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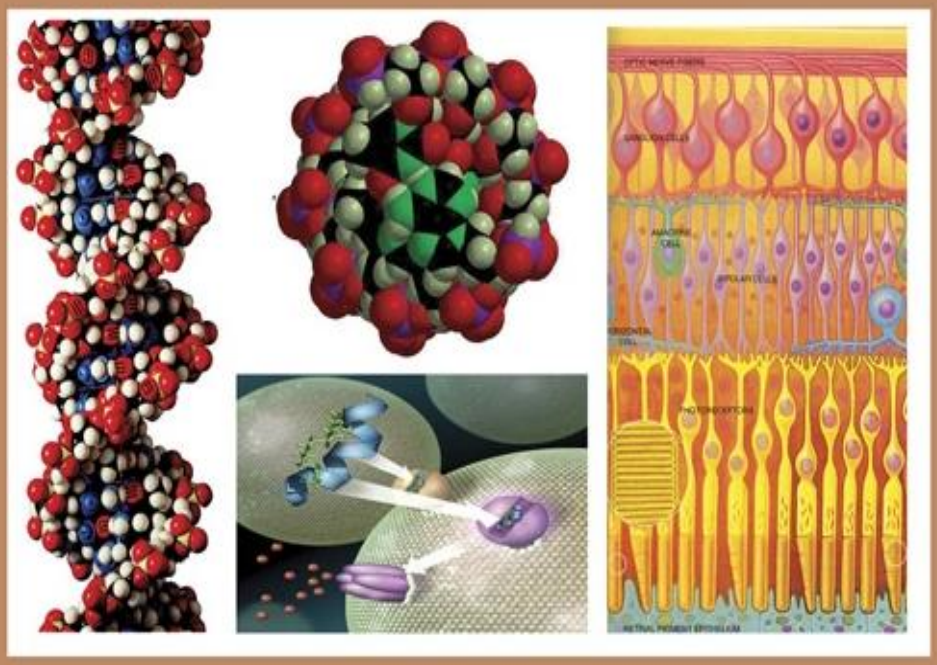

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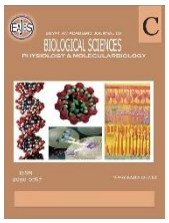

Impact of Climatic Factors on the Mekerra watershed (North-West Algeria) via Hydrometeorological Series Provided By The Google Earth Engine Platform

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ABSTRACT

Algeria is facing an endemic drought spread over 40 years and the lack of rainfall makes us fear the worst for the country's water security. The variability in the amount of rainfall and its irregularities in time and space are the main causes of the behavior of a climatic regime.

This work focuses on the analysis of climatic data provided by the google earth engine platform in order to detect temporal changes in the hydrometeorological series.

The climatic results of our Mekerra watershed show a very irregular hydrometeorological system, a long dry season, an LST that reaches 54 C°, an average annual rainfall amount is 390.41 mm and a rainfall deficit estimated at 30%, a very low rainfall deficit of a maximum value of 0.42 and an NDWI globally negative.

INTRODUCTION

Changes in climate variability and extreme weather and climate events have received increased attention in recent years **(**Yles, 2022). Indeed, several studies have been carried out analyzing the evolution of rainfall in various parts of the globe and at different time scales (Vannikov *et al.,* 1990), (Balling *et al.,* 1990), (Zai *et al.,* 2003), (Gautam, 2016). Algeria has experienced a severe and persistent water deficit over the last 30 years, resulting from a rainfall deficit estimated at 30% (FAO 2008). A considerable decrease has been noted in several regions of the North (Meddi and Meddi, 2009), (Taibi *et al.,* 2015). In the Algerian Northwest, the rainfall deficit reached 36%, (Ghenim and Megnounif, 2013) leading to a severe decrease in surface runoff. In the Upper Tafna, runoff has decreased by 69% (Ghenim *et al.,* 2010). Knowing that the recharge of water tables is provided mainly by precipitation (Yles, 2022).

The objective of this work is to analyze trends and detect temporal changes in the hydrometeorological series.

MATERIALS AND METHODS

1.Study Area and Data Description :

Located in the northwest of Algeria, the Mekerra watershed lies between latitude 34°34' and 35°79' North and between longitude 0°56' East and 1°06' West (Fig. 1) (Yles, 2022).

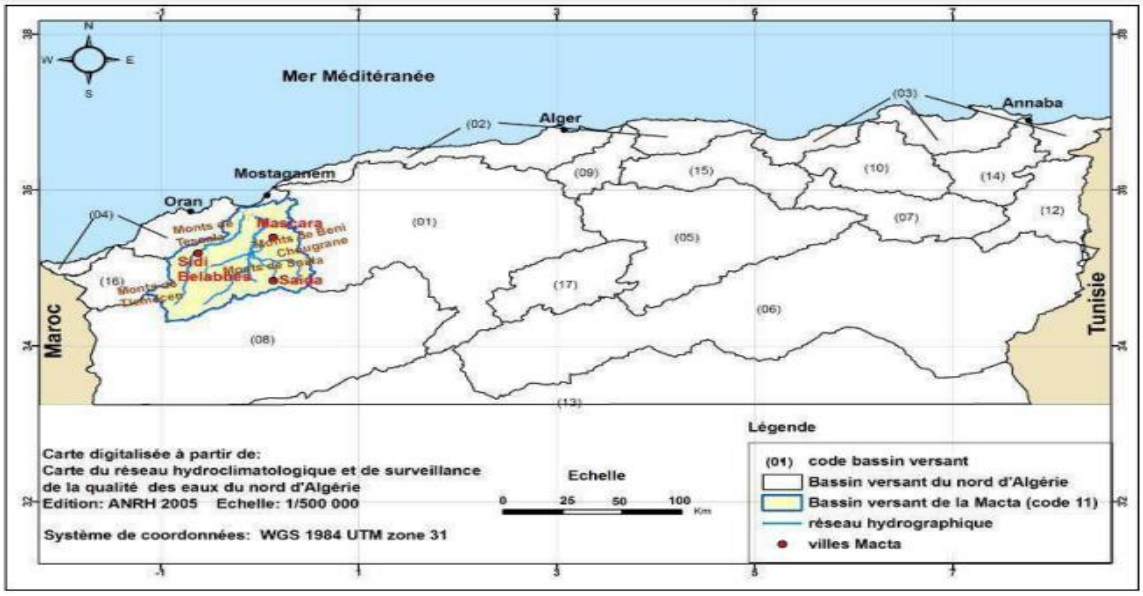

Fig. 1 : Geographical location of the Mekerra watershed. **(Beddal. 2015).**

The watershed of the Macta covers an area of about 14,389 Km2. (Khediri A, 2018). It flows directly into the Mediterranean Sea through the Macta Marsh.It is drained by two main rivers: Oued Mekerra, in the west and Oued El Hammam in the east (Beddal, 2015).

2. Methodology:

Our work is based on the use of Google Earth Engine, which is a powerful web-based platform for outsourced cloud-based processing of large-scale remote sensing data (Fig. 2). This global-scale platform is dedicated to environmental data analysis. It is an extremely valuable tool for students who want to learn more about the impacts of climate change and many other topics.

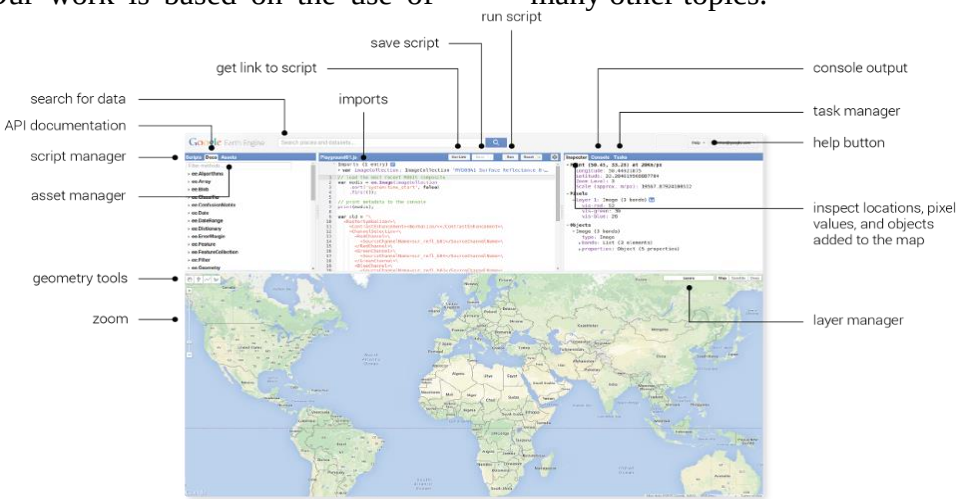

Fig. 2 : Platform - Google Earth Engine our Normalized Difference Water Index (NDWI) Potential Evapotranspiration (PTE) Normalized Difference Vegetation Index (NDVI).

1. Precipitation :

Precipitation is the primary factor in the hydrological behavior of the basin. The measurements of these allow us to evaluate the amount of water that falls and especially to estimate the quantity destined for the runoff.

The Figure 3, shows the monthly and inter-annual variations in precipitation from 2012 to 2022.

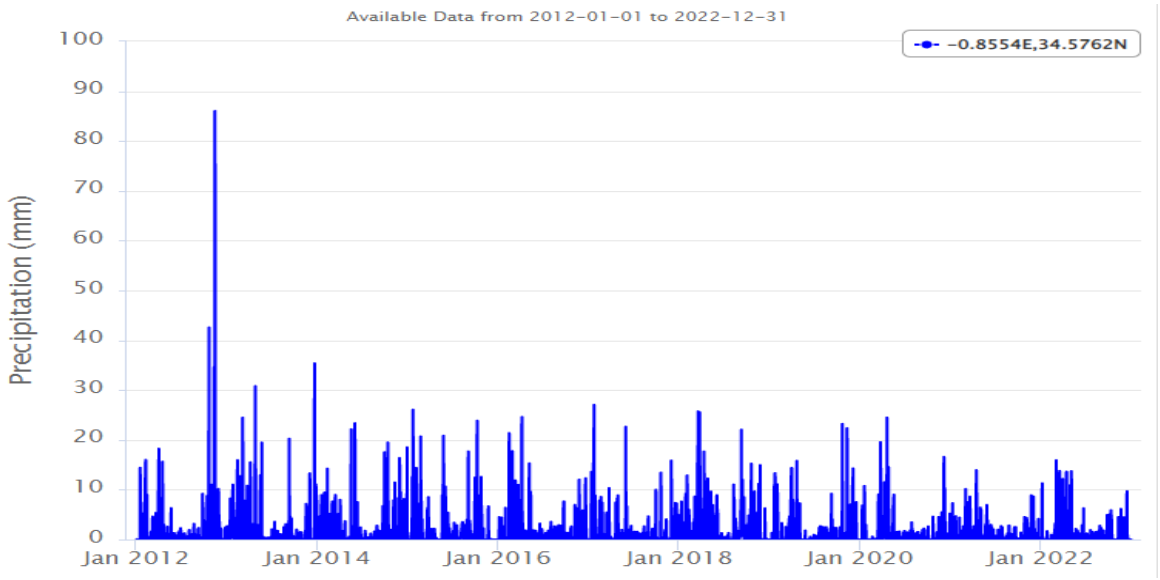

Fig. 3 : Monthly and inter-annual variations of precipitation in the Mekerra watershed during the period (2012-2022).

According to the graph of figure 07, we observe an inter-annual variability of average rainfall the average annual amount is 390.41 mm. So, our study area knows a scarcity of rainfall to say the least frightening with a rainfall deficit estimated at 30%.

2. **Surface Runoff :**

Surface runoff is the flow of water that occurs on the surface of the soil when excess rainwater, stormwater, meltwater, or other sources can no longer infiltrate quickly enough into the soil (Fig. 4). This can occur when the soil is saturated with water to its full capacity and rainfall arrives faster than the soil can absorb it (Horton, 1933) (Beven and Horton, 2004).

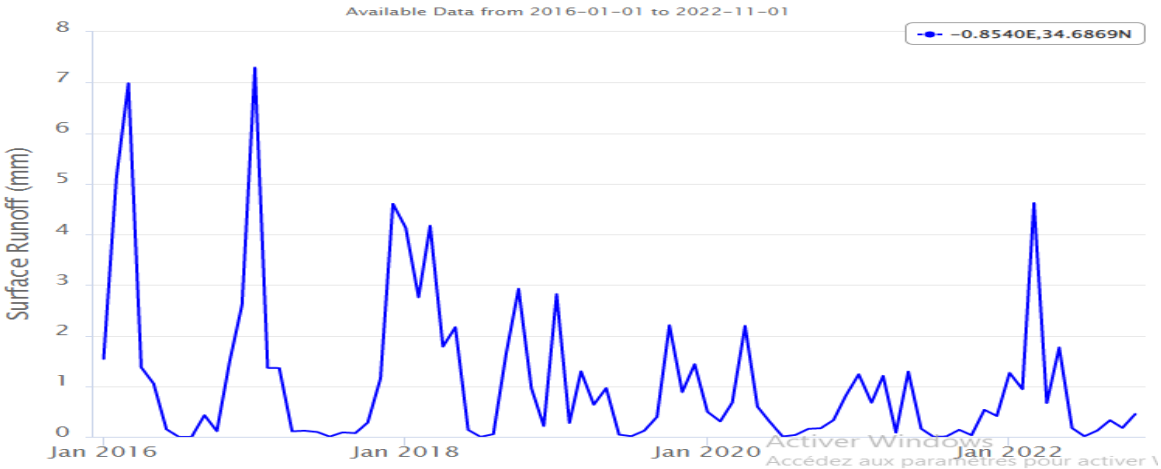

Fig. 4 : Monthly and inter-annual variations of surface runoff of Mekerra watershed during the period (2012-2022).

According to the results, the most important monthly surface runoff is recorded in 2019 in the month of January while the lowest was in July with a value of 0.001 mm. this shows that water infiltrates quickly into the soil.

Our basin is characterized by a rainfall deficit estimated at 30% (50% during the year 2017- 2018), which had a negative impact on the flow regimes of rivers, causing serious consequences on all socio-economic activities.

3. **Specific Humidity:**

Specific humidity it's a mass of water vapour in a unit mass of moist air, usually expressed as grams of vapour per kilogram of air, or, in air conditioning, as grains per pound. The specific humidity is an extremely useful quantity in meteorology.

The monthly and inter-annual variations of specific humidity are shown in the Figure 5.

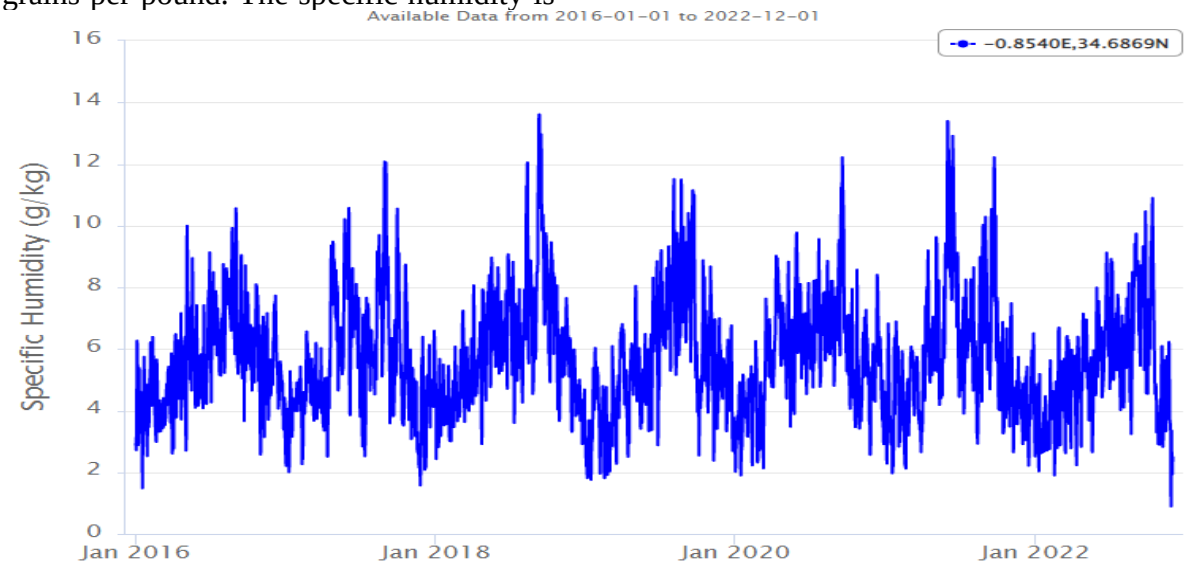

Fig. 5 : Monthly and inter-annual variations of specific humidity of the Mekerra watershed during the period (2012-2022).

The reading of the figure shows that the specific humidity is very variable in our study area with a maximum value recorded in September estimated at 11.98 g/kg in 2008.

4.Surface Soil Moisture (SSM):

Surface soil moisture (SSM) is a key factor in the flow of water and heat between the soil and the atmosphere, regulating the temperature and humidity of the air. In addition, in its role as a water supply, it is vital for the health of vegetation.Monthly and inter-annual variations in surface soil moisture are shown in the Figure 6.

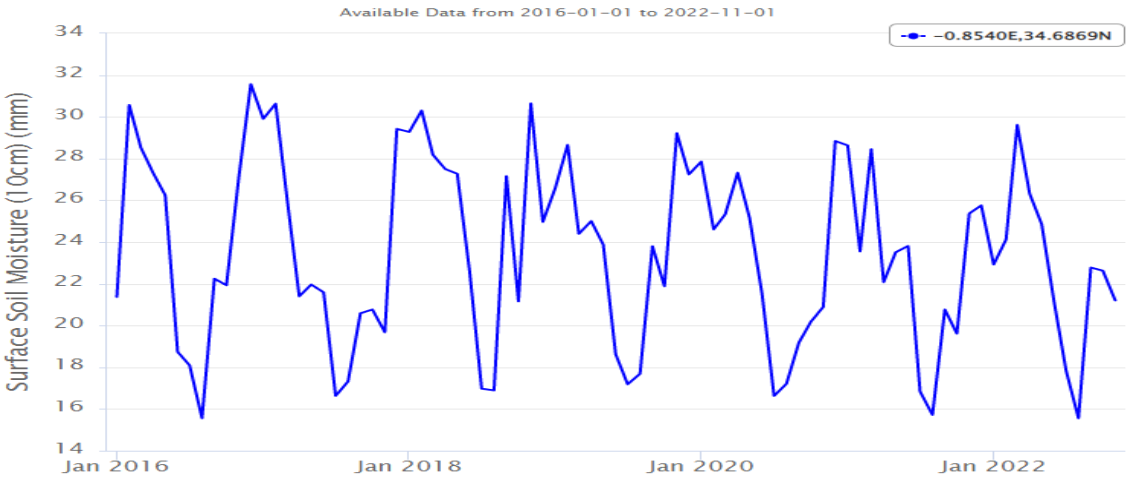

Fig. 6 : Monthly and inter-annual variation of the surface soil moisture of the Mekerra watershed during the period (2012-2022).

In Figure 6, we note that the surface soil moisture reaches its maximum value in the winter period exactly during the month of January with a value of 31.39 (mm) and a minimum value in the summer period month of July 15.81 (mm).

5. Air Temperature:

The air temperature is a key parameter in the evaporation process. (Guezel *et al.,* 2018). The monthly and inter-annual temperature variations from 2012 until 2022 are represented by the Figure 7**.**

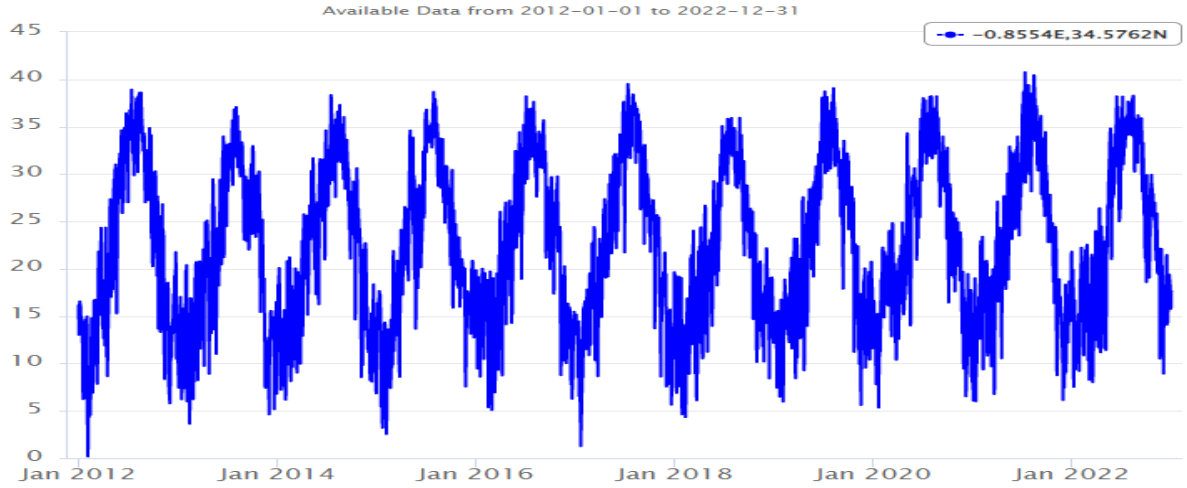

Fig. 7 : Monthly and inter-annual temperature variations in the Mekerra watershed during the period (2012-2022).

From the graph in Figure 07, we can clearly see that the maximum temperature is 39.41°C in July, and the minimum temperature is - 0.01 in January.

6. Land Surface Temperature (LST) :

The land surface temperature (LST) is the radiative temperature of the skin of the earth. LST plays an important role in the physics of the Earth's surface because it is involved in the processes of energy and water exchange with the atmosphere.

The monthly and inter-annual variations of LST temperatures from 2012 to 2022 are shown in the Figure 8.

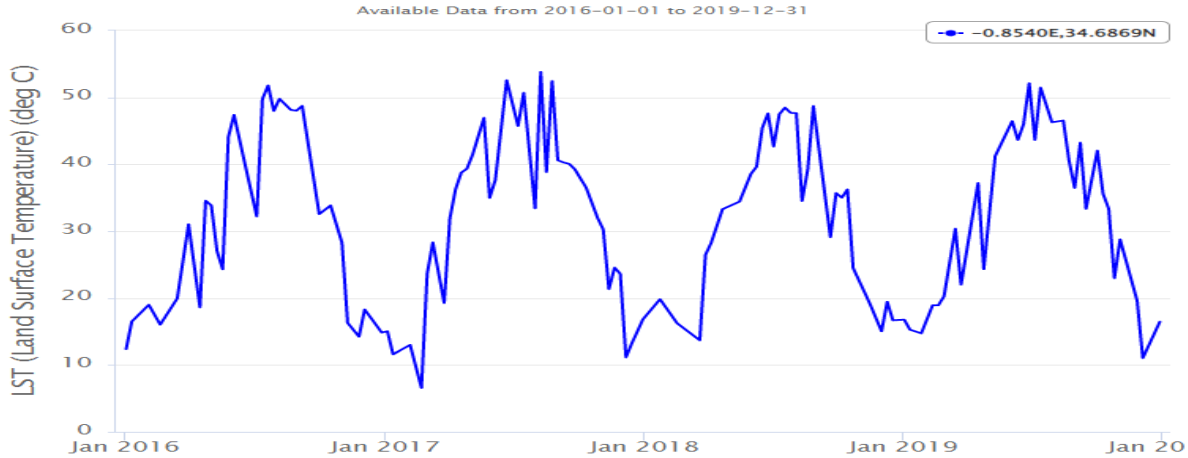

Fig. 8: Monthly and inter-annual variations of the LST temperature of the Mekerra watershed during the period (2012-2022).

According to the results obtained from the Mekerra watershed, knows a remarkable increase in the temperature of LST reaches 54 C°.

7. Evapotranspiration (ET):

Evapotranspiration (ET) is an essential component of the water cycle and a useful indicator for several environmental studies (Immerzeel, 2008), including research on climate change. for several environmental studies (Mobilia, 2021), including research on climate change.Quantifying this climate parameter is difficult because of the diversity of interactions that occur at the soil-vegetation-atmosphere interface (Lu, 2020).

Monthly and inter-annual variations in LST temperatures from 2012 through 2022 are shown in the Figure 9**.**

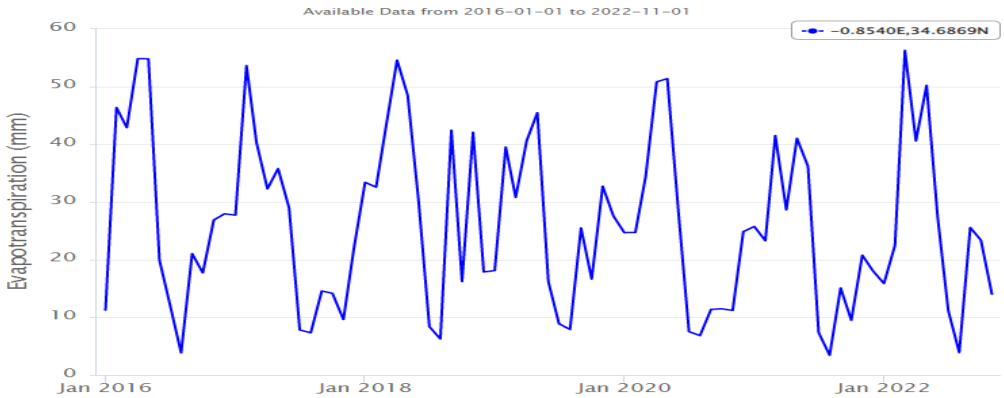

Fig. 9 : Monthly and inter-annual temperature variations in the Mekerra watershed during the period (2012-2022).

8. Potential Evapotranspiration (ETP):

Potential evapotranspiration (PTE) is an index used to represent the environmental demand for evapotranspiration. Changes in PTE can affect crop water requirements, water allocation and food production. Therefore, knowledge of ETP estimation has been widely used in water resource management, water balance estimation, agricultural water productivity studies, irrigation studies and agricultural water demand analysis (Tran & Honti 2017 ; Farzanpour *et al.*, 2019 ; Pan *et al.*, 2019). The monthly and inter-annual variations of potential evapotranspiration from 2012 to 2022 are shown in the Figure 10.

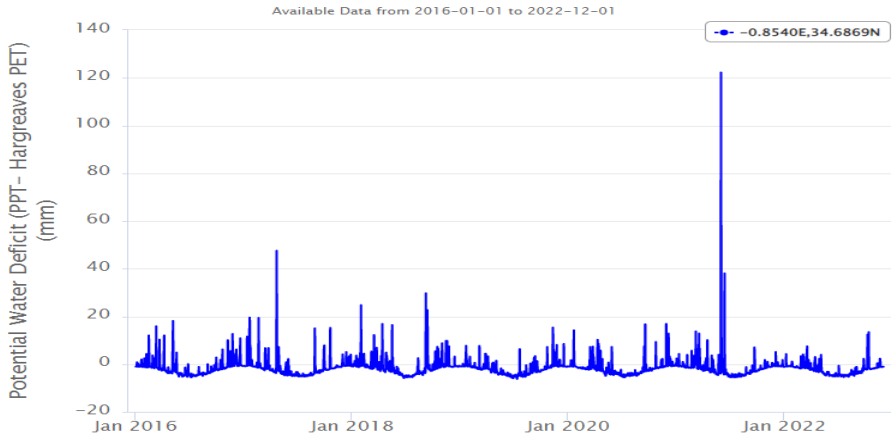

Fig. 10 : Variations in monthly and inter-annual potential evapotranspiration of the Mekerra watershed during the period (2012-2022).

According to the results obtained, the most important ETP was detected on June 2, 2021, with an estimated value of 120.94 mm.

The consequences of environmental stresses are more complex for the leaves of the basin species, which grow in two dimensions and for which no steady state can be defined (Wolf *et al.*, 1986). The effect of short-term water deficits on leaf area and cell number depends on the timing of the deficit (Lecoeur *et al.*, 1995). A given water deficit affects areas near the base and near the tip of the leaf differently in terms of cell expansion and mitotic index (Heckenberger *et al.*, 1998). A short-term water deficit affects the rate of expansion during the deficit, but also for a long period after the plants have been rehydrated (Lecoeur *et al.*, 1995).

9. NDVI Index :

The NDVI (Normalized Difference Vegetation Index) is a normalized index for generating an image displaying vegetation cover (relative biomass). The NDVI is used worldwide to monitor drought, control and predict agricultural production, assist in fire prevention, and map desertification. (Lillesand 2004).

Negative NDVI values (values near -1) correspond to water. Values near zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Finally, low and positive values represent shrublands and grasslands (about 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching 1).

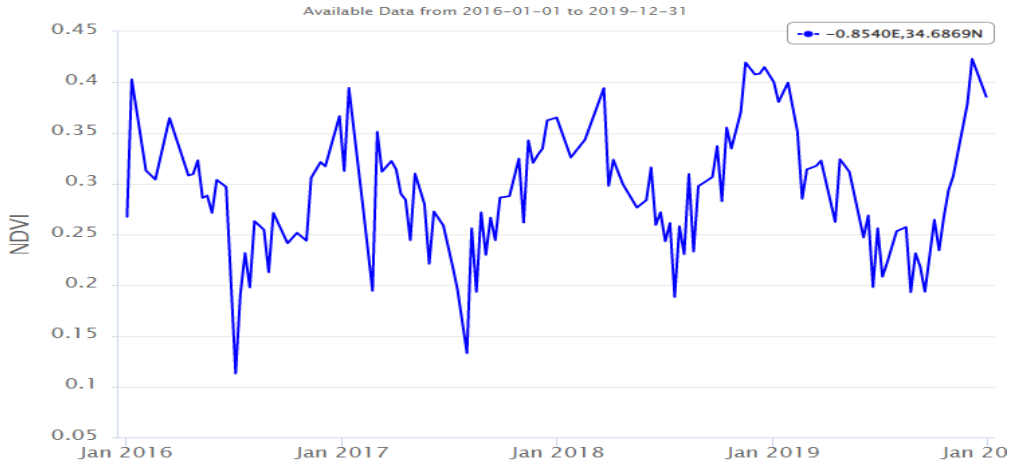

Fig. 11: Monthly and inter-annual NDVI variations in the Mekerra watershed during the period (2012-2022).

According to the results obtained (Fig.11), the NDVI is very low, the most important was detected on March 2, 2021, with an estimated value of 0.43.

10. Normalized Water Difference Index (NDWI):

The normalized difference water index (NDWI) can refer to one of at least two remote sensing indices related to liquid water (Fig. 12).

One is used to monitor changes in leaf water content, using near-infrared (NIR) and shortwave infrared (SWIR) wavelengths, proposed by Gao in 1996.

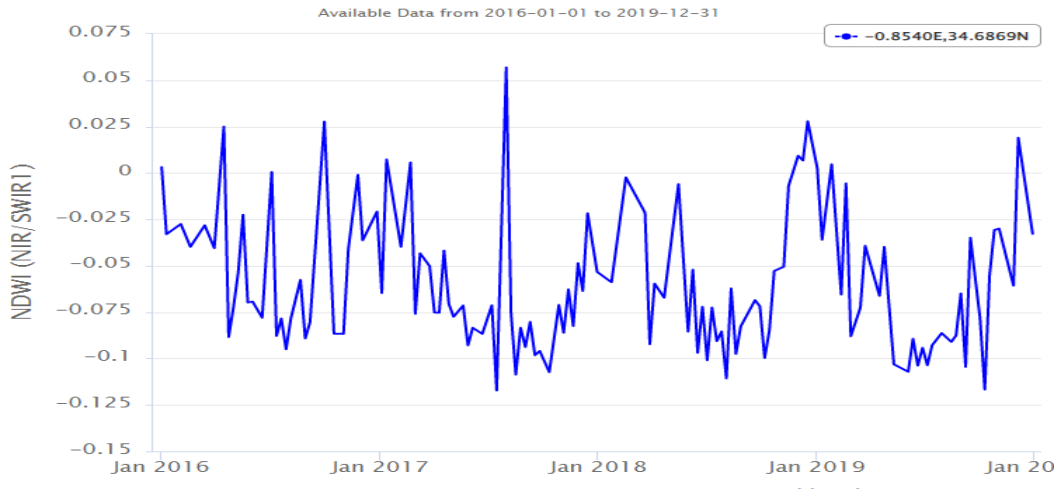

Fig. 12: Monthly and inter-annual NDWI variations in the Mekerra watershed during the period (2012-2022).

Relationship between NDVI and Rainfall:

The relationship between rain-NDVI remains complex (Figs.13 &14). Indeed, the NDVI is affected by a threshold effect, it is sensitive to rainfall when the annual rainfall is between 200 and 1000 mm (Malo and Nicholson 1990 ; Davenport and Nicholson, 1993). In semi-arid environments, the threshold above which NDVI is no longer sensitive to interannual variability in rainfall volumes varies for South Africa between 500 mm (Nicholson and Farrar, 1994) and 600 mm (Fuller and Prince, 1996). The NDVI no longer increases proportionally with rainfall. Conversely, a minimum of 200 mm/year seems to be necessary to induce a sensitivity of NDVI to rainfall (Nicholson *et al.*, 1990). Below this threshold, NDVI is contaminated by bare soil properties.

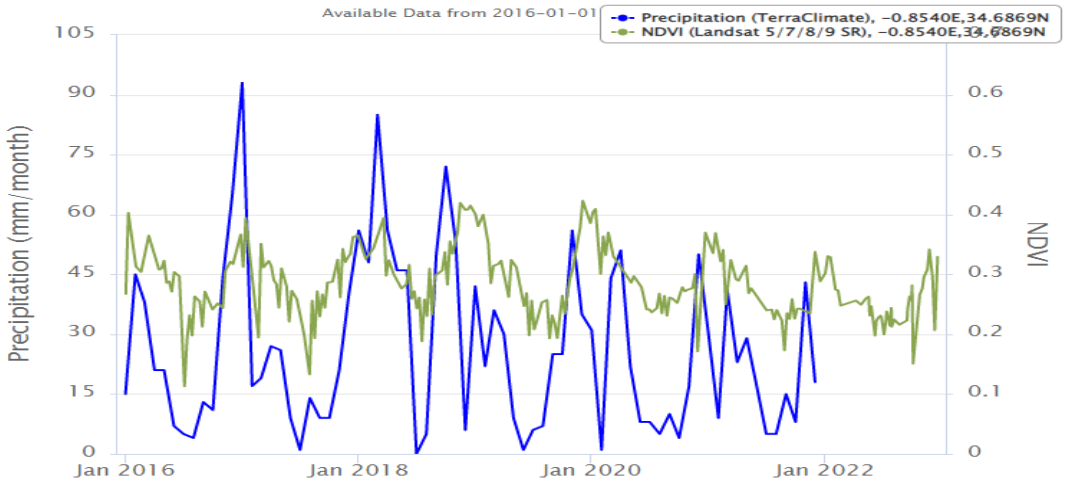

Fig. 13 : Monthly and inter-annual variations of the relationship between NDVI and rainfall in the Mekerra watershed during the period (2012-2022)

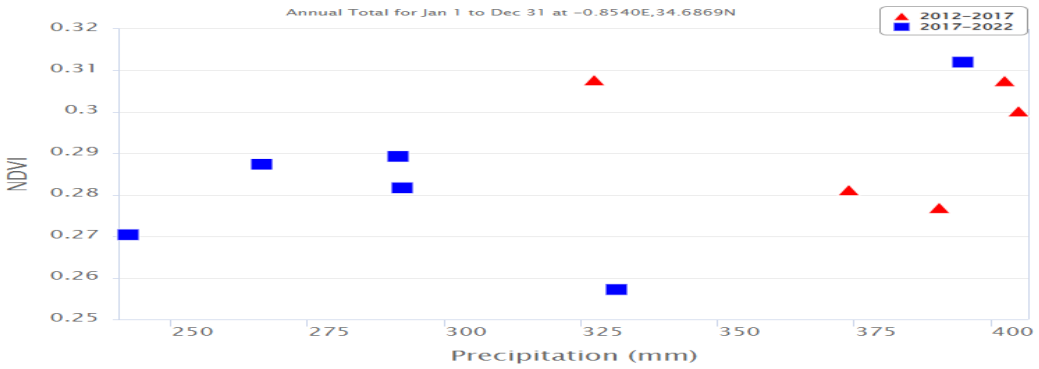

Fig. 14 : Correlation between NDVI and rainfall in the Mekerra watershed during the period (2012-2022)

Relationship between NDVI and Maximum Temperatures (Fig.15) :

During the dry period or the temperatures are very high the plant closes its stomata to avoid leaf loss is very high consequently the activities of photosynthesis decrease.

The Figure 16, summarizes the results obtained.

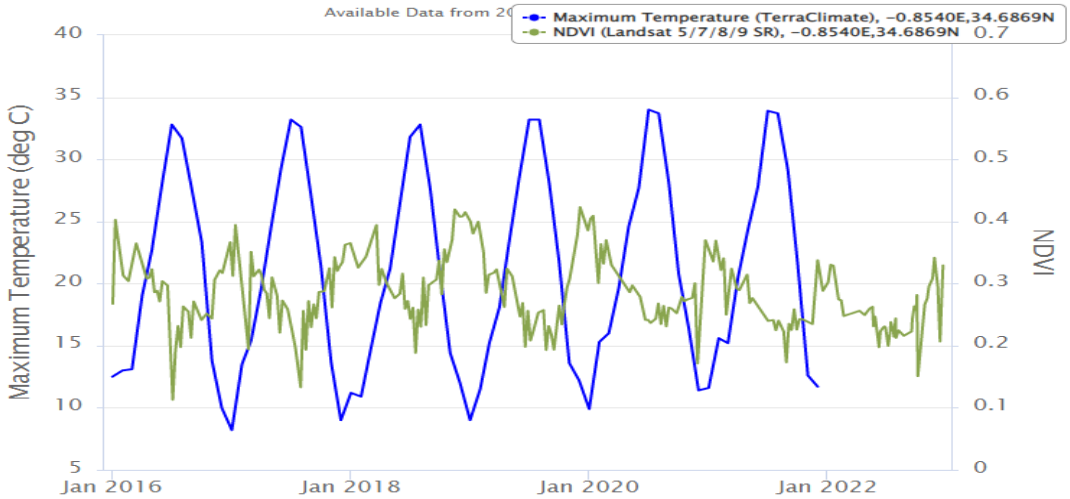

Fig. 15 : Monthly and inter-annual variations between NDVI and maximum temperatures in the Mekerra watershed during the period (2012-2022)

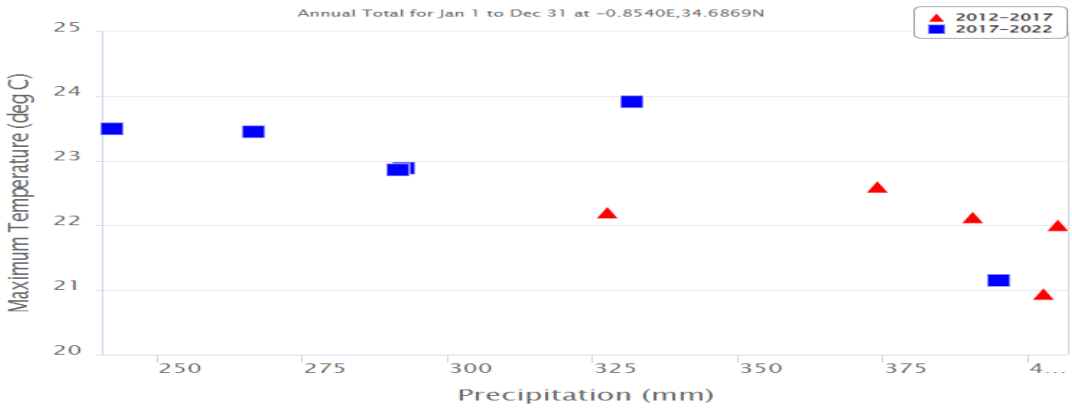

Fig. 16 : Correlation between maximum temperatures and precipitation in the Mekerra watershed during the period (2012-2022).

Relationship between NDWI and Precipitation:

The normalized difference water index (NDWI) is a measure of liquid water molecules in vegetation canopies that interact with incoming solar radiation, specifically designed for the estimation of soil moisture and canopy water content.

The results from the processing of satellite imagery including the relationship between NDWI and precipitation are presented in Figure 17.

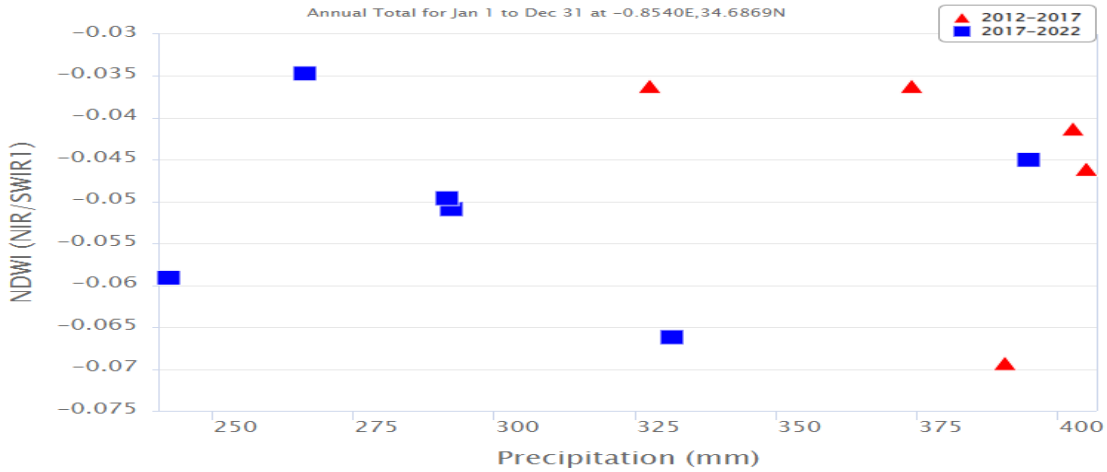

Fig. 17 : Correlation between NDWI and precipitation in the Mekerra watershed during the period (2012-2022)

The reading of the data presented above shows an imbalance between water and vegetation canopies and soil with negative values.

The results (Figs.18 & 19) of the relationship between potential water deficit EDDI and precipitation terminate once the imbalance.

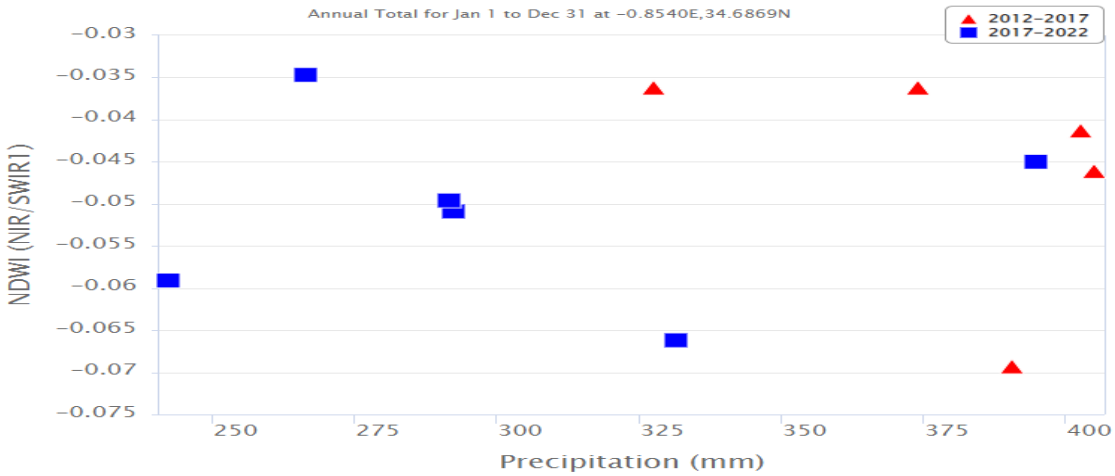

Fig. 18 : Correlation between potential water deficit and rainfall in the Mekerra watershed during the period (2012-2022)

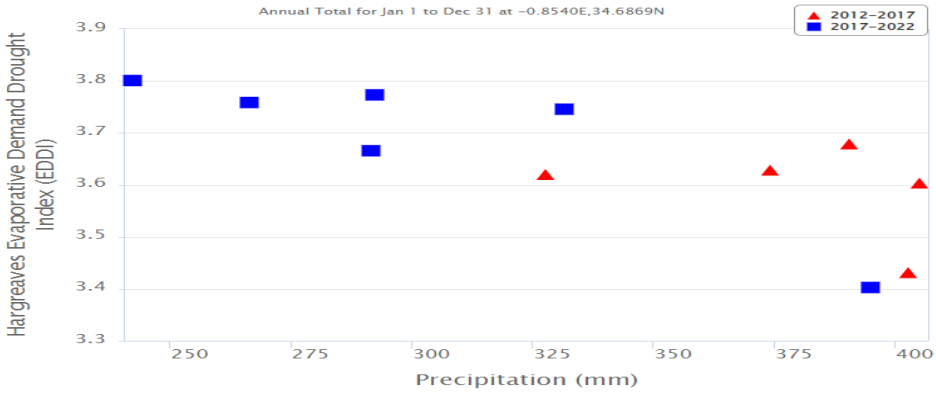

Fig. 19 : Correlation between l'EDDI and rainfall in the Mekerra watershed during the period (2012-2022).

Relationship between Precipitation and the Evaporative Demand Drought Index (EDDI) :

EDDI is a drought index that characterizes abnormal atmospheric evaporative demand over space and time (Hobbins, 2016). EDDI can be applied to monitor agricultural and hydrological droughts. It provides near-real-time information on the persistence of water stress and excess relevance to natural hazard preparedness.

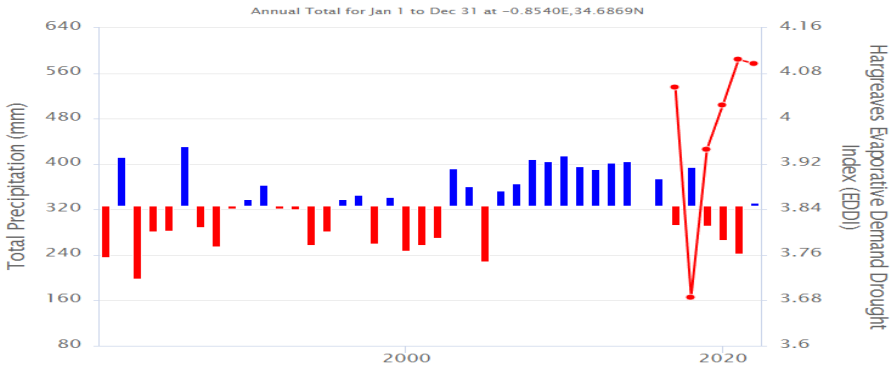

Fig. 20 : Anomalie between potential water deficit EDDI and rainfall in the Mekerra watershed during the period (2012-2022).

From the reading of histograms and graphs of the Relationship between Precipitation and Index (EDDI), we can see that the mekerra watershed suffers from low precipitation combined with abnormal atmospheric evaporative demand.

Conclusion

In Algeria, rainfall is characterized by a very marked spatiotemporal variability. The annual rainfall slice decreases as one moves southward and falls to less than 100 mm south of the Saharan Atlas, this value is usually considered as marking the beginning of the desert. The decrease in rainfall from north to south is superimposed by a decrease from east to west.The climatic results of our Mekerra watershed show a very unstable and irregular hydrometeorological system, a period of prolonged drought, an LST that reaches 54 C°, a medium-low average annual rainfall amount and a rainfall deficit estimated at 30%, a very low NDVI with a maximum value of 0.42 and an NDWI globally negative.

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