOLOGICAL ALTERNATIVE

Two methods have been suggested for biological alternative, the first macrophyte harvesting, and the second floating plants for removing access nutrients and heavy metals from lake water.

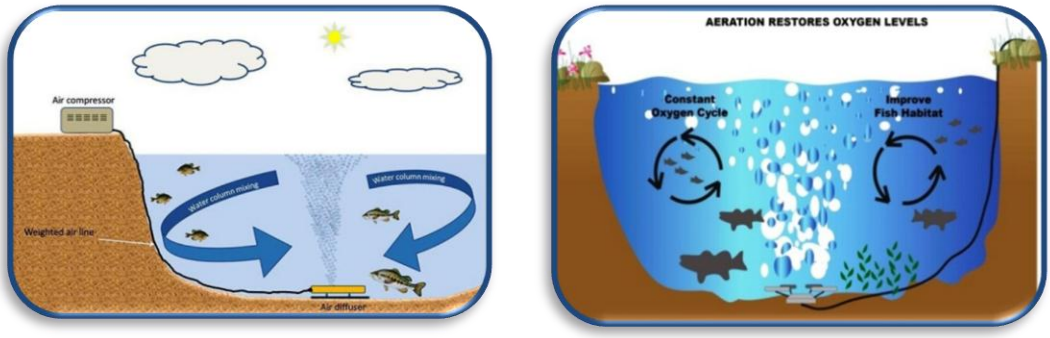

Figure (7): Artificial Aeration System (www.Watergardengems.com)

Figure (8): Artificial Circulation System (www.nanasupplier.com)

4.2.1 MACROPHYTE HARVESTING

The idea behind macrophyte harvest as a restoration technique is that it will reduce the internal productivity of the water body and remove phosphorus that is stored in the plant by removing the plant. The harvesters units are paddle wheel propelled and have a large frame extending down into the water ahead of the bow figure (9). This frame is made up of vertical sickles on the sides and a sickle across the bottom connecting the two sides. A conveyer belt extends up from this frame to the boat and carries the cut macrophyes to the surface where they are collected. Repeated harvesting can reduce the macrophyte growth and can have a carryover affect that could be more cost effective. The main advantage of macrophyte harvesting is that it is a highly visible technique that provides instant results. The main disadvantage is that the process does not remove a significant amount of phosphorus from the system.

4.2.2 FLOATING PLANTS

There are certain required characteristics that aquatic plants most possess, for them to be selected as useful plants for application in Lake water system.

Duckweed commonly refers to a group of floating, flowering plants of the family Lemnaceae. The different species (Lemna, Spirodela, Wolffia and Wolfiella) are worldwide distributed in freshwater and wetlands, ponds and some effluents are the most common sites to find duckweed. The plants are fast growing and adapt easily to various aquatic conditions. The plants are found in temperate climates and serve as an important food source for various water birds and fish (Khellaf et al., 2010).

"Lemna Gibba" Figure (10); have been utilized to treat municipal wastewater and a very high biochemical oxygen demand (BOD) removal (Sree, 2015).Since if the wastewater does not contain toxic components, Lemna Gibba may be harvested and utilized as feed for fish. This represented a major advantage of the use of this kind of aquatic plant in the treatment of wastewater, as nutrients are recovered and the economic viability of the whole system increases. "Salvinia" is a floating aquatic plant Figure (10) that grows wildly in sub-tropic and tropical regions. Salvinia grows best when the water temperature is between 20 and 30°C; growth is limited or absent under 10°C. It grows faster when nutrients are abundant (Salvinia molesta, 2010). "Salvinia" have been utilized to remove heavy metals from wastewater especially for the removal of Cadmium and Lead.

Diffuse of "Lemna gibba" and "Salvinia" plants, could apply inside the lake Maryut in suitable seasons. So, we did not expend any effort or money if we applied this alternative to remove access nutrients and heavy metals. Only one thing remainder, these plant must be removed from the lake (manually) with timetable (depend on the season of growth).

4.3 Bio-Manipulation Alternative

Eutrophication phenomena are the accumulation of the nutrients, especially phosphorous, in aquatic system. This process does occur naturally in all bodies of water but human activities accelerate the process. Intense nutrient influxes into lakes cause dramatic changes to lakes dynamics. High concentration of phosphorous through external and internal nutrient loading promotes algae blooms. Blooms cause fish death, macrophyts decline, and decrease in dissolved oxygen. Bio-manipulation seeks to control blooms by increasing zooplanktons to promote heavy grazing of algae.

Raw domestic sewage in Alexandria, Egypt typically contains between 5 and 20 mg/liter of phosphor and this concentration reduce to 4.5 mg/liter after treatment processes. Inorganic fertilizers include super phosphate about (9% P) and triple superphosphate (20%P), Phosphorus causes eutrophication (Moharem and Zaki, 2011).

Bio-Manipulation is typically used in lakes that are small, shallow, and closed systems, tends to work well since organisms are not spatially separated by depth. Lakes need to be closed systems because organisms entering the lake through connections with other water bodies will inhibit the ability to control the lakes fauna. One method to increase zooplankton populations is the removal of planktivores through a fish kill or removal. Biological controls represent a relatively new effort to control the growth of algae and weeds through manipulation of the ecological connections within a lake (Hussen, 2004).

Figure (9): Macrophyte Harvesting machine (www.aquamarine.ca)

Salvinia Plant (www.agric.wa.gov.au) **Lemna Gibba plant (www.ruduckweed.org)**

Figure (10): Floating Plants

5. ENVIRONMENTAL IMPACT ASSESSMENT FOR SUGGESTED ALTERNATIVES

In order to choose the most suitable alternative, an accurate computerized method should be used with specific analysis method. This method name interaction matrix method and it applied through modern Software called RAPID IMPACT ASSESSMENT MATRIX "RIAM" (Pastakia, 1998). RAPID IMPACT ASSESSMENT MATRIX (RIAM) is the analytical tool that was used in prioritizing the water resources management problems was originally developed for carrying out Environmental Impact Assessment (EIA) RIAM has an advantage over the existing EIA methods (Yeboah, et al., 2005; Araújo, et al., 2005). Generally, all potential direct and indirect impacts should take into consideration and a detailed interaction matrix analysis based on Delphi technique has been carried. Matrices are used not only for the identification of possible impacts but also for evaluating those impacts, often by entering numbers into matrix that represent subjects estimates of the significance of the relevant impacts. Summary addition of such numbers in matrices, completed for different design alternatives, has been used

to compare the environmental significance of those alternatives. The Rapid Impact Assessment Matrix (RIAM) method is based on a standard definition of the important assessment criteria as well as the means by which semi-quantitative values for each of these criteria can be collated to provide an accurate and independent score for each condition.

This system is based on the knowledge that certain specific criteria are common to all impact assessments, and by scaling these criteria it becomes possible to record the values of the assessments made. RIAM works with both negative and positive impacts (Dannisoe, 2009).

In this study after completing the RIAM matrix, three diagrams were obtained for the study area according to the study alternatives, each diagrams has four colors one for each component used. By overlapping the three diagrams a summary diagram was obtained as illustrate in figure (11). In that diagrams the horizontal axis represents the level of negative and positive (or neutral, N) impacts, ascending in value from A till E. the vertical axis represent the magnitude of contribution of each group of environmental components (physical and chemical, biological and ecological, social and cultural and economic and operational) according to the length of the specific representative color. Result of the analysis of impact matrix indicates that the "bio-manipulation alternatives" has some significant positive impact on the surrounding environment, and with some negative impacts especially on biological and ecological component. On the other hand the Result indicates that the most suitable alternatives are "mechanical alternative", and biological alternative. Those alternatives are most suitable for Lake Maryut restoration process with some mitigation measures. Also the combination between more than one alternative could give better results for Lake Maryut restoration plan.

6. CONCLUSIONS

Lake Maryut is suffering from different problems due to pollution that deteriorated the ecosystem, functions and services of the lake such as, fishing, irrigation and aquaculture, as a consequence of the environmental degradation. Recreational and Aesthetic view is considered to be completely absent due to the bad odor from the emission of Hydrogen Sulphide gas especially near the entrance to Alexandria, and unpleasant view of the lake. Therefore, people living around the lake are facing real problem due to low productivity of the lake fish, and the borders of the lake Maryut are invaded by insects, and it is also the main source of mosquitoes that infects the diseases. According to this reasons a number of alternatives could be proposed for Lake Management based on the information derived from Remote Sensing, GIS, and field survey, each proposed alternatives are Mechanical, Biological, and Bio-Manipulation Alternative. Three alternatives for restoration of the lake were investigated for assessing the environmental impact using new software called RAPID IMPACT ASSESSMENT MATRIX. Those are willing to work with, Mechanical

alternatives. This action was found to be the best alternatives for lake restoration, and Biological alternatives. On the other hand the result indicates that the "bio-manipulation alternatives" has some positive impact on the environment, and with some negative impacts especially on biological and ecological component.

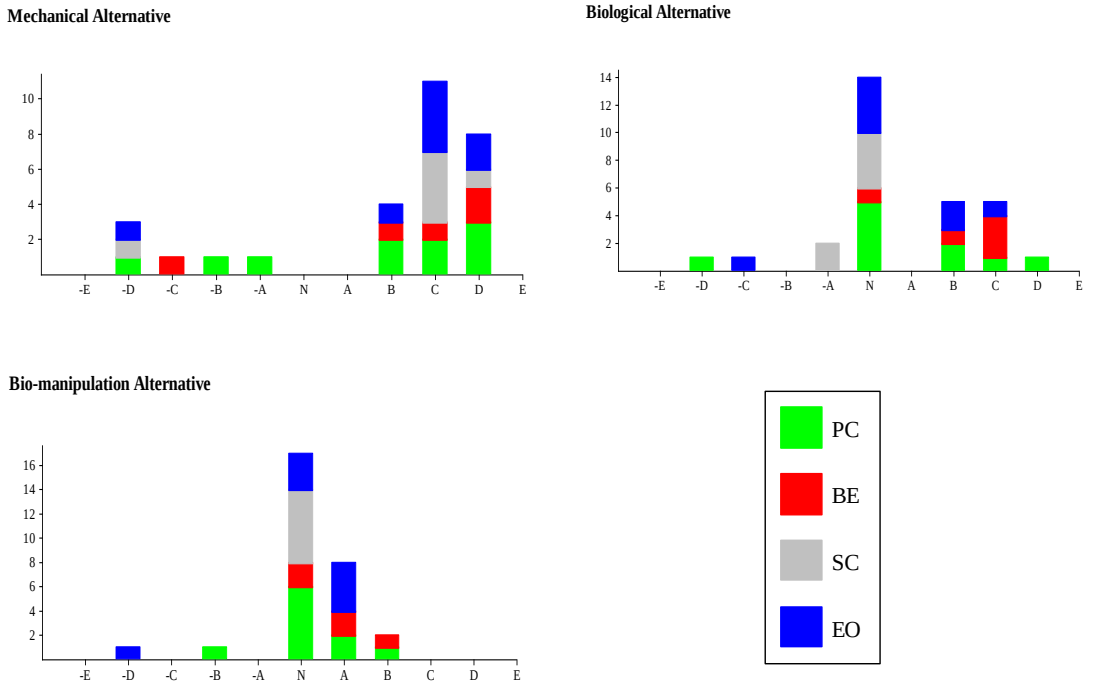

Figure (11): Result of EIA Alternatives Comparison Analysis

7. RECOMMENDATION FOR ALEXANDRIA GOVERNORATE

1. **Active the role of an ICZM Committee for management the lake, with main objective Sustainability of the lake, the Committee in cooperation with EEAA must issue State of Lake Maryut yearly.**
2. **Periodic monitoring and reporting of Lake Maryut area by Satellite image and Regularly updating GIS database for the Lake has a great importance to assessment of its environmental changes, is crucial for decision making expectation, and future plan for improving the study area.**
3. **Improve law enforcement and human impact may be occurring in the region.**
4. **Developing fishermen cultural to improve and conserve the lake from any deterioration, through the cooperation between fishermen, local inhabitant around the lake, Stakeholders, and governorate personnel.**
5. **Upgrading of Slum Areas and Degraded Land around the lake, and providing fishermen houses in compensation.**
6. **Support the role of governmental and non-governmental organizations to provide the local communities around the Lake by services such as health care centers, educational units, Market, and**

Infrastructure such as electricity, water, and sewage network.

7. **Stop Urban encroachment over Lake Maryut margin and over wastewater drain (Daier El-Matar and El-Umum Drain) because it is very serious. In addition to its impact on public health, it is located in risky areas that are located 2.8 m below sea level.**
8. **Take serious action towards reducing and mitigation of the pollution sources affecting on the Lake.**
9. **Increasing the public awareness about the importance of the lake for Aesthetic view for Alexandria Governorate visitor especially near the entrance to Alexandria. That leaving a bad impression for visitor and adversely affecting tourism and investment in the area.**

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تقييم الأثر البيئى لبدائل التنمية المستدامة لبحيرة مريوط بإستخدام نظم المعلومات الجغرافية، الإستشعار عن بعد، وبرنامج RIAM

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الملخص العربي :

أدى النمو السكاني والصناعي السريع بمحافظة الإسكندرية فى الأونة الأخيرة إلى زيادة أستغلال الأراضي والموارد المائية بالمحافظة، ومن أهم مظاهر هذا الأستغلال التعديات على المسطح المائى لبحيرة مريوط جنوب محافظة الإسكندرية، فضلا عن زيادة مصادر التلوث التى تصب بالبحيرة مما آثر سلبا على الأنظمة البيئية بالبحيرة. حيث تعاني بحيرة مريوط حاليا من مظاهر عدة للتدهور البيئى والتى تشمل كلا من زيادة الأملاح المغذية، المواد الكيميائية ، الرواسب الملوثة، وزيادة أنتشار النباتات المائية مثل ورد النيل والبوص. مما أدى فى النهاية إلى تغير النظام البيئى الهيدرولوجى للبحيرة وحدوث ظاهرة التشبع الغذائى والتى تعتبر من أهم مظاهر التدهور البيئى للبحيرات، لذلك تحتاج بحيرة مريوط لإعادة تأهيلها بيئيا وذلك بإستخدام بدائل التنمية المستدامة من خلال التكامل الفعال بين أصحاب المصالح المشتركة بالبحيرة، مع الأخذ فى الاعتبار التوازن بين ازدهار الموارد البيئية، التنمية الاجتماعية، القيم الثقافية، وسلامة النظام البيئى بالمحافظة. يهدف هذا البحث إلى إقتراح عدد من بدائل التنمية المستدامة لإعادة تأهيل بحيرة مريوط إستنادًا إلى المعلومات المستقاه من الإستشعارعن بعد ونظم المعلومات الجغرافية والمسح الميداني، والتى تشمل البدائل الميكانيكية، البيولوجية، وبديل المناوبة البيولوجية. وقد تم دراسة الأثار البيئية السلبية والإيجابية لكل بديل على حدة بإستخدام برنامج (RIAM). وتشير النتائج النهائية لهذا البرنامج أن البدائل "الميكانيكية، والبيولوجية، هى انسب البدائل لإعادة تأهيل البحيرة ويمكن الدمج بينهما لإعطاء نتائج أفضل. على الجانب الاخر تشير النتائج ان بديل المناوبة البيولوجية له بعض الآثار السلبية على البيئة المحيطة.