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Assessing Aeolian Sand Potential in Ain Sefra Region - South-western of Algeria

Bouarfa Said, Youb Okkacha, Khaouani B, Berrabah D, Djoudi W

Centre of Scientific and Technical Research on Arid Regions (CRSTRA), Campus Universities BP n° 1682 RP 07000 Tel/Fax: 033 52 20 90&52 20 92, Biskra Algeria

said_bouarfa_07@hotmail.com

Abstract. Ain Sefra is a semi-arid area located in south-western Algeria carried out by sand barring, which has made any development in the area impossible. Thus, to understand this phenomenon, it is useful to estimate the displacement of the quantity of sand and the directions of the effective winds during 30 years (1985-2015) to quantify the phenomenon of silting and categorize the danger. Using the method of Fryberger, anemometric (wind) data from meteorological stations were analyzed to examine the potential for sand drift potential (DP) at Ain Sefra between 1985 and 2015. The objective is to identify the hazard level by estimating the sand displacement and effective wind directions over 30 years (1985-2015). The resulting (potential displacement) DP and directional wind variability are estimated and discussed. The average annual sand DP is expected to be 222VU (vector units). These figures have led to the classification of the Ain Sefra location as a wind environment with intermediate energy levels (medium energy wind environment) (Fryberger and Dean 1979). It is determined that the drift potential is 76 with a migration coefficient of 0.3 and that the area has a medium classification. It is also shown that the complex system of wind erosion and its interrelationship with other components are in play. The sand drift potential environment varies greatly from location to location, and 80% of the resulting annual PDR occurs during the fall season from March to June. In addition, effective winds often blow from the southwest to the northeast at an angle of 234°. In addition, the sand can be in different directions, leading it to drift. We should also mention that the directional variability is also quite high.

Keywords. semi-arid area ; Aeolian Sand ; development ; wind ; sand

1. Introduction

Ain Sefra is located in the Ksour (southwestern Algeria). It is considered one of the most vulnerable regions in Algeria, as it is at risk of being invaded by sand. Located in the Saharan zone, it benefits from a continental climate due to its location. Cold winters bring temperatures up to the arid bioclimatic stage in the north, while temperate winters bring temperatures down to the arid bioclimatic stage in the south. In the lows, it is at a lower altitude of 1100 m, but in the sums, it is at a higher altitude of 2200 m. The amount of rain that falls in the Ksour summits is minimal, rarely exceeding 200 mm per year (BOUARFA 2012). The average annual temperature is close to 2°C, and the average maximum temperature in July is about 37°C. This region is plagued by a significant sandbagging problem, which is especially accentuated during the dry seasons and is further aggravated by human actions to survive (overgrazing, harvesting steppe plants for firewood, etc.).

The Ain Sefra region adds originality to an otherwise monotonous landscape with its diversity of dune forms. Its geographical location, at the meeting point of two different climatic zones and topographic obstacles at the confluence of the Ksour Mountains, explains in large part why this area is so unique [1]. The outcrops, which are predominantly Jurassic in age, form long, narrow anticlinal structures divided by huge synclines, and where Lower Cretaceous sandy outcrops represent the main hydrogeological systems [1]. A geological structure with fragile and erosion-sensitive surface formations, combined with climatic effects and the absence of perennial cover, has resulted in a poor-quality soil for agriculture and steppe vegetation, subject to the perverse effects of climate and overgrazing, resulting in a poor-quality soil for agriculture and steppe vegetation, subject to the perverse effects of climate and overgrazing. The area is shrinking due to erosion and desertification.Arid to the semi-arid climate of the continent, characterized by minimum rainfall of less than 200 mm per year and large seasonal and annual variations, which have been exacerbated in recent decades by climate change. Soils in the high plains region are shallow and have low fertility, with a material concentration of organic matter that does not exceed 3% [2]. Wind remains the main factor in modeling the landforms. To understand the different dune shapes, it is important to conduct a thorough investigation in the areas of Ain Sefra and bring them in contact with the typical winds of the region.

The rapid and severe degradation of the vegetation cover allows the wind to carry the sand-laden material easily. Subsequently, the transported materials are stored in other areas, resulting in the construction of various sand and hill accumulations and the initiation of desertification processes in various locations [3]

Wind regimes, including frequency, magnitude, and direction, are important factors in the formation, migration, and accumulation of dunes in areas with frequent wind events in different directions [4]. Classification of dunes is based on three factors in most cases: the shape of the dunes, the prevailing wind regime, and the amount of energy the wind carries [5]. The ability of the dunes to move [6]. Specifically, anemometric records made at the National Meteorological Office in Ain Sefra between 1985 and 2015 will be used for this purpose.

In this work, we are particularly interested in the impacts of winds on sand displacement and dune modeling in the region; however, it is important to distinguish between “wind regime” and “potential sand displacement” to make this distinction. From 1985 to 2015, AIN SEFRA was observed from 16 directions and 8 observation records per day for a total of 30 years. These data were analyzed to estimate the amount of sand moved and to evaluate the silting phenomena, and the results were published. Sand transport velocity is extremely difficult to measure accurately, and many possible expressions were twisted to fit the experimental data. These expressions have been twisted to fit various environmental theories [7].

Several authors have proposed and explored alternative assessments based on the wind in sand or the possibility of sand transport over the past two and a half decades, including [8]. These analytical methods, such as Fryberger’s (1979) Press method, have been most widely accepted and used in dry conditions worldwide. Fryberger’s approach, which is a modification of the Lettau (1978) equation, is designed to provide a relative rather than an absolute indication of the effect of wind strength on the sand drift.

When examining potential sand drift, wind strength is an important component to consider. For example, the indicators created by Lancaster (1988) and Bullard and colleagues (1996) to measure status activity in the Kalahari Dune both depend on wind strength. The

Fryberger method is a good tool for evaluating these issues and recommending sand control measures in various applications. The shape and behavior of dunes in desert environments are influenced by wind patterns and particle size, among other considerations [4]. This paper aims to evaluate the role played by the wind regimes observed at this meteorological station in determining the potential drift of sand in the area of Ain Sefra.[9]

2. Materials and methods

2.1 The study area

The area of is located between latitudes 33° 9’54.09 “N and 32°42’57.58 “N and longitudes 0°13’22.24 “w and 0°57’20.48 “w, Ain Sefra is a mountainous massif in Algeria that is part of the Ksour Mountains and constitutes the western half of the Algerian Atlas chain. The Ksour Mountains have robust reliefs that cross the Oran lowlands immediately by more attenuated reliefs by the Tops, which have an altitude of about 1200 m and fall consistently to the depression of the chotts on the southern side of the mountains. The transition between the flat and Saharan forms is violent, and the difference in altitude can easily reach more than 1200 meters. The study area is bounded on the north by the chotts Ech-chergui and el Gharbi, and south by the northern foothills of the Saharan Atlas, the northern foothills serving as a natural boundary (Fig. 1).

The watershed of Oued (valley) AIN SEFRA is formed by two valleys, Tirkounte and Breidj, which are both located in the basin of AIN SEFRA. Ain Sefra is located in the southwest of Algeria, near the western border. It belongs to the arid bioclimatic stage with cool winters, with rainfall rarely exceeding 200 mm per year. The two wadis (valleys) that cross the city of Ain Sefra meet to form the AIN SEFRA valley, which is located in the center of the urban fabric. Further downstream is the El Rghouiba ravine, which forms the upper part of the main Saharan basin of Namous, which discharges its waters into the large basin of AIN SEFRA.

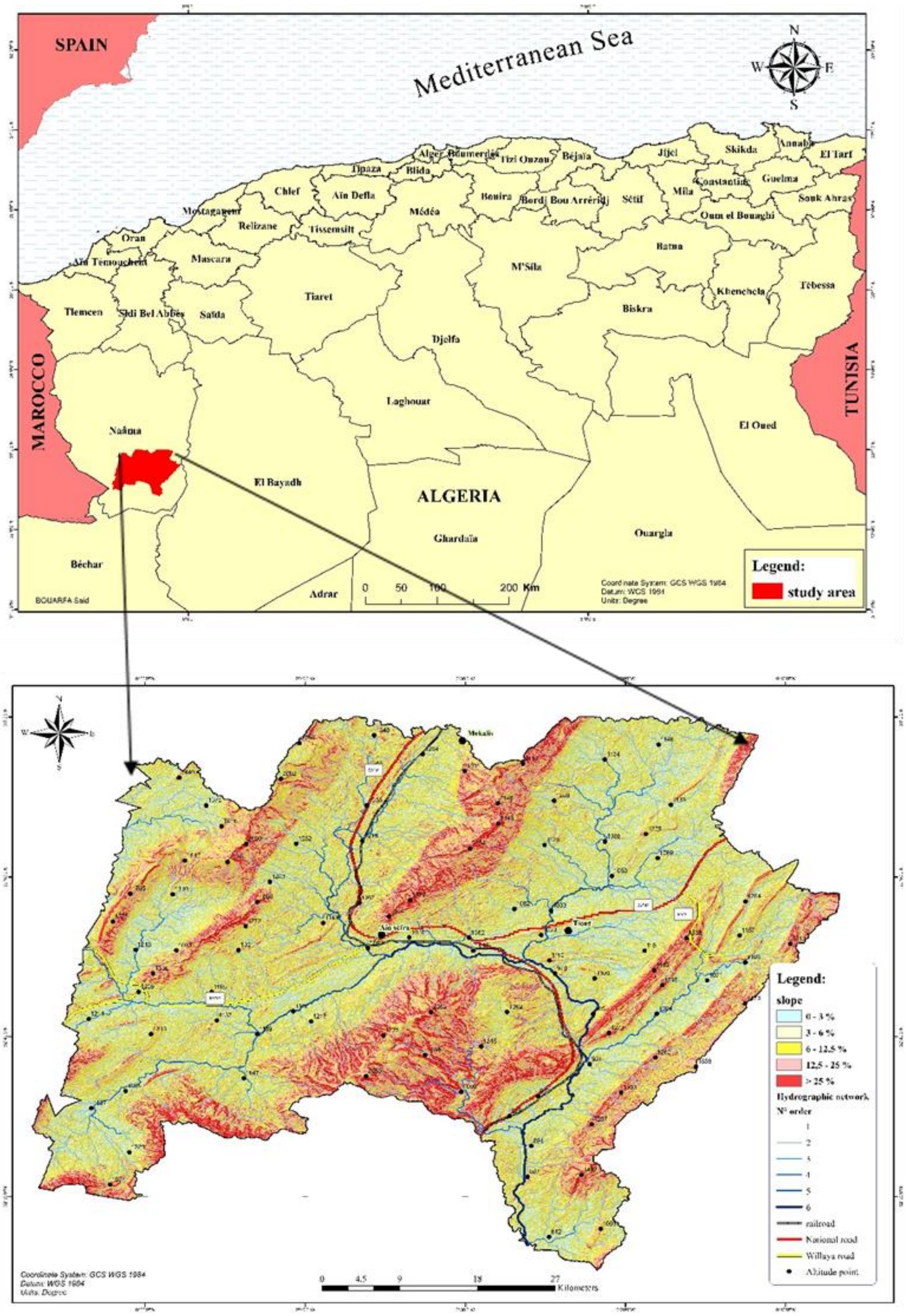


Fig. 01: Location map of the study area and reliefs: The depressions and plains have a gentle slope,

The mountains and highlands have a slope of medium to high.(The slope ratio between (0-3%) is estimated at about 12,2%;(3-6%) is 24,4%; (6-12,5%) is 34,5% ;(12,5-25%) is 21% and the >25% is estimated by 7%.

2.2 Wind data and analysis method

Data from stations in the Ain Sefra region were collected for 30 years. The data were collected from 1985 to 2015. Callot (1987) chose a wind speed higher than 4 m/s for the study to be able to monitor the wind speed in 16 directions for 8 recordings per day (00, 03, 06, 09, 12, 15, 18, 21 h), the study of the wind efficiency rate (the ability of the wind to detach and carry an item of sand). The study of wind speed in 16 directions was required in Ain Sefra, and we distributed the observations from 1985 to 2015, the observations being grouped into speed classes as follows: light wind speed class, effective wind, and strong wind (Figure 1).

2.3 Data analysis

Laboratory measurements of wind speed revealed that wind speed varies between 14.4 km/h and 23.4 km/h, depending on the characteristics of the environment considered [10]. The granulometric analysis revealed that the average diameter of sand in the region of Ain Sefra is between 0.20 and 0.25 mm, according to the graph of Bagnold (1941), which provides a theoretical higher speed of 25 cm/s at ground level, that is to say, 5 m/s at 10 m height for 0.20 mm and 6 m/s for 0.25 mm at ground level. We assume that 6m/s is the minimum pull-out velocity (which can move the grains from the sands), also known as the threshold velocity (Vt). The software of Chopy (1987) programmed according to a formula of Lettau (1967) facilitated by Fryberger (1979) is written as follows:

q = V* 2 (V* - V t) q = V* 2 (V* - V t) c''. s / g.... c'' (1)

where, q is the amount of sand transported, V* is the wind speed, VT is the threshold speed (minimum sand extraction speed), S represents the air density, and g represents gravity. The constancy can be defined as follows: empirical constancy is based on the shape of the particles. Alternatively, C" = C' (£ / £ *) n, where, C' is the universal constancy of sand (= 6'7); $ is the diameter of the transported sand particles; £* is the standard diameter of 0.25 mm, and N is the empirical constancy of sand. Fryberger reduced this equation to the following:

q=V 2 (V - V t)... (2)

In addition, Q is the required amount of sand drift expressed in vector units (UV). V is the average wind speed at 10 m height for time t, Vt is the threshold wind speed at 10 m height for time t, and Vt is the threshold wind speed at 10m height, called V t in the equation. The time period during which the wind blew, shown as a percentage in a wind summary, is given by Eq. (1), and t is the time that the wind blew, expressed as a percentage in a wind summary.

Fryberger (1979) estimated these DPS in m3/m/year or kg/m/year by using equations allowing the correlation between the transport capacity and the volume of sand moved: it is necessary to go from a theoretical operation to an estimate in volume or in mass of the material transported through a given section and during a given time. The equivalent in m3/m/year of a (DP) in "vector unit" varies according to the quantification equation and the values of the parameters used (roughness coefficient, etc.). But this equivalent is always proportional to the DP. A mass (m) of sand occupies a volume in a beaker and using a test tube, we saturate the sand with water by adding a volume (V), adding this water until it is flush with the surface of the sediment [11].Thus the DPS in volume (q) can be converted to (DPS) in mass (Q") in kg/m). Q' = 0.0692 q is the quantity of sand transported in m3/m/year. Q" = 1670 Q' is the quantity of sand transported in kg/m/year. From this correlation, a temporo-patial comparison in directions and intensities is made possible. We can calculate the quantity of sand transported for each speed and direction of the surveys. The coefficient for a given direction results from the product between the frequency of observation (f) of each speed greater than the pullout speed and the displacement potential (DPS) obtained by formula (2). In order to make the use of this coefficient more practical, it is necessary to divide the coefficient by 100 but also to divide it by 12.5 [12], in order to make it compatible with the speeds expressed in m/s.

Velocity category (Km/h)	Velocity category (knots)	Mean velocity of winds in category V	V^2	(V-vt) 1.5	Weighting factor V^2 (v-vt)/100
20-30	11–16	13.5	182.3	1.5	2.7
31-39	17–21	19.0	361.0	7.0	25.3
40-50	22–27	24.5	600.3	12.5	75.0
52-61	28–33	30.5	930.3	18.5	172.1
63-74	34–40	37.0	1369.0	25.0	342.3

Table 1. Example of Fryberger (1979) demonstrating the calculation of weighting factors. [13]

Depending on the strong winds in the area, this coefficient distinguishes between a high-energy environment where the coefficient is above 400, a medium-energy environment where the coefficient is between 400 and 200, and a low-energy environment where the coefficient is below 200. It provides information on the overall drift potential of the sand—the amount of pipe required in each of the sixteen directions. Based on the different wind energies present in the environment, the transmission capacity distinguishes 200-DP400: medium energy zone, 200-DP200: low energy zone, and 400-DP400: high energy zone. A DP >400 indicates significant wind energy.

Therefore, the resulting drift potential (RDP) is a vector of the potential migration force in each of the sixteen directions; this results in a vector quantity of the resulting transport capacity. RDD (resultant drift direction) is an average orientation angle that indicates the direction of sand migration. It is represented by the resultant vector of the sand migration wind rose, which indicates the direction of sand migration.

This information, which can be compared to photographs of the ground or air or a satellite image, is extremely valuable because it provides information about the direction of the wind. The RDP/DP ratio is a standardized indicator of the directional variability of the wind, expressed as a ratio between 0 and 1. The RDP/DP ratio approaches 100% in areas where the wind is unidirectional. It was decided to do a simple statistical analysis to compare the average DP, RDD, and indices between months.

This coefficient is designated as follows: High: when the sand transport distance is greater than 0.8 and the sand is transported a long distance. Medium: when it is between 0.8 and 0.3, it can still transport sand over long distances. When the value is below zero, it is low. The winds tend to blow in all directions and stir up the sand but do not move it in this situation. These coefficients allowed us to create compass maps of the potential for sand entrainment, which we then studied and compared later in the process.

The sand migration rose refers to the graphical representation of potential sand movement and, in particular, to the coefficients described above. Based on the order of increasing dispersion (Fryberger, 1979), there are five types of sand migration roses:

- Uni modal narrow with more than 90% of the transport potential located in two adjacent directions, within a 45° arc.

- Broad Uni modal with a single peak transport direction but where, the distribution is wider. Bi modal sharp with a two mode direction or distribution and where, the peaks of both modes form a sharp angle (including 90°).

- Bi modal obtuse, the distribution is similar to the previous one but there, the peaks of both modes form an obtuse angle. Complex with a distribution that includes more than two modes, difficult to establish on only sixteen directions and most frequently, there are no well defined modes. .

Results and discussion :

3.1 Wind speed

The calm rate (sales with very low speed between 0 - 3 m/s); data from the station of Ain Sefra, which cover the years 1985 to 2015, are presented. Compared to the typical sum of immobility of 50, 30%, this represents a comparatively strong wind flow. During our research, we found that the rate of calmness varies from month to month. It exceeds 50% in only seven months: January, February, August, September, October, November, and December, with a maximum of 57% in the following months: January, February, August, September, October, November, and December. All other months have a percentage below 50%, with April having the lowest at 39.23%. The effective wind is most prevalent during the spring (vernal) and summer (aestival) seasons. The lowest occurrence of calm weather characterizes this time of year (Fig. 2).

The directional variability of the surface wind data shows that all speed classes, including the effective winds (above 21.6 km/h), have significant directional variability. 49.69% of the effective wind frequencies are divided into two-speed classes: the speed class between 14.4 and 21.6 km/h, which is the most frequent with 77.70%, and the speed class above 21.6 km/h, which is the least frequent with 22.29%.

Table 2. Monthly frequency (in percentage) of wind classes and monthly average wind speed at Ain sefra station for the period 1985-2015.

% **1985-2015**	***<14.4 km/h***	***14.4-21.6 km/h***	***>21.6 km/h***
September	*53*	*39*	*8*
October	*57*	*35*	*8*
November	*56*	*38*	*6*
December	*57*	*37*	*6*
January	*54*	*38*	*8*
February	*54*	*37*	*8*
March	*48*	*38*	*14*
April	*39*	*41*	*19*
May	*42*	*41*	*18*
June	*47*	*42*	*12*
July	*50*	*40*	*10*
August	*55*	*35*	*9*

Table 3. Periodic effective wind rates by 16 directions 1985-2015 in Ain Sefra

%	<14.4 km/h	14.4-21.6 km/h	>21.6 km/h	Total%
N	4	4	1	8
NNE	3	2	0	5
NE	3	2	0	5
ENE	4	2	0	6
E	5	3	1	9
ESE	2	1	0	3
SE	1	1	0	2
SSE	2	2	1	4
S	4	4	2	11
SSW	3	3	1	7
SW	3	2	1	6
WSW	3	2	1	7
W	5	3	1	9
WNW	3	2	0	5
NW	2	2	1	5
NNW	3	4	1	8

In the station of Ain Sefra, the annual wind rates show that the station is under the influence of two opposite sectors and that the station is dominated by the S, SW, and N sectors. (Table 3 and Fig. 2). A total of 11% of the time (Table 3) is devoted to the south sector, where southeast winds predominate with 10.7%, east winds with 12.1%, and west-southwest winds with 24.7% of the time (Fig. 2).

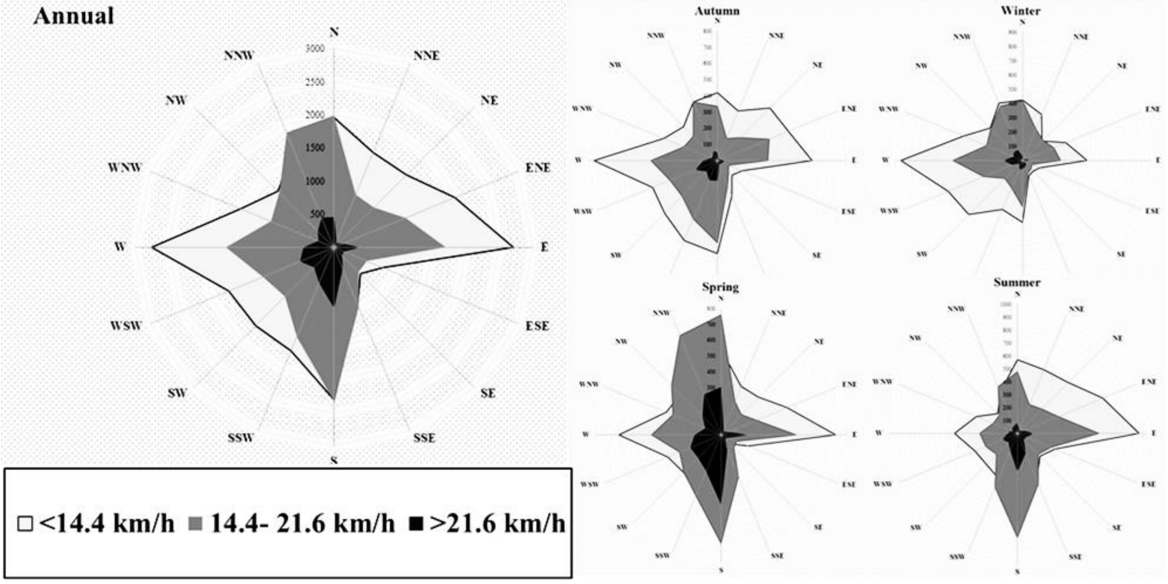


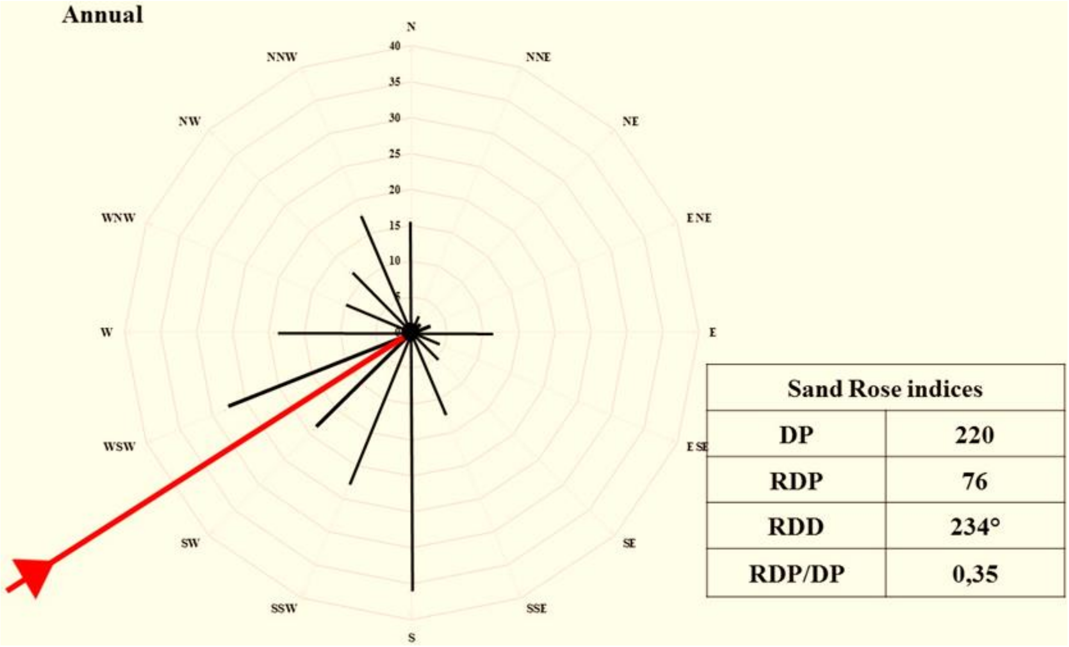
Fig.02: Wind rose diagram showing the directional and frequency variability of the all wind speed categories, from the station Ain sefra airport. Similar to the whole period: Annual and seasonal by observations of 1985-2015.

At Ain Sefra, 30 years of records (1985-2015) were used to divide the year into four periods: spring (March, April, and May), summer (September, June, July, and August), autumn (October and November), and winter (December, January, and February). This division is associated with wind rates based on station records (Fig. 2). Fall is a beautiful time of year. The effective wind recurrence is lower at this time, at 22.7%. We find that the wind comes from various directions, including south, southwest, and north-northwest.

Winds are most frequent in the spring when the wind is most effective. The recorded data, representing 30% of the total, are distributed in the south, north, and northwest (NNW). It is observed that effective winds are present 27.6% of the time during the summer season and are most frequent in the south, followed by the SSW, SSE, and east. Winter is the time of year when effective winds are less frequent: we have only 20.89% of them throughout the year. They are found in different locations, mainly in the north and north-northwest (Fig. 2). The relationship between these annual fluctuations shows that the effective winds are more frequent in spring, although they come from various directions and are sometimes reversed (north and south).

3.2 Drift potential of the sand

The volume and drift potential pattern are the most important factors determining wind energy categorization and sand movement capability [14].To quantify the potential sand movement in the Ain Sefra study area, we used the wind records from 1985 to 2015 to calculate the potential energy coefficients for the region. The potential movement and drift of the amount of sand that the wind can transport are done in a northeast direction (SW to NE) between 1985 and 2015. Table 3 and Fig. 3 summarize the obtained results.



Sand Rose indices	
DP	220
RDP	76
RDD	234°
RDP/DP	0,35

Fig.03: Average annual sand roses of drift potential in the region of Ain Sefra during the period 1985-2015.

According to Fryberger's 1979 classification, the drift potentials in Ain Sefra are quite high, and the area is designated as a medium energy milieu. According to Fryberger's classification, the sand migration coefficient is low and is defined by a mutability of the sand that is not accompanied by any significant movement (1979). The probability of winds blowing in all directions increases when this coefficient falls below 0.03. The winds stir the sand without moving it when this coefficient falls below 0.03. There are discrepancies between the two methodologies concerning wind turbulence phenomena, which are not measured by either weather station [15] . The drift potential (DP) is defined as the transport capacity for the entire series from 1985 to 2015 at a retrieval speed of 21.6km/h (12 knots), multiplied by the number of years in the series. Consequently, we can say that the region of Ain Sefra has an average amount of wind energy. According to the formulas developed by Fryberger (1979) for the association between the transport capacity and the volume of sand extracted, the mass of sand that could be mobilized from 1985 to 2015 is calculated as Q= 15.224 m3/m/year, which is equivalent to 25.424 T/year. Overall, the resulting drift potential (RDP), a vector of the potential migration force in each of the sixteen directions, is 76 VU for the sixteen-direction sequence. The migration coefficient (RDP/DP) measures the migration coefficient over 30 years and is considered low with values between 0.3 and 0.35. Therefore, there is sand movement but no actual movement. Despite this, the varies from 0.43 (fall) to 0.37 (winter); the resulting direction and average angular orientation of the series are 234°N, a resulting direction from WSW to ENE (Table 3). Wind compass looks like a huge bimodal type, with the South to North and NNW, WSW to NNE (predominant) winds in opposition to each other, it would look like this: (Fig. 3). There is atemporal variability in the amounts of sand drift potential relative to the effective wind distribution, although directional constancy is relative to the effective wind distribution. First, according to Table 4, the monthly drift potentials (DP) vary from 138 UV in January to 450 UV in April. The Ain Sefra station shows high drift potentials in spring and summer, with the highest values in April, March, or 258 VU, May 355 VU, and June 79 VU. During January, net drift potentials (RDP) ranged from 40 VU to 208 VU. The resulting drift direction RDD is frequently restricted to a range of 190° to 260°, i.e., between the south and west of the globe (Table 4 and Figure 4 for more information).

Table 4. Results obtained from B. Choppy "sand" software remuneration of wind records at AIN SEFRA, from 1985-2015

Threshold speed	**21.6 km/h**
RDP/DP	**0.34**
The resultant drift direction (RDD)	**234°**
Drift potential (VU)	**220**
The resultant drift potential (RDP) (VU)	**76**
Quantity sand :transport capacity :Q= 15,224 m3/m/year which is 25,424 T/m/year	

The migration coefficient (RDP/DP) is estimated to be less than 0.3 in January and March (0.29-0.26), meaning that winds tend to blow in all directions and stir up the sand without actually moving it. During this period, it does not exceed 0.8 and is greater than 0.3 during the rest of the months, which is average energy, and its interpretation always produces long-distance sand transport. Figure 5 shows the seasonal average sand DP values estimated in 16 directions for the Ain Sefra station and plotted against time.

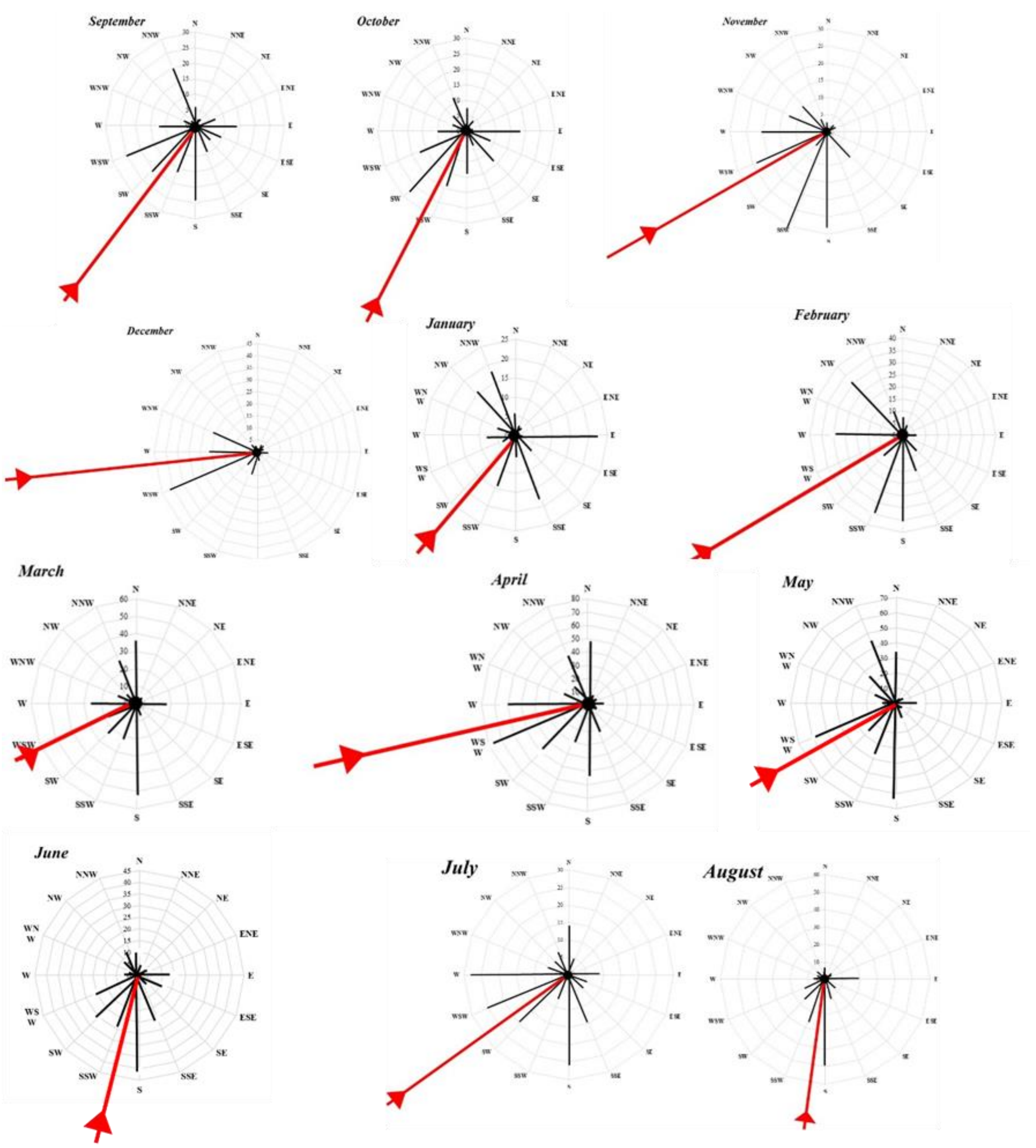
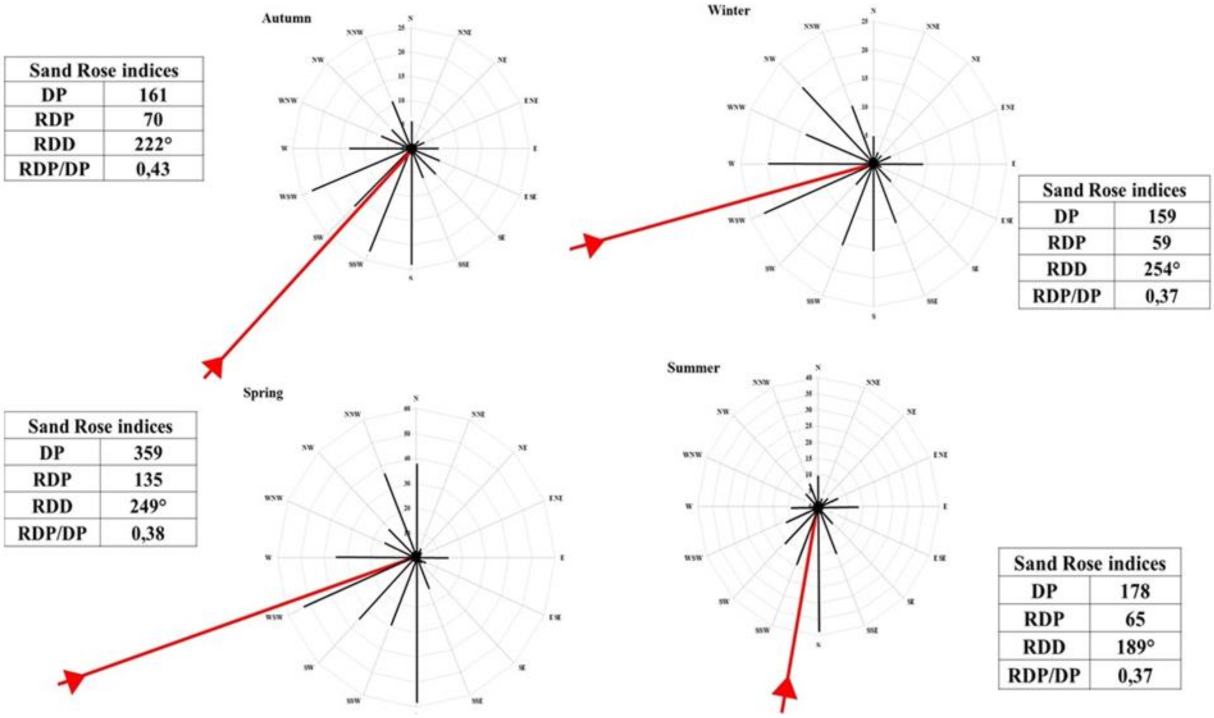


Fig.04: Average monthly sand drift potential rose in Ain sefra 1985-2015.

A wind rose plot was used to create the images seen here. The DP estimates over the different seasons revealed that the strongest winds were in spring and summer (359 and 178 VU, respectively), followed by fall and winter, which had the lowest PDs, respectively (159-161 VU). As a result of these measurements, the Ain Sefra region was classified as an intermediate energy wind environment. In addition, the seasonal value of RDP/DP ranged from 0.37 to 0.43, which showed a medium energy source that still produced long-distance sand transport.

Using seasonal wind roses for the area, it was found that the most frequent winds were from the west to the northeast. The most frequent winds in the spring and summer were from the south and west to the northeast, likely due to the seasonal flow patterns of a southwest wind, which coincides with the morphology of the area and the dunes (Fig. 5).



Autumn

Sand Rose indices	
DP	161
RDP	70
RDD	222°
RDP/DP	0,43

Winter

Sand Rose indices	
DP	159
RDP	59
RDD	254°
RDP/DP	0,37

Spring

Sand Rose indices	
DP	359
RDP	135
RDD	249°
RDP/DP	0,38

Summer

Sand Rose indices	
DP	178
RDP	65
RDD	189°
RDP/DP	0,37

Fig.05: Average seasonal sand roses of drift potential in the region of Ain Sefra during the period 1985-2015.

Seasonal throughput is predicted to be between 11 and 15 m3/m /yr, with a peak of 24.84 m3/m /yr in the spring. Based on the results summarized in Table 5, it can be noted that the greatest frequency of effective winds is contained in the south and west directions throughout the year.

Table 5. Summary of monthly and annual drift potential, resultant drift potential, resultant drift direction, and wind variability index for Ain Sefra airport station (1985 – 2015).

Month	DP	RDP	RDD	DP/RDP
Sept	161	70	222°	0.43
Oct	168	52	209°	0.31
Nov	153	83	230°	0.54
Dec	126	82	264°	**0.65**
Jan	**138**	**40**	222°	0.29
Feb	214	101	235°	0.47
Mar	**258**	67	248°	**0.26**
Apr	**450**	**208**	256°	0.46
May	**355**	116	245°	0.33
Jun	**208**	84	194°	0.40
July	179	66	230°	0.37
Aug	181	89	188°	0.49

The RDP varies between 59 VU and 135 VU degrees during the winter, implying that sand transport is primarily from the southwest to the northeast (SW-NE). It can be observed that the effective wind direction is between 189° and 254°, implying that the wind blows from the south and west and that the result is somewhere in the middle.

3.3 *The state of sand silting in the region and the risk it represents*

Digital remote sensing data are often used to map land cover classes, accomplished through supervised digital image classification [16]. The overall goal of the image classification technique is to automatically classify all pixels in an image into land cover classes or themes based on their appearance [17]. Since it is based on statistical parameters, the maximum likelihood classifier quantitatively evaluates both the variance and covariance of the spectral response patterns of the categories when classifying an unknown pixel, and therefore, it is considered one of the most accurate classifiers because it is one of the most accurate classifiers. The area was divided into five major classifications: seawater, urban, quires, and others. Table 6 and Figure 6 show the many land cover types that exist.

Table 6. Directional distribution of seasonal potential displacement.
(Q: Quantity of sand carrier from 1985-2015 in Ain Sefra).

	Autumn	**Winter**	**Spring**	**Summer**	**Annual**
N	6	5	38	9	16
NNE	1	2	4	3	3
NE	2	2	3	3	2
ENE	3	3	4	7	3
E	6	9	14	13	11
ESE	6	1	4	6	4
SE	7	4	2	7	5
SSE	6	11	13	16	12
S	24	15	58	39	36
SSW	23	15	30	19	22
SW	17	5	35	16	19
WSW	23	22	53	12	28
W	13	20	34	9	19
WNW	7	14	15	4	10
NW	6	19	17	6	12
NNW	11	11	36	8	18
total DP	161	159	359	178	220
RDP	70	59	135	65	76
RDP/DP	0.43	0.37	0.38	0.37	0.35
RDD	222°	254°	249°	189°	234°
Direction	SW	WSW	WSW	S	WSW
Q m3/m/year	11.14	11.00	24.84	12.32	15.22

Table 7. Different land use classes in the study area in 2015.

Class%	**Surface (area in ha)**	**Percentage**
Dune	37083.525	12.33
Sand	12371.158	4.11
Rocky outcrop	118222.262	38.67
Pasture	116300.634	5.36
Bare ground	16107.951	39.31

The results in Table 6 and Figure 6 indicate that the proportion of total sand equals 16% (dune+sand) of the total area; this is a significant proportion. The previous analysis showed that the high proportion of effective winds might cause this phenomenon. The present investigation confirmed this hypothesis. In addition, other elements such as the environment, morphology, and geological outcrop of the cut, among others, must be considered. In addition, other human factors such as overgrazing, forest fires, and haphazard plowing contribute to the problem. Due to the high proportion of sand in the soil, the sand invasion occurs, threatening the area, its inhabitants, and the infrastructure. Therefore, the search for reasons can help solve the silting problem, especially for effective winds.

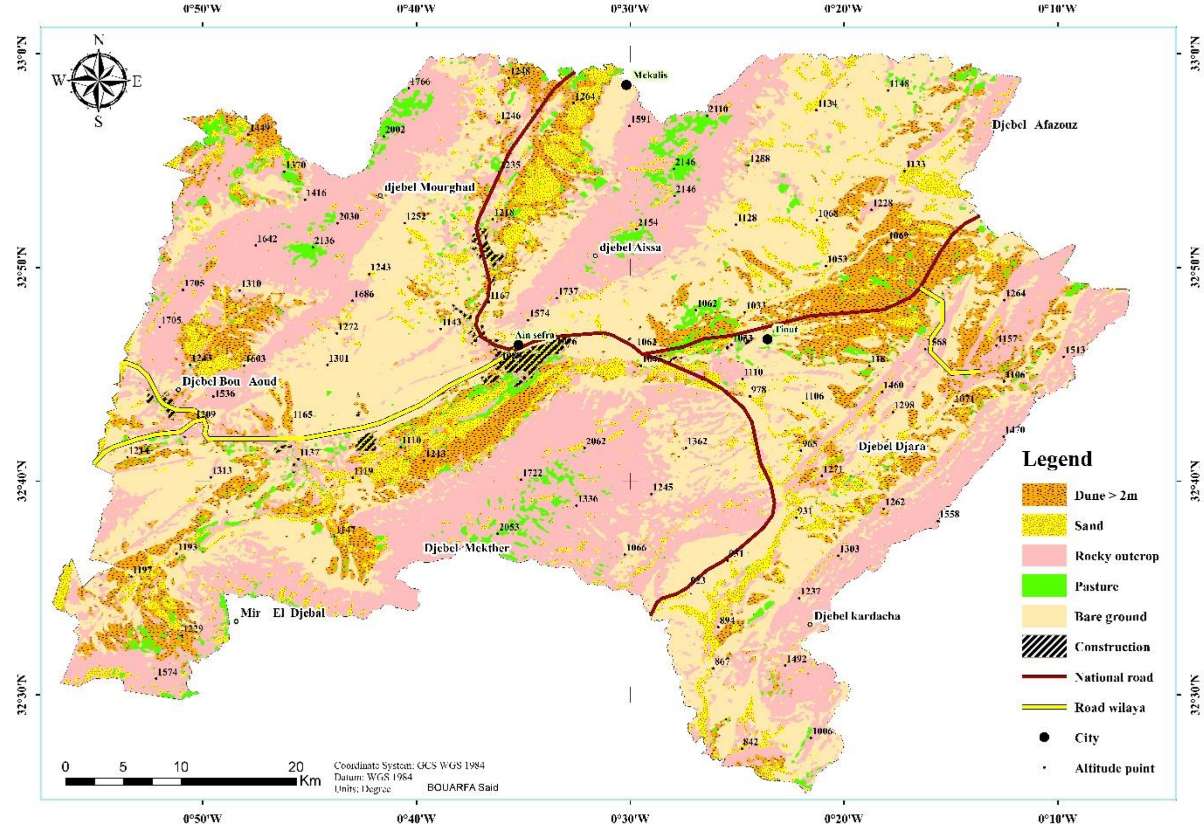


Fig. 6 Different land cover classes of the study area from 2015 in the study area: Percentage of sand area (dune + sand) is equal 16, 4%; the Rocky outcrop is 39%; the Pasture is 6, 6 %, the Bare ground is estimated 40, 7%).

4 . Conclusion

A vast problem of sand silting has been identified in the region of Ain Sefra. These difficulties are due to difficult climatic circumstances. Analysis of the wind data, either by wind rate or by sand potential movement, allowed the determination of the actual wind directions, the resulting annual direction of sand potential movement, and the seasonal directions of sand potential movement. In addition, it allowed for an estimate of the likely mass of sand mobilized. Prevailing winds are primarily from the south and north sectors, with secondary winds from the east and west sectors, with the rate of sand transport being unidirectional. Only south and west-southwest winds are effective and capable of causing sand movement.

This sand transport occurs in two phases: a spring phase and a summer phase: during the spring phase, PDs are extremely high, and sand generally moves from WSW to NNE, and from S to S, during the summer phase, the mean migration coefficient (0.37) is constantly present, resulting in long-distance sand transport. In addition, there is an autumn and winter: during which the DP is quite low, and sands are present. During this time of the year, the winds are the least strong and do not blow in any particular direction. Therefore, we need to integrate this technique with extremely accurate topographic surveys that allow us to calculate the total volume and shape of sand deposits formed or eroded by the wind to understand the impact of sand silting on the morphology and evolution of sand these deposits.

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