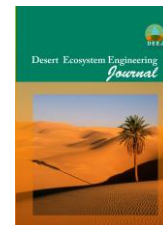




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The Morphology and Morphodynamics of Aeolian Landforms in the Jazmurian Erg: An Analysis of Environmental Controls

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Extended Abstract

Introduction: Sand dunes are distinctive features of arid landscapes, notable both for their tourism potential and the environmental hazards associated with their dynamic morphology. In Iran, sand dunes are widespread and cover extensive areas. Given their active morphodynamics, these dunes can pose significant risks to nearby infrastructure and land use, including agricultural areas and residential zones, many of which are situated in close proximity to dune fields. In recent years, sand dunes have been increasingly recognized as mobile elements of desert systems. Understanding their characteristics is essential to deciphering the complex processes that drive their activity and evolution. Despite the considerable extent of dunes across Iran's deserts, they remain inadequately studied, with a notable lack of comprehensive research on their morphological diversity and behavior. This gap underscores the need for detailed investigation into the morphology of Iran's sand dunes. The present study aims to address this by not only identifying and analyzing the dynamic state of dunes and the factors influencing them but also by proposing a localized classification framework tailored to specific ergs. Such a classification would enable systematic categorization of dunes within each sand sea. The Jazmurian Erg, one of the largest dune fields in Iran, was selected as the study area due to its considerable size and proximity to population centers such as Iranshahr and Bampur. Assessing the morphological and morphodynamic status of its dunes is therefore of considerable practical importance—an objective that this research seeks to fulfill.

Materials and Methods: This study employed multiple data sources, including MODIS and Landsat satellite imagery, Google Earth images, and statistical data on wind speed and direction. The primary analytical tools consisted of ArcGIS for spatial mapping, Google Earth Engine for generating vegetation density and dust concentration maps, and Google Earth for creating shapefiles and assessing sand dune dynamics. The research was conducted in three sequential stages: The precise boundaries of the Jazmurian Erg were delineated using Google Earth imagery. Following this delineation, a comprehensive morphometric analysis was conducted. Based on morphological characteristics, the erg was systematically classified into distinct dune types. To evaluate dune mobility, 81 sample points were strategically selected across the study area. Using time-series imagery from Google Earth and Landsat platforms, the displacement rates of individual dunes were quantified over a 15-year period (2005-2020). To investigate the relationship between dune dynamics and environmental conditions, vegetation density maps were generated using MODIS satellite data processed through Google Earth Engine, applying the Normalized Difference Vegetation Index (NDVI). Additionally, dust concentration patterns were analyzed through Aerosol Optical Depth (AOD) index calculations derived from MODIS imagery spanning 2018-2023.

Results and Discussion: The Jazmurian Erg, spanning an area of 4,261 km², constitutes a significant geomorphic feature within the Jazmurian Basin. Classification of dune morphologies reveals that compound linear dunes are the dominant landform, covering 1,649 km² (37.7% of the total erg area). Additional extensive forms include sand sheets of medium thickness and simple linear dunes, occupying 669 km² (15.7%) and 577 km² (13.5%) of the erg, respectively. Displacement analysis conducted between 2005 and 2020 indicates dune movement ranging from 2 to 47 meters across the study area. The most significant migration rates (>40 meters) were observed in central, western, and certain eastern sectors of the erg, while remaining areas showed more modest displacement of less than 20 meters. This translates to an annual migration rate varying between 0.15 and approximately 3 meters, highlighting considerable spatial variation in dune activity across the Jazmurian Erg.

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Conclusion: This study demonstrates that the Jazmurian Erg represents a significant geomorphological feature, covering an extensive portion of the Jazmurian Basin and ranking among Iran's largest sand dune systems. The erg exhibits considerable morphological diversity, with dune forms classified into 12 distinct types influenced by varying climatic and topographic conditions. Analysis confirms that the Jazmurian dunes maintain active dynamics, showing a significant correlation with environmental parameters, particularly vegetation density and dust concentration. The notably low NDVI values across the erg indicate sparse vegetation cover, creating conditions favorable for dune mobility. Furthermore, areas exhibiting higher aerosol optical depth (AOD) values, particularly in central sectors, correlate strongly with observed increases in dune displacement rates. The findings collectively indicate that environmental factors drive active dune dynamics within the Jazmurian Erg. Given the potential for these mobile sediments to generate dust sources and encroach upon agricultural lands and human infrastructure, the implementation of targeted stabilization measures is strongly recommended to mitigate environmental and socio-economic impacts.

Keywords: Sand dune dynamics, Sand Dune Morphology, Classification of Sand Dune.