Shahid Beheshti University

Sustainable Earth Review

Journal homepage: http://sustainearth.sbu.ac.ir

Analysis of anthropogenic and climate change effects on Mesopotamian marshland- Iraq

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ABSTRACT

Among the world's most essential natural environmental resources are wetlands. In Iraq, the Mesopotamia marshes are considered as among the most significant swamplands worldwide. They are situated in the massive flood plains of the rivers Tigris and Euphrates in the lower basin of Mesopotamia. In this paper, there will be a thoughtful study of the effect of climate and microclimate change on these Marshes. The main sources of data and scientific knowledge will be gathered and summarized from almost all previous research conducted in the area. Most of the papers involved in this summarized study are those related to remote sensing, since remote sensing tends to be the most effective approach as it is less costly and consumes less time. Most of the reviewed papers that have studied the marshland circumstances of the area showed a deterioration in the level of the area's water bodies due to climate change. However, there are other factors that influence and degrade these marshlands other than the effects of climate change. These extra factors are represented by the political and military actions conducted by the previous Iraq regime during the middle of the 1980s. According to most of the most research implemented in the area, the water system in Iraq is experiencing significant challenges, thus increasing concerns about the Mesopotamian marshes that have been sustaining the region for thousands of years and which may possibly vanish soon.

ARTICLE INFO

Keywords:
Anthropogenic effects
Climate change
Mesopotamian marshland
Remote sensing

Article history:
Received: 21 Dec 2022
Accepted: 02 Feb 2023

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Citation:
Farajzadeh, M., & Jameel Khalid, N. (2023). Analysis of Anthropogenic and Climate Change Effects on Mesopotamian Marshland- Iraq. *Sustainable Earth Review*: 3(2), (1-14).

DOI: 10.48308/SER.2023.233928.1027

1. Introduction

Among the world's most essential natural environmental resources are wetlands. As a consequence of drastic climate change and land use change most of the marshlands have disappeared in many regions of the globe (Albarakat et al., 2018). In Iraq, the Mesopotamia marshes are considered to be among the most significant swamplands worldwide. They are situated in the massive flood plains of the rivers Tigris and Euphrates in the lower basin of Mesopotamia (Figures 1 and 2). In this paper, there will be a summary comprised of the study of several papers conducted on the area in both Arabic and English of the effect of climate and microclimate changing on these Marshes.

In considering the importance of remote sensing to monitor land changes, the selection of articles is based on this approach. The Mesopotamian swamplands are situated in Southern Iraq between latitude 30.55 to 32.23° N and longitude 46.38- 47.01° E. The marshlands formed from shallow freshwater lakes, some being permanent and others seasonal. Therefore, the study area is situated in an arid area with high year mean of temperatures and low rainfall rates (Fig. 1). There are three main marshes of southern Iraq. The Hawizeh Marshes have an area of about 3000 km^2 during the spring seasons and shrink to 650 km^2 in the arid seasons. They are a complex of marshes that straddle the Iran–Iraq border with about 79 percent inside Iraq territories and 21 percent inside Iran territories (Abed, 2007).

The marshes are fed by two branches of the Tigris River - the Al-Kahla and Al Musharrah in Iraq and the Karkheh River in Iran. The Hawizeh marsh is critical to the survival of the other two main marshes in Iraq which are the Central and Hammar marshes. They are a refuge for species that may recolonize or reproduce in other marshlands. Hawizeh Marshes are drained by the Al-Kassarah. This river plays a critical role in maintaining the marshes as a flow-through system and preventing it from becoming a closed saline basin (Abed, 2007). The area have been inhabited from the time of the Sumerians and Babylonians (Al-Sheikhly and Nader, 2013). At around 3,000 BC, the marshes started to form at the confluence of the Tigris and Euphrates rivers. The land flooded by These Rivers then created the marshes and started a new ecosystem with new plants and animals. This affected the Sumerians and Babylonians who lived there. They lived off the marshes by planting, fishing, and hunting. In 1990-1992 when the Saddam Hussein regime decided to dry the marshes due to the existence of conflicting armed groups there, the inhabitants moved to the cities while others moved to Iran. After the war in 2003, the new Iraqi government reopened the flow, and the inhabitants returned to the marshes (Al-Sheikhly, 2013; Nader, 2013). The Central Marshes (Al-Qurnah Marshes) stretch between Al-Qurnah and Nasiriya, Al-Uzair (Ezra's Tomb), and were mainly fed by the Tigris and its distributaries (the Majar al-Kabir and Shatt al-Muminah). They were drained by the partially artificial Prosperity Canal, and by the Glory River at the beginning of nineteens of the last century. The Central Marshes were characterized by tall qasab reeds but included a number of freshwater lakes, of which the largest were the Haur az-Zikri and Umm al-Binni, the latter being a species of barbel. The marshes enhance breeding populations of the marbled teal and Basra reed-warbler, along with several other species of non-breeding birds. (Abed, 2007). The area was formerly populated by the Marsh Arabs or Ma'dan, who carried out cultivation of rice and grazed buffalo on the natural vegetation. In the early 1980s, it was noticeable that irrigation projects were already affecting water levels in the marshes, particularly the Central Marshes. Furthermore, by the early 1990s, the government of Saddam's regime implemented a series of major drainage projects to prevent the central marshes from being used as a refuge by Shie militias. Blocking the flow southwards from the distributary streams of the Tigris by large embankments and reversing discharges into the Al-Amarah or Glory Canal, lead to the loss of two-thirds of the Central Marshes in 1993 (Scott, 1995). The Prosperity Canal is a further canal, that was built to prevent any overflow into the marsh from the main channel of the Tigris. Consequently, by the late 1990s, the Central Marsh had become completely desiccated and semi-dried, and unfortunately, by 2000, 90 percent of the marshlands had disappeared as estimated by the United Nations Environment Programme (UNEP). The last main marsh in Iraq is the Hammar Marsh. It is also considered the largest wetland complex in southeastern Iraq that is part of the Mesopotamian Marshes. In the past, the Hammar Marshes extended up to about 4,500 km^2 during seasonal floods (Richardson and Hussain, 2006). Unfortunately, other main marshes in the south of Iraq were destroyed by large-scale drainage, dam, and dike construction during the 1990s. However, since 2003 the marsh recovered following reflooding and destruction of dams (Al Shabeeb, 2015). The Hammar Marshes are situated between Basra Governorate in the south, the Dhi Qar Governorate and the city of Al-Qurnah in the north and in the west and northwest by the urban centers of Al-Chibayish and Nasiriya. The main water sources are the Euphrates and its tributaries. Additional water from the Tigris supplies the wetland through overflow from the Central Marshes. Till the 1970s, the wetland extended over approximately 120 km × 25 km and permanently filled an area of 2,800 km^2 that stretched to about 4,500 km^2 during flood seasons. Therefore, it was considered the largest in West Asia. (Richardson and Hussain, 2006). In the south of Iraq, massive drainage projects were conducted in the 1990s. Embankments and canals were built that split the wetland into two parts, the East and the West Hammar Marshes. An additional separation between the two parts is the oil field of Rumaila Al (Al Shabeeb, 2015). Drastically, by 2000, about less than 15 percent of the Hammar Marshes remained. In 2003 returning Marsh Arabs broke the drainage works and embankments so that the wetland was initiated to reflood. By the following year, wildlife species returned as a result of vegetation regrowth in the western part of the Hammar Marshes. Recovery of the marshland habitat has been unexpected; in spite of this there are still long-term risks to the habitat's viability because of water extraction from the Euphrates and pollution (Richardson and Hussain, 2006). The main plant species in the Hammar Marshes are whorl-leaf water milfoil, shining, sago pondweed, common reed hornwort, and bulrush (Al Shabeeb, 2015). Moreover, black-headed gull, little egret, slender-billed gull, little ternbird, and common gull counts between 2003 and 2005 revealed that they are the most common species in the Hammar Marshes (Richardson and Hussain, 2006).

Fig. 1. Map of Mesopotamian Marshes in the south of Iraq. Blue circles indicate the location of the main marsh land in Iraq, Remapped (Al-Zahery et al., 2011).

Fig. 2. Image of the Mesopotamian Marshes in the south of Iraq. Taken from Moderate Resolution Imaging Spectra diameter (MODIS) on NASA'S Aqua satellite, http://earthobervatory.nasa.gov/IOTD/view.php?id=38409

Over the past four decades, there have been many Land Cover and Land Use Changes experienced by all of the riparian countries within the Tigris-Euphrates watershed. None have been as severe as the drastic changes experienced within the Mesopotamian Marshlands in southern Iraq. Many of these changes are due to engineering projects constructed within the watershed between 1985 and 2000. Most important were the implementation of the Southern Anatolian Project (GAP) in Turkey (22 dams, 25 irrigation projects, and 19 hydroelectric plants) and the rerouting of the Tigris and Euphrates Rivers in Iraq around the marshlands using a complex system of diversion canals. The degradation on such a large scale ecologically could cause significant drawbacks to nearby dwellers' health, for instance, increased pollution, possibly contaminated dust storms from saltpans and dried marsh beds, and exposure to extreme temperatures and to water scarcity. Further, the surrounding initial marshlands and fragile land are prone to suffer from land dilapidation and desertification due to wind erosion accompanied by sand encroachment from dried marsh beds. A report by the Iraqi Water Resources Ministry indicates that there has been a constant decline in water inflow at the Iraqi-Syria and Turkey border. The water system in Iraq is experiencing significant challenges, thus increasing concerns about the Mesopotamian marshes that have been sustaining the region for thousands of years and are likely to disappear soon (Al Shabeeb, 2015). This study aims to compare several studies conducted and dealt with Mesopotamia marshland, where each study adopted different methods and ideas to explain the reality of this vulnerable area. Moreover, the study displays alterations that are signs of ecological degradation. Ultimately, this research aims to define the core human activities contributing to land humiliation in the Mesopotamia Marshlands, Iraq, using remote sensing and geographical information system (GIS) techniques.

2. Material and Methods

The main methods implemented in this study are the gathering and analyzing of the most recent papers conducted on Mesopotamian marshlands in any available language. Moreover, it discusses the most outcoming findings of each research. Highlighting the most reasonable facts regarding the area situation and presenting the probable suggested scenarios to the study area. Finally, it recommends new policies and ideas in order to protect the area from reaching the tipping point.

In most research implemented on Mesopotamian marshlands the following satellite data were used:

Advanced Very High-Resolution Radiometer (AVHRR LTDR V5 Daily NDVI Product that was acquired almost over the previous two decades, The Advanced, Very High-Resolution Radiometer is found in polar-orbiting ecological satellites to estimate the Normalized Difference Vegetation Index. Essentially, two ethereal stations located on sensor NOAA AVHRR are recycled to compute the day-to-day value of NDVI. In this case, the NDVI is the different proportion between the red band and the Near-Infrared Band alienated by the amount of the NIR and RED bands. For instance, this study used a subset of the area under study from the international dataset, ranging from the end of the last century to 2017. The values were extracted from these datasets and indicated the surface of the vegetation, hence neglecting the values that were less than 0. GLDAS is the other dataset that some study used. These datasets can be accessed from NASA Goddard Earth Sciences. It integrates satellite and ground-based observational produces with the help of progressive land surface demonstrating and the adjustment of data procedures. The GLDAS is responsible for running the global exposure at a perseverance of approximately 0 to 1. Since the spatial resolution of NDVI is approximately 5 km, the study used a Landsat 30 km thematic mapper information to define alterations in the Mesopotamian marshlands at this three-dimensional tenacity (Albarakat et al., 2018). Furthermore, most studies also use ArcGIS software to evaluate the distantly detected information by incorporating various investigative measures such as data acquirement, data dispensation and analysis, data alteration, valuation of mistakes and errors, and concluding product exhibition (Aboelnour and Engel, 2018). For instance, the supervised classification technique is essential in the ArcGIS software. This method is grounded on the idea of arithmetical design acknowledgment methods used for multispectral remote data sensors (Albarakat et al., 2018). The study integrates three areas: Al-Basra, Al-Nasiriyah, and Al-Amarah. Biomass Dynamics Long-Term Trends of the NDVI were statistically assessed based on linear regression.

3. Results and discussion

The temporal variations of the Mesopotamian swamps on the three dates 1984, 2002 and 2020 are shown through Google Earth images (Fig 3. According to fig (3) in 1984, there were good moisture conditions in the region and vegetation and surface water resources were significantly expanded in the region. In 2020, extreme drought conditions prevailed in the region and natural resources have experienced severe negative fluctuations due to the role of human activity and climate change. These changes reflect the impact of human activities along with climate change in the natural conditions of the region.

Fig. 3. Temporal changes in the Mesopotamian marshes in three time periods 1984, 2002 and 2020 (Google earth).

Several interesting kinds of research have been implemented in the area, despite most of these studies being implemented in the light of remote sensing methods but still, there are other papers which carried out the study with pure geological principles and methods. It is not appropriate to compare some different disciplinary approaches together, but there will be a link when these different disciplines focus on one area generally and when discussing the effect of climate change in particular. Albarakat et al. (2018), is one of the most noticeable works done in the area up to date, in spite of its more related technique to GIS, but the research brings to the status some interesting findings and notices regarding the degradation of Mesopotamian marshland from the period of 1982-2017. The land use change is one of the significant aspects that Albarakat et al. (2018) dealt with in their paper. The paper uses Landsat data to display land use changes during the time. Fig. 4 indicated a statistically important negative drift between 1982-2017 on both Rivers Euphrates and Tigris, which means a drop in the yearly discharge (Ziboon et al., 2022). The considerable reduction is due to the construction of a vast dam in Turkey and a chain of dams in Syria and downstream in Iraq. Despite a good river flow from 1990-2003 it hardly aided the marshlands (Abdollahi et al., 2021).

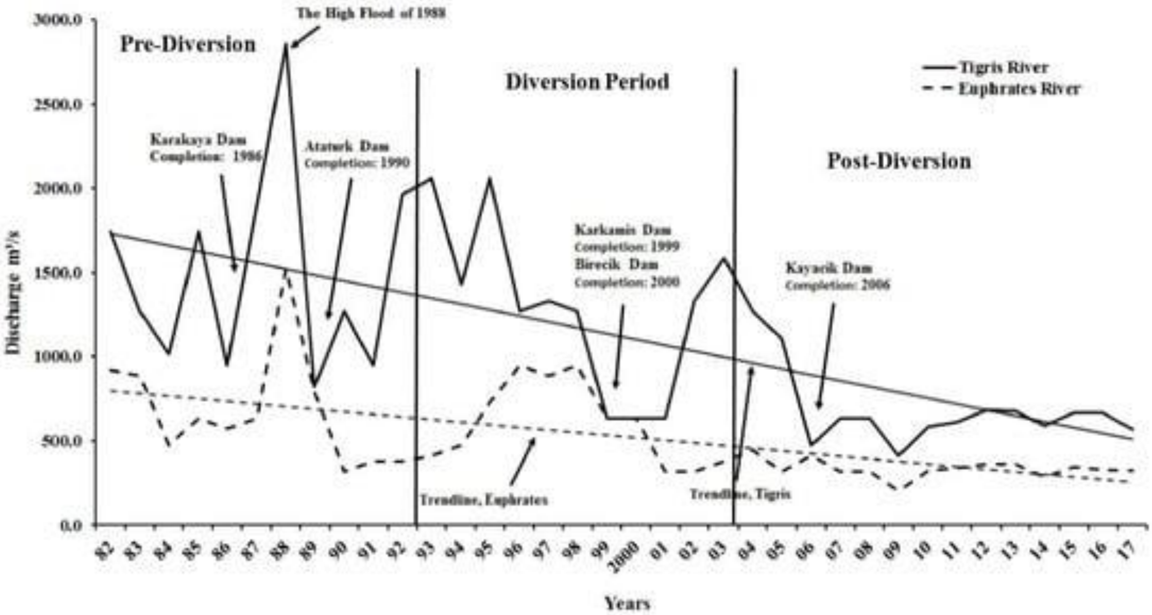

Fig. 4. The annual discharge (m3/s) of the Tigris and Euphrates rivers (The Ministry of Water Resources, Iraq). (Albarakat et al., 2018).

To identify vegetation change from 1982-2017, a long-term AVHRR/NDVI was used in each swampland. Albarakat et al. (2018) grouped the study into three phases, the first ten years referred to as "pre-diversion", the second ten years as "diversion", and the third fourteen years as "post-diversion." Fig. 5 represents the NDVI monthly series from 1982-2017 in Mesopotamia, Iraq. Albarakat et al. (2018) divided the time series of satellite observations into three phases (Fig. 5). In the first phase all the swamps demonstrated high NDVI values apart from 1988-1989 because the drying operations started in the late 1980s when Sadam Hussein was in power. The period from 1993 to 2003 demonstrated the least NDVI values as a result of upstream weirs and draining operations downstream across the swamplands. 1994 represents the lowest values of NDVI for the Mesopotamian marshes (Ziboon et al., 2022). At the time of canal and dam construction on the rivers Euphrates and Tigris, small canals from these rivers were used to feed the marshes during the diversion time. Hence the slight increase in the behavior of NDVI from 1996-1999 owing to the surge in upstream nation's precipitation and the rise in the water discharge to the marshlands through the small diversion channels.

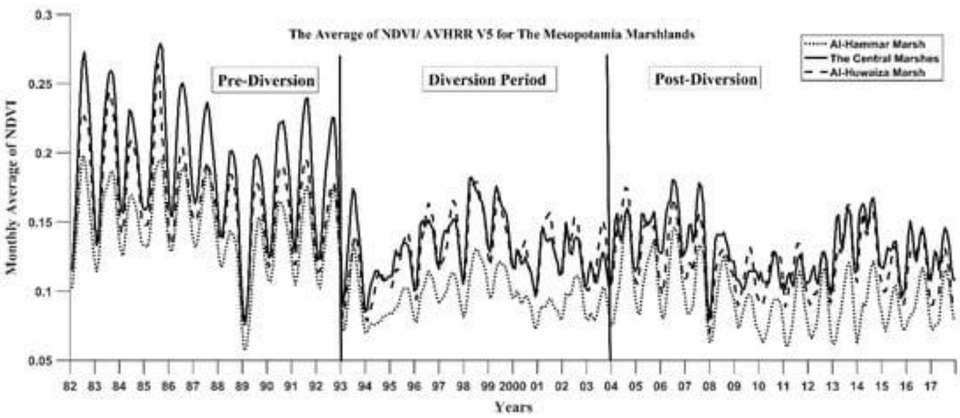

Fig. 5. Monthly averages of the daily AVHRR/NDVI data for the three marshes. (Albarakat et al., 2018).

The vegetation growth in the wetlands was not affected by the precipitation because of the absence of rain in Southern Iraq. Rainfall in parched regions is scarce; hence its efficiency is minimal because of the high evaporation rate leading to nearly 80 percent loss of the average rainfall (Al-Quraishi & Negm, 2020). Then in the second phase Albarakat et al., (2018) refer to NDVI increasing from 2004-2007 due to improved human practices such as dam constructions, diversion of water supply, and local and regional precipitations. The increase in the discharge rate and decline results in a drought catastrophe. After the fall of Sadam's administration, high snow and heavy precipitation were witnessed in the Anatolian Zagros highlands and Iran. The melting of the snow resulted in the increased water volume in the Euphrates and Tigris, the primary water sources for the marshlands from 2004-2008. Approximately 85 percent of the River Euphrates flows through swamplands prior to reaching the Shatt Al-Arab. Conversely, in the last phase small NDVI values from 2009 to 2017 indicate that most swampland regions have received little water because of heightened drought and the low flow of upstream water nations. Based on figure 6, Albarakat et al., (2018) suggested the AVHRR/NDVI observations provided a time series from 1982 to 2017 for the three marshes and quantified environmental changes that determined vegetation and hydrology. Three time periods were observed for 1982–1992, 1993–2003, and 2004–2017 which were distinct and characterized the environmental and anthropogenic conditions that affected the marshes. The Al-Hammar marsh green biomass for nearly four decades increased by about 13 percent and decreased by more than 85 percent (Al-Quraishi and Negm, 2020). The Central wetlands increased in vegetation cover by about 1 percent while demonstrating a massive vegetation degradation of around 99 percent. For the Al-Huwaiza marsh, the vegetation cover increased by about 16 percent and declined by more than 80 percent. The Al-Huwaiza marsh has had an increase in green biomass compared to the other wetlands since the central area of the swamp has been experiencing consistent water flow from the Karkha River from Iran during the drying operations. Another study related to Mesopotamian marshland and Remote Sensing was implemented by Al-Nasrawi et al. (2021). The result of their work presented in fig. 7. Their findings indicate a clear wetland over time dynamism. Like the previous study they found a reduction of incoming flow to the region because of the dam's construction in the way of upstream tributaries, besides a noticeable loss in marshlands extent, in spite of there is no significant long-term change was registered in rainfall from 1982, and also during periods where no meteorological drought had been recorded. Al-Nasrawi et al. (2021) indicate that human interventions have altered and disturbed the ecosystems, which is evident when studying the changes in water occurrence. These show that the alteration of rivers and the construction of a recent drainage system caused displacement and spatiotemporal changes in marshlands. Nevertheless, restoration plans after 2003, and wetter conditions during the period 2018–2021 have helped to recover the ecosystems, but these have not led the marshlands to regain their former extent. Finally, the study recommended more studies should pay attention to the drainage network within the study area, and the adjacent regions to reveal their impact on the stream flow that feeds the marshes.

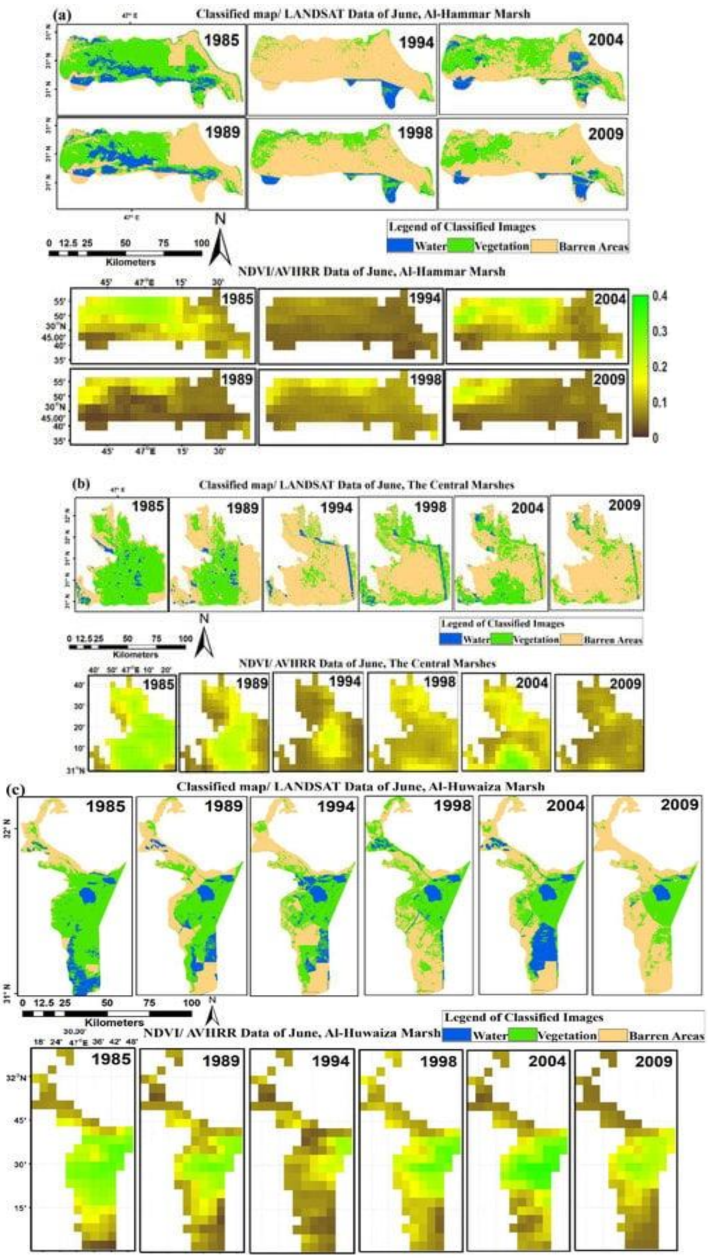

Fig. 6. (a) Al-Hammar, (b) The Central, and (c) Al-Huwaiza marshes showing the comparison between the classified maps of Landsat images (in the upper row) and maps of AVHRR/NDVI (Albarakat et al., 2018).

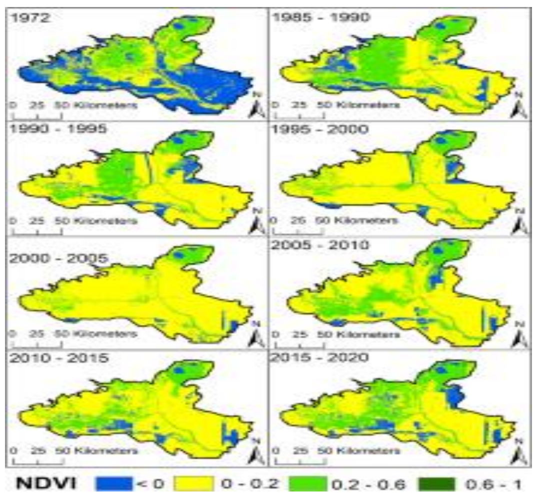

Fig. 7. NDVI extraction for the marshland ecosystem across time; (Al-Nasrawi et al., 2021).

Abdul Jabbar et al. (2010) explained the situation of Mesopotamian marshland in the light of GIS and Remote Sensing techniques. However, most of the previous studies and even this study shows significant degradation in the Mesopotamian marshland from the time of first satellite availability at the beginning of the 1970s till the current time. Abdul Jabbar et al. (2010) indicated in their results that the barren lands increased between the years 1973 and 2000, (Fig. 8). As a consequence, the marsh areas decreased, and the drying operations influenced the topsoil properties. Thus, it became unfavorable for cultivation and agriculture. Moreover, the aeolian sands started creeping towards the dried marsh territories. The clear water marshes were reduced approximately to 0.3 percent from their original areas, between 1973 and 2000 (Fig. 9). Furthermore, the natural vegetation cover within the marsh areas decreased. However, the cultivated areas increased after the drying operations in the year 1990, but they started to shrink again after 2000, because of the drying operations. Fortunately, the areas of Al- Al-Hammar Marshes and Huwaizah Marshes increased by about 50 percent from the dried areas after rehabilitation, in the year 2005, otherwise in the Central Marsh areas the increased area represented only 24 percent.

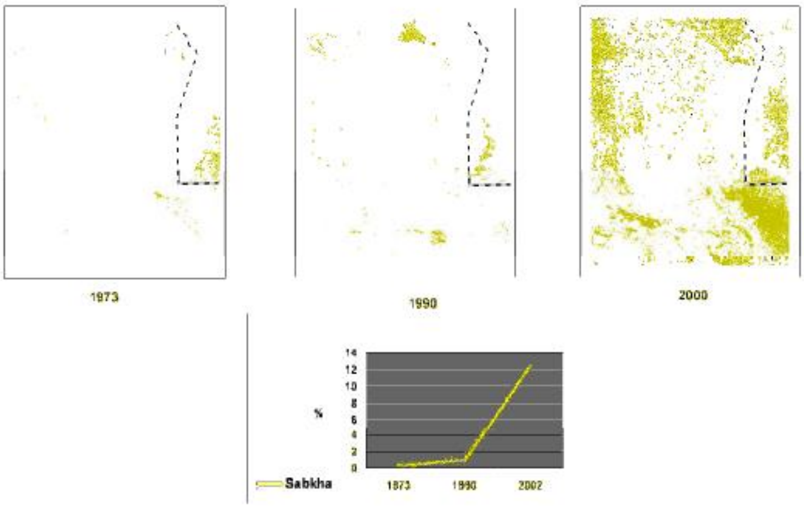

Fig. 8. Digital map showing the changes in the coverage areas of Sabkhas during the years 1973-2000, with linear digram. (Abdul Jabbar et al., 2010)

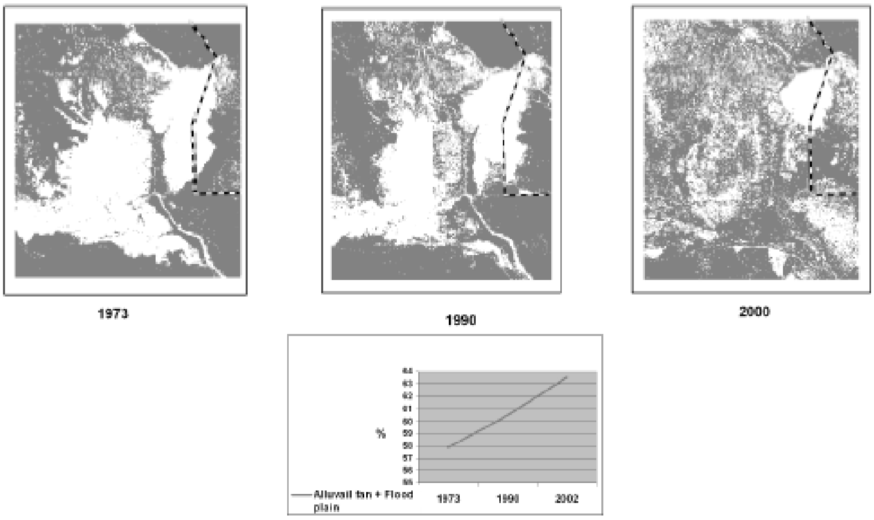

Fig. 9. Digital map showing the changes in the coverage areas of barren lands, which includes the old floodplain and alluvial fans during the years 1973-2000, with linear diagram. (Abdul Jabbar et al., 2010).

In another study, Chen et al. (2011) assesses the hydrologic conditions in the Mesopotamian Marshes under different water utilization scenarios (Figure 10). A marshland hydrologic model for the Hawr Al Hammar Marshes near the downstream end of the Tigris - Euphrates River Network has been developed in conjunction with the regional hydro-climate model of Tigris-Euphrates (RegHCMTE) Watershed and the water resources system model of the Euphrates-Tigris River Basin. The marshland hydrologic model they created accounts for rainfall, evapotranspiration, surface water inflows and outflows, and soil water inflows and outflows. Chen et al. (2011), described the marshland hydrologic model for the Hawr Al Hammar Marshes, and the reconstruction of historical marshland hydrologic data over Hawr Al Hammar Marshes by using the coupled Tigris- Euphrates (RegHCMTE) modeling system. They developed and quantified the impact of various water resource utilization alternatives in the Tigris-Euphrates Basin on the hydrology of the Hawr Al Hammar marshes (Figure 10). Summarizing, their model simulation findings indicate that by treating the Euphrates-Tigris Basin as one hydrologic unit, where water is moved from the Tigris to the Euphrates River to meet the demands of water irrigation in the basin for various release scenarios from the Turkish area, the sustaining of the Al Hammar Marshes is possible at their pre-dam-construction (before-1970) conditions in the Euphrates-Tigris Basin under the hydroclimate conditions of the critical dry historical period. However, the last study is more related to hydrologic modeling but it has some common results and concerns regarding the past and future of the Mesopotamian Marshes of the area. Most of the previous versions of Landsat showing the beginning of marshland degradation in the area in the late seventies.

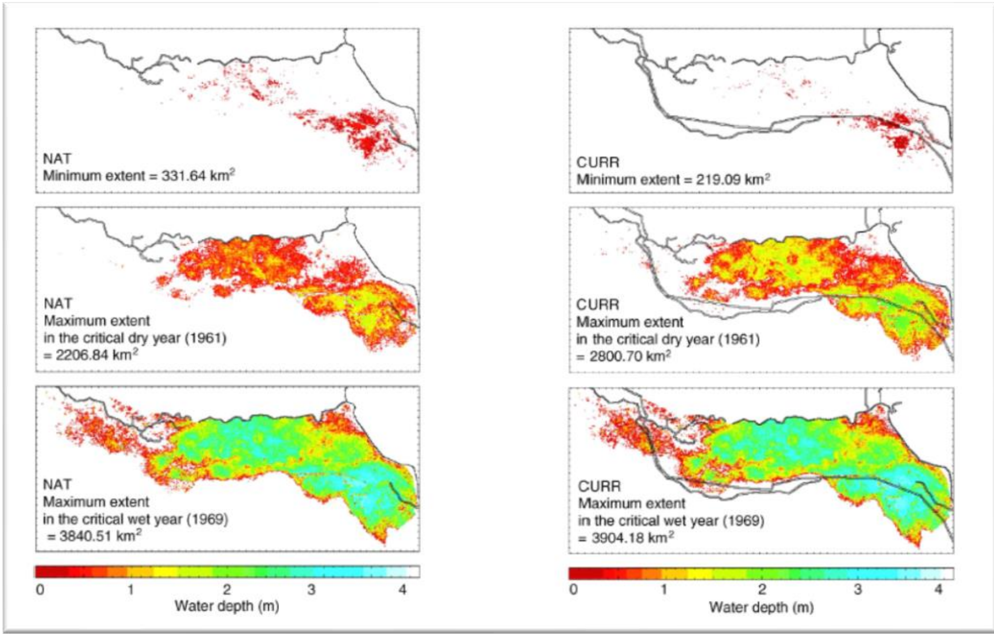

Fig. 10. Model-simulated minimum and maximum extents of the inundated area in Al Hammar marshes in the critical dry and wet years under CURR scenario Right and NAT scenario Left. (Chen et al., 2011).

Current water resources utilization conditions in Syria and Iraq (scenario CURR), indicate that the mean water level within the Al Hammar Marshes can decrease to a minimum of 0.3 m, and the water-inundated area can decrease to a minimum of approximately 219 km^2 during the historical-critical period. For example, it was demonstrated that Al Hammar Marshes discharged only during the wet seasons, winters, and springs under the scenario NAT. This indicates that a prime reason for the existence of the inundated area at Al Hammar Marshland is because the bottom elevations of this marshland are fundamentally less than the outlet region around the Al-Basrah. Consequently, as long as the water in the marshland is not drained by artificial canals, even under high water utilization scenarios, at least a minimum marshland area would be preserved because of the topography of the water utilization scenario simulations considered in this study. However, a significant portion of the original Al Hammer Marshland area is currently utilized in current petroleum extraction operations. Hence, it is not certain how much area of the Al Hammer Marshlands will actually become available in the future as actual marshlands. As with the previously mentioned studies, this later study also mentions the effect of the artificial canal and dams that have been created on the feeding rivers to the Al-Hammar marshland. However, Chen et al. (2011) argues that at least a minimum portion of the marshland area would be preserved in case of future severe drought due to the topography of the water utilization scenario simulation adopted in their study. There are also some studies that havedealt with and explained the salinity of the Mesopotamian plain. Where about 60 percent of the cultivated land in the Mesopotamian plain in Iraq is affected seriously by salinity (edenagain.org, 2021); 20–30% has been abandoned in the past 4000 years, (Buringh, 1960). Due to soil salinity, the yield of crops, especially, wheat has declined by 20–50 percent by the 1950s (Buringh, 1960), but the severity and distribution of soil salinity vary with time and space (Buringh, 1960; Jacobsen and Adams, 1958). Hence, in order to treat and prioritize any effort with a better plan for food security and agricultural improvements, it is an urgent need for local and central governments to understand and evaluate the severity and distribution of salinity in the Mesopotamian plain. Wu et al. (2014), revealed in their study that in spite of challenges, the possibility of demonstrating a map and quantifying the spatial distribution of the salt-affected land at the regional level based on the development of local- and regional-scale salinity models in the Mesopotamian plain (Fig. 11). A multiyear, multiresolution, and multisensor dataset composed of mainly Landsat ETM+ and MODIS data of the period 2009–2012 was used. The findings of Wu et al. (2014) indicated that the local scale salinity models developed from pilot sites with vegetated and no vegetated areas can reliably predict salinity. Salinity maps produced by these models have a high accuracy of about 82.5–83.3% against the ground measurements. Moreover, regional salinity models developed by using integrated samples from all pilot sites can estimate soil salinity with an accuracy of about 80% based on comparison to regional measurements along two transects. The study finally concluded that the multiscale models are reasonably reliable for the assessment of soil salinity at regional and local scales.

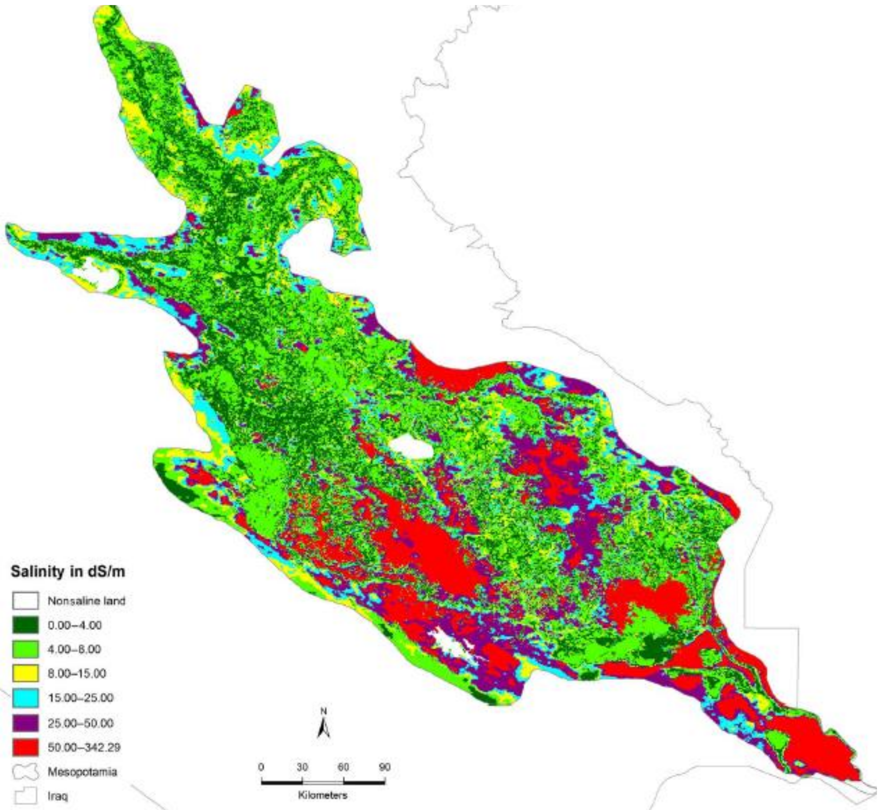

Fig. 11. Salinity map in Mesopotamian Plain (Wu et al., 2014).

The validated maps that Wu et al. (2014) produced can tentatively support the decision-makers in facilitating their future land use planning in the Mesopotamian Plain. Their study suggested methods that could reduce the problems related to soil moisture and crop rotation/fallow practices. The models could be applied for multitemporal salinity mapping to follow the temporal and spatial changes in the Mesopotamian plain. However, Wu et al. (2014) faced some problems during their study related to the coarse resolution LST data (1000 m), since it is really not ideal for soil salinity quantification as spatial variability of salinity has been greatly homogenized. Hopefully, these issues can be sorted out or improved when field accessibility is improved and new thermal data with higher resolution (e.g., 60–250 m) are available. Finally, the study recommended in future work, that the involving of (ET and LST) Eva transpiration and land surface temperature with high resolution as one of the indicators, can be taken into account. Thus, in this case, remote sensing-based salinity models shall be more comprehensive and relevant for both local- and regional-scale assessments. Jones et al. (2006) in a very interesting study adopted an integrated approach (hydrological modeling, remote sensing, and GIS techniques) for a better understanding of the observed temporal and spatial land cover and land use over the marshes and the forcing parameters that introduced these changes. Their approach is formed of two phases: Firstly, by analyzing archival remote sensing data (Landsat Multi-spectral Scanner [MSS], [MODIS], Landsat Thematic Mapper [TM], and [AVHRR] in a web-based GIS environment(http://ims.esrs.wmich.edu/website/Eden) to map the temporal of about (1969-present) and spatial variations of the land cover and land use throughout the catchment and identifying the impacts of the individual anthropogenic constructed projects and dams on the land cover and land use throughout the marshlands. Jones et al.'s (2006) findings from 1984 to 1992 indicate concentrating on the land cover and land use experienced from the GAP project that led to the marshlands declining from 8500 km^2 to 6500 km^2. In the period of 1992 to 1998, the compound effects of the GAP project and drainage projects in and around the marshlands exposed the marshlands to decline from 6500 km^2 to 2200 km^2, while in 2002 the marshlands occupied an area of 745 km^2, recording the least area occupied before the onset of sustaining efforts. Fortunately, the marshlands began to pour the desiccated lands, and the marshlands become occupying of the area about 4000 km^2 after ad-hoc sustaining and remediation efforts to dam drainages in and around the marshland area that led to the natural flow of water into the marshlands in several areas. Therefore, by using satellite imagery after May 2003 the evidence of these remediation efforts can be seen significantly. Secondly, in order to conduct rainfall-runoff computations (Water Assessment Tool: SWAT & using the Soil) the study developed a continuous catchment-based rainfall-runoff model for the entire watershed to better figure out the forcing parameters behind the observed land cover and land use (man-made and/or climate-related) and to simulate the observed temporal and spatial variations in the land cover and land use. Finally, to eliminate problems that exist from the availability of rain gauges within the catchment area; satellite-based sensors were used to extract precipitation data, 4 hourly precipitation data: Special Sensor Microwave Imager [SSMI], 1987 to present. 3-hourly precipitation data: Tropical Rainfall Measuring Mission datasets [TRMM 3B42.v6], 1997 to present; The spatial extent of drainage basins is being derived from Shuttle Radar Topographic Mission (SRTM) data, soil moisture content and surface temperature are being extracted from AVHRR data (during and after storm events), an index of saturation (0-100%) is being utilized, and by using the Penman-Monteith method evaporation on bare soils and evapotranspiration (ET) on vegetated canopy are being calculated (Monteith, 1981).

4. Conclusion

This review was based on the important results of the studies carried out in the Mesopotamian marshland. This research is mainly based on remote sensing knowledge that including other studies such as land use, geology, hydrology, etc.., can explain the unstable conditions in the region due to human activities and climate change. In this regard, human activities in this area can reduce the flow rate of rivers and climate change can play an important role in the instability of the region. the results of the study show that the condition of these limitations is gradually increased, and the existing ecosystems are exposed to a serious threat. Key strategies to prevent the destruction of system ecology are strengthening of river water supply systems and optimal agriculture which can reasonably manage existing water resources.

Acknowledgement

This article was not under any financial support. We equally acknowledge the anonymous reviewers for their constructive criticism and thoughtful comments that were beneficial to the improvement of the revised manuscript.

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