African Journal of Advanced Pure and Applied Sciences (AJAPAS)
Online ISSN: 2957-644X
Volume 5, Issue 3, 2026
Page No: 352-359
Website: *https://aaasjournals.com/index.php/ajapas/index*
ISI 2025: 1.126 **SJIFactor 2024: 6.752** **معامل التأثير العربي: 1.62**

A Regional Baseline Assessment of Natural Vegetation Degradation in Al-Jabal Al-Akhdar Region, Northeastern Libya

Khaled Elmeer [1*] , Abdalla Zaied [2]
[1] Libyan Authority for Scientific Research, Tripoli, Libya
[2] Omar Al Mukhtar University, Al Bayda, Libya

تقييم مرجعي إقليمي لتدهور الغطاء النباتي الطبيعي في منطقة الجبل الأخضر، شمال شرق ليبيا

خالد المير [1*]، عبد الله زايد [2]
[1] الهيئة الليبية للبحث العلمي، طرابلس، ليبيا
[2] جامعة عمر المختار، البيضاء، ليبيا

[*]*Corresponding author: Elmeer@gmail.com*

Received: May 23, 2026	Accepted: August 14, 2026	Published: August 24, 2026

Abstract:
Al-Jabal Al-Akhdar in northeastern Libya represents one of the most ecologically significant Mediterranean ecosystems in North Africa, yet it has undergone progressive vegetation degradation over recent decades. This study presents a regional baseline assessment and synthesized case study of natural vegetation degradation, based on an extensive official multidisciplinary survey conducted by Omar Al-Mukhtar University. The assessment integrates multitemporal satellite imagery, GIS-based spatial analysis, and large-scale field investigations covering approximately 26,300 hectares across 55 representative sites distributed along three geomorphological terraces. Vegetation condition and degradation intensity were evaluated using internationally recognized indicators developed by FAO, UNEP, and IUCN, focusing on changes in canopy cover, vegetation density, regeneration capacity, and overall ecosystem vitality. Results reveal a substantial decline in natural vegetation compared with 1970s baselines. Evergreen forests dominated by Juniperus spp. experienced an estimated canopy cover reduction of 25–30%, shrublands declined by 15–20%, and rangeland productivity decreased by nearly 30%, while fire-affected areas expanded by approximately 40–50%. Degradation was most pronounced in coastal zones and the lower and middle geomorphological terraces, whereas selected upper terrace areas retained relatively better vegetation conditions. The observed patterns reflect the combined impacts of overgrazing, recurrent wildfires, land-use intensification, fragile soil conditions, and weak governance frameworks. This study offers a valuable reference framework for conservation planning, ecosystem restoration, and land degradation neutrality initiatives in Mediterranean environments under increasing climatic and anthropogenic pressures.

Keywords: Vegetation degradation, Regional baseline assessment, Al-Jabal Al-Akhdar, Remote sensing, GIS, Mediterranean ecosystems, Land degradation neutrality.

الملخص
يُعدّ الجبل الأخضر في شمال شرق ليبيا واحدًا من أبرز النظم البيئية المتوسطية ذات الأهمية الإيكولوجية في شمال أفريقيا، غير أنه شهد على مدى العقود الماضية تدهورًا تدريجيًا ومطّردًا في غطائه النباتي الطبيعي. تقدّم هذه الدراسة تقييمًا مرجعيًا إقليميًا ودراسة حالة توليفية لظاهرة تدهور الغطاء النباتي الطبيعي، استنادًا إلى مسح رسمي واسع النطاق ومتعدد التخصصات أجرته جامعة عمر المختار. ويعتمد هذا التقييم على تكامل الصور الفضائية متعددة الأزمنة، والتحليل المكاني بنظم المعلومات الجغرافية، إلى جانب دراسات ميدانية موسّعة غطّت نحو 26,300 هكتار، موزّعة على 55 موقعًا تمثيليًا على امتداد ثلاث مصاطب جيومورفولوجية. وقد جرى تقييم حالة الغطاء النباتي وشدة تدهوره باستخدام مؤشرات معتمدة دوليًا، طوّرتها منظمة الأغذية والزراعة (الفاو)، وبرنامج الأمم المتحدة للبيئة، والاتحاد الدولي لحفظ الطبيعة، مع التركيز

على التغيرات في الغطاء التاجي، وكثافة الغطاء النباتي، والقدرة على التجدد الطبيعي، والحيوية العامة للنظام البيئي. وتكشف النتائج عن تراجع ملموس في الغطاء النباتي الطبيعي مقارنة بخط الأساس المرجعي لسبعينيات القرن الماضي؛ إذ سجّلت الغابات دائمة الخضرة التي يهيمن عليها جنس العرعر (Juniperus spp) انخفاضًا في الغطاء التاجي يتراوح بين 25% و30%، فيما تراجعت الأراضي الشجرية بنسبة تتراوح بين 15% و20%، وانخفضت إنتاجية المراعي بنحو 30%، في حين اتسعت رقعة المناطق المتضررة من الحرائق بنسبة تتراوح بين 40% و50%. وقد كان التدهور أكثر وضوحًا في المناطق الساحلية وفي المصطبتين الجيومورفولوجيتين السفلى والوسطى، في حين حافظت بعض مواقع المصطبة العليا على حالة نباتية أفضل نسبيًا. وتعكس هذه الأنماط المرصودة جملة من العوامل، أبرزها الرعي الجائر، وتكرار حرائق الغابات، وتكثيف استخدامات الأراضي، وهشاشة خصائص التربة، فضلًا عن ضعف الأطر الحوكمية. ومن خلال توفير خط أساس تاريخي محدد مكانيًا، وتوليف متكامل يجمع بين الأبعاد الإيكولوجية والبيئية-الاجتماعية، تقدّم هذه الدراسة إطارًا مرجعيًا ذا قيمة لتخطيط الحفظ، وإعادة التأهيل الإيكولوجي، ومبادرات تحييد أثر تدهور الأراضي، في البيئات المتوسطية التي تتزايد فيها الضغوط المناخية والبشرية.

الكلمات المفتاحية: تدهور الغطاء النباتي؛ التقييم المرجعي الإقليمي؛ الجبل الأخضر؛ الاستشعار عن بُعد؛ نظم المعلومات الجغرافية؛ النظم البيئية المتوسطية؛ تحييد أثر تدهور الأراضي.

Introduction

Mediterranean ecosystems play a critical role in biodiversity conservation, soil stabilization, hydrological regulation, and climate mitigation. Across the Mediterranean basin, vegetation degradation has intensified due to the combined effects of climatic stress and persistent anthropogenic pressures such as land-use change, overgrazing, and recurrent wildfires [1, 2], as highlighted in recent global and Mediterranean-scale assessments [3].

Remote sensing and Geographic Information Systems (GIS) have become essential tools for monitoring vegetation dynamics and land degradation in arid and semi-arid environments, enabling long-term regional assessments [4, 5], with recent reviews emphasizing their effectiveness for long-term vegetation monitoring in Mediterranean and dryland ecosystems [6]. In North Africa, evergreen forest ecosystems dominated by Juniperus species are particularly sensitive to drought and human disturbance, which reduce ecosystem resilience and regeneration capacity [7].

Al-Jabal Al-Akhdar in northeastern Libya (Figure 1) constitutes the only extensive evergreen forest belt along the southern Mediterranean coast between the Atlas Mountains and the Levant. Despite occupying less than 1% of Libya's total area, the region hosts more than half of the country's plant biodiversity. However, accelerating land-use change, grazing pressure, and wildfire occurrence have significantly degraded natural vegetation, threatening ecosystem services and regional environmental stability.

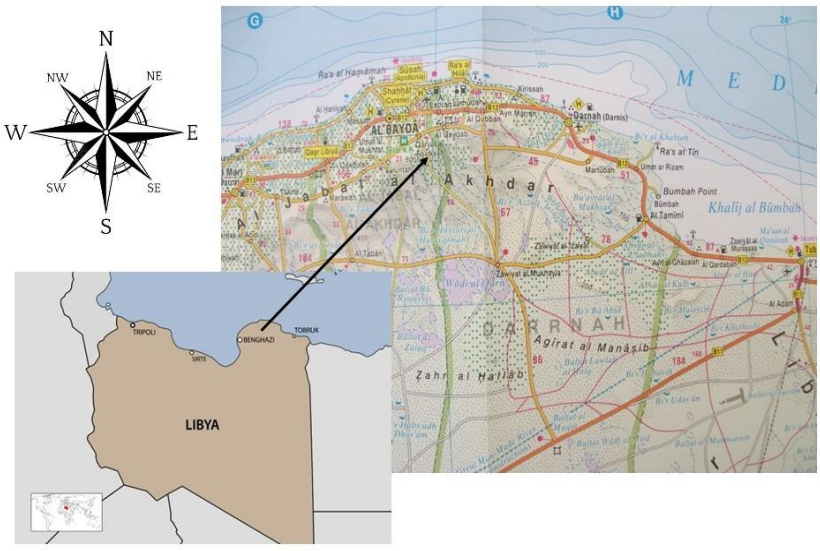

Figure 1: Location map of the Al-Jabal Al-Akhdar region, northeastern Libya.

This paper presents a synthesized scientific assessment derived from an official technical committee report prepared by Omar Al-Mukhtar University [8]. It is framed as a regional baseline and case study intended to support long-term vegetation monitoring, restoration planning, and land degradation neutrality efforts across Mediterranean environments. The following sections describe the study area, the methodological framework

applied by the original assessment team, and the resulting findings, before discussing their broader implications for regional conservation and land management.

Material and methods

Study area. Al-Jabal Al-Akhdar is located in northeastern Libya (32°-33° N, 20°-23° E), bordered by the Mediterranean Sea to the north and arid desert landscapes to the south. The region is characterized by rugged topography, including coastal plains, plateaus, valleys, and mountainous terrain. The climate is typically Mediterranean, with semi-humid conditions in northern highlands and semi-arid conditions toward the southern margins; mean annual rainfall averages approximately 400 mm, reaching up to 650 mm in elevated areas such as Shahat, and declining sharply southward. The region comprises three main geomorphological terraces differing in elevation, soil properties, and microclimatic conditions, which support diverse vegetation assemblages, including evergreen forests, shrublands, and natural rangelands, as well as a rich diversity of medicinal and aromatic plant species.

Study team, temporal framework, and spatial coverage. The original assessment was conducted by a multidisciplinary scientific team formed under the supervision of Omar Al-Mukhtar University. The team comprised 54 members, including senior experts and technical assistants, whose expertise spanned vegetation ecology, forestry, rangeland management, soil science, plant protection, environmental sciences, geography, remote sensing, GIS, and socio-environmental studies. This collaborative structure was designed to integrate biophysical and human-induced drivers of vegetation degradation by combining field-based ecological observations with spatial analyses. The study was conducted over an extended period, from June 2002 to December 2004, allowing vegetation conditions to be assessed across multiple seasons and strengthening the reliability of temporal comparisons and degradation evaluations.

Scope and domains of the study. The assessment was structured around five core thematic domains: (1) map preparation and production, including spatial data processing and cartographic analysis; (2) soil studies, focusing on soil properties, erosion processes, and land degradation characteristics; (3) forest and rangeland studies, addressing vegetation structure, composition, productivity, and regeneration; (4) plant disease and pest studies, assessing biotic stressors affecting natural vegetation systems; and (5) social studies, examining human activities, land-use practices, and socio-economic drivers of vegetation degradation.

Sampling design and study sites. Based on geomorphological and altitudinal gradients, the study area was divided into three main geomorphological terraces, which served as the primary spatial units for field surveys and spatial analysis. The lower terrace (0–200 m a.s.l.) included 8 representative sites across coastal and low-elevation zones, covering approximately 2,814 hectares. The middle terrace (200–450 m a.s.l.) comprised 22 representative sites characterized by mixed forest and shrubland systems, covering approximately 6,678 hectares. The upper terrace (>450 m a.s.l.) included 25 representative sites dominated by evergreen woody vegetation and relatively less disturbed ecosystems, covering approximately 16,813 hectares. In total, 55 representative sites were surveyed, with a combined area of approximately 26,305 hectares, providing a robust spatial basis for assessing vegetation condition, degradation intensity, and ecosystem variability across the region.

Remote sensing and GIS analysis. Multitemporal Landsat satellite imagery was processed to analyze vegetation cover patterns and land-use changes. Image preprocessing included radiometric and geometric correction, classification, and spatial overlay analysis. GIS techniques were applied to estimate vegetation cover extent and identify spatial degradation hotspots [4, 9], following widely adopted multi-temporal Landsat-based approaches for land degradation detection [10]. Recent Mediterranean wildfire mapping approaches based on Sentinel-2 and Landsat imagery were considered to interpret burned-area dynamics and post-fire recovery patterns [11, 12].

Field surveys. Field surveys were conducted across representative sites to assess vegetation structure and ecosystem condition. Parameters included tree and shrub density, canopy cover, natural regeneration potential, and visible soil degradation indicators. These observations were used to validate satellite-derived results and improve the accuracy of spatial interpretation.

Degradation indicators. Vegetation degradation was evaluated using internationally recognized criteria developed by FAO, UNEP, and IUCN [4, 13], focusing on declines in vegetation density, canopy fragmentation, regeneration capacity, and overall ecosystem vitality.

Results and discussion

Mapping and cartographic studies. The cartographic and remote sensing analyses revealed a clear decline in natural vegetation cover across Al-Jabal Al-Akhdar region when compared with historical aerial photographs and satellite imagery. The integration of GIS enabled accurate delineation of the study area boundaries, classification of vegetation units, and spatial monitoring of changes in vegetation density and distribution. Marked spatial variability was observed among the three geomorphological terraces: the lower terrace and coastal zones exhibited the most pronounced degradation, while portions of the upper terrace retained relatively better vegetation condition. Spatial analyses also identified degradation hotspots strongly associated with recurrent wildfires, overgrazing, agricultural expansion, and urban development, providing a critical planning tool for prioritizing conservation and restoration interventions. Spatial analysis revealed a substantial reduction in forested areas compared to historical records from the 1970s, accompanied by an expansion of degraded rangelands and fire-affected zones, indicating progressive fragmentation of natural vegetation.

Soil studies. Soil investigations indicated that much of the region is characterized by shallow soil profiles, high rock and gravel content, and strong susceptibility to water erosion, particularly on sloping terrain. The removal or degradation of natural vegetation cover was found to directly accelerate erosion processes, leading to rapid soil loss and further limiting vegetation recovery. Physical and chemical analyses showed that soils are predominantly clayey to silty-clay in texture, generally calcareous, and low in salinity; however, organic matter content and plant-available water were consistently low, constraining plant growth. Five major soil orders were identified across the study area, reflecting substantial edaphic diversity coupled with high ecological fragility. The study also highlighted the positive role of traditional stone terraces and water-harvesting structures in reducing erosion and locally improving soil properties, particularly within wadis, emphasizing the importance of conserving and rehabilitating such structures as part of sustainable land management strategies.

Forest and rangeland studies. Forest and rangeland assessments indicate that evergreen woody vegetation dominated by Juniperus spp. forms the core component of the natural ecosystem. Field observations and spatial analyses revealed a general decline in tree density, canopy cover, and vitality across many sites, particularly within coastal zones and the lower and middle geomorphological terraces, while selected areas of the upper terrace retained comparatively healthier vegetation conditions. Juniperus spp. was identified as both the most widespread and the most vulnerable woody species, being strongly affected by recurrent wildfires, uncontrolled cutting, and grazing pressure. Natural regeneration showed limited recovery potential in protected or minimally disturbed areas, whereas regeneration was weak or absent on steep slopes and in heavily grazed sites. These spatial patterns correspond closely with the distribution of vegetation cover types shown in Figure 2, which illustrates the concentration of woody vegetation in upper terrace areas and its fragmentation toward lower elevations.

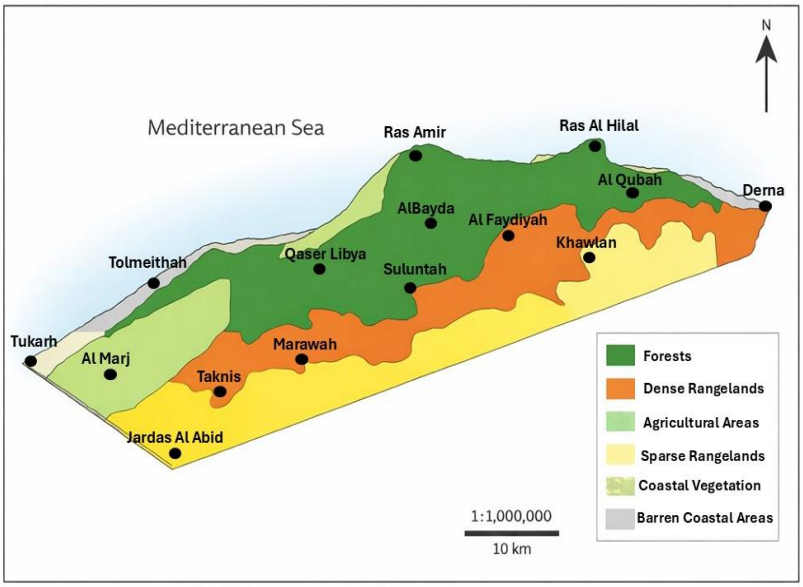

Figure 2: Spatial distribution of natural vegetation cover types across the study area.

Rangeland assessments further revealed a pronounced decline in forage productivity, particularly south of the main woody vegetation belt. Continuous overgrazing and seed depletion promoted the dominance of low-palatability species, while annual herbaceous productivity remained relatively higher within forested areas, highlighting the close ecological linkage between woody cover and rangeland condition. Temporal comparison between historical aerial photographs from the 1970s and field-based assessments conducted during the early 2000s confirms a marked decline in natural vegetation cover across the study area. As summarized in Table 1, evergreen forests experienced an estimated reduction of approximately 25–30% in canopy cover, shrublands declined by about 15–20%, and natural rangelands showed a decrease in productivity of nearly 30%. In contrast, fire-affected areas expanded substantially, increasing by an estimated 40–50%. Overall, the combined field and spatial evidence demonstrates that vegetation degradation in Al-Jabal Al-Akhdar is spatially heterogeneous and closely associated with geomorphological position and disturbance intensity, with lower and middle terraces exhibiting the most pronounced deterioration.

Table 1: Temporal changes in natural vegetation cover in Al-Jabal Al-Akhdar, northeastern Libya (1970s–early 2000s).

Vegetation component	1970s condition	Early 2000s condition	Estimated change
Evergreen forests (Juniperus-dominated)	Dense, continuous cover	Fragmented, reduced canopy	-25 to -30%
Shrublands	Moderately intact	Partially degraded	-15 to -20%
Natural rangelands	High productivity	Low cover, invasive dominance	-30% productivity
Fire-affected areas	Limited extent	Expanded and recurrent	+40 to +50%

Plant disease and pest studies. The assessment documented the presence of several plant diseases and pest organisms affecting natural vegetation, particularly juniper, Pistacia, Juniperus phoenicea, wild olive, and other dominant woody species. Common symptoms included dieback, leaf spotting, branch mortality, abnormal growth, and extensive lichen colonization on weakened or dead trees. Various insect pests and non-insect organisms were recorded, some of which contribute to physiological stress or act as vectors for pathogenic agents; nematodes were also detected in several soil samples. Overall, the deterioration of plant health was found to be more strongly associated with environmental stressors such as drought, poor soil conditions, and human disturbance than with a single dominant pathogen. The absence of systematic monitoring and integrated pest management programs was identified as a key factor exacerbating vegetation decline under increasing environmental stress.

Social studies. Social studies confirmed that human activities represent the primary driving force behind natural vegetation degradation in the region. Rapid population growth, unregulated agricultural expansion, and urban development have intensified pressure on forests and rangelands. Traditional land tenure systems, weak regulation of grazing practices, charcoal production, and deliberate burning for agricultural or grazing purposes have significantly contributed to vegetation loss, while survey results also indicated limited environmental awareness among some community groups, coupled with insufficient enforcement of environmental legislation. Conversely, the findings highlighted the critical role of households, educational institutions, religious organizations, and governmental bodies in promoting environmental awareness and conservation practices; the social dimension was identified as a decisive factor in the success of any long-term vegetation management and restoration strategy.

Integrated synthesis. The results across the five thematic domains demonstrate that vegetation degradation in Al-Jabal Al-Akhdar arises from complex interactions between natural environmental constraints and escalating anthropogenic pressures. Despite its high biodiversity value, the regional ecosystem remains highly fragile and sensitive to disturbance. These findings underscore the urgent need for an integrated management approach that combines spatial planning, soil conservation, sustainable forest and rangeland management, disease and pest monitoring, and strong community engagement to safeguard the natural vegetation resources of Al-Jabal Al-Akhdar and ensure their sustainability for future generations.

Integrated field, spatial, and temporal analyses indicate that natural vegetation degradation in Al-Jabal Al-Akhdar results from the interaction between inherent biophysical fragility and intensified human pressure. Evergreen woody vegetation dominated by Juniperus spp. exhibits marked declines in density and canopy cover, particularly within coastal zones and the lower and middle geomorphological terraces. These patterns are

consistent with trends widely reported across Mediterranean ecosystems, where overgrazing, recurrent wildfires, and land-use intensification have reduced forest resilience and altered vegetation structure [7, 11, 14].

The spatial distribution of vegetation cover types (Figure 2) reveals a clear geomorphological gradient, with relatively intact woody vegetation concentrated in upper terrace areas and increasing fragmentation toward lower elevations. Temporal comparisons (Table 1) indicate an estimated 25–30% reduction in evergreen forest canopy cover since the 1970s, alongside declines of 15–20% in shrublands and nearly 30% in rangeland productivity. The substantial expansion of fire-affected areas (40–50%) highlights the role of fire as a major disturbance amplifier under increasing climatic stress [15].

Soil conditions further exacerbate degradation processes, as shallow, rocky, erosion-prone soils with low organic matter and limited plant-available water constrain vegetation recovery and reinforce negative soil–vegetation feedbacks [16, 17]. In contrast, traditional stone terraces and water-harvesting structures demonstrate clear potential for reducing erosion and improving local soil conditions, consistent with Mediterranean restoration studies [2].

Plant health deterioration appears primarily stress-driven rather than pathogen-specific, reflecting drought, poor soils, and human disturbance, a pattern commonly observed in Mediterranean forests under climate stress [18]. Social drivers including unregulated grazing, land-use change, and weak governance emerge as dominant underlying factors, underscoring that effective restoration requires integrated ecological management, strengthened institutions, and community engagement to achieve land degradation neutrality and ecosystem resilience under the Sustainable Development Goals [19]. These findings are consistent with regional Mediterranean degradation assessments emphasizing integrated land management and policy-driven restoration [2, 20].

Conclusion

The synthesized assessment confirms a clear decline in natural vegetation cover and ecosystem quality in Al-Jabal Al-Akhdar. Human-induced pressures, particularly overgrazing, wildfires, and uncontrolled land clearing, are the dominant drivers of degradation, while remaining areas of partial resilience offer opportunities for targeted restoration and conservation interventions. Addressing this decline will require a coordinated set of actions, including: strengthening governance and conservation frameworks by updating and enforcing environmental legislation and establishing protected areas; enhancing monitoring and scientific assessment through regular ecological surveys and continued application of remote sensing and GIS; promoting ecosystem restoration through afforestation, rangeland rehabilitation, and grazing regulation; conserving native, medicinal, and aromatic plant genetic resources; improving water resource management through rainwater harvesting and wastewater reuse; and strengthening community engagement and regional cooperation, particularly within the Mediterranean region. Taken together, these measures offer a practical pathway for safeguarding one of North Africa's most ecologically significant Mediterranean ecosystems for future generations.

Compliance with ethical standards

Ethical statement

This article represents a scientific synthesis of an official technical report prepared by an academic committee at Omar Al-Mukhtar University. All data and findings are fully attributed to the original report, with no modification of results.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

Author contributions

All authors contributed to this work. The corresponding author was primarily responsible for writing, organizing, and summarizing the manuscript, while the co-author provided constructive feedback, edited the document, and contributed other related work.

Disclosure of conflict of interest

The author(s) declare that they have no conflict of interest.

References

[1] Á. Enríquez-de-Salamanca, "Expected impacts on Mediterranean forest species under climate change," Climate, vol. 13, no. 2, p. 41, 2025. https://doi.org/10.3390/cli13020041

[2] F. Ziadat, G. Conchedda, F. Haddad, J. Njeru, A. Brès, M. Dawelbait, and L. Li, "Desertification and agrifood systems: restoration of degraded agricultural lands in the Arab region," Agriculture, vol. 15, no. 12, p. 1249, 2025. https://doi.org/10.3390/agriculture15121249

[3] M. Cherlet, C. Hutchinson, J. Reynolds, J. Hill, S. Sommer, and G. von Maltitz, Eds., World Atlas of Desertification, 3rd ed. Luxembourg: Publication Office of the European Union, 2018. https://doi.org/10.2760/06292

[4] G. Dadhich, B. Nwer, F. Chenini, H. Aboelsoud, R. Jalal, F. Sarvia, C.A. Rodas, M. Abdourahman, F. Mushtaq, and M. Henry, "Land cover and crop type mapping of Libya for the period 2022–2023," FAO, Rome, 2025. https://doi.org/10.4060/cd1312en

[5] T. Hegazy, M. Abd El Galil, R.M. Abou Samra, M.T. Mohamed, and S.S. Al Saleh, "Detecting NDVI and LST in the municipalities of Al Jabal Al Akhdar region, Libya, using remote sensing and GIS," Scientific Journal for Damietta Faculty of Science, vol. 12, no. 1, pp. 63–70, 2022.

[6] X. Ziang, C. Zhang, S. Feng, F. Zhang, H. Cai, M. Tang, and J. Kong, "Reviews of methods for vegetation phenology monitoring from remote sensing data," Remote Sensing Technology and Application, vol. 38, no. 1, pp. 1–14, 2023. https://doi.org/10.11873/j.issn.1004-0323.2023.1.0001

[7] R.F. El-Barougy, M.A. Dakhil, M.W.A. Halmy, M. Cadotte, S. Dias, E.A. Farahat, A. El-keblawy, and L.F. Bersier, "Potential extinction risk of Juniperus phoenicea under global climate change: towards conservation planning," Global Ecology and Conservation, vol. 46, p. e02541, 2023. https://doi.org/10.1016/j.gecco.2023.e02541

[8] Omar Al-Mukhtar University, "A study and evaluation of the natural vegetation cover in the Green Mountain region," Committee Final Report, Al-Bayda, Libya, 2005, pp. 1–946.

[9] S. Elshatshat and F. Alsaeh, "Using GIS and NDVI applications to evaluate Storm Daniel impacts on El-Gabal El-Akhdar area, Libya: Wadi El-kof as example," Humanities & Natural Sciences Journal, vol. 5, no. 2, pp. 241–251, 2024. https://doi.org/10.53796/hnsj52/16

[10] C. Liu, H. Huang, J.M. Melack, Y. Tian, J. Jiang, X. Fu, Z. Cao, and S. Wang, "Assessing land degradation and restoration in Eastern China grasslands from 1985 to 2018 using multitemporal Landsat data," IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 17, pp. 19328–19342, 2024. https://doi.org/10.1109/JSTARS.2024.3483992

[11] R. Tiengo, S. Merino-De-Miguel, J. Uchôa, N. Guiomar, and A. Gil, "Burned areas mapping using Sentinel-2 data and a Rao's Q index-based change detection approach: a case study in three Mediterranean islands' wildfires (2019–2022)," Remote Sensing, vol. 17, no. 5, p. 830, 2025. https://doi.org/10.3390/rs17050830

[12] F. Boudjemline, "Mapping and assessing forest fire severity using remote sensing indices: a case study of Tizi Ouzou, Algeria," SSRN, 2021.

[13] L.M. Bland, E. Nicholson, R.M. Miller, A. Andrade, A. Carré, A. Etter, J.R. Ferrer-Paris, B. Herrera, T. Kontula, A. Lindgaard, and P. Pliscoff, "Impacts of the IUCN Red List of Ecosystems on conservation policy and practice," Conservation Letters, vol. 12, no. 5, p. e12666, 2019. https://doi.org/10.1111/conl.12666

[14] J.M. García-Ruiz, E. Nadal-Romero, N. Lana-Renault, and S. Begueria, "Erosion in Mediterranean landscapes: changes and future challenges," Geomorphology, vol. 198, pp. 20–36, 2013. https://doi.org/10.1016/j.geomorph.2013.05.023

[15] S. van der Esch, A. Sewell, M. Bakkenes, E. Berkhout, J.C. Doelman, E. Stehfest, C. Langhans, L. Fleskens, A. Bouwman, and B. Ten Brink, "The global potential for land restoration: scenarios for the Global Land Outlook 2," PBL Netherlands Environmental Assessment Agency, The Hague, 2022.

[16] R. Lal, "Soil quality and sustainability," in Methods for Assessment of Soil Degradation, Boca Raton, FL: CRC Press, 2020, pp. 17–30.

[17] M.J. Riva, I.N. Daliakopoulos, S. Eckert, E. Hodel, and H. Liniger, "Assessment of land degradation in Mediterranean forests and grazing lands using a landscape unit approach and the normalized difference vegetation index," Applied Geography, vol. 86, pp. 8–21, 2017. https://doi.org/10.1016/j.apgeog.2017.06.017

[18] R.M. Navarro-Cerrillo and A.J. Ariza-Salamanca, "Uncovering hazards and adaptive capacity: a comprehensive risk assessment study in three conservation areas in Spain," Forest Ecology and Management, vol. 572, p. 122324, 2024. https://doi.org/10.1016/j.foreco.2024.122324

[19] IPBES, The IPBES Assessment Report on Land Degradation and Restoration, Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2018. https://doi.org/10.5281/zenodo.3237393

[20] F.M. Ziadat, P. Zdruli, S. Christiansen, L. Caon, M. Abdel Monem, and T. Fetsi, "An overview of land degradation and sustainable land management in the Near East and North Africa," Sustainable Agriculture Research, vol. 11, no. 1, pp. 11–24, 2022. https://doi.org/10.5539/sar.v11n1p11

