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Environmental Monitoring of Changes in the Flooded Areas of the Marshes and Their Relationship to Water Quality Using GIS Techniques

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Abstract

This study aims to examine the relationship between the flooded areas of the marshes in southern Iraq and their water quality, as well as their relationship with climatic factors such as temperatures and rainfall amounts and their impact on the water discharge into the marshes of southern Iraq in the provinces (Basra, Maysan, and Dhi Qar) through the interpretation of maps with remote sensing tools of the wet cover (water and vegetation), descriptive and quantitative analysis of the flooded areas comparing them with the values of salt concentrations and clarifying the monitoring sites of the water quality and water discharge into the marshes through GIS, as well as the relationship of the wet cover with temperatures, rainfall amounts, and evaporation. The data of this study were obtained from environmental field observation data at climate monitoring stations, incoming water discharge stations, and water quality measurement sites in the three southern governorates. As for the areas of vegetation, the data was obtained through the interpretation of the satellites' visuals (Sentinel-2 satellite) with a resolution of 15 m using GIS programs through a temporal and spatial comparison of the marshland for April -June-October for ten years (2010-2015-2020) respectively, The results showed that there is a direct relationship between the water quality and the wet cover (vegetation and water) through classification as well as the effect of climatic elements in the marshes.

Keywords: Marshes, Vegetation cover, Water cover, Climate, Drainage, Water quality, Geographic Information Systems (GIS).

المراقبة البيئية للتغييرات في المساحات المغموره للاهوار وعلاقتها بنوعية المياه باستخدام تقنيات نظم المعلومات الجغرافية

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الخلاصة

الهدف من هذه الدراسة هو دراسة العلاقة بين المساحة المغمورة للاهوار في جنوب العراق مع جودة نوعية المياه فيها وكذلك علاقتها مع العوامل المناخية كدرجات الحرارة وكميات سقوط الامطار وتاثيرها على التصاريف الواردة لاهوار جنوب العراق في المحافظات(البصرة,ميسان, ذي قار) من خلال تفسير الخرائط بأدوات التحسس النائي للغطاء الرطوبي(المائي والنباتي) والتحليل الوصفي والكمي للمساحات المغمورة ومقارنتها مع قيم الاملاح الذائبة وتوضيح مواقع الرصد لنوعية المياه والتصاريف الواردة للاهوار

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من خلال نظم المعلومات الجغرافية وايضا علاقة الغطاء الرطوبي مع درجات الحرارة وكميات سقوط الامطار والتبخر ,وتم الحصول على بيانات هذه الدراسة من خلال بيانات المراقبة الميدانية البيئية في محطات الرصد المناخي ومحطات التصاريف الواردة ومواقع قياس نوعية المياه في المحافظات الجنوبية الثلاثة اما مساحات الغطاء النباتي فقد تم الحصول على بياناتها من خلال تفسير المرئيات للاقمار الصناعية (قمر سينتنال 2) بدرجة وضوح 15 م ببرامج نظم المعلومات الجغرافية من خلال إجراء مقارنة زمانية ومكانية لمنطقة الاهوار للاشهر نيسان–حزيران– تشرين الاول لعشرة سنوات (2010–2015–2020) على التوالي واظهرت النتائج ان هناك علاقة مباشرة بين نوعية المياه والغطاء ارطوبي(النباتي والمائي) من خلال التصنيف بالاضافة الى تاثير العناصر المناخية في الاهوار .

Introduction

Environmental applications are among the primary uses of GIS, and in most countries, land and natural resources are limited, which requires highly efficient management. GIS also provides a technical tool for following up and monitoring changes in land use and modeling environmental changes [1], as well as using satellite data sources to classify land cover [2]. Moreover, GIS shows trends in land cover changes and the reasons for increased or decreased areas [3]. It is considered one of the essential applications for environmental monitoring of the marshes because of its importance in the ecological balance; GIS provides an outstanding possibility to monitor and collect data about a specific area or goal for different periods at the same time and with high accuracy and with simple costs to analyze, interpret and studying them and discovering the changes that occur during these periods and many other processes provided by this science, it allows the possibility of studying the features of the land cover Which can be linked to the marshland To know the extent of the relationship between the flooded areas of the marshes in southern Iraq and their water quality as well as their relationship with climatic factors such as temperatures and rainfall amounts and their impact on the water discharge into the marshes of southern Iraq.

The marshes of southern Iraq were formed in low areas during ancient historical periods. Interestingly, human life in those marshes has not witnessed significant development, as the means of subsistence and economic activities in the twenty-first century are still not much different from what they were in the past. The marshes in southern Iraq are complex, including a unique wetland ecosystem and human civilization within an area of exceptional historical value. Long marshes are one of the biggest water bodies in the Middle East; they are the oldest natural habitat for animal and plant organisms, including the rare ones [4]. It must be known that the marshes are considered a habitat with a vast and unique environment for several classes of objects of interest. Regarding biodiversity, the Iraqi marshes were classified into two types: temporary and permanent [5]. Temporary marshes are water-covered areas for no less than eight months in the year. The permanent marshes are constantly flooded in water; their lowness characterizes them, as their height rates range between 1-2 m above sea level, and in some areas, the height rates fall below this level. The areas of this study are Hawizeh Marsh, Central Marshes, and Hammar Marsh, and they are regarded as permanent and vital. Water quality has significant impacts:

1- It has an impact on the climate

The climate change in the marshland region has decreased relative humidity and high temperatures and increased evaporation, which has contributed to the decrease in the temperature range in summer between the land areas and the marsh waters to 2 m, and the

increase in the amount of surface evaporation from the marsh waters to 2.11 km/year, and thus the direct impact on the ecosystem of the marshes.

2- It has an impact on plant and animal life

The lives of plants and animals deteriorated as the quality of the vegetation cover changed, so plant environments became extinct, and new plant environments appeared that fit the region's environmental changes. As for animal life, many animal species, such as fish and birds, became extinct, as it was in the marshes of southern Iraq.

3- Its impact on agricultural production

The areas planted with crops [6] have decreased due to the exposure of large parts of the marsh to salinization and an adverse change in water quality. There is also the receding of the marsh's water from its planted areas, the high salinity of the soil, and its replacement by cultivating crops that can tolerate salinity and lack of water. The reason for the decrease is due to the deterioration of the hydrological characteristics and the different nourishing water sources, as well as the impact of the salty drainage water drained into it from the public outlet, which led to the pollution of the marsh waters and the decrease in its efficiency in agricultural investment.

4- Its implications for the spread of desertification

The phenomenon of desertification has spread due to the shrinking of the areas of the marshes and the exposure of large parts of them to salinization due to the receding and drying of water from their lands, which resulted in the problem of soil salinity, which a manifestation of desertification, and because of the high level of salty groundwater and its proximity to the surface of the soil, and then the accumulation of salts on its surface after evaporation, leaving deposits of salt for the three marshes.

The study areas' location and description

The marshes extend from Amarah in the north, the city of Suq Al-Shuyukh in the west, and the city of Basra in the east, which are called the marshes of southern Iraq [7]They extend between latitudes 32° 50″ and 30°50″ north, from the north to the south, and between the length of line 44°50″ and48°0″east from the east to the west [8]; it is not a continuous marsh, but rather a group of marshes.

Hawizeh marsh area surveys have indicated that its area is about 3000 km^2 during the flood season [9]. The flooded area is 1377 km^2 [10], and water sources from within Iraqi lands are from three branches (Al-Zubair, Umm Al-Tus, and Al-Husaiji) and Iranian lands through the rivers Karkheh and Al-Tayyib [11] The Central marsh extends to cover mostly the Dhi Qar governorate, with an extension towards Maysan governorate. It is located between the Euphrates River to the south and the Izz River to the east. The Marshlands extend with a total flooded area of 2420 km^2. Finally, Hammar Marsh extends in a west-east direction in the governorates Dhi Qar and Basra from a distance of 100 km between the city of Suq Al-Shuyukh in Dhi Qar governorate and the city of Garmat Ali to the east in Basra governorate. This marsh is divided by a series of small islands and continuous extensions of reeds and papyrus into two parts: the eastern section in Basra governorate, which is the deepest and consists of continuous bodies of water; its width reaches about 48 km from north to south, and the western section in Dhi Qar governorate which is considered the site of Biodiversity; its width reaches about 25-30 km, The flooded marsh covers around 1,763 km^2 [12]

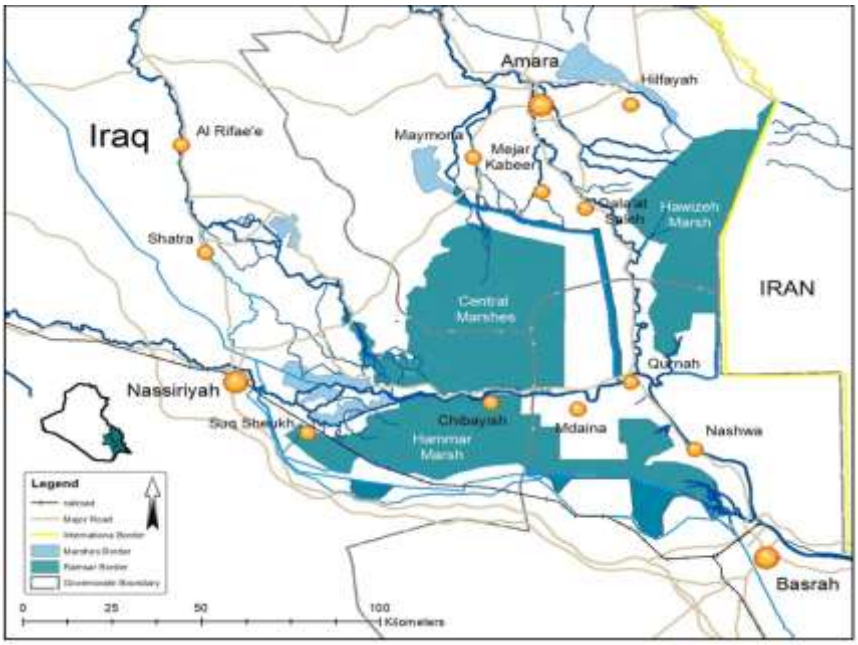

Figure 1. The areas of the marshes in southern Iraq in the governorates (Amarah, Basra, and Dhi Qar)

The marshes are part of the sedimentary plain, which represents the lowest region in Iraq, with little slope from the north and northwest [13]. The location of the marshes is in a basin area to which land descends from various sides and becomes more evident in its southeastern parts. In general, the surface of the southern part of Iraq descends gradually from the northwest to the southeast, and the land in the region is characterized as being completely flat and low at the same time, where the height of the area does not exceed 2,5 m above sea level in Qurna, and about 1,5 m near Al-Sabiyyah district.

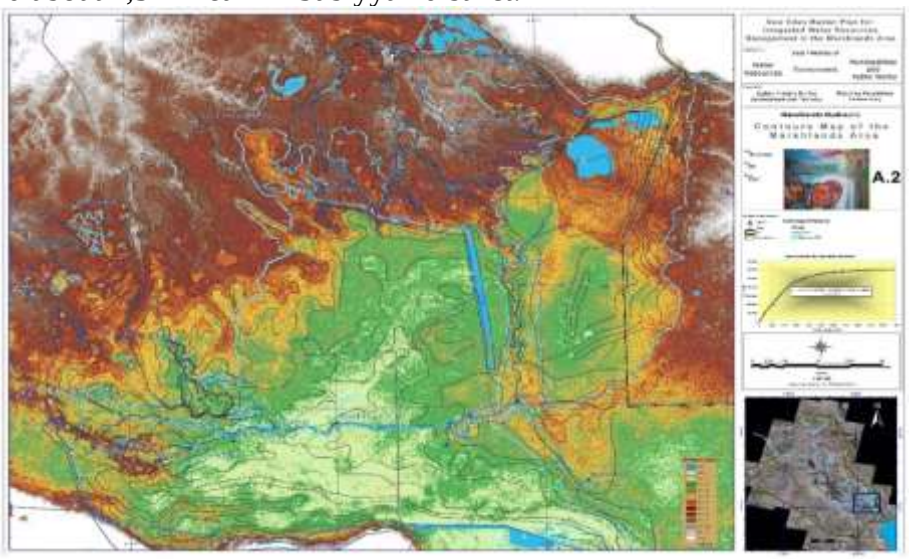

Figure 2. The topography of the marshes [14]

Methodology and materials

The study adopted a descriptive and quantitative approach to satellite data Sentinel 2 with a spatial resolution of 15 m, obtained from the U.S. Geological Survey (USGS), which was used in the study. The data were collected in April 2010, June 2015, and October 2020, by the classification of vegetation and water cover by software ARC MAP 10.5 using the Arc toolbox, NDMI, and connecting the extracted data with incoming discharges, water quality, and the impact of climatic elements too, And to see how influential the indicators are on each other. [15], Marshes are an integrated ecosystem and unique freshwater models in the world's

regions. The marshland is one of the most productive environments in terms of biodiversity on the Earth's surface, and this environment filters and deposits pollutants from rivers and tributaries [16]. The Mesopotamian marshes, listed as a UNESCO World Heritage Site, are the largest wetland ecosystem in southwest Asia. The natural environment, which directly impacts the areas of vegetation and water cover in the marshes, includes the climate. This study reviews the factors that affect flooded areas, most importantly, rain, temperatures, and evaporation.

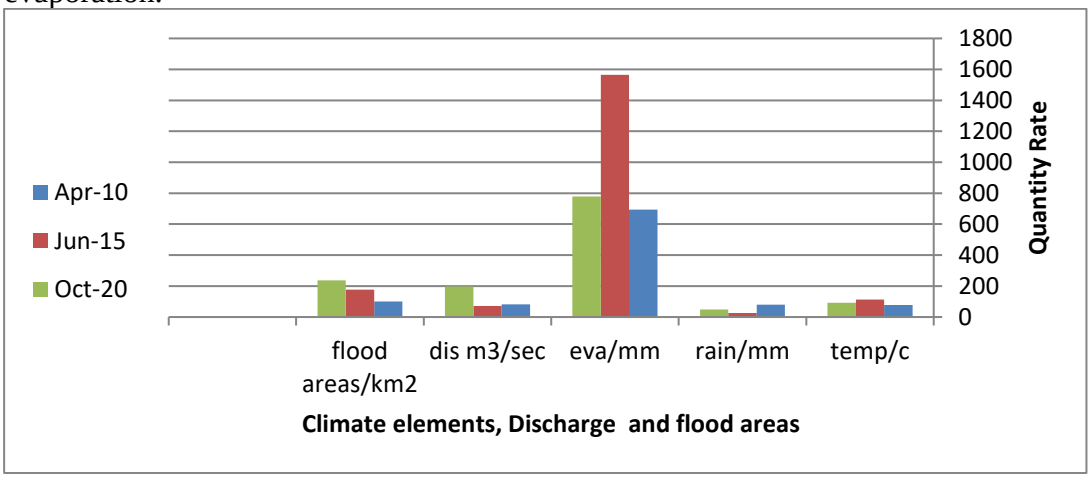

Figure 3. Amounts of precipitation, temperatures, evaporation, discharge, and percent of flooded area in the marshes for 2010-2015-2020. [17] [18]

The figure above shows the comparison between temperatures, rainfall rate, degree of evaporation, and discharge of the marsh-flooded areas in the years 2010 -2015 -2020, and It is illustrated in the results and discussion.

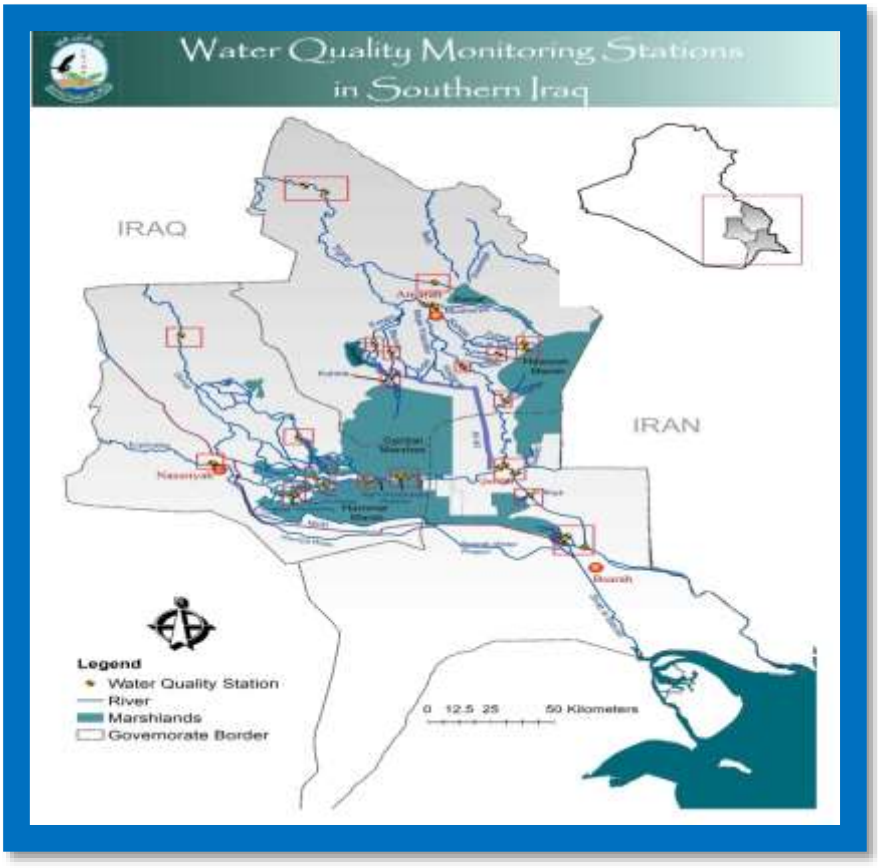

Figure 4. The locations of water quality stations in southern iraq

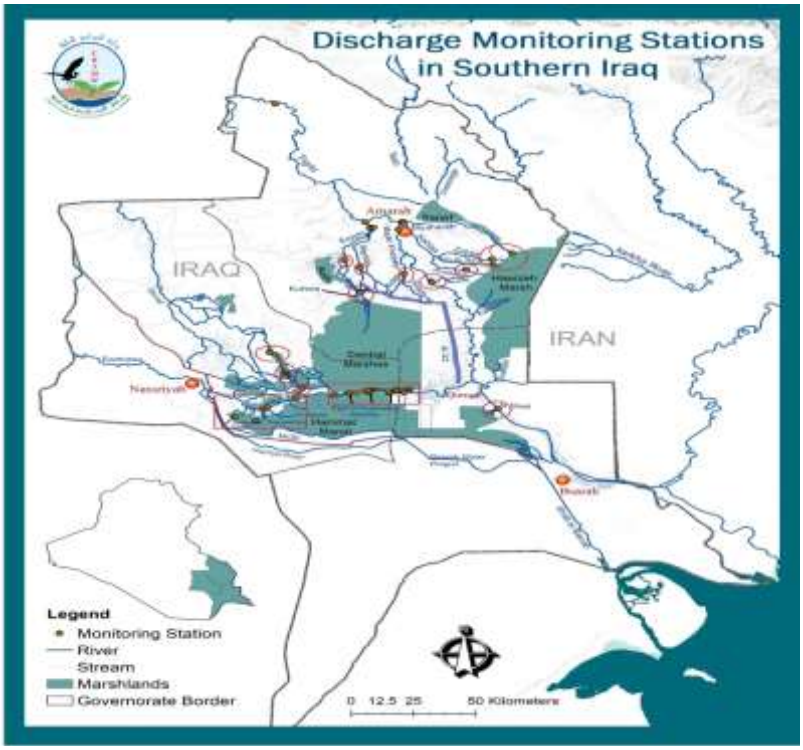

Figure 5. The locations of the Incoming water discharge stations in southern iraq

Monitoring the marshes' water quality

There are currently many networks for surface water quality monitoring [19], and the networks have been designed according to general statistical methods with certain standards but without a coherent or logical deterministic design strategy. In addition, they indicate that design practices in recent years have developed regarding the methodology of the water quality monitoring networks, which are cost-effective and logistically adaptable [20]. Therefore, sites for water quality monitoring stations must be identified as those points that best represent the state of water quality. The best water quality monitoring stations must also be determined using the hydrodynamic simulation results, water quality, and models showing water quality distribution patterns. These models represent an essential element because they can be integrated with maps of the spatial distribution of land uses, vegetation cover, and the main criteria for determining the schedule of monitoring in the marshes [21]

The below figure shows the relationship between water quality and flooded areas of specific time limits, and we conclude that the bad water quality affects poorly to the flooded area (water and vegetation) of the southern marshes.

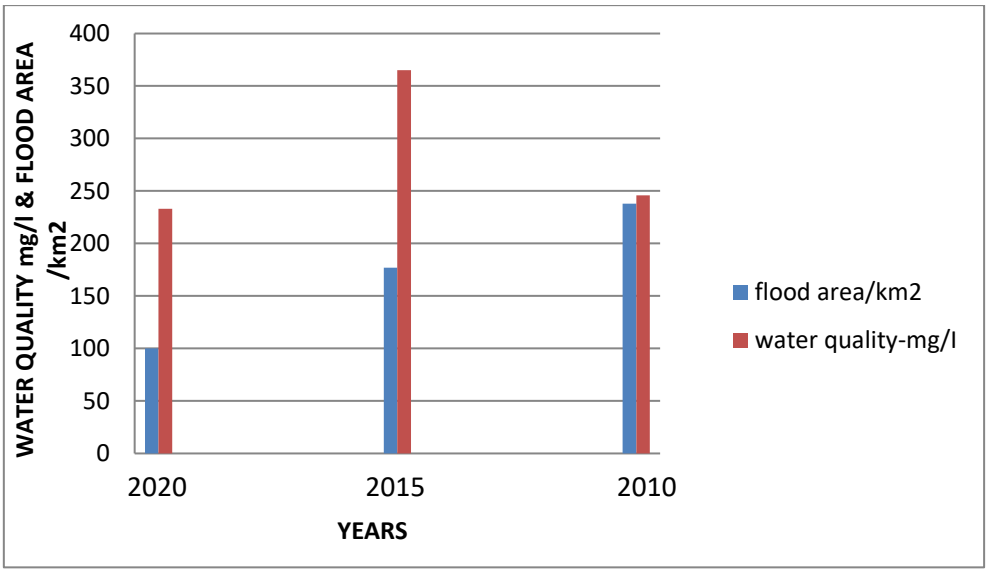

Figure 6. The relationship between water quality and the percentage of flooded areas in the marshes for the years 2010-2015-2020.

Table -1 Rate of TDS (Total Dissolved Solids) mg/l Values for 2010-2015-2020 [22].

Name	April /2010	June/2015	October/2020
Hawizeh marsh	5718	8530	13019
Central marshes	4853	5004	4600
Hammar marsh	12688	22916	16968
Total TDS mg/l	23259	36450	34587

The above table and Figure 6 shows that the total dissolved solids (T D S) rate is very high, directly affecting the water quality, vegetation, and biodiversity in the marshland parts.
Here we will explain the environmental monitoring of the marshes by the classification of vegetation and water cover by software ARC MAP 10.5 using the Arc toolbox, NDMI, for the Sentinel 2 satellite, with a resolution of 15 m and according to the months mentioned above.

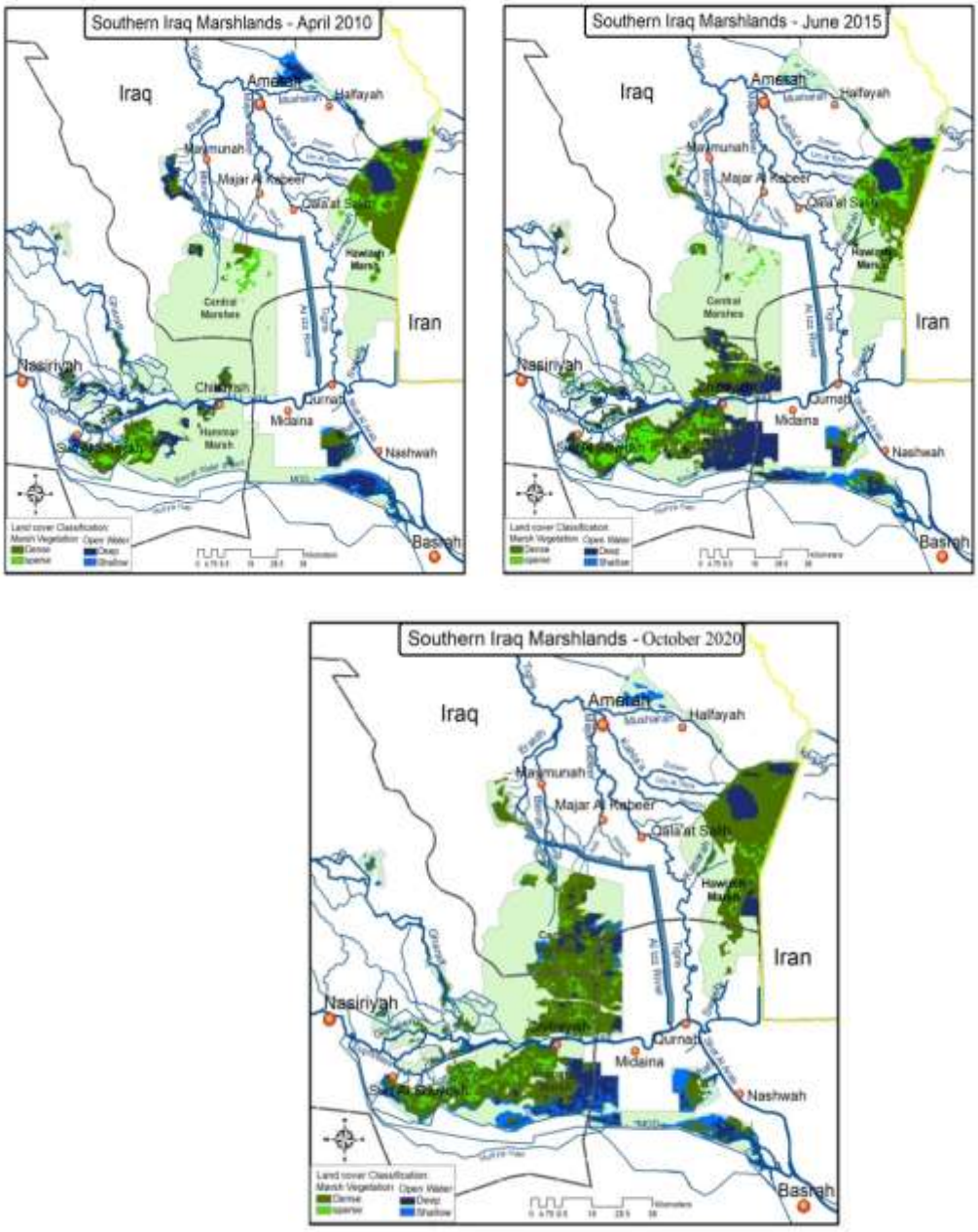

Figure 7. The parts of the marshes which are flooded to the years 2010-2015- 2020

Results and Discussion

Through the indicators (climatic factors, flooded areas, water quality, and incoming discharges) mentioned above, we will compare the ten years, as seen in the table below.

Table2. A comparison of climatic factors, flooded areas, water quality, and incoming discharges from

Results	Notes	2020-October	2015-June	2010-April
It needs to observe the environmental monitoring system through sustainable management of wetlands and the development of short-term plans that consider factors mentioned in comparison to years to prevent ecological damage affecting the marshes' permanency.	A direct relationship exists between natural climate factors, water quality, wet cover, and discharges into the marshes.	Noticing a decrease in temperatures because October is one of the fall months, with variable rains rate, a decrease in the evaporation rate, an increase in the quantities of incoming discharges, and a decrease in the water quality rate, which led to an increase in the wet cover.	Noticing a rise in temperatures, a high evaporation rate, and almost non-existent rains since June, one of the summer months. This led to a decrease in the discharges into the marshes, and the water quality rate was very high, and this also led to a decrease in the wet cover.	Noticing a rise in temperatures, although April is considered one of the spring months and the rainy season, the increase in temperatures helped increase the evaporation rate. The lack of rain in the governorates of Amarah and Dhi Qar led to a decrease in the incoming discharges to the marshes, but the rate of water quality was considered high; thus, it led to a decrease in the wet cover.

Table3. A comparison of climatic factors, flooded areas, water quality, and incoming discharges

Date	Temperature	Evaporation	Rain	Incoming Discharges	water quality(TDS)	Water cover
April 2010	Increase	Increase	decrease	decrease	High	decrease
June 2015	Increase	Increase	decrease	decrease	High	decrease
October 2020	decrease	decrease	increase	increase	low	increase

Results: After a temporal and spatial comparison between the flooded areas of Iraq's southern marshes for the above years, it was found that the increase in the flooded areas is due to rainfall and the flow of feeders water to the marshland, which reduces the bad water quality due to the tidal process and increased incoming discharges for marshes due to the Increasing water quota being an overflow season. High temperatures or low rainfall cause bad water quality, adversely affecting flooded areas and the general biodiversity of the marsh areas.

Conclusions

The increase in maximum and minimum temperatures of 2010-2015-2020 accounted for climate change. The study area witnessed a decrease in the amount of rain falling for the same period and for all study stations and an increase in the amount of evaporation during the same period, which led to the loss of large quantities of marsh water, and, thus, the concentration of salts increased significantly. The changes taking place in the hydrology of the marsh waters resulting from the construction of many dams in the upstream and riparian countries, and the diversion of the courses of several tributaries feeding the Tigris and Euphrates rivers, had significantly reduced the rivers' discharge and flow levels when they reached the marshes. These phenomena were reflected in the deterioration of plant and animal life and the spread of desertification in the marshes of southern Iraq. The marshes' water quality is no longer the same as before the drying process due to the different hydrological conditions and the high concentration of salts and their types. The lowest salinity rate was in the north of the Hawizeh marsh, north of Qurna, and the Abu Zarak marsh in the central marshes. Most of the marshes are closed, i.e., there is no outlet for draining the marsh water and its renewal, and the impact of this on the water quality in terms of salinity and other specifications constitutes a unique aspect of the marshes.

Not all dried marshlands can be re-flooded due to excessive salinity, environmental pollution, and lack of water supply noting that Turkey, Syria, and Iran control 70% of Iraq's water resources. Hence a need to implement an integrated environmental management system with all elements (hydrological, environmental, social, economic, and institutional); so, it is imperative to prepare a geographic information system (GIS) database that is unified for the marsh areas and use modern technologies such as geographic information systems and remote sensing to document potential points of entrances and exits and control systems. Planners rely on the analytical capabilities of geographic information systems and use them in their studies, research, and projects to ensure accuracy and speed in completion. There is a need to build a digital hydrological model to be used as an effective and valuable tool for monitoring the ecosystem of the marshes and monitoring qualitative changes in the area for rehabilitation, as well as carrying out water modeling periodically to determine its suitability for drinking purposes for humans, animals, or irrigation.

The need to monitor the environmental monitoring system is through sustainable management of wetlands and the development of short-term plans that consider the factors mentioned in the comparison of years to prevent environmental damage affecting the marshes' permanency.

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