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The Phenomenon of Desertification in the Northern Algerian Desert. from Danger to Disaster

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Abstarct

The increased exploration of the underground water and soil in the north east of the Algerian Sahara for the sake of drinking and irrigation has resulted in catastrophic hydro-geological and environmental problems, especially the rise of the level of the superficial layer which affects agriculture and environment .This is mainly a consequence of the mismanagement of the extracted water resources; which has in turn caused bio-climatic and geomorphologic problems, especially in the Oued Souf and Oued Righ region. This phenomenon has escalated, especially after the increase in the land cultivation projects, which were often practiced without prior hydro-cultural analyses as well as a consideration for irrigation water drainage. This has in turn created other problems, such as a significant increase of the amount of salt in soil and which has resulted in the spoiled and desertification of large fertile plots of land. Besides, the aggressive livestock herding causes poor biological renovation of the wild plantation.

In addition, there are some social communities that consume high amounts of water which exceed 500l per day per capita while the sewage system is underdeveloped and could not cope with such high levels of drained water. As a result, water is drained in some traditional wells (septic pits). The poor management of water resources resulted in disastrous outcomes which consisted mainly in the rise of the free level of the phreatic water and saltiness which affect agriculture and infrastructure. Therefore, this paper aims at shedding more lights on the desertification and degradation of the environment as well as compile additional scientific proofs for the research deals primarily with the results of the human interference in the environment.

In order to lessen such catastrophic results, a reasonable management of underground water resources is inevitable, especially in regions supplied with such a strategic resource, for a sustainable development. In that the escalating mismanagement of our water resources, with no planning and policy, would lead to disastrous outcomes. A continued disrespect of this precious resource means an unwise consideration of the fate of the future generations. Therefore, directory plans for the arrangement and management of the soil and water resources, in terms of hydro-agricultural capacities, should be put in place. In addition, regular measuring of the piezometric levels of different underground napes exploited should be recorded. The technical outline of research in the hydro-agricultural and urban arrangement fields should be identified before hand. That would improve the management of soil and water resources as well as stimulate search for irrigation systems suitable for the climate conditions of the region.

Key words: Lower Sahara - environment - salinity - irrigation - desertification.

INTRODUCTION

Dawn in history, so many well-known civilizations existed respectively on the two edges (sides) of the lower Sahara Rivers: Oued Souf and Oued Righ. In fact, they do not currently represent rivers by their geomorphological conception; but they are rather names of geographic regions. Nevertheless, one could not deny the fact that they are inherited rivers; in that the region has seen very rainy periods, especially during Pleistocene 4th geological age. Oued Righ for example, is generally situated in a lower region; its peak is 103 m high, it is located in the south (Goug) .The river flows towards the north and falls in Oued Khrouf which is 130 km far from. The latter flows and falls in the lake of Marouan and from there in the lake of Malghrigh.

It is important to mention that the basis of the ancient civilizations used to be the use of traditional irrigation means in hard and draughty environmental circumstances despite the fragile environmental system. Mankind was able to keep balance in nature with his interference, by using only the superficial layer which is found at a maximum depth of 60m.

Thus the water extracted from the layer used in agriculture and other human uses is turned back to the same superficial layer diminishing the amount of consumed or vaporized water. The last century has seen an increase in digging and drilling for water wells in different deep layers, in addition to the overexploitation of the under water in unprecedented ways. For instance, in 1956 the number did not exceed 300 wells. However, it has jumped to 1,033 in 1922 for the irrigation of 300,000 and 600,000 palm trees in the region of Oued Reigh. These new drilling operations and that huge number contributed to the drought of the superficial layer. This phenomenon simply expresses the degradation of the region from Sidi Rached until Ghuemra Oases. The region's superficial layer has been greatly degraded which has affected the neighbouring Oases like Tamarna region.

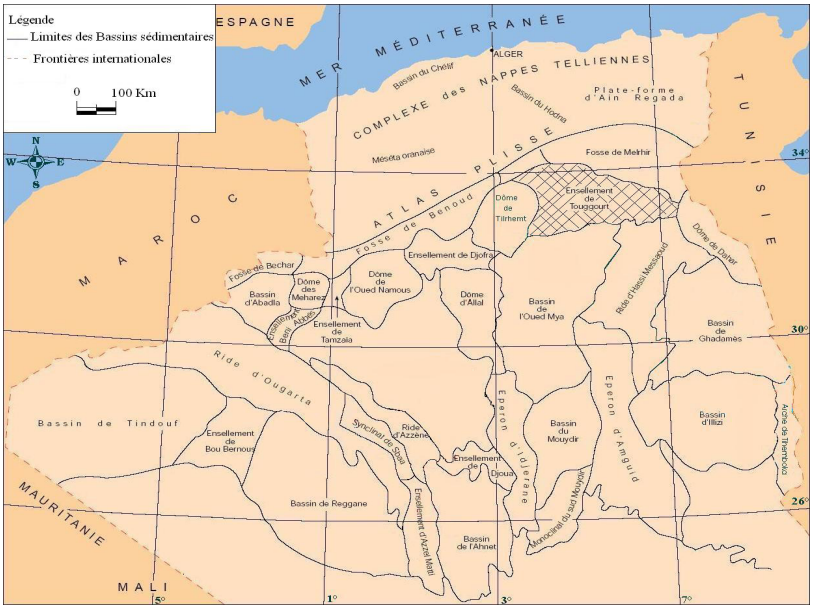
The different types of the human activities do not affect greatly the rich environment where the rich land and the biological variety help in the innovation process, whereas the human interference could lead to catastrophes in droughty regions such as the region under study here. The final consequence of the human interference is the spending of large sums of money in what is called the cultivation and urbanization of the region and their subsequent negative results.

In this lecture, it is necessary to have a geographical overview of the region before listing the most important example that explains this problem.

Location of the Region

The region is astronomically and geographically situated between Eastern longitudes 4°-8° and Northern latitudes 32°-34°. (See map No.01).

The region is bounded by the Aures Series Mountains from the North, the Great Erg from the East, the hill of Tadmate from the South, and the heights (platform) of M'zab from the West. As the region is divided geographically into Oued souf and Righ, it is also divided administratively between Ouargla and Oued Souf (see Map N 02).



Map 1. Geographic location

The geographical study location of the region has great importance because of its direct impact on the climate of the region in addition to other factors such as topography and hydrology, etc.

The paper does not allow here to elaborate on the above points; therefore, focus will be here on the degradation and desertification of the region. In fact, the causes of desertification are classified into natural and human.

METHODOLOGY

In this study, we depend on the inductive method; the project is therefore divided into three steps: First step is the Documentary Phase in which we determine the study field physically and the notions that are linked to the project through studies, reports, maps and aerial photos that have been done on the region. In the second step all of the statistics linked to the project from different technical and academic services are gathered and in the third step all the information

gathered above in addition to the field work, where measures taken which help in counting the speed of desertification and observing the symptoms of the physical field degradation, are analysed.

The Natural Causes

The natural causes can be summarized in the different drought figures which characterized the region in the Holocene period, especially before 5,000 to 6,000 years. So let's have a look on the climate of the region. (See the pictures n°01&02)

Pictures (1,2). Inherited aspects of Sahara (Region of Touggourt)

The interaction of the climate elements is clearly seen in the lower Sahara; each element is linked to the other either physically or by affecting the physical medium. The climate characteristics especially the high temperature, humidity deficiency, and high evaporation of precipitation (rainfall) affect the plants' need for water. This is of course followed by the extent to which the plants are affected by the additional salt concentration in the soil water due to increasing evaporation rates. Consequently, and over time, the plants' absorption to salt increases and its productivity decreases and hence the amount of money spent exceeds production .We therefore come to the conclusion that hydraulic systems and their relation with the climate is important.

In order to obtain an objective idea about the climate of the region we have chosen the climatic dada provided for long periods, beginning with Seltzer data from 1913 to 1938 and Gean Dupief data from 1926 to1956, in addition to the meteological station data in Gamar and Sidi Mehdi from 1970 to 2004 .

Generally, the region is characterized by yearly average temperature of 22°whereas the precipitation (rainfall) average is less than 100m.

The evaporation is directly affected by the high temperature and relative humidity (see the table01).

Table 1. Monthly Evaporation average in mm during the period from 1980 until 2002 in both sidi- mahdi & gmar stations

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Evaporation average in (Souf)	218.05	148.74	99.68	77.57	82.87	95.8	128.28	191.33	247.75	281.09	305.79	281.23	2158.8
Evaporation average in (Righ)	297.43	209.61	134.87	116.4	112.4	146.22	227.13	282.13	357.3	417.1	440.95	407.82	3149.16

***Source*: Gmar & sidi-Mahdi Meteorological Stations 2003**

Examining the data in the table above gives the initial perception that there has been a huge amount of water evaporation in the air as measured at the meteorological station. However, in reality this amount doesn't exist in the Sahara environment so that it could vaporise simply because the perception is deficient, thus I count the real ETR evapo-transpiration by Turc equation (see table No. 02).

Table 2. ETR Values during the period from 1970 until 2002

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
ETR(Souf	5.06	7.38	10.22	7.45	12.75	8.54	9.70	6.75	5.37	1.79	5.27	1.05	81.36
ETR(Righ	4.41	5.07	8.74	6.24	10.41	9.91	9.21	6.14	4.78	1.88	0.61	0.86	65.26

Source: counted by the researcher according to TURC's equation.

in support of these data. We calculate the dehydration index for Demarton. Which depends on the data of precipitation and temperature. These data are taken from the climatic station El-Wad. And calculated according to Table No. 03. This is in the period between 1985 and 2020

Table 3. Demartonne Aridity Index from 1985until 2020

Month	S	O	N	D	J	F	M	A	M	J	JL	A
P mm	5.4	4.93	9.27	6.04	15.02	5.98	10.64	6.05	4.74	1.16	1.05	1.61
Tc°	28.86	22.21	15.49	11.22	10.16	12.74	16.11	20.25	25.47	30.78	33.27	32.93
I = p/t+10	0.16	0.15	0.37	0.3	0.75	0.24	0.43	0.18	0.13	0.003	0.002	0.03

Source: Oued Sauf Meteorological Station 2020

By comparing the calculated monthly values. Based on Demarton's law. We find that the values of the dryness index range between 0.02 and 0.75, which means that the area is very dry. This is due to natural causes. The same analysis applies to the northern desert. But in varying proportions. If we move from the northeast of the desert to the northwest of the desert, we find the same observations, see Table No. 04.

Table 4. Hydrological balance of the Bechar station (1985-2006)

Parameters (mm)	P	ETP	ETR	R
Béchar 1985 -2006	76.97	1223.79	76.92	0.1015

Source: Kabour A.1, Hani A.[2], Mekkaoui A.1, Chebbah L.1 2011

Whereas: P = ETR + I + R

With: P: The average annual water depth (mm)

ETR: Average annual real Evapo-transpiration (mm)

R: Average annual runoff (mm).

I: Average annual infiltration (mm).

The result, then, by processing the climatic data, especially the precipitation and temperature factors, shows us the continuous state of drought throughout the year, and this is what allows another climatic factor to dominate, and it is related to the wind factor, especially in light of the topographic monotony that characterizes the region.

Winds

Winds play an important geomorphological role particularly in the droughty, semi-droughty and coastal region. In fact, the principle morphological features in the region that are constituted by winds reflect clearly its characteristics in direction, speed and frequency. Therefore, the study of the forms resulting from winds and air operations becomes more important by repeated measuring of the winds speed, frequency and directions. Generally, the frequency speed in the region is slow, but it is more effective in April and July when the winds become stormy, especially in the East and Southeast (see the table N°:03**)**

Table 5. The average speed of winds in m/s during the period from 1980 until 2002 in both sidi- mahdi & gmar stations

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug
Sidi Mehdi . Station	2.71	2.65	2.73	3.83	2.56	2.73	2.26	3.93	4.61	3.66	3.26	2.93
Gmar Station	3.04	2.53	2.50	2.40	2.82	3.14	3.65	4.38	4.66	4.77	3.83	3.38

Source: Gmar & sidi-Mahdi Meteorological Stations 2003

The above table confirms and demonstrates what has already been explained. It is clear that wind speed in El-Oued is faster than in Oued Reigh .It is between 4.38 and 3.83 m/s in April and July, the season of the strong winds. In Oued Reigh, the average of the winds in April is between 3.93m/s and 3.26m/s in July.

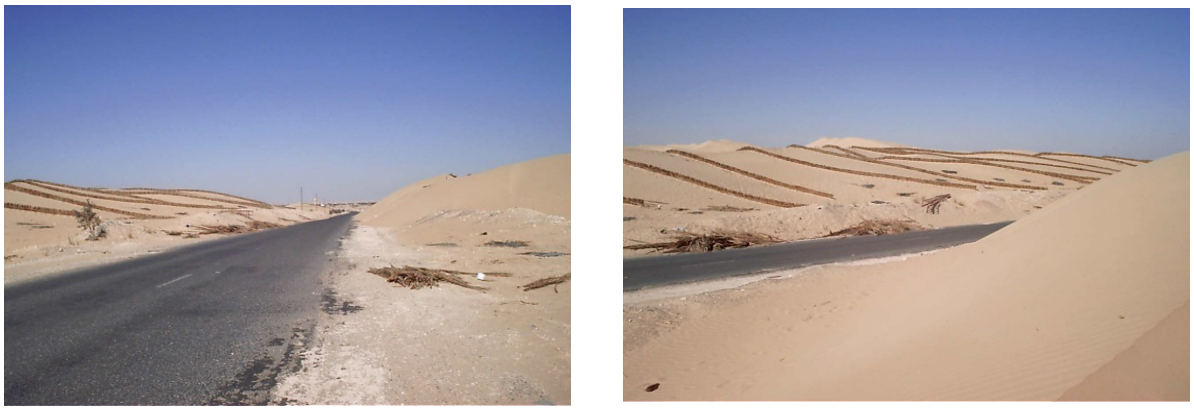
In general, the winds frequency in Oued Sauf blow from East and North –East, which are the dominant winds, as well as the seasonable southern winds, called locally the Shelly winds, which blow at a frequency of between 4.54m/s and 2m/s. (see the table N°:04**)**:

Table 6. The annual average of winds days according to their directions , during the period from 1980 until 1999 in Gmar station

Direction	North	NE	E	SE	S	SW	W	NW
Days number	40	45	75	35	13	40	23	43

***Source*:** Gamar Meteorological Station 2002

The study of the winds in the region is important because of the vulnerability of the region, especially in the movable sand regions. The winds displace the sand from place to another which leads to the covering and desertification of the agricultural fields .It also covers the buildings and roads after every strong wind causing the isolation of the region for many days. These catastrophes inspire people to install obstacles and barriers in an effort to break the movement of the sand (see the pictures N°: 3&4)



Photos (3,4). barriers for breaking sand movement (Region of EL Rebbah)

The Human Causes

The human causes of degradation and desertification of the physical medium can be summarised in the human interferences either in agriculture, industry or services, which do not respect the environmental balances, especially in the vulnerable regions. The human impact is clearly seen in the services factor by establishing different infrastructures (roads, railways, gas pipelines, etc.), in addition to tourism activities. These activities transform the stable sandy dunes into movable sands in case of blowing winds. In this paper, I will focus on human interferences through pasturage and water extraction.

The Hydro-Geological Features of the Region

Hydro-geologically, the region is well known thanks to the studies carried out. In addition to that, many drilling operations were performed either by Hydro-Directory, Hydro-Drilling or Sonatrach (national oil company)

Generally, the lower Sahara region is situated in a big sedimentary basin which constitutes a vast hydrological basin too; its surface covers 780,000 Km^2, its thickness is between 4,000 and 6,000m according to the UNESCO study. Therefore, it assimilates one of the biggest underground water resources in the world. The basin stretches to 700,000 km^2 in Algeria and 800,000km^2 in Tunisia. The basin's layers appear at the Atlas saharian series in the North. These boundaries are characterized by so many faults, whereas from the west, we find El Hadjri line and Ouad Essaoura, Tadmait which stretches towards the East-West from the south, the region of Kabiss and cretacy elevations in the mountain of El Dahir from the North East of the basin, and the political boundaries from the East, (see fig. 1).

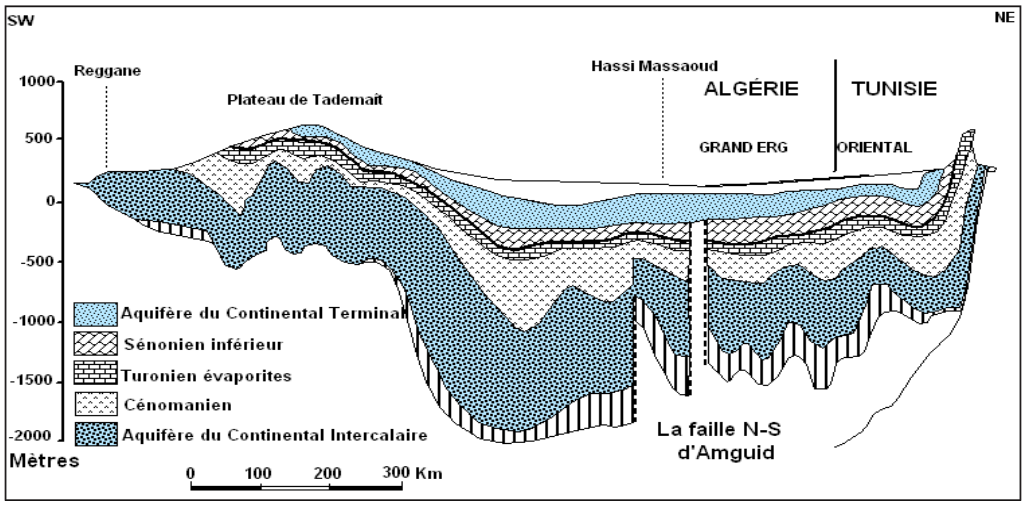


Figure 1. Hydro geological section towards NW /NE**.** ***Source: UNESCO 1972***

The problem lies in the fact that the extracted water exceeds the average of the water layer nutrition. Generally, in this vast basin we can distinguish two aquifers which are characterized by their independent hydrodynamic conditions.

The Aquifer Continental Intercalary System

It is the biggest water layer in the lower Sahara. Generally, the basin is situated in continental constitutions of the inferior caritas. It is formed of stone, clay, and grain, its depth changes from region to another. For instance, in Ouargla, it is 1,058m deep, in Djamma, 1,515m, and in Blidet Amor 1,650m. It seems that the aquifer depth decreases whenever we come close to the resonators that are characterized by hot water.

In general, water in continental constitutions is hot. It is over 60 c° alpine and Barmian layer.It is also lowly salt reaching 2-4g/l, therefore, it is different from the terminal complexion (aquifer).This aquifer covers a vast surface of about 850,000 km^2. It is characterized by three partial layers: Synonion / charbonic Iosan and Miupiusan . It is relatively highly salted. It is about 70-280m deep. The flow is approximately 30l/s (see the pictures n°05& 06).

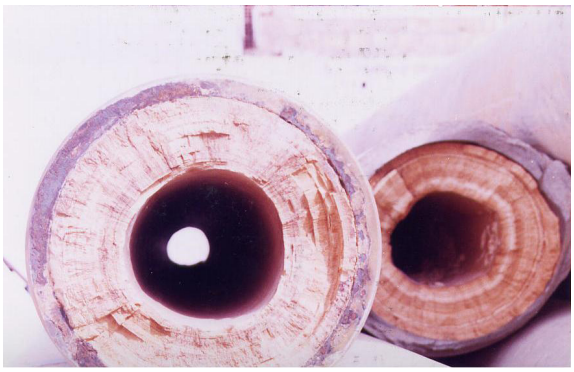
Pictures (5,6). Water pressure in Continental Intercalary & Terminal complexion

Quality of Water and its Effects on Desertification

The study of water quality becomes so important according to its direct impact in changing the irrigated lands into desert ones, owing to the accumulation of salt melted in this water, particularly in the hard climatic conditions, high temperature and evaporation. In addition to the geomorphologic cause, there are hydrological, Topographical and human causes. It has been confirmed that the region's sole contains very concentrated salt. This is clearly seen in the existence of superficial salty crust which differs in its components and appearance according to the dominant type of salt in the soil, amount of the organic substance and the soil humidity degree. The humid dark crust reveals that chloride, calcium and magnesium chloride are tense in the soil; Whereas, on the surface a soled crust is formed with the existence of gypsum, and the concentrated salt of $NaSo_4$ with (plaster) and CACOs give a soft powder crust on the surface of the soil. (See the pictures n°07 & 08).


Pictures (7,8). Salts sedimentation near Sebkhas due to evaporation

The most sediment salts are: $CaCo_3$ at 88,75 %, CaSo4 at 3,25 % and $MgSo_4$ at 6,05% One of the causes of salt accumulation in the soil is the water extracted from the aquifer continental intercalary system and complex terminal. In fact, this extracted water does not affect negatively only on the soil, but also the hydraulic infrastructure; by diminishing its prospective age. Some of the melted salts in the extracted water sediment in these infrastructures. (See the pictures below) .

Pictures (9,10,11,12). Salts sedimentation causes the degradation of hydraulic constructions

In fact, these salts result from the rocky composition of the aquifers .This can be seen by examining the stratigraphic unit.

The extraction of large amounts of water by mankind is the only cause of desertification but also aggressive pasturage in the region.

Pasturage as a Cause for Desertification

In fact, pasturage is one old function in the region, in that the region used to enjoy a rich biological variety so better than today's. The existence of a zoo in the region, full of different kinds of animals like deer and rabbits supports this opinion. However, many of these animals have are being threatened by extinction because of the man's interference either by hunting or pasturing, in that pasturing by the region's Bedouins camels and livestock strained the pastures for which other wild animals had to compete for surviving. (See the pictures)

Pictures (13,14,15,16). Pasturing humans contribute also in Desertification **:**

The Animal Resources in the Region:

Grazing is considered one of the most important jobs in the region in addition to agriculture. It can be divided into two kinds:

1) It depends on stall feed is brought to their stables.

2) It depends on pasturage in open fields .It includes cattle, goats, camels and cows.

A) goats are the most numerous in the region of Oued Reigh .There are about 98,815 heads, they are over 52.03% of the total livestock .The great percentage of it is in Jaama with 22.60% .The remaining is divided between Temacine,Touggort and Maggar. In Oued Souf the number of goats is higher, it is over 183,620 heads.

B) Sheep is second in number after goats with 80,328 heads and percentage of 64.54%; they concentrate in the north of the region because of the green fields for pasturage. The largest number of these sheep is in Oued Souf; it has over than 90,256 heads, whereas Touggourt has a lesser number with 7,255 heads. Generally, Oued Souf is more pastoral than Oued Reigh.

C) Camels : Ever since, camels have been linked to the region although their number is fewer than goats and sheep .There are around 6,213 heads with a percentage of 1.38% and 2,307 heads in Oued Souf . Oued Souf has a lesser number because of its worse pasturages. Generally, pasturages are poor in both regions because of the extensive exploitation either by man or animals.

D) Cows: Cows are new in the region and so are their pasturages. As a result, their number is still low. Moreover, the cows' hay is too expensive.

There is still another problem in the region which is the existence of huge numbers of livestock which invade the region's pasturages during fertile seasons.

CONCLUSION

hroughout this paper; the aim has been to summarize the natural and human causes of desertification in the region of the lower Sahara. In order to mitigate the disastrous consequences of the desertification phenomenon the following recommendations should be taken: First, launching an awareness-raising campaign explaining to the public policy administration as well as the region's inhabitants the vulnerability of their environment, so as to modify their style of interference. Second, rationalize water consumption for irrigation by observing the hydro-agricultural standards,

especially in soil salt cleaning and drainage, irrigation dose, irrigation techniques, as well as irrigation frequency. Third, building depuration stations for sewage water. Forth, periodic measuring of saltiness levels by physio-chemical analysis of soil. Fifth, regulating pasturage by protecting the natural biological renewal of the vegetation. Finally, using remote sensing technology in monitoring the most vulnerable regions to desertification and in updating the maps.

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