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# A study of the climate and human impact on the future survival of the Al-Sannya marsh in Iraq

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**Abstract:** The marshes are the most abundant water sources and ecological rich communities. They have a significant impact on the ecological and economic well-being of the communities surrounding them. However, climatic changes directly impact these bodies of water, especially those marshes which depend on rainwater and flooding for their survival. The Al-Sannya marsh is used as the example of marshes in Southern Iraq for this study between 1987–2017. The research takes place throughout the winter season due to the revival of marshes in southern Iraq at this time of year. The years 1987, 1990, 1995, 2000, 2007, 2014, 2017 are the focus of this study. Satellite imagery from the Landsat 5 (TM) and Landsat 8 (OLI) and the meteorological parameters affecting the marsh were acquired from NASA. The calculation of the areas of water bodies after classification using satellite imagery is done using the maximum likelihood method and comparing it with meteorological parameters. These results showed that these marshes are facing extinction due to the general change of climate and the interference of humans in utilising the drylands of the marsh for agricultural purposes. The vegetation area can be seen to have decreased from 51.15 km$^2$ in 2000 to 8.77 km$^2$ in 2017.

**Keywords:** climate change, human impact, Landsat 5, Landsat 8, maximum likelihood classification, south of Iraq

## INTRODUCTION

The use of remote sensing and geographic information systems in the analysis of satellite images of the Earth's resources is a vital resource to enable the extraction of information related to the Earth's cover with the required speed and accuracy needed for various applications [ABDULJABBAR 2017; MEGHRAOUI *et al.* 2017; NAJI, HATEM 2017]. Iraq is characterised by a varying terrain, from the mountainous region and sedimentary plain to the deserts. However, Iraq is regionally different from other countries in that it also contains a marshland area [ALBARAKAT *et al.* 2018] located in the south of the country. The biological diversity in the marsh's region made Iraq the incubator for the first human civilisations [GIBSON *et al.* 2015].

The ecosystem of the southern marshes of Iraq is the largest wetland ecosystem in the world with geological, hydrological, topographical, and demographic aspects. The Iraqi marshes located in the south of Iraq are considered as one of the most important and oldest areas that enjoy natural and economic potentials through the various forms of life contained in their rich environment [JASIM *et al.* 2018].

The marshes are considered an essential and unique component of Iraqi heritage and included in the world heritage list [SALEH 2012]. They are one of the most prominent landmarks in Iraq, formed within the sedimentary plain between two rivers to form the natural balance between the Tigris and Euphrates and the Shatt al-Arab Rivers leading to the Arabian Gulf [JABBAR *et al.* 2010].

The marshes are flat areas, and the level of water immersion in them depends on the water level of the Tigris and Euphrates Rivers and the seasonal changes related to them, as well as the depth, varies in different parts within the marsh areas [ABDULJABBAR, NAJI 2020]. The marshes contain different types of natural plants, as well as types of fish and birds, most of which are migratory birds, and there is also a special breed of bulls known locally as buffalo [ALBADRAN 2006].

In the 1980s and 1990s, the marshlands areas in Iraq suffered multiple setbacks due to natural and human factors, which led to changes in the land cover, in turn causing significant environmental degradation which affected the ecosystem of the marshes [Hussein *et al.* 2018].

The Iraqi marshes have gone through a period of drought due to lack of rain, which led to a decrease in the amount of reserve water in them [Naji, Abduljabbar 2019; Naji, Hatem 2017]. Additionally, the disastrous decision of the Iraqi government during the 1980s to drain the marshes in the south of Iraq as a result of the ongoing military conflict [UNEP 2007] caused the marshes to diminish even further.

Iraq has been exposed to multiple water crises, and these crises have implications on the humanitarian, economic, security, and social levels, including population movement. The situation is expected to worsen in Iraq, where the incoming water from the Tigris and Euphrates Rivers is declining. These rivers provide the two main sources of water for the country. The increase in hydraulic infrastructure construction at their sources, which are outside Iraq, is helping to reduce the water they contain. In addition, the temperatures in Iraq continue to rise while the average annual precipitation decreases due to climate change, which represents a challenge for the whole region. Therefore, the risk of population displacement in Iraq due to water shortage is still high due to the deteriorating situation of water in terms of quantity and quality [Lateef *et al.* 2020].

The conditions of the marshes have deteriorated, and their area has decreased to a quarter of their original size. Therefore, to assess the reality of the marshes, we need continuous study to monitor the changes in the land cover and the water quality of these marshes. Previous studies have also noted the importance of continued monitoring of marshes in Southern Iraq:

– Jabbar *et al.* [2010] – this study deals with remote sensing techniques and Geographic Information Systems (GIS) applications based on Landsat satellite data with different sensors for different periods (MSS 1973, TM 1990, ETM 2000). After classifying the study area (the southern marshes of Iraq) and calculating the area for each type, the results showed that the area of barren lands was increasing at the expense of the areas of water bodies and thus, the rate of desertification increased. It caused negative changes in the physical and chemical properties of the soil, and thus the soil became unfit for agriculture, and thus it led to the displacement of people from these areas for the period from 1973 to 2000;
– Saleh [2012] – this study dealt with the detection of the change in the ground cover of the Hammar marsh in southern Iraq by analysing satellite images captured of the study area for the years 1975–2002 using the MSS and TM sensor. They reveal that the desertification with expanses of vast lands covered with salt, while the final image of the satellite shows specific areas of the marshlands that have been reclaimed;
– Muhsin's [2017] study dealt with a change detection technique to detect the change occurring in the marshes of southern Iraq and its surrounding land areas through satellite images for the first two periods from 1973 to 1984 and the second from 1973 to 2014; the new images and the change detection technique were applied using a matching filter on the study area for each cultivar;
– Hussein *et al.* [2018] study aimed to detect the change in the land cover of the Hawizeh area and the surrounding areas for years with its sensors (Landsat TM-1990, Landsat ETM+ 2000, 2013 in addition to 2015 (Landsat LDCM). Using the vegetation cover index (*NDVI*) and the index of water (*NDWI*), and the sand dune index (*NDSDI*), and by monitoring the marshes via satellite data, the results showed a remarkable and significant change in the area of vegetation cover, whose area decreased to 43% during the study period.

Although Al-Sannya marsh belongs to the central marshes, there has been no research that inspects the status and changes in this marsh. Therefore, it is the Al-Sannya marsh that has formed the basis of our study, observing the marsh and documenting the changes to it during the period from 1987 to 2017 with the help of the satellite imagery from Landsat 5 and 8.

## MATERIALS AND METHODS

The Al-Sannya marsh is located in south-eastern Iraq (in the longitude ranged (from 46°31'12.66" to 46°39'14.68" E) and latitude range (32°4'37.77" to 32°10'3.34" N). It is positioned on the of border the Wasit and Maysan provinces, as shown in Figure 1. It is characterised by its longitudinal shape. The satellite images used for this research were acquired from the United States Geological Survey (USGS) Center for Earth recourses, observation and science website. In contrast, the meteorology parameters were obtained from the Prediction of Worldwide Energy Resources (POWER) website, NASA [NASA 2020].

Al-Sannya marsh is one of the central marsh regions in southern Iraq. The changes that occurred to its landcover features during the period 1987–2017 represented by the years (1987, 1990, 1995, 2000, 2007, 2014, and 2017) were studied, where the satellite imagery captured by the satellites Landsat 5 (TM) and Landsat 8 (OLI) were used, as shown in Table 1.

The winter season represents the period of recovery in the marshes of Iraq due to the increased rainfall and flooding. Therefore, the Al-Sannya marsh during the winter season was studied throughout December, January, and February. Across all of the years the mashes were studied, these months represent the best period. Unlike the winter season, the summer season, the marshlands generally suffer from a shortage of water and sometimes complete drought [Naji, Abduljabbar 2019].

The presence of cloud cover in the winter and the great temporal resolution of the Landsat satellites series (16 days) [Ihlen 2019] to capture the exact location led to difficulty obtaining clear images of the Al-Sannya marsh, causing the unequal periods between the images in this study.

The changes in the land cover features of Al-Sannya marsh were studied using the following steps.

1. The numerical values of the Landsat 5 (TM) and Landsat 8 (OLI) satellites were converted into their equivalent TOA reflectance values. The ENVI pre-processing package was used to calculate the reflectance values of Landsat 5. As for the Landsat 8 satellite, Equation (1) is used to calculate the amount of reflectance [Ihlen 2019].

$$\rho_{\lambda}' = \frac{M_p \cdot Q_{\text{cal}} + A_p}{\sin\theta} \tag{1}$$

where: $\rho_{\lambda}'$ = TOA planetary spectral reflectance, without correction for the solar angle (unitless); $M_p$ = reflectance multi-

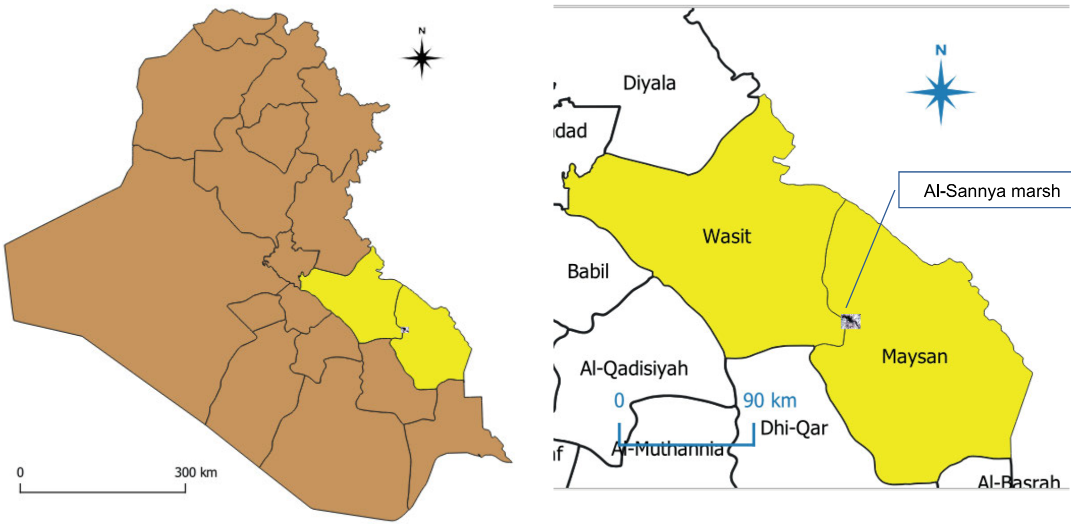


**Fig. 1.** The location of the Al-Sannya marsh (Iraq, between Wasit and Maysan provinces); source: own elaboration

**Table 1.** List of the adopted Landsat 5 and 8 scenes information

| Satellite imagery No. | Date (dd/mm/yy) | Acquiring time (GMT) | Landsat |
|---|---|---|---|
| 1 | 17/01/1987 | 06:47:36.3330000Z | 5 |
| 2 | 11/12/1990 | 06:47:10.0000500Z | 5 |
| 3 | 23/01/1995 | 06:40:06.7320130Z | 5 |
| 4 | 06/02/2000 | 07:02:01.6880940Z | 5 |
| 5 | 24/01/2007 | 07:22:45.8480310Z | 5 |
| 6 | 12/02/2014 | 07:28:42.4864260Z | 8 |
| 7 | 04/02/2017 | 07:27:51.3069100Z | 8 |

Source: own elaboration.

plicative scaling factor for the band (reflectance multiband in from the metadata); $A_p$ = reflectance additive scaling factor for the band (reflectance add the band in from the metadata); $Q_{cal}$ = pixel value in DN.

2. The satellite images were clipped to show the land cover change on Al-Sannya marsh only.
3. Training sets representing the land cover features were collected to be used by the supervised classifier to classify the scenes used in this study.
4. To determine how accurately the training sets represent the classes that make up the land cover of the study site, their separability was calculated using the Jeffries–Matusita distance criterion [Jeffreys 1946].
5. The maximum likely hood classifier is used to classify the land cover for the studied area and for different years.
6. Calculate the statistics for each classified scene.

## RESULTS AND DISCUSSION

The Al-Sannya marsh in the inner part of the central marshes in southern Iraq is located on path 167 and row 38 of the Landsat satellites series. The scenes are clipped to show the Al-Sannya marsh, specifically allowing the study of changes occurring in the marsh's land cover only, as shown in Figure 2.

Al-Sannya marsh land cover features can be grouped into four classes which are: vegetation, soil, deep water, and shallow water; as shown in Table 2, according to these classes, the training sets were collected. The separability between the training sets is calculated using the Jeffries–Matusita distance criterion, where the separability value was higher than 1.9 between each training set pair, ensuring the validity of the collected training sets to be used in the classification process.

**Table 2.** Al-Sannya marsh land cover classes with their colour representation in the classified results

| Class | Colour |
|---|---|
| Vegetation | |
| Soil | |
| Shallow water | |
| Deep water | |

Source: own elaboration

Separation of the classes that make up the land cover of Al-Sannya marsh was done using the supervised classifier (maximum likelihood), as shown in Figure 3. Each class was represented by a distinctive colour to facilitate the distinction of the land cover components, as shown in Table 2.

The land cover features of Al-Sannya marsh are constantly changing. These changes were further evident in the calculation of the area of each of the classes that make up the study area, where the area of each class and its percentage into the total area is calculated, as shown in Table 3 and Figure 4.

The accuracy of selecting training groups and achieving the highest separability criterion based on the Jeffries–Matusita distance criterion is reflected in the overall accuracy of the classification process for the satellite images, as shown in Figure 5.

Al-Sannya marsh depends on its presence on the water accumulated during the rainy season and the torrents that may come from the neighbouring areas, which greatly affected the survival of this marsh or its drying up. The amount of rain

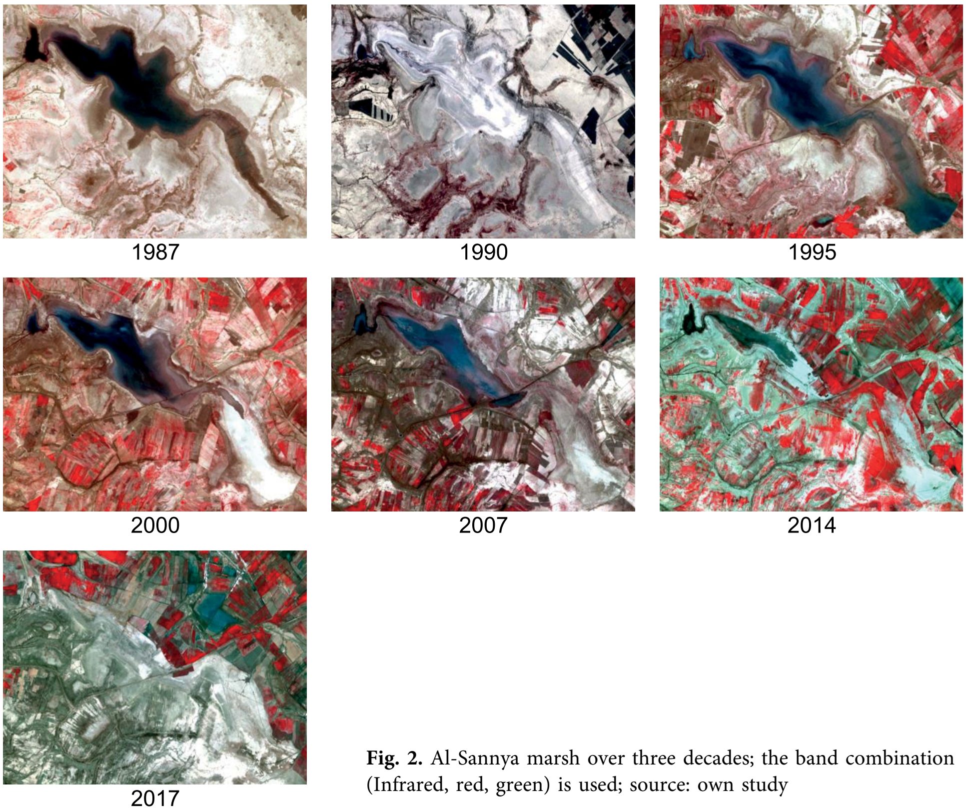


**Fig. 2.** Al-Sannya marsh over three decades; the band combination (Infrared, red, green) is used; source: own study

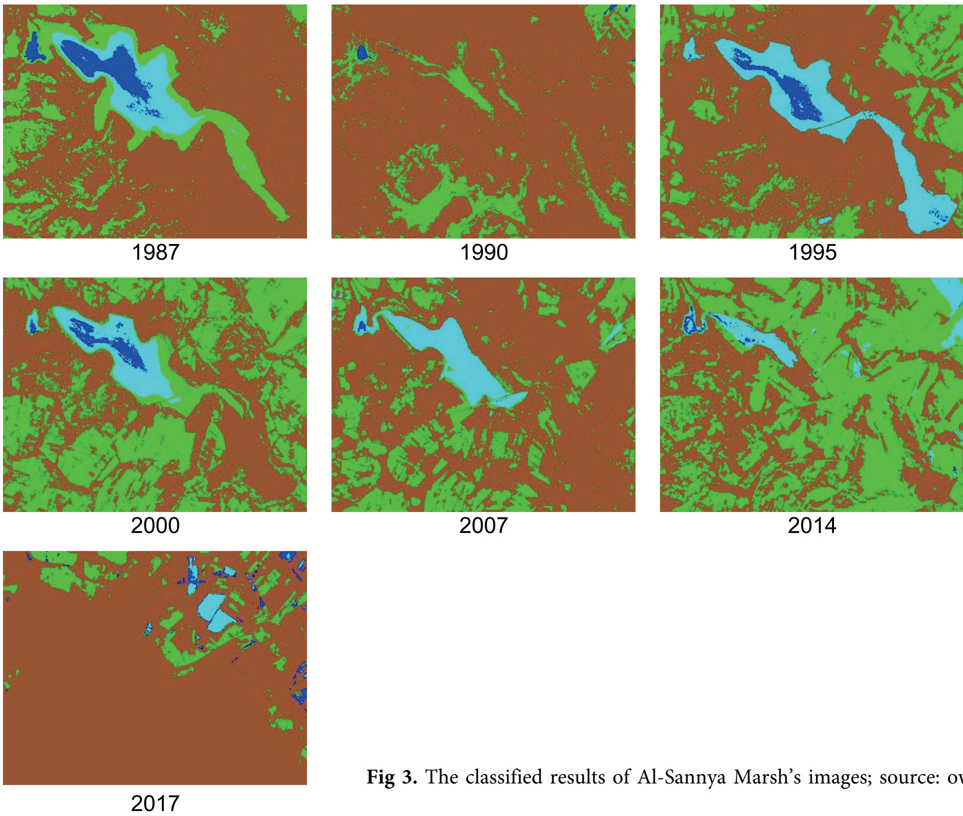


**Fig 3.** The classified results of Al-Sannya Marsh's images; source: own study

accumulated in the marsh until the satellite image was captured is a fluctuating quantity, as shown in Figure 6. In addition to the rest of the weather factors which affect it, including surface temperature, the relative humidity, and the average wind speed at the height of 2 m from the surface (Fig. 6), is generally oscillatory.

When the climatic conditions are unfavourable, for example, due to a decrease in the number of monsoon rains, with high temperatures, low relative humidity, and high wind speed, a reduction in the area of the marsh or even its disappearance due to high evaporation ratio may occur. These unfavourable conditions were present in 1990 when the marsh

**Table 3.** The area of Al-Sannya marsh and percentage share of each class in the selected scenes

| Year | Class | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | vegetation | | soil | | shallow water | | deep water | |
| | area ($km^2$) | share (%) | area ($km^2$) | share (%) | area ($km^2$) | share (%) | area ($km^2$) | share (%) |
| 1987 | 23.15 | 18.31 | 90.90 | 71.89 | 8.01 | 6.34 | 4.38 | 3.46 |
| 1990 | 15.27 | 12.08 | 110.82 | 87.65 | 0 | 0 | 0.35 | 0.27 |
| 1995 | 23.29 | 18.42 | 86.55 | 68.45 | 14.12 | 11.17 | 2.48 | 1.96 |
| 2000 | 51.15 | 40.46 | 66.75 | 52.80 | 6.72 | 5.31 | 1.81 | 1.43 |
| 2007 | 27.08 | 21.41 | 91.38 | 72.27 | 7.87 | 6.22 | 0.11 | 0.09 |
| 2014 | 64.71 | 51.18 | 55.99 | 44.28 | 5.20 | 4.11 | 0.55 | 0.43 |
| 2017 | 8.77 | 6.94 | 114.09 | 90.24 | 1.97 | 1.56 | 1.60 | 1.27 |

Source: own study.

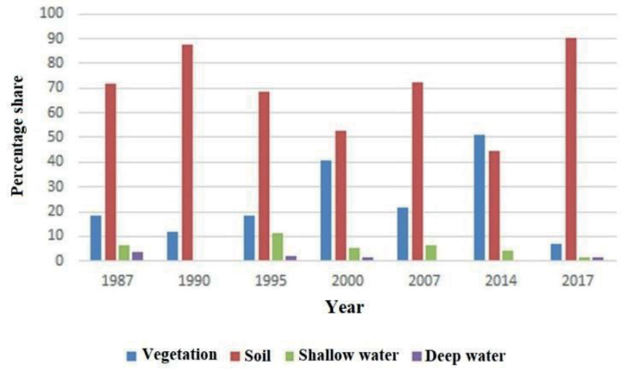


**Fig. 4.** The percentage share of each land cover class of Al-Sannya marsh for different years; source: own study

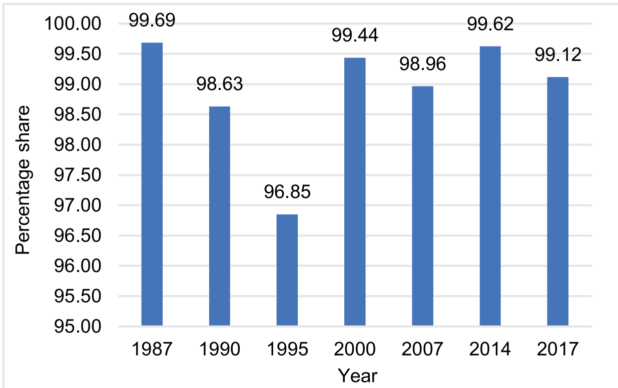


**Fig. 5.** Overall classification accuracy; source: own study

dried up almost completely. The climatic changes occurring across the globe due to global warming can be seen to influence Al-Sannya. The marsh area has decreased continuously due to the reduction in monsoon rainfall over the last ten years (Fig. 6).

The intervention of the human factor as one of the factors affecting Al-Sannya marsh has raised the possibility of the marsh's disappearance in the future due to the use of marshlands to cultivate crops. The disappearance of the marsh is apparent in the

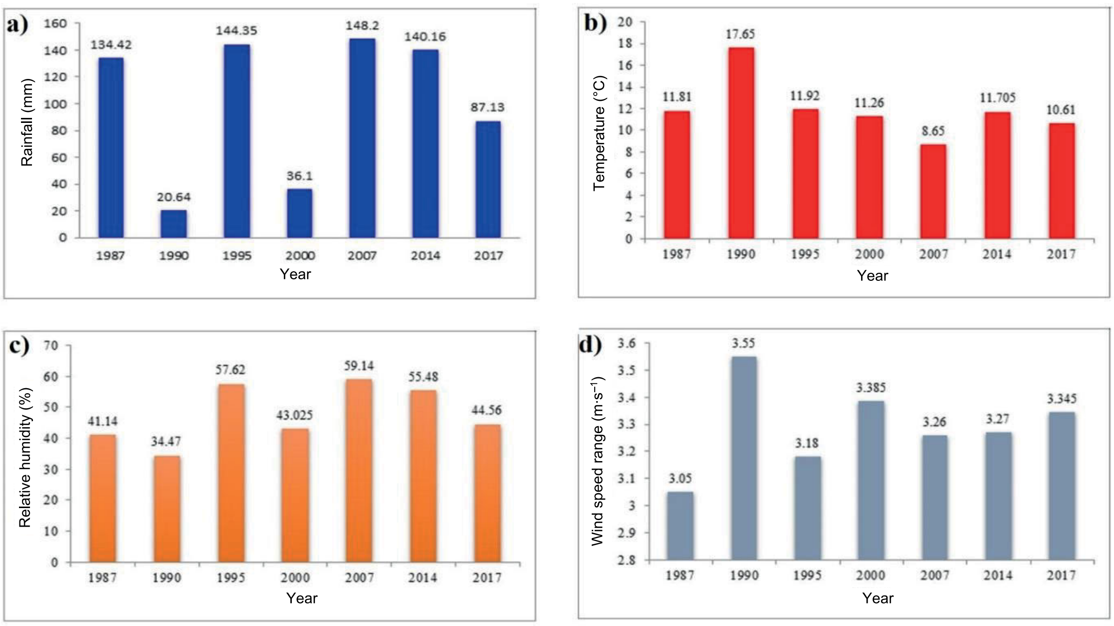


**Fig. 6.** Chosen meteorological parameters, at the satellite image acquiring date: a) accumulated rainfall, b) surface temperature, c) relative humidity, d) wind speed range; source: NASA [2020]

decreasing amount of wild vegetation, but despite the decreasing amount of rainfall, crops continue to be cultivated. This can be seen through the emergence of geometric shapes of crops around the marsh and the cultivation of field crops as a result of human intervention.

## CONCLUSIONS

The study of Al-Sannya marsh as an example of the internal marshes in the central marshlands in southern Iraq showed that these marshes depend on the accumulated water from seasonal rains and torrents from neighbouring regions for their survival, are threatened with extinction. The change in the world's weather conditions particularly affects Iraq, suffering from low amounts of monsoon rains. Additionally, the high surface temperature, low relative humidity, and high wind speed are all factors that increase the evaporation ratio of the marsh water.

In addition to the impact of climatic conditions, the human impact on the Al-Sannya marsh, due to the cultivation of crops, will prevent the future recovery of the marsh.

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