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Assessment Of Degraded Rangeland Extent In The Ouled Djellel Region By The Application Of The Soil Adjusted Vegetation Index (Savi) Derived From Remote Sensing Data

Gorma Ziane[1], Boureboune Lamia[2]

[1]Faculty of Earth Sciences, Geography and Spatial Planning, University of Constantine 1, (Algeria). zianovic@gmail.com / https://orcid.org/0009-0008-7777-1520
[2]Faculty of Earth Sciences, Geography and Spatial Planning, University of Constantine 1, (Algeria). lboureboune66@gmail.com / https://orcid.org/0009-0007-5134-1795

Abstract

The primary aim of this research is to assess the degree of degradation experienced by natural rangelands within the Ouled Djellal region. The pastures situated on the inclines and southern aspects of the Saharan Atlas in southern Algeria function as grazing territories for numerous livestock. These pastures comprise assemblages of shrubs that demonstrate resilience to arid and semi-arid climatic conditions.

At the commencement of this century, the region witnessed a significant reduction in its shrub vegetation cover, which is essential not only as a crucial food source for livestock but also as a fundamental component in sustaining the ecological equilibrium of these landscapes. This degradation has precipitated various challenges within the pastoral economic framework of the region.

The density of shrub vegetation cover, which is marked by considerable variability, is evaluated utilizing the Soil-Adjusted Vegetation Index (SAVI), a metric noted for its remarkable precision and accuracy in identifying sparse and less densely populated shrub areas. SAVI is recognized as a beneficial alternative to the Normalized Difference Vegetation Index (NDVI) owing to its enhanced efficacy in discerning vegetation attributes, particularly those pertinent to arid and semi-arid ecosystems. This index provides improved spatial resolution and sensitivity, facilitating more precise evaluations of vegetation density across diverse ecological contexts.

Keywords: *DEGRADATION; LIVESTOCK; SHRUBS VEGETATION; SAVI.*

INTRODUCTION

The Ouled Djellal region, characterized by its transition between the Sahara Desert and the steppe zone in southeastern Algeria, serves as a dual pastoral and agricultural zone. This unique geographical location has historically enabled it to thrive with both desert-specific farming systems such as oases, found along the Wadi Djedi's banks running northwest-southeast across the region

Not far from the oasesaeras, diverse shrub communities supporting livestock including sheep, goats, and camels.

However, despite its rich biodiversity, Ouled Djellal has also experienced climatic shifts over the past three decades that have led to increased aridity and the regression of these shrub formations. This transformation has resulted in a reduced availability of forage, necessitating breeders to supplement their livestock with state-subsidized fodder to meet nutritional demands.To assess the extent of degradation in these vital grazing lands, which form significant portions of both pastoral areas and critical biodiversity reserves, multiple methodologies can be employed. Among them is remote sensing, which provides insights into the spatial distribution of low-lying vegetation across the entire province (or state) by analyzing temporal data during periods when this regression occurred. Our study focused on three distinct time intervals—1995, 2005, and 2020—to quantify changes in degraded areas, thereby providing a comprehensive understanding of environmental degradation trends in the region.

The resistance of plant species to water deficiency exhibits spatial variability across the region, influenced by factors such as livestock grazing intensity and root system development. Areas subjected to higher grazing pressure and with plants possessing less extensive root systems tend to experience greater degrees of desiccation. This results in heterogeneous patterns of vegetation degradation, with some zones undergoing significant plant decline while others maintain relative resilience. Consequently, these variations contribute to a discernible shift in vegetation distribution gradients from northern to southern parts of the region, as well as along the aridity gradient from more arid to less arid environments.

The use of Geographic Information Systems (GIS) in assessing degraded vegetation areas provides valuable insights into both the current and historical states of this cover through comparative analysis of two or more satellite images.

This approach takes into account the sensor advancements across successive Landsat missions—from Landsat 4 and 5 to Landsat 8—to ensure more reliable and accurate calculations.

1-Materials and Methods

1.1 Study Area and Dataset used

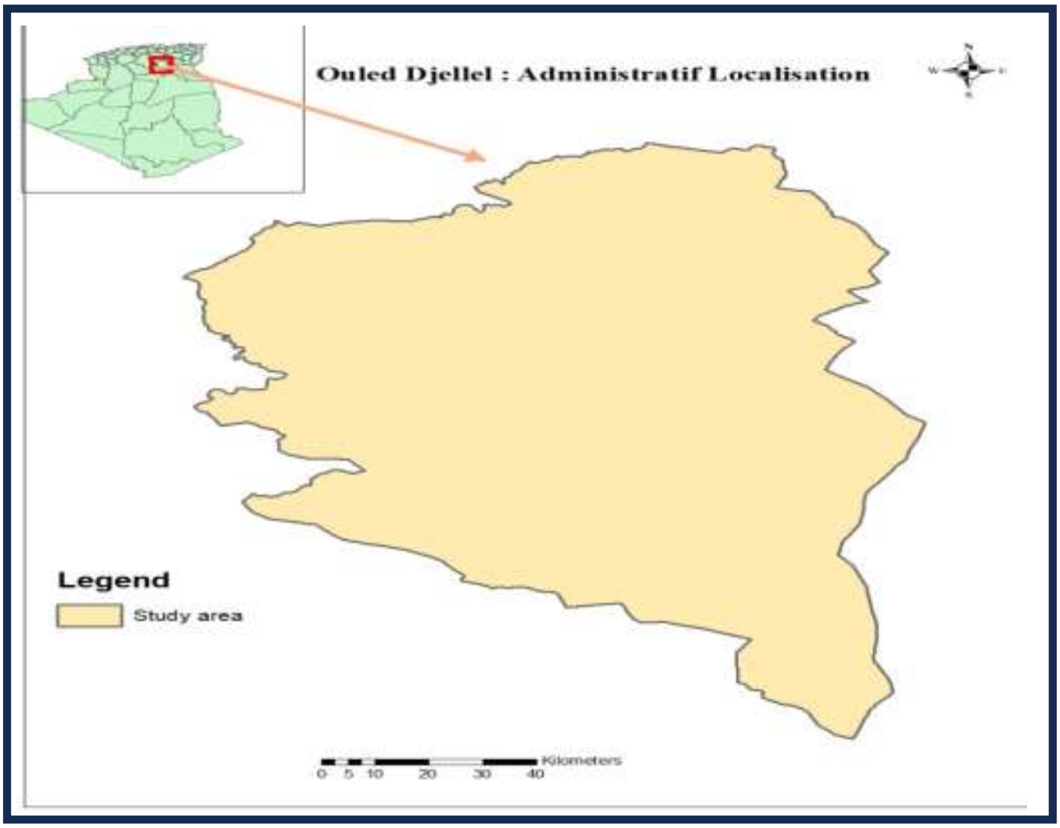

Fig.1. Administratif Localisation

The Ouled Djellal Province (Wilaya) is one of the newly established administrative divisions created under Law No. 19-12, dated December 11, 2019, which pertains to the territorial organization of the Algerian state. Prior to the enactment of this legislation, it was administratively integrated into the Biskra Province. Geographically, Ouled Djellal constitutes a transitional zone between the steppe and the Sahara Desert. It is located between the longitudes of 4° and 6° East and the latitudes of 32° and 35° North.

1.2 How to Calculate SAVI:

The Soil-Adjusted Vegetation Index (SAVI) is employed to mitigate the influence of soil brightness, making it particularly suitable for arid and semi-arid zones characterized by sparse vegetation cover.

$$SAVI=\left(\frac{NIR-RED}{NIR+RED+L}\right)*(1+L) \quad (1)$$

-NIR: Near-Infrared band (reflectance from healthy vegetation). Its the Band 4 for Landsat 4 et 5, and Band 5 for Landsat 8.
Red: Red band (absorbed by chlorophyll). Its the Band 3 for landsat 4 and 5, and the Band 4 for Landsat 8.
- L: Soil adjustment factor (typically 0.5 for moderate vegetation; ranges from 0 to 1) .

Following the download of satellite images from the USGS Earth Explorer portal, summer-acquired scenes were deliberately selected to minimize the influence of seasonal ephemeral vegetation. The selected images were processed in ArcGIS, where the three scenes covering the study area were mosaicked into a composite raster. Subsequently, the study area was extracted using a clipping operation.
The Soil-Adjusted Vegetation Index (SAVI) was then computed using the **Raster Calculator** function within the Map Algebra framework. To address sensor discrepancies between the **Thematic Mapper (TM)** on Landsat 5 and the **Operational Land Imager (OLI)** on Landsat 8, cross-sensor normalization was applied using the following equation: POLI=a *PTM+b (2)

b = 0.0004 for Band 5 and 0.0001 for Band 4
a=0.996 for Band 5 and 1.005 for Band

in other way :
("B5" - 0.0004) / 0.996
("B4" - 0.0001) / 1.005

Table 1. Summary of Landsat 8 bands used in the study

Band Number	name	Wavelength (µm)
4	Red	0.64 – 0.67
5	Near_Infrared	0.85 – 0.88

Results :
Using SAVI instead of NDVI in the study because of the sparse, scattered, and fluctuating vegetation cover as a result, the NDVI vegetation index does not provide a true and accurate representation of vegetation cover in arid regions. Therefore, we used SAVI to obtain more precise results for the calculation of degrated area
After converting the image from raster to vector (polygons), we calculated the area of each color displayed on the map separately, where each color represents a specific soil cover type, using the attribute table of each map . The results were as follows:

Table.2. Rangelands and degraded area

year	1995	2005	2020
Degraded area(ha)	127428,59	341528,71	503225,7
Rangelands(ha)	986494,53	777800,17	612008,7

The degraded area in rangelands from 1995 to 2005 amounted to 208,694.5 hectares over a 10-year period, while 165,792 hectares were degraded between 2005 and 2020 (a 15-year span). This change in rangeland area—primarily consisting of shrub communities critical for livestock forage (supporting thousands heads of livestock)—reflects a clear deterioration trend.

As illustrated in **Fig** (2), this degradation is concentrated in the eastern and southeastern parts of the study area, characterized by higher temperatures and lower precipitation. In contrast, the northern and western regions exhibit more complex topography, including elevated and mountainous terrain, where shrub communities have persisted due to the difficulty of grazing access.

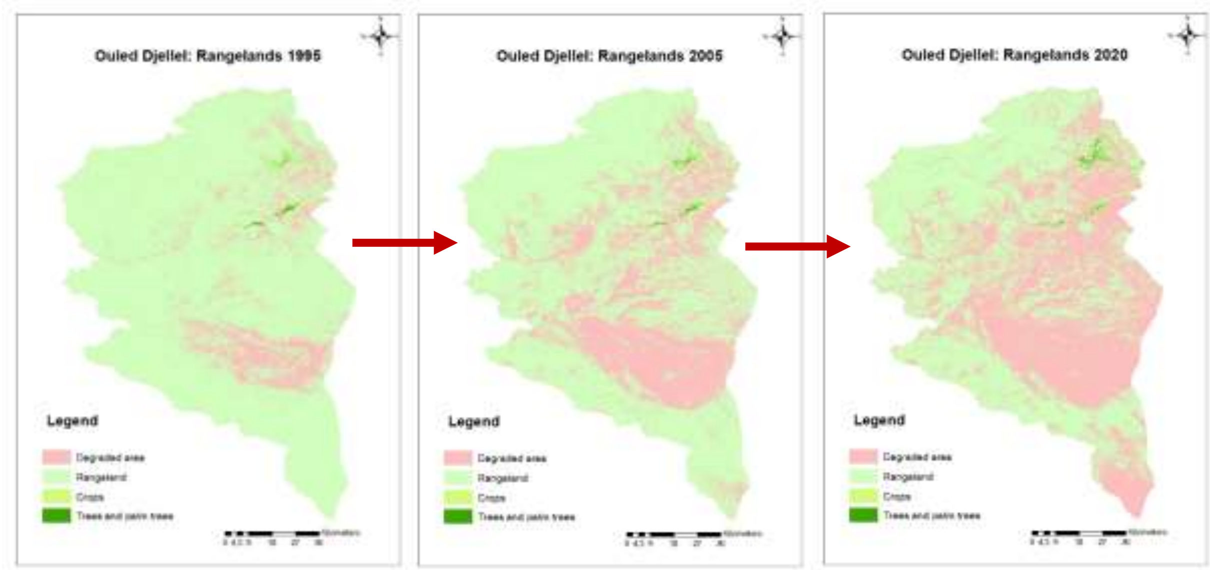

Fig.2. Rangeland degradation in the Study

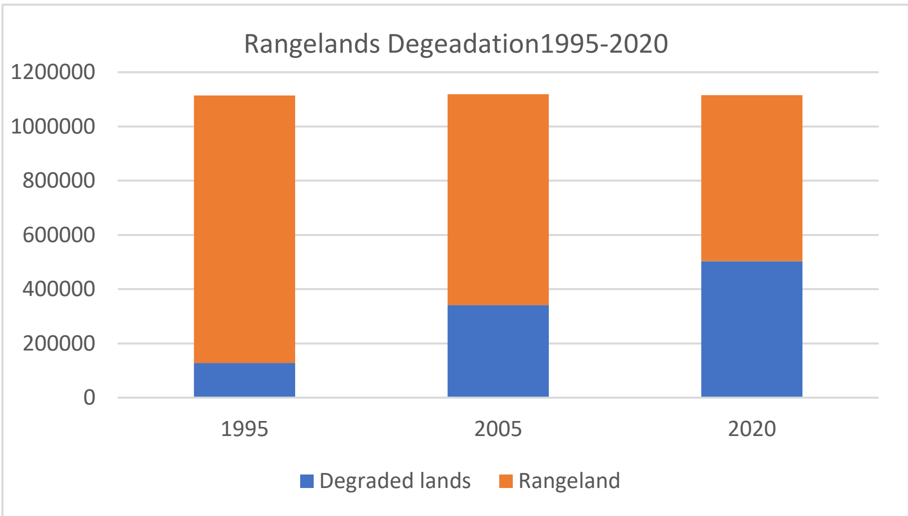

Fig.3. Increase in degraded land and decrease in rangelands

Discussion :

The degradation of vast areas of already fluctuating vegetation cover—which once served as a major grazing resource has coincided with an expansion of arid lands **Fig** (3)now at risk of desertification. This decline has also triggered a severe shortage of livestock forage, compelling herders to import large quantities of feed to compensate for the deficit in their herds' nutritional needs.

This large-scale regression in the region stems from multiple factors, including climatic drivers and anthropogenic pressures related to grazing management. For instance, the western zone, where vegetation

cover remains relatively intact, has experienced a near-total absence of grazing activity for years due to security concerns linked to Algeria's past instability, particularly in mountainous areas.
Beyond climatic influences, overgrazing and encroachment into fallow lands have exacerbated the degradation. The dual pressures of rising livestock numbers and uncontrolled plowing have significantly reduced shrub communities, depriving them of the opportunity for ecological recovery.
The region contains a total of 476,000 heads of livestock, including 415,000 sheep and 61,000 goats. This substantial livestock population requires adequate pastureland to provide sufficient food and grazing resources
Fallow and pastoral lands account for 78% of the total area of the region, which is 1,127,800 hectares. More than half of these lands have deteriorated over the past 25 years and have become non-grazing areas. The remaining half has an average productivity of 250 feed units (FU) per hectare.
Since the feed requirement of sheep is estimated at 420 FU, and the feed requirement of goats is 350 FU
The deficit can therefore be calculated as follows:

- Sheep requirement: 415,000 heads × 420 FU = 174,300,000 FU per year (1)
- Goat requirement: 61,000 heads × 300 FU = 18,300,000 FU per year (2)

The total feed requirement amounts to 192,600,000 FU per year. (3)
The available quantity is:
612,008.7 ha × 250 FU/ha = 153,002,175 FU per year. (4)
The deficit incurred here is estimated at 39,597,825 UF per year (5)
Livestock breeders resort to compensating with alternative fodder or relocating the animals to areas with better pastures outside the region."

Conclusion:
Natural pastures hold significant importance in the pastoral economy, primarily serving as a food source for hundreds of thousands of livestock. Additionally, they contribute to ecological balance in arid and semi-arid regions.
Preserving vegetation cover in areas vulnerable to desertification is a strategic approach that the state should adopt. The Ouled Djellal region acts as a vital link between the north and south, as well as between the eastern and central provinces of Algeria. Livestock represents the second-largest source of income for the inhabitants of this region, following Saharan agriculture. The degradation of pastures in this area poses a serious threat to the majority of its population, who rely on these lands for both pastoral and agricultural activities.
The application of Geographic Information Systems (GIS) to monitor vegetation regression is a modern and essential scientific tool. It helps identify degraded areas, assess their extent, and determine appropriate remediation measures. Key interventions include re-vegetating deteriorated zones, regulating grazing practices, and supporting nomadic populations in preserving this fragile environment.
The use of the Soil Adjusted Vegetation Index (SAVI) is particularly important in arid and semi-arid regions due to the variability, fragmentation, and indistinctness of the vegetation cover in satellite sensor data. It is essential to account for the differences among various satellite sensors in order to ensure the accuracy and reliability of the information obtained.
The variation in the degree of vegetation degradation in the region is attributed to two main factors. The first is climate, as the southern and eastern areas are relatively hot. The second factor is the intensity of rangeland exploitation; the western region has experienced limited exploitation and has thus maintained a dense shrub cover, largely because it is topographically challenging and was considered unsafe during certain periods.
The rehabilitation of degraded areas involves importing large quantities of fodder to feed thousands of sheep, as well as establishing forage crops over extensive degraded lands to convert them into irrigated pastures. Additionally, grazing activities are organized and regulated over carefully managed areas in a systematic manner.

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