Chapter 2
Geomatics-Based Analysis of Sand Dune Encroachment Dynamics in the Tafilalet Region, Morocco

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ABSTRACT

Aeolian sediments cover roughly 6% of the Earth's surface, mainly in arid regions, accounting for 97% of their occurrence and spanning about 20% of the terrestrial surface. Sand drifts in these areas threaten fragile ecosystems by disrupting their stability. This study analyzes sand dune encroachment dynamics in the Tafilalet region of southeastern Morocco using geomatics techniques. Sand encroachment endangers human settlements, agricultural lands, and infrastructure. Employing remote sensing methods, including satellite imagery and the Fryberger method for estimating sand dune drifting, this research examines sand movement from 1984 to 2015. Results show a significant increase in sand-covered areas by approximately 44,872 hectares, driven by climatic conditions and human activities. The study

DOI: 10.4018/979-8-3693-6452-9.ch002

highlights the severe risks to the Tafilalet oases and infrastructure, underscoring the need for continuous monitoring and sustainable management practices to mitigate sand encroachment impacts.

INTRODUCTION

In North Africa, arid lands represent more than 95% of the terrain area, except for the littoral zone of the Mediterranean Sea (Gherib et al., 2023). Arid lands are particularly vulnerable to soil degradation due to prolonged drought conditions and climatic variability, which can lead to severe ecosystem dysfunction and desertification (Ritsema et al., 2022). Manifestations of desertification in arid lands include soil salinization and sand encroachment, both of which significantly threaten agricultural productivity and infrastructure stability (Geist & Lambin, 2004; Cherlet et al., 2018). Mobile sand dunes are a major issue in these regions, encroaching on road networks, agricultural lands, and residential areas, exacerbating socio-economic challenges (Barchyn & Hugenholtz, 2012).

In terms of dune activity, recent studies have continued to identify active, dormant, and relict dunes, with active dunes posing the greatest hazard due to their lack of vegetation and abundant sand supply (Bourke et al., 2022; Thomas & Wiggs, 2021). Research on sand dunes has significantly advanced since the early 20th century, with modern techniques allowing for more precise measurements of wind velocities and sand flux (Swann & Walker, 2019; Baas, 2008). The problem addressed in this work is sand encroachment, manifesting as sandy accumulations at the edges of towns and within palm groves, leading to rural exodus. These sandy deposits sometimes cut off roads, further isolating communities and disrupting local economies (Issanova et al., 2023; Allahyari & Farjad, 2022).

One region of particular interest for sand dune monitoring is the Tafilalet region in southeastern Morocco, which is home to extensive and dynamic sand dune systems. The region's clear morphology and distinct dune forms, shaped by prevailing southwestern winds, provide an ideal setting for the application of remote sensing methodologies. In this region, the relentless advance of sand threatens human settlements and infrastructure, as exemplified by the late 1970s storm that devastated 60% of a village in the Tafilalet area.

Faced with this problem, which is likely to worsen in the future, the objective of this work is to analyze the spatio-temporal dynamics of sand encroachment with the overall aim of safeguarding the biodiversity of the oases of Tafilalet and protecting infrastructure such as roads, and irrigation canals. To do that it is essential to find effective ways to identify and monitor the dynamics and assess their environmental impact. Therefore, we employ remote sensing techniques alongside the Fryberger