DESERT

Sand Movement Patterns in Southern Iran

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Abstract

Wind regime data from the Jask meteorological station from a 20-year statistical period (1985-2005) was analyzed using the Fryberger method to investigate sand drift potential (DP) in this area. The resultant drift potential and directional variability of wind were calculated and illustrated. Average annual sand DP was estimated to be 460 vector units (VU), and the sand flux is 51 m^3/m.year. Therefore, in view of the wind's erosive power (calculated by software using the Lettau-Lettau equation) and according to Fryberger's classification (1979), this area is categorized as a high energy wind environment. Calculating DPt in different seasons showed that the strongest winds blow in summer and winter (158.8 and 152.4 VU), and autumn had the lowest DP. In summer, the wind blows in a south-southeast pattern which differs from that of other seasons. Autumn also has the highest frequency of winds swifter than threshold velocity. The unidirectional index (RDP/DPt) value is 0.08 for this region, which causes the formation of transverse dunes (barkhanoid) from south-southeast to north-northwest.

Keywords: Wide regime; Sand drifts potential; Fryberger method

1. Introduction

Much research has addressed the processes of wind regimes. Wind regimes are effective agents on the aeolian landforms in deserts. Three factors of prevailing winds (wind frequency, magnitude, and direction) control sand dune morphodynamics (Bagnold, 1941; Tsoar *et al*., 1998; Cook *et al*., 1993). There are many formulas for estimating sediment transport potential. Among them, the Fryberger (1979) model has been widely used (McKee, 1979). Many researchers have used this model to determine sand dune drift and wind regimes (Bullard *et al*., 1996; Fryberger and Lettaue and Lettau, 1979; Tsoar, 1990). Standard wind data from a meteorological station was used for this model. The main objective of this research was to determine sand dune potential and direction in the Jask desert.

2. Material and Methods

Jask is the capital city of Jask County, Hormozgan Province, Iran. At the 2006 census, its population was 11,133 people in 2,406 families. Jask is a port town situated on the Gulf of Oman. In the current study and regarding the aim of this project, the following were used:
- Topographical maps with a scale of 1:50000 for preparing the regional base map and determining physiographical characteristics including slope and hypsometric study;
- Geological maps with a scale of 1:250000 for determining the regional lithology;
 Satellite images with a scale of 1:100000 for considering the geomorphologic characteristics of the region as well as boundaries of sand dune forms;
- Aerial photos with a scale of 1:50000 for interpreting the morphological characteristics of the sand dunes;
- Anemometric data for calculating sand wind, wind storm, and storm rose from 1990-2005.

   In this study, we also used:

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- The method proposed by Fryberger (1979) for determining sand drift potential (DP).
- Sand Rose Graph software (3). This software is accessible for estimating sand drift potential (DP) by winds, resultant drift potential (RDP), and unidirectional Index (UDI), and for plotting sand roses.
- WRPLOT software. This software uses several meteorological data formats to plot wind roses and storm roses (Rajabi *et al*., 2006).

2.1. The sand rose graph software

Sand Rose Graph software is a simple computer program that can read wind speed and direction data from meteorological stations. It is accessible for estimating sand drift potential (DP) by winds, resultant drift potential (RDP), and the unidirectional index (UDI), and for

plotting sand roses. It was written using Microsoft Visual Basic and was provided by Yazd University. Wind data available in various formats has to be converted to Lake format before being used by this software. There are many equations such as the Lettau and Lettau (1978) and Bagnold (1941) equations that can be used to estimate DP for creating this computer program. In this research, we used the Lettau and Lettau (1978) equation.

3. Results and Discussion

Average seasonal and monthly sand DP values estimated in 8 directions for the Jask station are shown in Figure 1. These images were drawn by a sand rose graph. The resultant annual drift direction is north-northwest.

Summer

Sand Rose indices	
DPt	158.8
RDP	102.46
RDD	295
RDP/DPt	0.645

Autumn

Sand Rose indices	
DPt	51.6
RDP	6.403
RDD	51
RDP/DPt	0.124

Annual

DPt	459.4
RDP	36.497
RDD	351
RDP/DPt	0.079

Spring

Sand Rose indices	
DPt	96.7
RDP	35.511
RDD	80
RDP/DPt	0.367

Winter

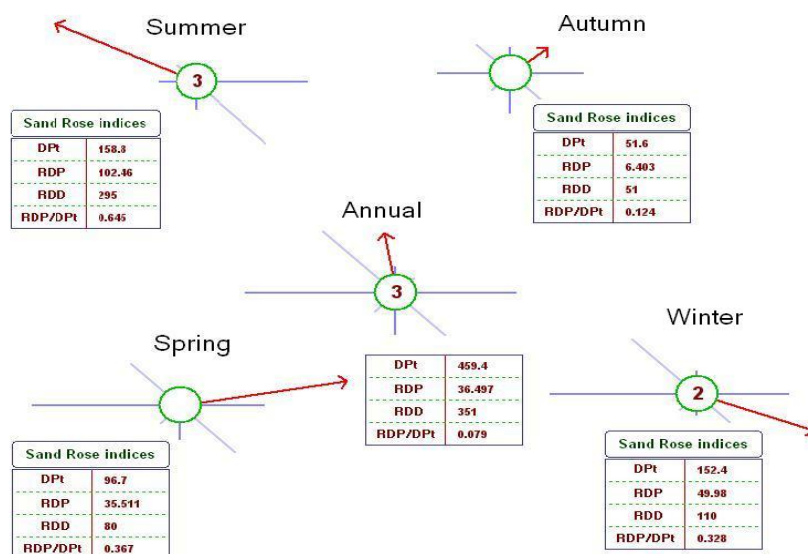| Sand Rose indices	
DPt	152.4
RDP	49.98
RDD	110
RDP/DPt	0.328

Fig. 1. Average annual, seasonal, and monthly sand DP (1990-2005)

The annual sand DP amount of the studied area was 460 VU (calculated by software using Lettau-Lettau equation). According to Fryberger's classification (1979), this area is categorized as a high energy wind environment. The calculations of DPt in different seasons showed that the strongest winds blew in summer and winter (158.8 and 152.4 VU[1]), followed by autumn which had the lowest DP (Fig. 2).

Annual UDI value was 0.08, which indicated powerful multi-directional winds in the region. Variability in wind direction was lowest in the month of April (0.82), followed by July, August, and September, respectively (0.7, 0.63,

0.62). The highest variability rates were related to the months of December and October (Fig. 3).

Calculating the resultant sand drift potential in different directions showed that the amount of sand drift flow during 20 years was 4.3 $m^3 m^{-1}$ $year^{-1}$ from west-southwest toward the northwest. Regarding speed classes, the highest value of DP belonged to winds with speeds of 11-22 knots (Fig. 4).

Drawing DPt over the 15-year period showed that sand drift potential in the year 1990 with a value of 715 was the highest and in the year 2005 with a value of 128 was the lowest (Fig. 5).
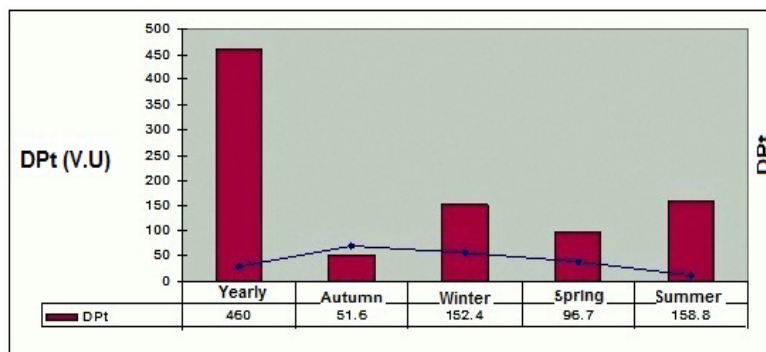

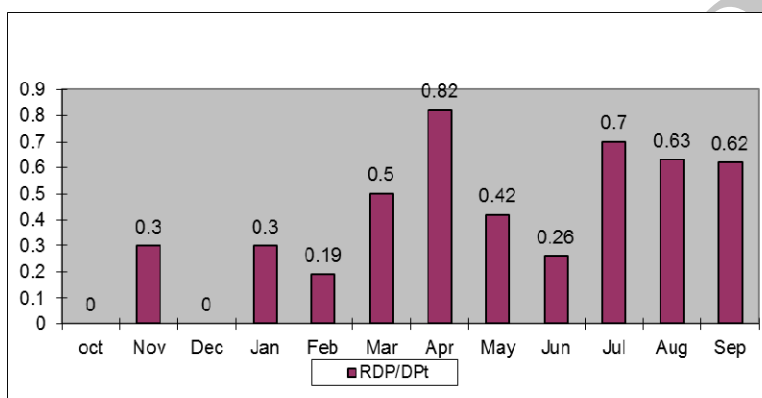[1.] Vector Unit

Fig. 2. Values of DP in each season

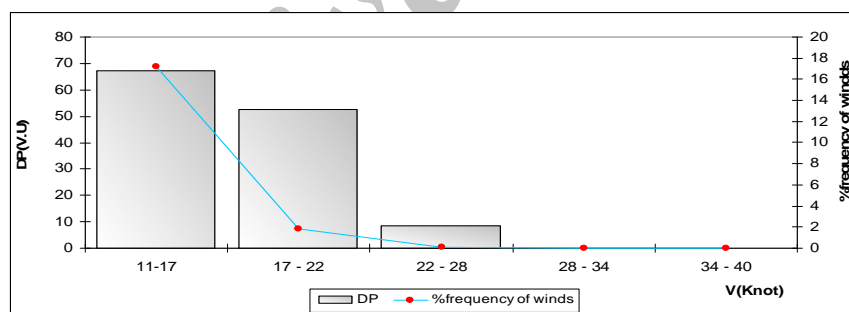Fig. 3. Variability in wind direction in different months

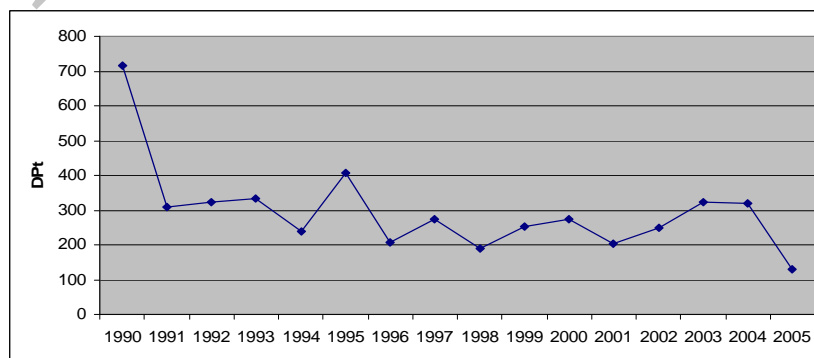Fig. 4. Relation between DP and percentage of frequency of winds

Fig. 5. DPt values between 1990 to 2005

Analysis of data through "WRPLOT"(Wind rose plot software) indicated that the direction of annual prevailing winds was from west and southeast. Seasonal wind roses of the region showed that in autumn, winter, and spring, winds were most common in the west. The most frequent summer winds blew from east to southeast, possibly because of the seasonal flow patterns in a southeast wind, which coincided with the morphology of the sand dunes and the resultant sand transport (Fig. 6). The annual storm rose of 20 years showed that the prevailing winds blew from the west and southeast, which was mostly coincidental with the direction of sand drift potential (Fig. 7).

Fig. 6. Annual and seasonal wind rose (1990-2005)

Fig. 7. Annual and seasonal storm roses (1990-2005)
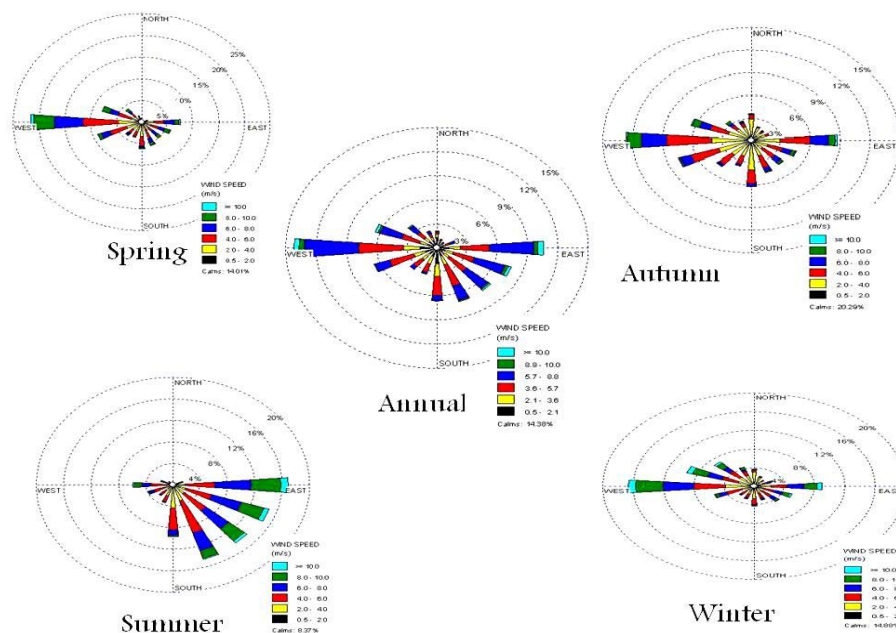
4. Discussion

Wind plays an important role in the formation of sand dunes (Maingut, 1986). Regarding satellite images, the direction of sand flow is the same as the morphology of sand dunes in this area. Wind roses in spring, autumn, and winter showed that the highest value of winds belonged to the west, while in summer, seasonal winds blew from east to south, which coincided with the morphology of sand dunes and sand drift potential. The highest value of sand drift potential was related to winds with speeds of 11-22 knots. In other words, in the formation of sand dunes, a larger number of winds with average speed plays a more important role. The value of the UDI index was 0.08, which indicates that wind blew from different directions and caused the formation of barkhanoid sand dunes from south-southwest to north-northwest. This index can be effective in shaping the morphology of sand dunes and sand hills in different areas (Mesbahzadeh and Ahmadi, 2012; Moursy et al., 2001; Saqqa and Atallah, 2004). The Fryberger method is a useful approach for evaluating sand drift potential by wind, and there is a negligible difference between *DP* obtained from manual methods and those obtained from Sand Rose Graph software (Mesbahzadeh and Ahmadi, 2012).

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