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Understanding the challenges in Libyan rangeland conservation: exploring pathways to sustainable rehabilitation

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Key words: arid rangelands; degradation; rehabilitation; paradigm shift.

Abstract

Libya, spanning 1.75 million km², has rangelands covering 7.7% of its area, supporting approximately six million sheep, goats, and camels. Historically, pastoralism has been the primary land use, deeply intertwined with the socio-economic fabric for millennia. Despite significant government investments in agricultural and rangeland development, these ecosystems have suffered extensive degradation in terms of declining vegetation cover, biodiversity loss, reduced soil fertility, and diminished productivity reflect a broader pattern seen across North Africa. The degradation of Libyan rangelands is rooted in decades of mismanagement, exacerbated by the government's frequent disregard for scientific recommendations and reliance on external consultants unfamiliar with local ecological and socio-economic contexts. Additionally, socio-economic changes, particularly following the oil boom of the 1960s, disrupted traditional grazing systems, while the limited involvement of local communities hindered effective conservation efforts. A significant challenge lies in balancing conservation initiatives with the livelihoods of pastoralists and local communities, often leading to conflicts of interest. This overview work underscores the urgent need for a paradigm shift toward holistic and adaptive strategies that integrate ecological, socio-cultural, and governance dimensions to address the challenges facing Libya's rangelands. Reforming rangeland survey methodologies, adopting sustainable rehabilitation techniques, and implementing controlled grazing regimes are critical steps in this process. Equally important is fostering active community participation to align conservation goals with local needs and interests. By pursuing locally informed and inclusive approaches, Libya can restore the resilience of its rangelands, ensure ecological sustainability, and support the livelihoods of local communities.

Introduction

North Africa is dominated by extensive steppe and Saharan landscapes, where pastoralism has been a cornerstone of human activity since ancient times. Traditionally, pastoralism was nomadic, relying on herding and animal husbandry under an open communal grazing system. Over the past century, profound societal transformations have significantly impacted the region's rangelands (Dutilly-Diane, 2007). Harsh

environmental conditions, a history of mismanagement, population growth, and increasing demand for livestock products have collectively disrupted ecological processes in these semi-arid and arid regions.

Libya's landscapes in particular, are distinguished by diverse terrains, geological formations, and significant climatic variations across its regions. Rangelands form a considerable part of the country's territory, covering approximately 13.2 million hectares. These rangelands primarily consist of arid ecosystems, stretching across the northern regions, around oases, and in mountainous areas within the desert interior. They are characterized by sparse vegetation, with limited perennial grasses and a dominance of drought-resistant shrubs (Shaghlan et al., 2023).

Pastoralism has been the predominant land use across Libya for countless generations, with rangelands serving as a vital resource for indigenous communities (El-Barasi and Saaed, 2013). These ecosystems have historically provided resources for animal fodder and ethnobotanical services. They have also been essential as hunting grounds for wild birds and animals (Saaed et al., 2022). Furthermore, they act as a critical barrier against desert encroachment from the south. However, extensive research (e.g., El-Barasi et al., 2013; Saaed et al., 2019; Habib et al., 2022; Saaed et al., 2022) reveals that Libyan rangelands face escalating threats from unsustainable anthropogenic activities and climate change. These ecosystems are particularly fragile due to limited and unpredictable rainfall (Al-Bukhari et al., 2018), low soil organic matter and nutrient levels, sparse vegetation cover, and a non-equilibrium ecological system (El-Barasi and Saaed, 2013; Habib et al., 2022).

This overview work aims to shed light on Libya's rangeland experience, detailing its historical context, current condition, and outlining a future vision for sustainable rehabilitation and management. It emphasizes the critical, yet often overlooked, factors that have contributed to the persistent failure of past efforts to improve Libya’s rangelands over recent decades.

Environmental settings

With its vast area (1.75 million km^2), Libya is the second-largest country in North Africa, lying along the southern Mediterranean coast and heavily influenced by the arid Sahara Desert (Fig. 1). Over 90% of its land is desert, except for a narrow coastal strip up to 150 km wide (El-Barasi & Saaed, 2013). The country has a 1,900 km Mediterranean coastline, with a predominantly flat topography broken by the Jabal Nafusa in the west, El-Jabal El-Akhdar in the east, and southern mountain ranges (Jansen, 1988). Libya is divided into two main phytogeographical regions: the Sahara, characterized by extreme aridity and sparse vegetation, and the Mediterranean coastal belt, which receives higher rainfall and supports richer vegetation (Saaed et al., 2019).

Situated between 19° and 33° north latitude, Libya is one of North Africa's driest regions, dominated by subtropical high-pressure systems that create pervasive aridity. Rainfall is limited to winter, with high variability and localized "thunderstorm cells," making it the primary surface water resource in the absence of perennial water sources (Saaed et al., 2022). About 91% of Libya is hyper-arid desert with under 50 mm of annual rainfall, 8% is rangeland receiving 50–200 mm, and only 0.7% is agricultural land receiving 200–400 mm. Forests make up 0.3% of the land in areas with over 400 mm of rainfall. Annual plants flourish briefly in the rainy season, while perennials form the main vegetation framework, varying with soil, water, and climate conditions. Temperatures range from 5°C to 35°C in the north and from below freezing to over 45°C in the southern desert. The harsh climate and sandy soils dominate much of Libya, with clay and loam soils found in localized northern areas, red soils in highlands, and saline soils along coastal regions and interior oases.

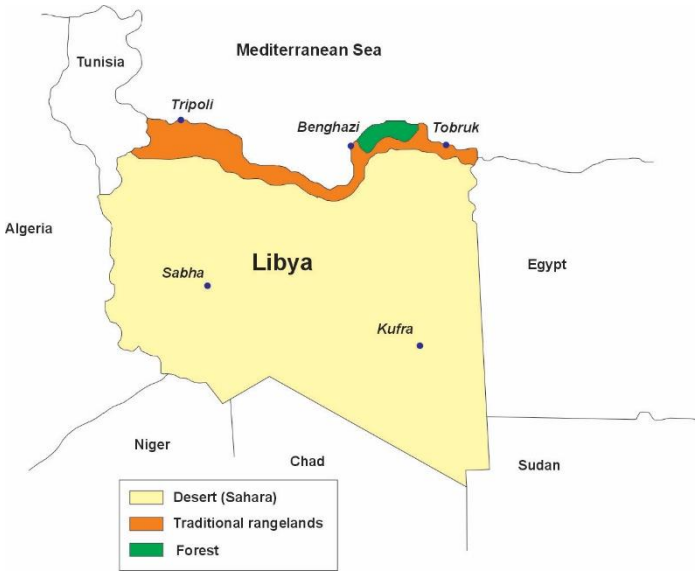

Fig. 1. The distribution of rangeland and forest areas in Libya

Rangelands current state

Archaeological evidence shows that human populations in Libya have been herding sheep and goats for over 7,000 years (Barker et al., 2012). Land use historically included grazing, grain cultivation, firewood collection, charcoal production, and harvesting plants for food, medicine, and construction and handicraft raw materials. Valleys and mountains provided habitats for birds and wildlife, essential for food and traditional medicine as well (Saaed et al., 2019). Pastoralism has long been privately managed, with nomadic households once comprising >5% of the population (Le Houerou, 1975). However, nomadism has nearly vanished, and most rural people now live-in cities. Livestock ownership has shifted from small subsistence flocks to larger commercial herds exceeding a thousand animals. Mechanized water transport and supplemental feeding allow year-round grazing in the same range, disrupting ecological balance and exacerbating rangeland degradation (Sidahmed, 1996).

Since 1960, Libya's livestock population has grown 3.5 times, surpassing the rangelands' carrying capacity, estimated at 2.8 million mature sheep (Le Houerou and Aly, 1982). Currently, livestock numbers are approximately 190% of this capacity, with rangelands contributing about 25% of livestock forage (Dutilly-Diane, 2007) in good years. This limited production is attributed to reduced reliance on rangelands, driven by sedentary production systems and complementary feeding practices. Degradation is evident in declining vegetation cover, biodiversity loss, and the spread of invasive species. In many areas, perennial vegetation has fallen below 25%, while soil erosion and fertility loss have rendered the landscape increasingly dysfunctional, jeopardizing ecosystem stability and wildlife survival (El-Barasi et al., 2013; Shaghlan et al., 2023).

Challenges and limitations in rangeland rehabilitation

Since Libya's independence in 1951, agriculture, livestock, and rangelands were prioritized as key economic sectors before the discovery of oil. Early efforts included studies and rehabilitation initiatives in collaboration with international organizations, like the FAO, involving numerous experts in rangeland management. However, despite these efforts, limited progress has been achieved in improving rangelands. Key obstacles include inadequate understanding of ecosystems, ineffective resource management, and insufficient awareness of the long-term consequences of degradation (Saaed et al., 2019). Management

practices often conflicted with regional ecology, such as large-scale tree planting in areas naturally dominated by sparse shrubs, disrupting ecological balance. Additionally, rangeland projects have largely excluded local communities, whose involvement in protection and rehabilitation remains minimal despite recent acknowledgment of its importance. Political instability and weak legal protections have further hindered progress, leaving rangelands vulnerable to degradation and overexploitation. Foreign-led conservation efforts often overlooked local cultural, historical, and tribal dynamics, while unregulated communal grazing continues to exacerbate degradation. The population surge, from 1.089 million in 1954 to 6.931 million in 2020, has added further strain on natural resources. Balancing the economic, cultural, and social needs of rangeland residents with conservation objectives remains a significant challenge, particularly as these fragile landscapes, dominated by xerophytic shrubs, are highly vulnerable and challenging to rehabilitate.

Looking forward

Rehabilitation in arid and semi-arid regions, such as those in Libya, is inherently complex and challenging due to their unique biodiversity, limited rainfall, and the intricate spatial and biological dynamics driven by stochastic events (Carrick et al., 2015). Additionally, these areas are often subject to significant anthropogenic pressures due to the scarcity of natural resources (Saaed et al., 2022). To enhance biodiversity, maintain ecological processes such as clean air and water, and achieve sustainable management and rehabilitation of Libya's degraded rangelands, several strategies are proposed. First, comprehensive ecological studies should be conducted to better understand the drivers of rangeland degradation, ecological thresholds, and potential recovery opportunities, with an emphasis on soil studies, vegetation mapping, and climate impact assessments. Second, protected areas should be established, aiming to safeguard at least 5% of the rangelands within the next decade, accompanied by clear management plans focused on conservation and sustainable use. Third, a reform of the pastoralism system is necessary, transitioning from communal grazing to a controlled, closed, rotational grazing system that enhances vegetation recovery and soil stability. This could be supported by education programs for local communities and infrastructure like fenced enclosures and designated grazing zones, while also reducing the number of domestic grazing animals to under three million head. Fourth, enforcing a ban on rainfed agriculture in arid zones with less than 250 mm/year of rainfall is critical, with incentives for alternative practices like greenhouse farming or agroforestry. Fifth, anthropogenic activities such as wood gathering, medicinal plant collection, overhunting, and pollution need to be regulated through strict laws and monitoring systems, promoting sustainable alternatives like regulated harvesting and waste management. Sixth, providing alternative livelihoods for local communities can mitigate dependence on unsustainable practices, through programs such as ecotourism, solar energy jobs, and small-scale industries like beekeeping and craft production. Special attention must be paid to local populations; their activities should not be banned but adapted to the area's potential, with a focus on altering behaviour to maximize economic gain while minimizing environmental costs (El-Barasi and Saaed, 2013). Seventh, long-term rehabilitation programs should focus on landscape functionality, prioritizing soil health, water retention, and the recovery of native vegetation, supported by large-scale seeding programs and the use of modern techniques like hydrological interventions and remote sensing. Eighth, the promotion of renewable energy, particularly solar power, should be encouraged through community-based solar projects and subsidies for solar panel installation to reduce reliance on traditional fuels. Ninth, local communities must be educated and empowered through workshops, awareness campaigns, and training programs on sustainable practices and the importance of preserving rangeland ecosystems. Lastly, strong policy frameworks are essential for supporting sustainable rangeland management. This entails updating national policies to prioritize rangeland conservation, enforcing anti-degradation laws, and securing funding for rehabilitation and research. Implementing these

strategies can transform Libya's rangelands from degradation to a sustainable and productive system that supports both the environment and local communities.

Conclusion

The sustainable management and rehabilitation of Libya's rangelands require a multifaceted approach that integrates ecological understanding, community engagement, and effective policy frameworks. The proposed strategies—ranging from ecological studies and the establishment of protected areas to the promotion of renewable energy and alternative livelihoods—aim to address the root causes of degradation while ensuring the resilience and profitability of rangeland systems. By prioritizing both environmental conservation and the socioeconomic needs of local communities, Libya can foster a balanced and sustainable future for its rangelands, securing their ecological integrity and long-term viability for generations to come.

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