Wadi Alshatti University Journal of Pure and Applied Sciences

مجلة جامعة وادي الشاطئ للعلوم البحتة و التطبيقية

Volume 4, No. 2, July-December 2026 Online ISSN: 3006-0877 المجلد 4، الاصدار 2، يوليو-ديسمبر 2026

RESEARCH PAPER **COMPUTER SCIENCE**

Geochemical Approaches to Combating Desertification and Enhancing Sustainable Development in Libya

Osama R. Shaltami[1,*], Mustafa A. Ben Hkoma[2], Kamal A. Almahdi[3], Firas K. Mohammed[3], Mansour Salem[4], Yasser F. Nassar[5]

[1]Department of Earth Sciences, Faculty of Science, Benghazi University, Libya
[2]Sustainable Development Research Center, Ubari, Libya
[3]Department of Earth Sciences, Faculty of Science, Omar Al-Mukhtar University, Libya
[4]Department of Environmental Sciences, faculty of Environment and Natural Resources, Wadi Alshatti University, Brack, Libya
[5]Department of Mechanical and Renewable Energy Engineering, Wadi Alshatti University, Brack, Libya

ARTICLE HISTORY

Received 12 May 2026
Revised 15 July 2026
Accepted 20 July 2026
Online 01 August 2026

KEYWORDS

Combating Desertification;
Geochemical Approaches;
Remote Sensing;
Geographic Information System;
Sustainable Development;
Libya.

ABSTRACT

One of Libya's biggest environmental problems is desertification, which is caused by the country's arid and semi-arid climate, low rainfall, high temperatures and evaporation, drought, groundwater depletion, soil salinization, wind erosion, vegetation degradation, and unsustainable land-use practices. The potential of geochemical methods for comprehending, tracking, and preventing desertification as well as promoting sustainable development in Libya is assessed in this study. In order to examine climatic and environmental changes from 2000 to 2025 and their implications for future desertification, the study combines geochemical examination of soil and groundwater with satellite remote sensing and spatial analysis. Temperature, rainfall, and vegetation-cover variations were investigated using MODIS Terra land surface temperature (LST), NASA GPM IMERG precipitation, and Landsat data. With average July LST rising from roughly 29.6°C in 2000 to 34.3°C in 2025 and yearly rainfall falling from 98.6 to 55.2 mm, the results show a significant warming trend. Additionally, there is a general decrease in vegetation cover, especially in inland agricultural areas, oasis systems, and portions of mountainous and coastal regions. By 2050, almost 80% of Libya's geographical area might undergo high to intense desertification, according to a business-as-usual forecast. For evaluating soil fertility, salinity, nutrient availability, pollutant movement, groundwater quality, water–rock interactions, and seawater intrusion, geochemical techniques offer useful instruments. As a foundation for sustainable land and water management, the study highlights the combination of geochemistry, remote sensing, GIS, sophisticated analytical technologies, isotopic techniques, and data science.

المقاربات الجيوكيميائية لمكافحة التصحر وتعزيز التنمية المستدامة في ليبيا

أسامة رحيل الشلطامي[1,*]، مصطفى بن حكومة[2]، كمال أبراهيم المهدي[3]، فراس خميس محمد[3]، منصور عويدات سالم[4]، ياسر فنحي نصَّار[5]

الكلمات المفتاحية

مكافحة التصحر
المناهج الجيوكيميائية
الاستشعار عن بُعد
نظم المعلومات الجغرافية
التنمية المستدامة
ليبيا

الملخص

تُقيّم هذه الدراسة إمكانات استخدام الأساليب الجيوكيميائية في فهم ظاهرة التصحر وتتبعها والوقاية منها، فضلاً عن تعزيز التنمية المستدامة في ليبيا. ولغرض دراسة التغيرات المناخية والبيئية في الفترة الممتدة من عام 2000 إلى عام 2025 وتداعياتها على التصحر في المستقبل، تجمع الدراسة بين التحليل الجيوكيميائي للتربة والمياه الجوفية وبين تقنيات الاستشعار عن بُعد عبر الأقمار الصناعية والتحليل المكاني. وقد جرى فحص التغيرات في درجات الحرارة وهطول الأمطار والغطاء النباتي بالاستناد إلى بيانات مستشعر الخاص بدرجة حرارة سطح الأرض، وبيانات هطول الأمطار من مهمة التابعة لوكالة ناسا، وبيانات الأقمار الصناعية. وأظهرت النتائج اتجاهاً ملحوظاً نحو الاحترار، حيث ارتفع متوسط درجة حرارة سطح الأرض في شهر يوليو من حوالي 29.6 درجة مئوية في عام 2000 إلى 34.3 درجة مئوية في عام 2025، بينما انخفض معدل هطول الأمطار السنوي من 98.6 ملم إلى 55.2 ملم. وبالإضافة إلى ذلك، لوحظ انخفاض عام في الغطاء النباتي، لا سيما في المناطق الزراعية الداخلية، وأنظمة الواحات، وأجزاء من المناطق الجبلية والساحلية. وتشير التوقعات المبنية على استمرار الأوضاع الراهنة (سيناريو "العمل كالمعتاد") إلى أن ما يقرب من 80% من مساحة ليبيا الجغرافية قد تتعرض لمستويات تتراوح بين التصحر المرتفع والشديد بحلول عام 2050. وتوفر التقنيات الجيوكيميائية أدوات مفيدة لتقييم خصوبة التربة، والملوحة، وتوفر العناصر الغذائية، وحركة الملوثات، وجودة المياه الجوفية، وتفاعلات المياه والصخور، وتداخل مياه البحر. وتُبرز الدراسة أهمية الجمع بين الجيوكيمياء، والاستشعار عن بُعد، ونظم المعلومات الجغرافية (GIS)،

*Corresponding author
https://doi.org/10.63318/waujpasv4i2_19

والتقنيات التحليلية المتقدمة، والتقنيات النظائرية، وعلم البيانات، لتشكل جميعها ركيزة أساسية للإدارة المستدامة للأراضي والموارد المائية.

Introduction

The phenomenon of desertification involves the transformation of productive lands into less fertile regions due to various climatic changes coupled with human activities. This usually happens in drylands such as arid and semi-arid areas [1-8]. The process of stopping, managing, and reversing land deterioration in order to preserve productive ecosystems and promote sustainable development is known as combating desertification [9-15].

Libya is a state located in North Africa covering an area of about 1.76 million km^2 and having mostly dry and semiarid climates. The region receives low levels of rainfall, with high levels of evaporation and poor availability of renewable sources of water. The environmental threat faced by Libya is desertification. Soil salinization, wind erosion, sand dune migration, groundwater depletion, vegetation degradation, climate change impacts, and unsustainable land-use practices are some of the current environmental stresses. The natural factors leading to desertification in Libya include low yearly rainfall, high temperature and evaporation rates, climate change, wind activities, and drought cycles. The human activities contributing to desertification include overgrazing, inefficient irrigation practices, over-reliance on groundwater, deforestation, urbanization, and mismanaged agricultural practices.

A number of local researchers have evaluated desertification, soil fertility, salinity, nutrient availability, pollutant movement, groundwater quality, water–rock interactions, floods, and seawater intrusion in Libya [16-36]. Geochemical studies offer critical insights into soil characteristics, nutrient cycles, contaminant migration, and environmental alterations. Such studies can facilitate sustainable resource management and restoration efforts.

Objective

The primary goal of this study is to assess how geochemical methods might help Libya fight desertification and advance sustainable development. Specific aims are to:

(1) Evaluate Libya's recent rainfall and temperature patterns from 2000 to 2025.

(2) Look at how variations in vegetation cover relate to human activity and climatic variability.

(3) Consider a business-as-usual scenario and assess the possible spatial development of desertification through 2050.

(4) Show how soil and groundwater geochemistry can be applied to environmental management and desertification assessment.

(5) Determine the geochemical parameters that are helpful in assessing the degradation of soil fertility, salinity, nutrient availability, pollution, groundwater quality, water-rock interactions, and seawater intrusion.

(6) Examine new geochemistry technologies such as spectroscopy, isotope methods, nanotechnology, microbial and molecular tools, IoT sensor networks, portable geochemical analyzers, drone-based remote sensing, and AI/data modeling.

(7) List the main institutional, financial, technical, and environmental obstacles to the use of geochemical methods in Libya.

(8) Make recommendations for future directions in research and management that use data science, sophisticated analytical technologies, remote sensing, geochemistry, GIS, and sustainable land and water management.

Methodology

The study evaluates desertification and its effects on Libya's sustainable development using an integrated geochemical, remote sensing, and spatial analysis approach. From 2000 to 2025, the temporal and spatial evolution of climate conditions was evaluated. NASA GPM IMERG V07 satellite data was used to assess annual precipitation, whereas NASA MODIS Terra MOD11A2 was used to determine summer land surface temperature. These datasets were utilized to detect variations in rainfall and temperature as well as assess their possible role in escalating aridity and desertification. A business-as-usual scenario for 2050 was used to assess the regional distribution of desertification. Six categories were used to categorize the intensity of desertification, ranging from extensive to stable/non-desertified. Areas that would be vulnerable to serious land degradation, soil erosion, decreasing productivity, vegetation loss, water scarcity, biodiversity loss, and threats to food security were identified using the anticipated distribution. Both soil and groundwater systems are the focus of the geochemical component. Major and trace elements, heavy metals, organic matter, nutrient availability, and salinity are all used in soil evaluation as markers of soil quality and declining fertility. Salinity development, seawater intrusion, water-rock interactions, irrigation quality, and pollution sources are all taken into consideration while analyzing groundwater geochemistry. The study takes into account new technologies such as field-portable geochemical analyzers, drone-based remote sensing, spectroscopic soil analysis, isotope techniques, nanotechnology-based amendments, microbial and molecular tools, IoT sensor networks, and data integration with AI modeling that can enhance desertification monitoring and management. Finally, the environmental findings are related to sustainable-development priorities, including food security, water-resource protection, ecosystem conservation, poverty reduction, economic diversification, and climate resilience.

Results and Discussion

Temperature and Rainfall

The summer LST taken from MODIS (Fig. 1) shows a clear warming trend throughout Libya from 2000 to 2025. Between 2000 and 2025, the average LST rose by roughly 4.7°C, from roughly 29.6°C to 34.3°C. The warming is regionally diverse, with comparatively lower temperatures seen along the Mediterranean coastline zone and the largest rises focused throughout the middle and southern interior desert regions. Evapotranspiration, water stress, desertification, agricultural heat stress, and ecological degradation may all worsen as a result of the observed warming. Increasing surface temperatures further underscore the significance of managing water resources, developing Libya's solar energy potential, and adapting to climate change. Based on satellite precipitation data from NASA GPM IMERG V07, Fig. 2 illustrates a distinct declining trend in yearly rainfall in Libya between 2000 and 2025. The findings show a gradual decline in precipitation, with the southern and interior regions experiencing the biggest drops, while the Mediterranean coastal regions continue to be comparatively wetter. The total amount of rainfall dropped by about 43.4 mm, or 44%, from 98.6 mm in 2000 to 55.2 mm in 2025. An approximate linear drop of 1.74 mm/year, or roughly 17.4 mm per decade, is implied by the shown numbers. There doesn't seem to have been a significant turnaround in the drop throughout this time.

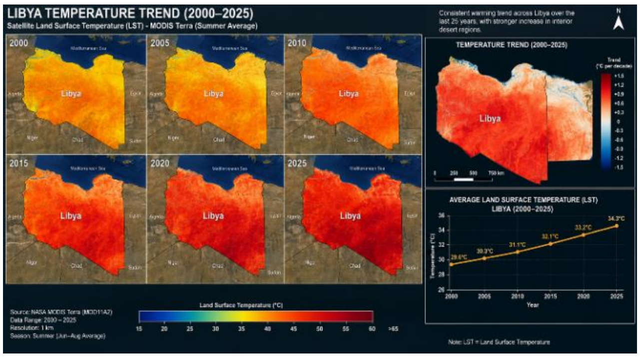

Figure 1: Spatial and temporal variation of LST across Libya from 2000 to 2025 derived from NASA MODIS Terra (MOD11A2) satellite data

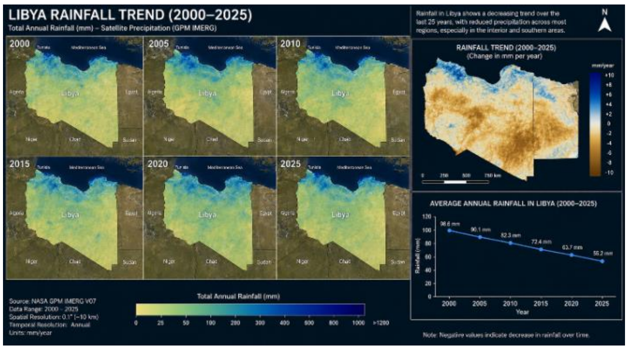

Figure 2: Spatial and temporal distribution of annual rainfall in Libya during 2000–2025 derived from NASA GPM IMERG V07 satellite precipitation data

Vegetation Cover

Al Jabal Al Akhdar, Jefara Plain, southern oasis, wadi systems, and coastal agricultural zones are where Libya's vegetation is primarily found (Fig. 3). In many areas, rising temperatures and decreasing precipitation have led to progressive vegetation degradation. A comparison of Landsat true-color satellite images taken in May, the peak growing season, between 2000 and 2025 is shown in Fig. 4, which shows how Libya's vegetation cover changed during a 25-year span. Inland valleys, sporadic oasis systems, the Jabal Al Akhdar region in northeastern Libya, the Jabal Nafusa region in the northwest, and the Mediterranean coastal belt are all included in the 2000 image. These regions have dark to moderate green hues, which are indicative of denser and healthier vegetation. The 2025 image, on the other hand, shows a discernible decline in the amount and density of vegetation throughout a large portion of the nation. Inland agricultural areas, the northwest coastal plain, and a number of oasis regions—where green vegetation has become more sparse and fragmented—are where the reduction is most noticeable. There are indications of vegetation degradation in the Jabal Al Akhdar region, even though it is still one of Libya's most vegetated areas. The comparison points to a general decline in vegetation cover during the study period, which is probably related to rising temperatures, decreasing precipitation, protracted drought, land degradation, and increasing pressure from human activities like urbanization, agricultural expansion, and groundwater depletion. In contrast to the hyper-arid interior, the persistence of vegetation in coastal and mountainous areas is a result of comparatively higher rainfall and more suitable climatic conditions. Assuming no further land management or climate adaption measures are put in place, Fig. 5 shows a predicted regional distribution of desertification throughout Libya by 2050 under a business-as-usual scenario. Six categories—from stable/non-desertified to extensive desertification—are used to categorize the severity of desertification. According to the prediction, desertification is predicted to worsen throughout a large portion of the nation, especially in the southern, southwestern, and southeastern regions, where large areas are categorized as having extremely high to extreme desertification. Due to the combined effects of increased aridity, extended drought, and environmental stress, these places are expected to experience severe land degradation, significant soil erosion, decreased soil productivity, and nearly total loss of natural vegetation. On the other hand, it is anticipated that the Mediterranean coastal belt, which includes portions of Tripoli, Benghazi, Al Bayda, and Tobruk, will continue to be relatively less affected, with the majority of these areas being categorized as either generally stable or mild to moderate desertification. In comparison to the country's core, the coast's more favorable climate—which is marked by more rainfall and milder temperatures—contributes to better vegetation persistence and less land degradation. The estimated land area data, which show that almost 45% of Libya's land area may experience acute desertification and 35% may be classified as very highly desertified, highlight the severity of future desertification. Less than 1% of the nation is predicted to remain stable or non-desertified, while only roughly 6% of the country is predicted to endure moderate desertification and 2% low desertification. By 2050, it is anticipated that over 80% of Libya's land area will experience high to intense desertification. According to these projections, Libya is likely to suffer significant environmental degradation, including decreased agricultural productivity, the growth of arid landscapes, more frequent dust storms, worsening water scarcity, biodiversity loss, and increased risks to food security and rural livelihoods, if current land-use and climate trends continue. In order to prevent further desertification, the map emphasizes the critical need for sustainable land management, ecosystem restoration, better water resource management, and climate change adaption techniques.

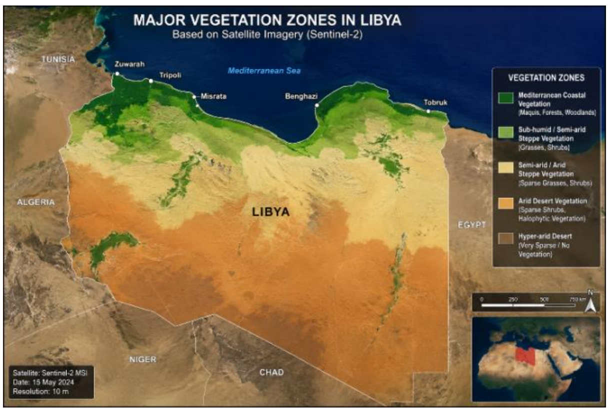

Figure 3: Satellite image showing the major vegetation zones in Libya

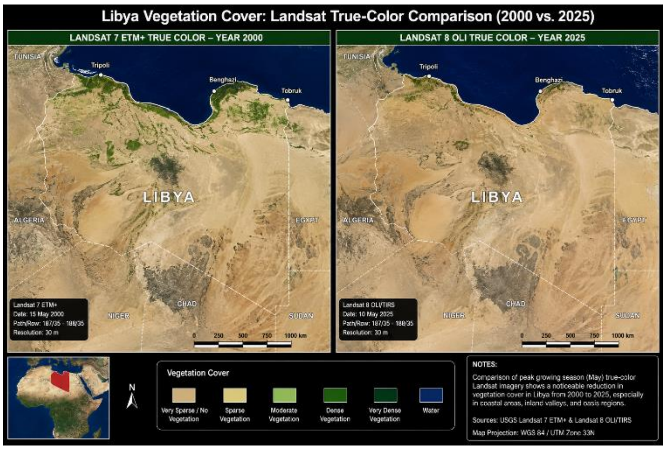

Figure 4: Landsat true-color images of vegetation cover in Libya (2000 vs. 2025)

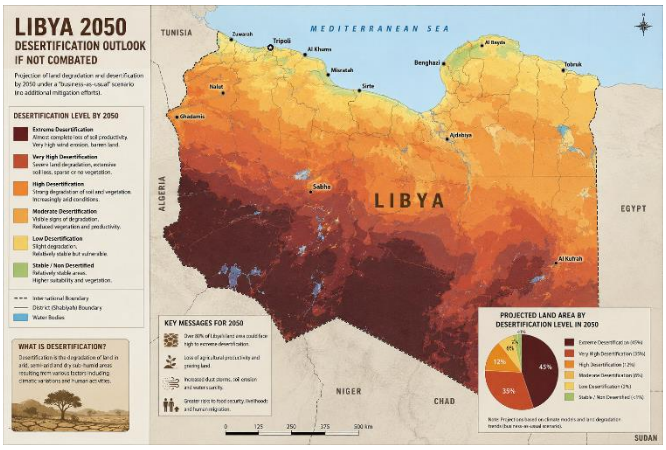

Figure 5: Projected desertification risk across Libya by 2050 under a business-as-usual climate and land-use scenario

Geochemical Approaches

The geochemical approaches to combating desertification and enhancing sustainable development in Libya can be explained in the flowchart shown in Fig. 6. Geochemistry can be useful for analyzing the problem of desertification because of the involvement of the geochemistry of soil and groundwater (Fig. 7). For soil geochemistry, major and trace elements (including heavy metals), organic matter, nutrient availability, and salinity are assessed. Soil fertility degradation can be inferred from these parameters. Moreover, salinity development, seawater intrusion, water-rock interactions, irrigation quality, and pollution sources are all evaluated in relation to groundwater geochemistry. The sustainability of agriculture is significantly impacted by groundwater quality. Geochemical approaches for combating desertification include soil quality monitoring, groundwater management, sustainable agriculture, and ecosystem restoration (Fig. 8). The emerging geochemical technologies for combating desertification include: (1) Field-portable geochemical analyzers; (2) Drone-based remote sensing; (3) Spectroscopic soil analysis; (4) Isotope techniques; (5) Nanotechnology-based amendments; (6) Microbial and molecular tools; (7) Sensor networks and internet of things (IoT); and (8) Data integration and AI modeling (Fig. 9).

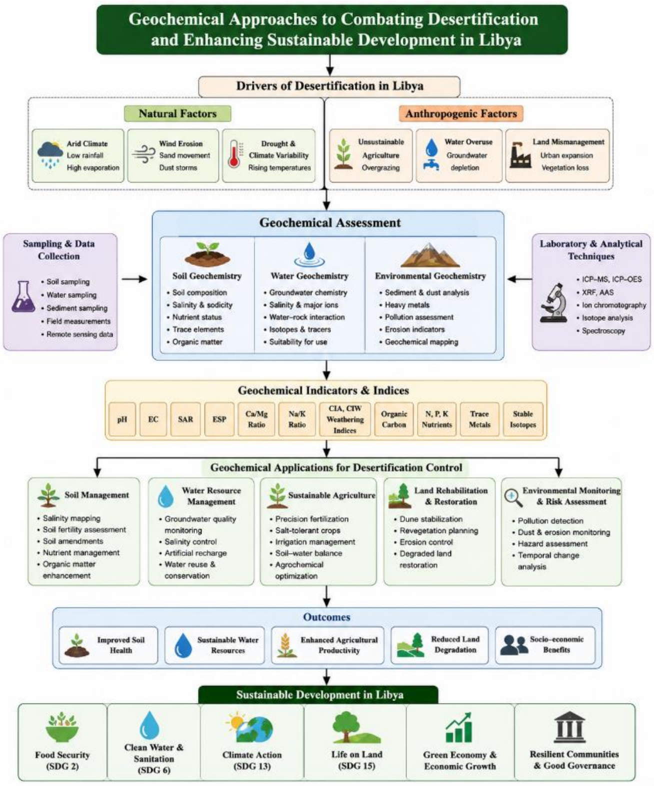

Figure 6: Flowchart for geochemical approaches to combating desertification and enhancing sustainable development in Libya

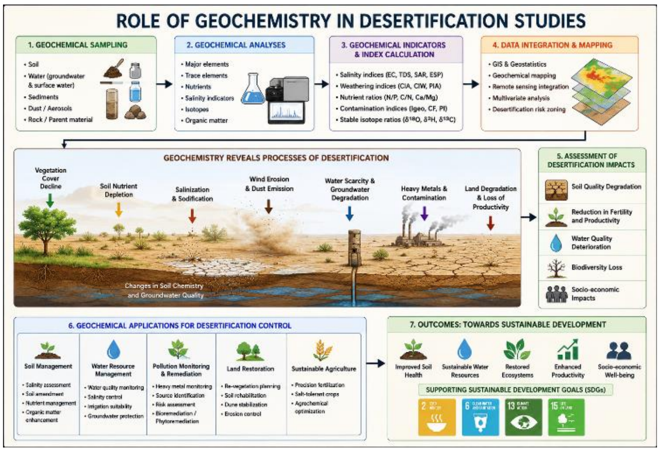

Figure 7: Role of geochemistry in desertification studies

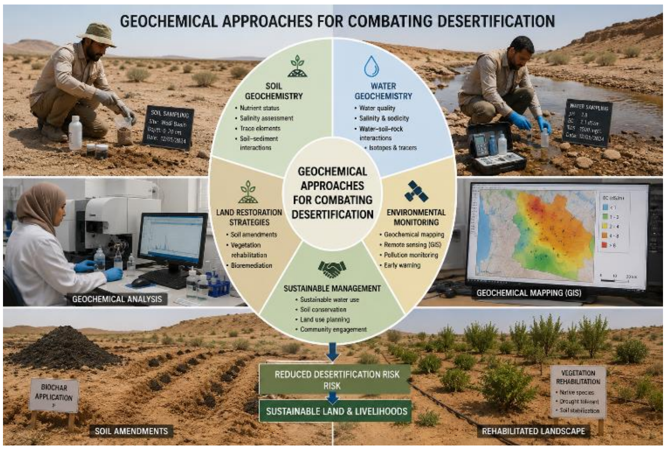

Figure 8: Geochemical approaches for combating desertification

Figure 9: Emerging geochemical technologies for combating desertification

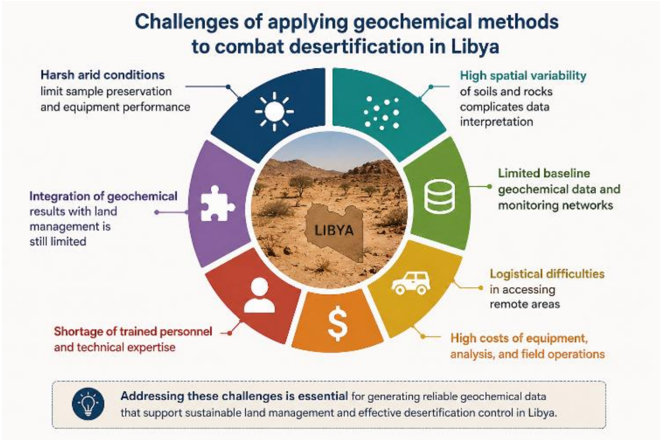

Figure 11: Challenges of applying geochemical methods to combat desertification in Libya

Sustainable Development Implications

Combating desertification contributes to sustainable development through food security, water resource protection, ecosystem conservation, poverty reduction, economic diversification, and climate resilience (Fig. 10).

Figure 10: The role of combating desertification in advancing sustainable development

There exist some issues that make the efforts to combating desertification difficult in Libya; these include lack of databases on soil geochemistry, weak environmental monitoring systems, inadequate laboratories, lack of funds and skilled personnel, organizational fragmentation, political instability, and lack of environmental laws. Gaps in soil knowledge continue to be a significant obstacle to sustainable development and ecosystem administration (Fig. 11). Future research on combating desertification in Libya ought to concentrate on the following: (1) Advanced analytical technologies; (2) Integration remote sensing and geochemistry; (3) Geochemical baseline mapping and databases; (4) Isotopic and tracer approaches; (5) Biogeochemistry and soil health; (6) Geochemical modeling and data science; (7) Sustainable management solutions; and (8) Capacity building and collaboration (Fig. 12).

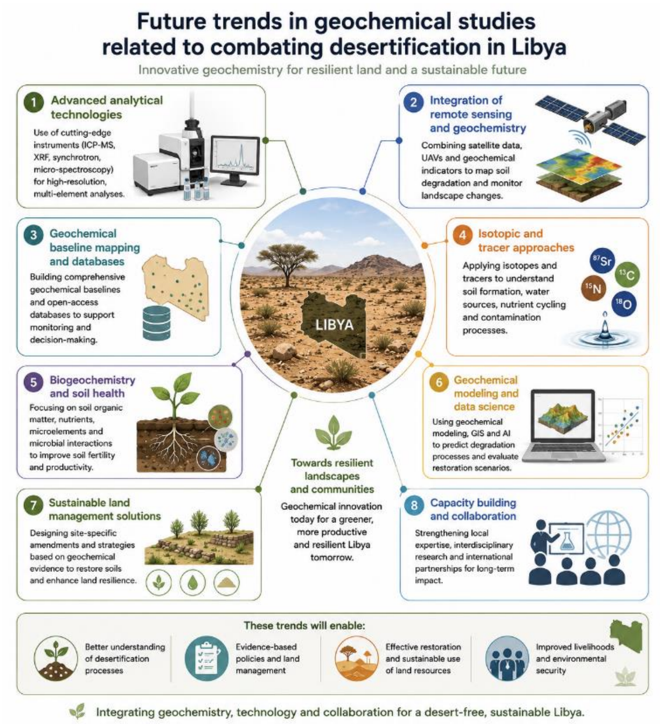

Figure 12: Future trends in geochemical studies related to combating desertification in Libya

Conclusions and Recommendations

The study shows that anthropogenic and climatic factors interact to cause desertification in Libya, which is expected to worsen with ongoing warming, decreasing rainfall, degraded vegetation, and unsustainable resource usage. A strong foundation for identifying soil and groundwater deterioration and promoting sustainable land, water, and ecosystem management is offered by geochemistry. A viable route for national desertification monitoring, early warning, ecosystem restoration, and climate-resilient sustainable development in Libya is provided by the combination of geochemistry with remote sensing, GIS, sophisticated analytical technologies, and AI-based modeling. Based on the findings, the following recommendations are proposed:

(1) Create a national geochemical database.
(2) Establish a methodical mapping of geochemical baselines.
(3) Combine geochemistry with GIS and remote sensing.
(4) Boost management of water resources.

(5) Set up ongoing environmental surveillance.
(6) Encourage environmentally friendly farming.
(7) Use cutting-edge technologies.
(8) Set up early warning systems for desertification.
(9) Repair damaged ecosystems.
(10) Strengthen institutional and scientific capabilities.
(11) Promote national environmental regulations.
(12) Give future research top priority.

Author Contributions: "**Shaltami** and **Ben Hkoma**: Conceptualization, methodology; **Shaltami**, **Ben Hkoma** and **Almahdi**: writing—original draft preparation; **Mohammed** and **Salem**: Data collection; **Nassar**: review and editing. All authors have read and agreed to the published version of the manuscript."

Funding: "This research received no external funding."

Data Availability Statement: "No data were used to support this study."

Conflicts of Interest: "The authors declare that they have no conflict of interest."

References

[1] X. Yang, K. Zhang, B. Jia, and L. Ci. "Desertification assessment in China: An overview." *Journal of Arid Environments*, vol. 63, no. 2, pp. 517–531, 2005. https://doi.org/10.1016/j.jaridenv.2005.03.032

[2] X. Wang, F. Chen, E. Hasi, and J. Li. "Desertification in China: An assessment." *Earth-Science Reviews*, vol. 88, nos. 3–4, pp. 188–206, 2008. https://doi.org/10.1016/j.earscirev.2008.02.001

[3] Y. Deng and Z. C. Jiang. "Characteristic of rocky desertification and comprehensive improving model in karst peak-cluster depression in Guohua, Guangxi, China." *Procedia Environmental Sciences*, vol. 10, pt. C, pp. 2449–2452, 2011. https://doi.org/10.1016/j.proenv.2011.09.381

[4] D. Xu, C. Li, X. Song, and H. Ren. "The dynamics of desertification in the farming-pastoral region of North China over the past 10 years and their relationship to climate change and human activity." *CATENA*, vol. 123, pp. 11–22, 2014. https://doi.org/10.1016/j.catena.2014.07.004

[5] F. Cheng, et al. "Integrated emergy and economic evaluation of three typical rocky desertification control modes in karst areas of Guizhou Province, China." *Journal of Cleaner Production*, vol. 161, pp. 1104–1128, 2017. https://doi.org/10.1016/j.jclepro.2017.05.065

[6] C. Zhang, X. Wang, J. Li, and T. Hua. "Identifying the effect of climate change on desertification in northern China via trend analysis of potential evapotranspiration and precipitation." *Ecological Indicators*, vol. 112, Art. no. 106141, 2020. https://doi.org/10.1016/j.ecolind.2020.106141

[7] S. Pal, et al. "Anthropogenic drivers induced desertification under changing climate: Issues, policy interventions, and the way forward." *Progress in Disaster Science*, vol. 20, Art. no. 100303, 2023. https://doi.org/10.1016/j.ecolind.2020.106141

[8] L. Xi, Z. Qi, Y. Feng, X. Cao, J. Zou, and J. Han. "An explainable machine learning approach (SHAP) to assessing desertification risk and its drivers in the Ring-Tarim Basin, 1990–2020." *Environmental Impact Assessment Review*, vol. 118, Art. no. 108309, 2026. https://doi.org/10.1016/j.eiar.2025.108309

[9] B. Portnov, and U. Safriel. "Combating desertification in the Negev: Dryland agriculture vs. dryland urbanization." *Journal of Arid Environments*, vol. 56, no. 4, pp. 659–680, 2004. https://doi.org/10.1016/S0140-1963(03)00087-9

[10] L. Stringer. "Reviewing the international year of deserts and desertification 2006: What contribution towards combating global desertification and implementing the United Nations convention to combat desertification?" *Journal of Arid Environments*, vol. 72, no. 11, pp. 2065–2074, 2008. https://doi.org/10.1016/j.jaridenv.2008.06.010

[11] L. Yang, and J. Wu. "Knowledge-driven institutional change: An empirical study on combating desertification in northern China from 1949 to 2004." *Journal of Environmental Management*, vol. 110, pp. 254–266, 2012. https://doi.org/10.1016/j.jenvman.2012.06.025

[12] E. Elsen, and V. Jetten. "Combatting desertification using a multidisciplinary approach." *CATENA*, vol. 128, pp. 211–213, 2015. https://doi.org/10.1016/j.catena.2014.10.001

[13] Z. Zhang, and D. Huisingh. "Combating desertification in China: Monitoring, control, management and revegetation." Journal of Cleaner Production, vol. 182, pp. 765–775, 2018. https://doi.org/10.1016/j.jclepro.2018.01.233

[14] M. Alherbawi, G. McKay, R. Govindan, M. Haji, and T. Al-Ansari. "A novel approach on the delineation of a multipurpose energy-greenbelt to produce biofuel and combat desertification in arid regions." *Journal of Environmental Management*, vol. 323, Art. no. 116223, 2022. https://doi.org/10.1016/j.jenvman.2022.116223

[15] L. Lévesque, et al. "Assessing UNCCD's role in advancing social learning for combating desertification, land degradation, and drought." *Environmental Science and Policy*, vol. 177, Art. no. 104330, 2026. https://doi.org/10.1016/j.envsci.2026.104330

[16] A. Saad, N. hariff, and S. Gairola. "Nature and causes of land degradation and desertification in Libya: Need for sustainable land management." *African Journal of Biotechnology*, vol. 10, no. 63, pp. 13680–13687, 2011. https://doi.org/10.5897/AJB11.1235

[17] A. Saad, N. Shariff, and S. Gairola. "Libya: Reversal of land degradation and desertification through better land management." in *Combating Desertification in Asia, Africa and the Middle East*, G. Heshmati and V. Squires, Eds. Dordrecht, The Netherlands: Springer, 2013, pp. 75–89. https://doi.org/10.1007/978-94-007-6652-5_4

[18] M. El Zarroug, I. Daghari, and A. Abou Zakhar. "A survey of desertification in Al-Hira and its surroundings areas in Libya." *Journal of New Sciences, Agriculture and Biotechnology*, vol. 74, no. 2, pp. 4382–4387, 2020. https://www.researchgate.net/publication/344409350

[19] E. Emgaily. "Environmental awareness and its role in risk mitigation in northwestern Libya." *Libya Journal of Geographical Studies*, vol. 5, no. 2, pp. 77–108, 2025. https://www.researchgate.net/publication/393925557

[20] M. Salem, O. Sharif, M. Alshatory, and M. Assad. "Evaluation of groundwater quality and its suitability for irrigation of ALSHATI Agricultural Project, Libya." *Ned University Journal of Research*, vol. 21, no. 2, pp. 19-35, 2024. https://doi.org/10.35453/NEDJR-ASCN-2023-0017.R5

[21] H. Algassie, M. Fakroun, M. Miskeen, and I. Gargar. "The Use of GIS and Multi-Criteria Fuzzy Logic to Assess and Identify Flood-Prone Areas in the Greater Ghat Region." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 1, no. 1, pp. 37-47, 2023. https://waujpas.com/index.php/journal/article/view/15

[22] A. Binmiskeen, and Y. Bohajar. "The Prevailing Saline Composition in Some Soils of the Southwestern Regions of Libya." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 3, no. 2, pp. 85-91, 2025. https://doi.org/10.63318/waujpasv3i2_09

[23] N. Aboalasad, and M. Salem. "Phosphorus Dynamics and Their Relationship with Soil Properties in Soils of Tasawa Agricultural Project, Fazzan-Libya." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 4, no. 2, pp. 36-46, 2026. https://doi.org/10.63318/waujpasv4i2_06

[24] M. Salem, and L. Al-ethawi. "Evaluation of Salinity in Some Soils of Irrigated Brack –Ashkada Agriculture Project, Fezzan, Libya." *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, vol. 2, no. 1, pp. 05-09, 2013. https://www.researchgate.net/publication/271255809

[25] M. Salem, A. Alnaas, A. Alzarqa, O. Sharif, Y. Nassar, and M. Assad. "Assessment of heavy metal levels in urban soils of Tripoli, Libya, using pollution indices and multivariate analysis." *NED University Journal of Research*, vol. 21, no. 3, pp. 37-59, 2024. https://www.researchgate.net/publication/386163252

[26] O. Shaltami, H. Al Matoni, R. Salem, M. Hkoma, and A. Alshabani "Geochemical Investigation of Quaternary Sabkha Sediments in the Sirte Basin, North Central Libya." *Libya Journal of Applied Sciences and Technology*, vol. 13, no. 2, pp. 11-22, 2025. https://ljast.ly/ojs3504/index.php/ljast/article/view/21

[27] H. Hamed, R. Najem, and M. Hkoma. "Determine The Contamination of Heavy Metals in Rural Soils from Benghazi-Libya." *Libyan Journal of Medical and Applied Sciences*, vol. 3, no. 2, pp. 125–130, 2025. https://doi.org/10.64943/ljmas.v3i2.87

[28] S. Mohammed, et al. "Exploring Promised Sites for Establishing Hydropower Energy Storage (PHES) Stations in Libya by Using the Geographic Information Systems (GIS)." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 3, no. 1, pp. 85-94, 2025. https://doi.org/10.63318/waujpasv3i1_13

[29] R. Eissa, K. Elzobair, and A. Adda. "Influence of Biochar Feedstock and Application Rate on Physical Properties of Sandy Aridisol Soil." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 4, no. 1, pp. 453-461, 2026. https://doi.org/10.63318/waujpasv4i1_49

[30] S. Alakhdhari, F. Alzouam, and M. Salem. "Assessment of Nitrate Concentration in Some Leafy Vegetables in Brack Alshatti Local Market." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 3, no. 2, pp. 44-51, 2025. https://doi.org/10.63318/waujpasv3i2_05

[31] A. Mohamed, and E. Al-Kilani. "The Role of Non-Profit Organizations in Promoting Environmental Awareness in the Al-Jabal Al-Akhdar Region: A Case Study of Al Bayda City." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 4, no. 1, pp. 494-512, 2026. https://doi.org/10.63318/waujpasv4i1_55

[32] Y. Abdulqadir. "Role of inclusive financial in growth of Libyan economy." *Wadi Alshatti University Journal of of Human Sciences*, vol. 1, no. 2, pp. 17-26, 2025.

[33] B. Ajkhari. "The Role of Educational Graduation Research in Developing the Local Community from the Perspective of Teachers in the Education Sector in the City of Hun." *Wadi Alshatti University Journal of of Human Sciences*, S.I., pp.272-297, 2025.

[34] O. Almakhzoum. "Assessment of the adequacy of primary education institutions in the city of Brack." *Wadi Alshatti University Journal of of Human Sciences*, vol. 1, no. 1, pp. 51-61, 2025. https://waujhs.com.ly/index.php/waujhs/article/view/23/11

[35] O. Shaltami, et al. " Seismic Geochemistry: A Sustainable Approach to Hydrocarbon Exploration in Libya." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 4, no. 2, pp. 170-176, 2026. https://doi.org/10.63318/waujpasv4i2_20

[36] K. Khamis, and F. Farouj. "Study of Natural Marble Specifications in Southern Libya." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 4, no. 2, pp. 155-162, 2026. https://doi.org/10.63318/waujpasv4i2_18