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Wetland Quality for Sustainable Development Northwest of the Suez Canal: Components and Constraints

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ABSTRACT

Wetlands northwest of the Suez Canal were classified into two types: lands submerged with water, and lands saturated with groundwater. The resources of water in the study area vary, as they are derived from drains, aqueducts, and sea water through Ashtoum El-Gamil Bogaz and El-Qabouti Canal.

The wetlands in the study area are characterized by their biological diversity, which included producing organisms (plants) and consuming organisms (birds and fish). Moreover, the economic importance and benefits of wetland biodiversity are evident in the fields of agriculture, medicine, industry, environment, recreation and tourism. However, they are exposed to many problems resulting from human activities. This is mainly due to the fact that the human factor is responsible for causing deterioration, change, and even destruction of the components of the biosphere in the region.

Keywords: Wetlands, sustainable development, water rsources, plant, economic components.

Wetlands are lands that are saturated with surface water or groundwater for periods sufficient to support the life of plants, animals, birds, and aquatic biota. They can also be defined as the lands that are shallowly submerged by water in several centimeters up to six meters, and this water is stagnant or running, temporarily or permanently, whether it is fresh or salty. Lakes, springs and rivers are types of wetlands, which also include coastal lands from the margins of the seas and oceans represented in the coastal plains, and the lands affected by them, including the network of irrigation and drainage canals with a length of more than 40 km (Shaltout, 2011).

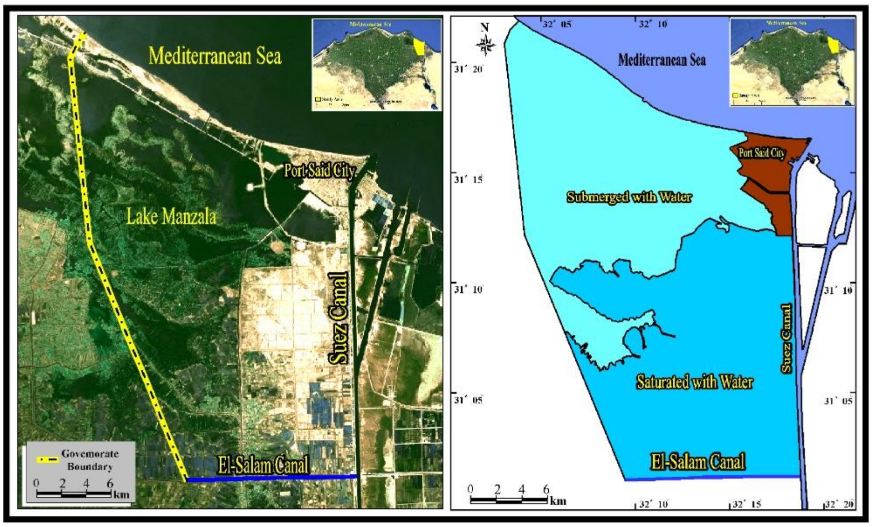
The degradation of wetlands is proceeding much faster than other ecosystems, and therefore there was an urgent need to protect them globally, which actually began in 1971 with the Ramsar Convention, an international agreement on the conservation and wise use of all wetlands in the world. This is mainly due to the importance of wetlands as they perform ecological and biological functions in the field of maintaining ecological balance, and they have great economic importance for being a source of fish, animal and plant wealth.

The study aims to identify the economic dimensions of wetlands, and to determine the environmental problems that threaten them so as to protect and restore water-related ecosystems and to manage them sustainably to achieve sustainable development.

To achieve the aim of the study, the area northwest of the Suez Canal is selected, where wetlands are spread and characterized by a diversity of water-related ecosystems, extending between latitudes 01/30° and 22/31° N, and longitudes 03/32° and 19/32° E, with an area of 659.9 km^2. It is bordered to the north by the Mediterranean Sea, to the east by the Suez Canal, and to the south by El-Salam Canal. As to the west, it has been identified with the western administrative borders of Port Said Governorate (Fig. 1).

Based on Saber's (2015) study, the wetlands in the study area are classified into two types (Fig. 1):

- **Lands submerged with water**: They are located in the western part of the study area, and include the eastern part of Lake Manzala, which are lands that are always submerged with water, where the depth of the bottom of Lake Manzala ranges between 55 cm and 130 cm, with an average of 84.5 cm from the water surface in the study area. The water source is the Nile River and drains, particularly Bahr El-Baqar and Hadous, and the Mediterranean.
- **Lands saturated with groundwater:** They are located in the eastern part of the study area, where the term groundwater is applied to the water in the saturated range of the ground layers. The boundary between the saturated and unsaturated area is usually not exactly at the groundwater level, but rather at a height above it, where it is the upper limit of the capillary range (Saber, 2003).



Source: Prepared by the researcher and Google Earth, 2014.

Fig. 1: Location of the Study Area and Classification of Wetlands

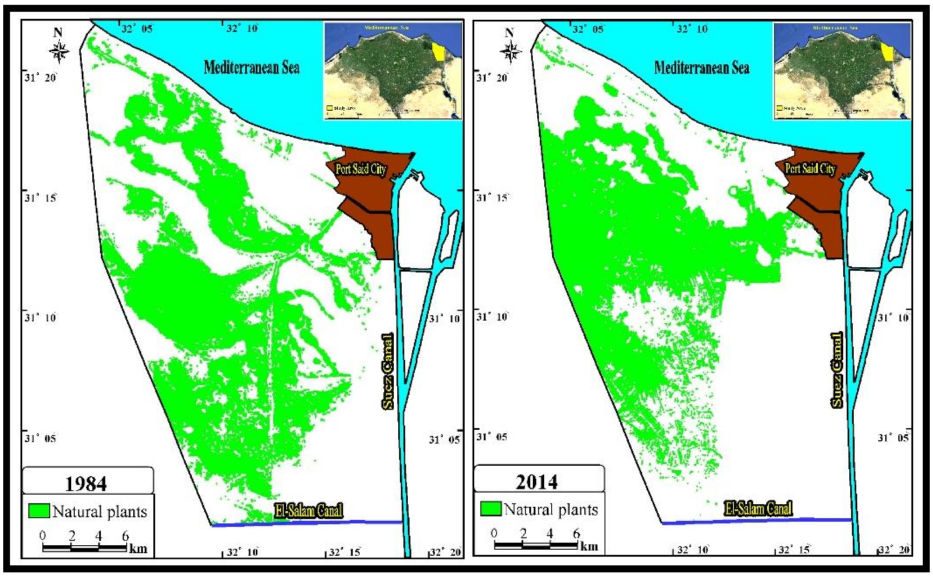
What follows is a detailed presentation of the quality of wetlands, represented by the economic components, constraints and problems faced by the wetlands northwest of the Suez Canal:

First: The Economic Components of Wetlands

The importance and benefits of biodiversity in wetlands in the study area emerge from an economic point of view in four areas: agriculture, medicine, industry, and environment, based on the studies of Naguib (2014), Hussein (1999), Mosaad (1999), Abdulfattah (2002), and the Ministry of Environmental Affairs (2014), Ashtoum El-Gamil Reserve, along with the field study 2015/2016.

1. The Economic Components of Wetland Plants

The area of areas covered by natural plants increased from 199.36 km^2 in 1984 by 30.21% to 230.16 km^2 in 2014 by 34.88% of the total area of the study area (Fig. 2). The total number of natural plants found within the boundaries of Ashtoum El-Gamil Reserve is estimated at 77 species (Fig. 3).



Source: Prepared by the researcher based on satellite images TM and ETM+ for the years 1984 and 2014, and the field review 2014/2015.

Fig. 2: Changes of Natural Plants Northwest of the Suez Canal (1984-2014)

Source: Taken by the researcher, 2015.

Fig. 3: The Diversity of Natural Plants in Wetlands Northwest of the Suez Canal

Wetland plants are a source of animal food, and such plants include phragmites australis, arecaceae, and cyperus rotundus. In some areas, aquatic plants, such as some types of azolla, lemna gibba, and eichhornia crassipes, gather in large quantities to be used as fertilizer or green fodder for livestock, in addition to the plants of cyperus papyrus, suaeda, and juncus acutus, all of which are edible for most types of animals.

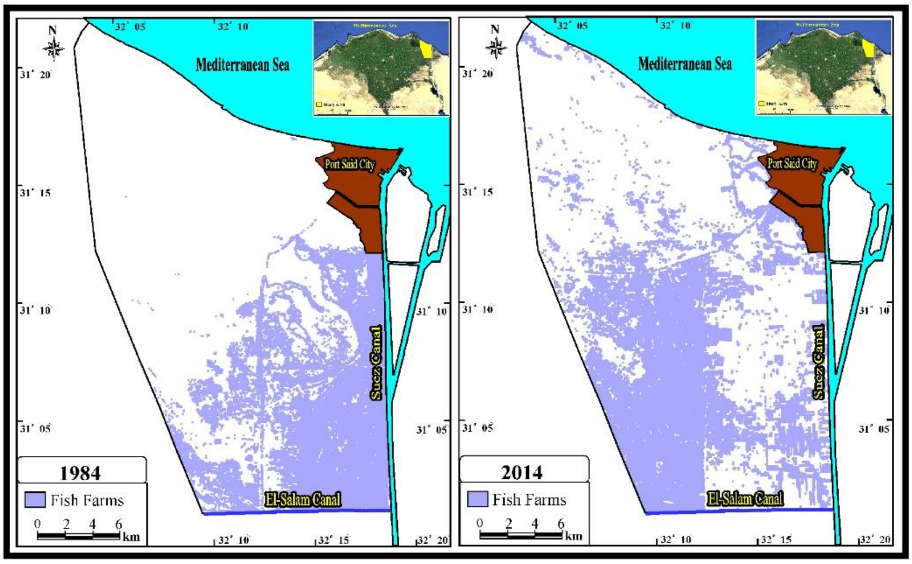
Eichhornia crassipes is very important, as it removes heavy metals polluting the aquatic environment, and it is able to efficiently remove nitrates and ammonium (Ahmed, 2003). Moreover, Fishermen use it for fishing in the southern and southeastern regions of the lake. As for the phragmites australis, it is used in manufacturing paper and fishing nets, making fences for homes, and making mats, as well as being used in the construction of some bridges. Many aquatic wild plants are also used in the treatment of sewage, and industrial and agricultural drainage, in the so-called biological treatment. On the borders of the reserve, there is one of these plants which uses this plant in the treatment.

2. The Economic Components of Fish in Wetlands

Fishing is one of the most important benefits offered by the wetlands in the study area, as well as being the main activity of the population. The fish production of Ashtoum El-Gamil Reserve is estimated at about 25 thousand tons annually, with the largest share of tilapia being 80% and about 20% for other marine fish species (Naguib, 2014). It is evident from the analysis of Figure (4) that fish farms spread widely in the study area, with an area of 146.79 km^2 and percentage of 22.24% of the total area in 2014, an increase of 27.94 km^2 over the year 1984 (Fig. 5).

Source: Taken by the researcher, 2015.

Fig. 4: Fish Farms in the Study Area



Source: Prepared by the researcher based on satellite images TM and ETM+ for the years 1984 and 2014, and the field review 2014/2015.

Fig. 5: The Development of Fish Farms in the Study Area (1984 - 2014)

3. The Economic Components of Wet Birds

The wetlands in the study area are characterized by the great diversity of bird species, whether the ones that reach them during the migration period of birds in the spring and autumn, where they are located on the migratory lines of birds, or the endemic birds in them (Fig. 6). 263 species of birds are recorded in the reserve, representing 52 genera and 27 families (Ashtoum El-Gamil Reserve).

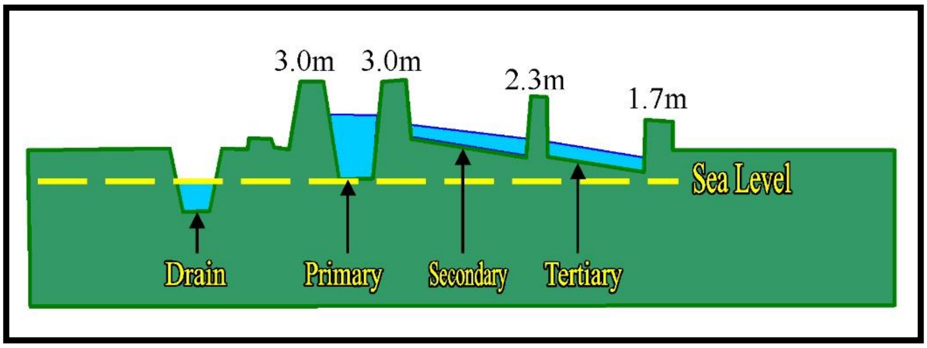
Source: Taken by the researcher, 2015.

Fig. 6: The spread of Birds in the Wetlands in the Study Area

Lake Manzala is located on the migratory path of birds, which made it one of the areas of international importance as it is a major station for migratory birds in Egypt. During the migration seasons, there are about 224,000 birds come to it annually. The most common species are as follows: podiceps, phalacrocorax nigrogularis, egretta thula, phoenicopterus roseus, anatidae, and larus.

4. Water Purification

Research on the use of wetlands to purify water began in the early seventies in Germany, then this research expanded greatly to spread in all countries of the world, working in particular to purify water from its excess loads of nitrogen and phosphorus. The water enters these lakes and remains there for several days, during which microorganisms, plants and soil work to rid the water of a large part of suspended matter and salts. Furthermore, wetlands are considered an inexpensive treatment method when compared to traditional treatment methods. The Ministry of Environmental Affairs, in cooperation with the Global Environment Facility and the United Nations Program, implemented the biological treatment project in the study area (Fig. 7 and 8).



Source: United Nations Development Agency, Lake Manzala Engineered Wetland, One United Nations Plaza, New York, United States 10017, March 31, 1997.

Fig. 7: An Illustration Showing the Idea of Bahr El-Baqar Drain Water Treatment through Biological Treatment in the Study Area

Source: Taken by the researcher, 2015.

Fig. 8: The Project of Wetlands North of Bahr El-Baqar Drain in the Study Area

The project covers an area of 200 feddans, and aims to treat 25 thousand m^3/day of Bahr El-Baqar drain water, which may reach 50 thousand m^3/day before it pours into Lake Manzala using an economic and eco-friendly technology simultaneously (Farid, 2009):

The plants available in the wetland environment in the study area were commonly used, such as phragmites australis, cyperus papyrus, lemna gibba, and others. Surface treatment ponds were planted with this plant, and the general efficiency of pollutant removal by plants and then the validity of the water after treatment were tested. Results were excellent in the plants' ability to treat water, which is evident from Tables (1 and 2) that show the effect of Bahr El-Baqar drain water treatment on the degree of concentration of toxic elements (contaminated).

Table 1: The Effect of Biological Treatment on the Percentage of Concentration Removal of Some Elements

Parameter	Removal Efficiency (%)	Parameter	Removal Efficiency (%)
Biological Oxigen Demand	61.21	Amounia (NH4)	62.12
Total Suspended Solids	81.03	Nitrate (NO3)	68.72
Total Phosphorus	20.95	Organic Nitroen	25.93
Total Niterogen	52.39		

Source: Tahoun, 2007.

Table 2: The Effect of Biological Treatment on the Degree of Concentration of Heavy Metals according to the Stages of Treatment

Metal	Input kg/yr	Sedimentation kg/yr	Harvested kg/yr	Discharged kg/yr	Removal Efficiency %
Copper (Cu)	390	330	42.4	12	97
Nickel (Ni)	236	203	18	13.6	94
Lead (Pb)	250	215	1.5	33	87
Zinc (Zn)	707	607	92	6	99
Chromium(Cr)	463	400	52	13.6	97
Iron (Fe)	96300	91500	5	4795	95
Manganese (Mn)	1490	1400	5	85	94
Mercury (Hg)	8.03	2.06	0	5.97	26
Cadmium (Cd)	886	762	0	124	86

Source: United Nations Development Agency, Lake Manzala Engineered Wetland, One United Nations Plaza, New York, United States 10017, March 31, 1997.

From the analysis of the two tables, the extent of the change in the degree of concentration of contaminating elements is evident as the following is demonstrated:

- Removal of a large percentage of toxic elements above 85% of its total concentration degree before treatment, however, noting that some elements have a low removal percentage of less than 30%, such as mercury, phosphorous, and organic nitrogen.
- The first stage is one of the stages that reduces the degree of pollutant concentration.
- The highest decrease was recorded for the following elements: manganese, iron, chromium, zinc, nickel and copper, which exceeded 94% of its total concentration degree before treatment.

It is worth noting that this percentage varies with the different amount of treated water (Table 3). At the lowest flow (7000 m^3/day), the decrease increases to no less than 54% for all elements, while it decreases by between 3 and 95% in the high flows (40 thousand m^3/day), except for the salinity that rises as a result of increased evaporation. Experiments have proven that the percentage of removal of both the total suspended solids, and biologically consumed oxygen in the winter increases, ranging between 88 and 95%, while the percentage of removal in the summer ranges between 12 and 58% due to the high temperature and then the high degree of evaporation (United Nations Development Agency, 1997).

It is evident from the previous analysis that the wetlands in the study area are the best alternative for treating drains, particularly Bahr El-Baqar drain, due to their low cost and their ability to treat a large amount of water.

Secondly: The Constraints (Environmental Problems) Affecting Wetlands

1. Contamination

Wetlands, whether submerged or saturated with groundwater in the study area, are considered among the most contaminated areas, to the extent that the Environmental Affairs Agency in 1992 called the submerged areas (Lake Manzala) environmental black spots.

It is found from the study of Saber (2015) that the chemical properties of either submerged or saturated lands with groundwater are almost unsuitable for most uses, whether drinking, irrigation or industry, with the exception of some very small areas, particularly in the west, somewhat far from sources of contamination and salty sea water. This is mainly due to the high degree of salinity in general, and to the multiplicity of contamination sources, which can be clarified as follows:

A. Drains

The contamination of the water of Lake Manzala is mainly caused by its poor water movement, as well as the sources of contamination of drains coming from Bahr El-Baqar and Bahr Hadous, which are loaded with untreated sewage water. The quantities of water drained from drains to Lake Manzala are about 5.4 billion m^3. Bahr El-Baqar drain represents 47.3% of the total water drained into it, and Hadous drain is about 18.7% (Saber, 2015). Table (3) shows some chemical characteristics of the waters of Bahr El-Baqar and Hadous drains, which flow into the study area.

It is evident from the analysis of the table that water of drains contains high concentrations of salts. A high concentration of some elements, such as sodium, chlorides, and bicarbonates, is also noted, which made this water not conform to specifications, and hence this led to multiple changes in the chemical characteristics of wetlands in the study area.

Table 3: Chemical Characteristics of Drain Water (mg/L) in the Study Area

Quality Parameters / Drain	TDS	Na	K	Ca	Mg	HCO3	CL	SO4
Bahr El Baqar	923	6.4	0.5	3.8	2.2	5.9	4.3	2.9
Bahr Hadous	1310	10.0	0.3	4.6	4.1	6.4	11.0	3.0

Source: Khadr & Elshemy, 2015.

B. Factories and Sewage

Some environmental reports indicates that the sewage treatment plant in West Port Said operates in a binary treatment method without biological or chemical treatment. The reports also proves that the treatment plants for the villages of El-Jarbaa and El-Manasra are not working very efficiently, which causes the fish of licensed fish farms in West Port Said to die, as they flow into the irrigation canals of those farms. The lake also receives all types of industrial drainage, especially in the north and east (Fig. 9). This is owing to the fact that the scope of factories, particularly oil companies, west of Port Said city, drains the liquid wastes to the sea and the lake.

Source: Taken by the researcher, 2015.

Fig. 9: Factories of Gas and Its Derivatives North of the Wetlands in the Study Area

The results of the analysis of the liquid waste from those factories confirmed that it did not conform to the specifications, which led to the death of fish and the spread of diseases (Ministry of Health and Population, 2014/2015):

The studies that dealt with the contamination of Lake Manzala water and its effect on fish and then humans showed high heavy metals in the water of Lake Manzala in the study area, particularly iron and cadmium, which amounted to 1.73 mg/l and 0.02 mg/l respectively (Table 4).

Table 4: The Average Concentration of Heavy Metals in the Lands Submerged with Water (Lake Manzala) in the Study Area

Parameter	Concentration degree (mg/L)	Parameter	Concentration degree (mg/L)
Iron (Fe)	1.73	Lead (Pb)	0.04
Manganese (Mn)	0.13	Zinc (Zn)	0.02
Copper (Cu)	0.02	Cadmium (Cd)	0.02

Source: Elewa et al., 2007–Ahmed et al., 2013.

This increase in the degree of concentration of heavy metals led to a high degree of concentration in the soil of the bottom of Lake Manzala in the study area, where the general average reached 17.8 µg/l for lead, 84.7 µg/l for zinc, 133 µg/l for copper, and finally 366 µg/l for manganese. The highest concentration of all previous heavy metals is recorded in Bahr El-Baqar estuary area. As for the lowest concentration, it varied from one site to another. The lowest concentration of lead was 7.8 µg/l in Ashtoum El-Gamil area, north of the study area, while the rest of the elements recorded 179.3 µg/l for manganese, 82.8 µg/l for copper, and 7.8 µg/l for lead in Bahr El-Bashtir area in the middle of the study area (Abdel-Rasheed, 2011).

It is evident from the previous analysis that the highest concentration of toxic substances is found at Bahr El-Baqar drainage site, as a result of untreated industrial drainage in the lake. Furthermore, the rise in lead metal in the waters of Lake Manzala near Ashtoum El-Gamil Bogaz confirms the presence of drainage of factories, particularly factories of gas and its derivatives.

This contamination with heavy metals has led to human infection with serious diseases when consuming milk and meat from animals that feed on contaminated plants directly due to the accumulation of heavy metals in their meat and milk (Fig. 10 and 11). The studies also confirm that all fish samples contained high concentrations of heavy metals (Table 5), particularly lead. They also recorded high concentrations of zinc, copper, manganese, and iron, particularly fish from fish farms east of the study area, which use drains, especially Bahr El-Baqar drains feeding them with the water needed for fish growth (Fig. 10 and 11).

Table 5: The Degree of Concentration of Heavy Metals in Fish in the Study Area

Heavy metals	Concentration degree **(µg/ml)**	Heavy metals	Concentration degree **(µg/ml)**
Iron (Fe)	158.3	Manganese (Mn)	26.7
Copper (Cu)	34.0	Zinc (Zn)	55.0
Cadmium (Cd)	0.11	Lead (Pb)	3.8

Source: Hamed et al., 2013.

Fig. 10: Feeding Animals on Contaminated Plants in the Study Area

Fig. 11: Feeding Fish Farms with Water from Bahr El-Baqar Drain in the Study Area

It was also indicated from the analysis of Table (5) that the degree of concentration of heavy metals in Lake Manzala fish in the study area ranged between 0.11 µg/l for cadmium, and 158.3 µg/l for iron, while the rest of the elements ranged between 3.8 and 55 µg/l (Hamed et al., 2013). Accordingly, Lake Manzala fish is unsuitable for human consumption, stressing that its consumption is a severe danger to public health, as the accumulation of these heavy elements causes malignant diseases such as cancer and kidney failure.

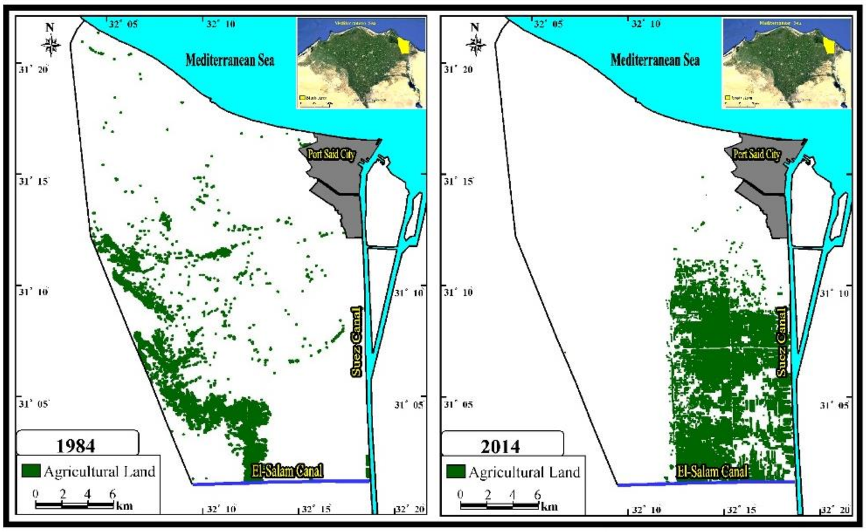
2. Draining Wetlands

Wetlands are subject to many changes resulting from human activities. That is, the human factor is responsible for causing deterioration, change, and even destruction of the components of the biosphere in the region. The following is a study of some human interventions and their impact on wetlands.

A. Land Reclamation

The eastern region of Lake Manzala, which was known as the Nasser project, was drained, which left an area of approximately 45,000 feddans to be used in agriculture. The project is located in Port Said Governorate, bordered to the west by Bahr El-Baqar drain, to the east by the Ismailia-Port Said road, and to the south by El-Salam Canal. Infrastructure projects necessary for the reclamation and cultivation of this area were established, where the area is irrigated from El-Salam Canal after mixing it with the waters of Bahr Hadous and El-Serw Drains. These lands were distributed to cooperative societies for land reclamation (Najib, 2014).

There has been a significant change in the geographical distribution of agricultural lands in the study area. That is, after it was scattered next to drains and some islands in Lake Manzala in 1984, it became aggregated in almost one area located between Bahr El-Baqar drain in the west and the Suez Canal in the east in 2014. Previous agricultural lands were transformed into fish farms in in 1984, and the agricultural land area amounted to 82.3 km^2 with a percentage of 12.4% of the total area in 2014, with an increase of 5.5 km^2 over 1984 (Fig. 12).



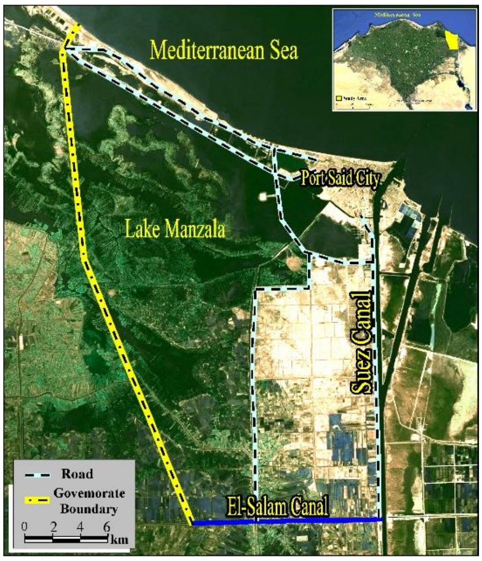
Source: Prepared by the researcher based on satellite images TM and ETM+ for the years 1984 and 2014, and the field review 2014/2015.

Fig. 12: The Development of Agricultural Lands in the Study Area (1984-2014)

B. Construction of Roads and Urban Expansion

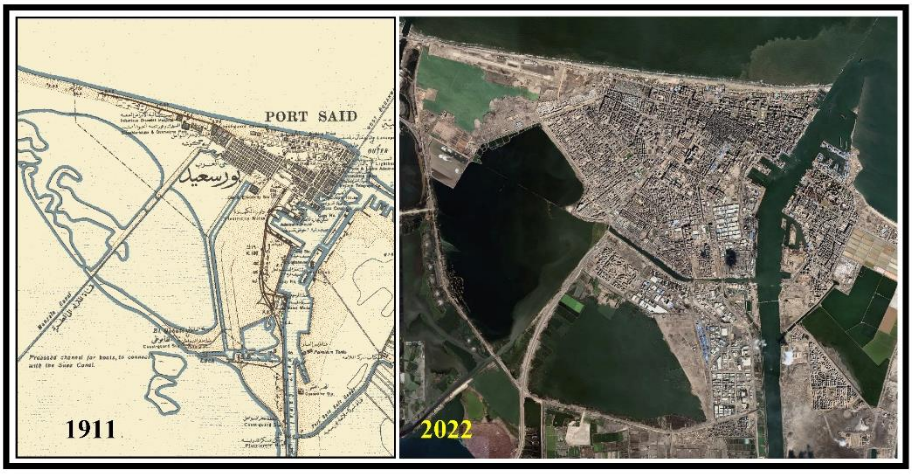
Over the past decades, the wetlands northwest of the Suez Canal have been subjected to intense draining processes due to human interventions, whether for the purposes of urban, industrial, or agricultural expansion, or road construction, which negatively affected the sustainability of wetlands in relation to the qualitative composition of their environment, whether animal or plant, as the following is shown:

Draining with the aim of building new roads, such as Damietta-Port Said road as an alternative to the coastal road, led to the division of the lake into two parts. The Port Said Ring Road, which was specifically established to facilitate traffic outside the city of Port Said, starting at the kilo 4.5 south of Port Said to cross the navigational canal linking Port Said to El-Mataria, was a result of the construction of the ring road extending from the ancient Ashtoum El-Gamil Bogaz in the form of an arc surrounding the city of Port Said. This road separated an area estimated at 20,000 feddans, in the form of a pond that was connected to the lake only by one opening at the bottom of the bridge (Mossad, 1999). This area has been exposed to draining operations of large parts, due to the city's location on the narrow barrier separating the lake from the Mediterranean Sea. This, in turn, led to the lack of lands that would enable the governorate to expand urbanization. Since the city of Port Said was built on the narrow coastal strip between the Mediterranean Sea and Lake Manzala, the direction of its growth was to the west and southwest (Fig. 13 and 14), through filling shallow lands and large parts of its swampy edges, lands generated on which urbanization could sprawl.



Source: Google Earth, 2022.

Fig. 13: Roads in the Study Area



Source: Topographic Maps, Scale 1: 50000, 1911, Google Earth, 2022.

Fig. 14: The Urban Growth of Port Said (1911-2022)

It is worth noting that the area of Port Said city in 1866 did not exceed 1.0 km^2, reaching 0.74 km^2, and the city of Port Said continued to grow until it reached approximately 28 km^2 in 2022[1]. In all stages of growth, the city of Port Said was growing successively by filling in parts of Lake Manzala (wetlands). As this situation continues, it will have catastrophic repercussions and a very high environmental and economic cost.

It is evident from the previous analysis that the wetlands northwest of the Suez Canal are exposed to many constraints that have a negative impact on ecosystems, and therefore **the principles of sustainable development require proper planning and management so as to preserve wetlands. They can be summarized as follows:**

[1] Calculated by the researcher based on Google Earth using AutoCAD Civil 3D 2015

- Permanently stopping draining operations related to agricultural reclamation and urban expansion projects, which represent the most serious challenges to the wetlands in the study area.
- Ensuring the availability and sustainable management of water.
- Treating water that contains elements harmful to ecosystems.
- Preventing dumping of factory waste scattered north and east of the study area completely in the wetlands.

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جودة الأراضي الرطبة للتنمية المستدامة شمال غرب قناة السويس: المقومات والمعوقات

مستخلص

صنفت الأراضي الرطبة بمنطقة شمال غرب قناة السويس إلى نوعين، هما: الأراضي المغمورة بالمياه، والأراضي المشبعة بالمياه الأرضية. وتتنوع مصادر المياه في منطقة الدراسة، حيث تستمد مصادرها من مياه المصارف، ومياه القنوات المائية، ومياه البحر عن طريق بوغازا أشتوم الجميل وقناة القابوطي.

وتتسم الأراضي الرطبة بمنطقة الدراسة بتنوعها البيولوجي، فشملت: الكائنات المنتجة (النبات)، والكائنات المستهلكة (الطيور والأسماك). وتبرز أهمية وفوائد التنوع البيولوجي بالأراضي الرطبة من الناحية الاقتصادية في مجالات الزراعة،

والطب، والصناعة، والبيئة، والترفية، والسياحة. ولكنها تتعرض للعديد من المشكلات الناتجة عن الأنشطة التي يمارسها الإنسان، فالعامل البشري هو المسئول عن إحداث تدهور وتغير بل وتدمير مكونات المحيط الحيوي بالإقليم.

الكلمات المفتاحية: الأراضي الرطبة، التنمية المستدامة، مصادر المياة، النبات، المقومات الاقتصادية.