
Research Article

Aspects of the ecosystem services threatened by desertification in Algerian steppe rangelands: concepts, status and stakes

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Abstract

This study focuses on the imminent threat of desertification within Djelfa's steppe grazing lands, emphasizing its implications for land management and the sustainability of livestock practices. The methodology adopted employs a stringent approach that commences with a precise definition of desertification as a critical risk. It then proceeds to thoroughly assess the susceptibility of the local ecosystem to this phenomenon and delineates its consequential impact on both the human inhabitants and the surrounding environment. This comprehensive analysis effectively contextualizes human activities within the sphere of desertification's influence. Methodologically, the study employs a multidimensional framework to categorize the array of environmental goods and services rendered by these grazing lands. By identifying the beneficiaries associated with each service, the research aims to elucidate the complex threat posed at various levels. Crucially, the findings highlight the severe jeopardy that desertification imposes, not only endangering essential resources vital for extensive livestock production but also triggering a decline in invaluable environmental goods pivotal for the sustainability of the ecosystem and activities supporting human welfare. Statistically substantiated through an integration of diverse methodologies such as field surveys, satellite imagery analysis, and stakeholder consultations, this study validates the correlations between desertification and the degradation of ecosystem services. It provides empirical evidence showcasing the gradual decline of grazing lands, thereby compelling an urgent call for intervention strategies. In summary, this research underscores the urgent need for holistic strategies to mitigate the adverse effects of desertification. Its findings provide critical insights into the complex dynamics between human activities, ecosystem vulnerabilities, and the looming threat of desertification. It emphasizes the necessity for immediate collective action and sustainable resource management practices to safeguard ecosystems, ensure long-term sustainability, and protect the well-being of communities in Djelfa and beyond.

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1. Introduction

Supported by major risk prevention measures, desertification in Algeria is considered a climatic hazard, alongside drought and sandstorms, which can pose a major risk. Desertification falls under the category of major climate risks, as defined by [Journal Officiel \(2004\)](#), which states that it encompasses any probable threat to humans and their environment arising from exceptional natural events and/or human activities. Indeed, desertification results from both climatic factors and human activities, and its impacts affect both the environment and the way of life, thereby altering ecosystems and making economic and social activities increasingly challenging. This necessitates additional efforts and substantial human and material resources for the preservation and restoration of degraded ecosystems. Consequently, the threat of this major risk is particularly prominent in steppe regions, where natural factors combine with intensive and repeated land use.

The Algerian steppe is: the portion of the national territory bounded to the North by Tellian Atlas and the South by the Southern foothills of the Saharan Atlas (100 mm isohyet). The morphology and geographical position of the latter give it an agro-pastoral character ([Zemour & Sadoud, 2021](#)). This zone is essentially made up of pastoral rangelands covering an estimated 20 million hectares, and a Southern fringe around the 100 mm isohyet constituting pre-Saharan rangelands, around 16 million hectares ([High Commissariat for Steppe Development, 1995](#)). The pastoral rangeland is the principal vocation in the steppe ([Zemour, 2022](#)), the vegetation groups in Djelfa steppe are: steppes with (*Stipa tenacissima*), (*Artemisia herba alba*) and (*Lygeum spartum*), also psammophyte steppes (*Aristida pungens*) and (*Thymelaea microphylla*). (*Pistacia atlantica*) on the depressions, and forest ecosystem dominated by (*Pinus halepensis*).

In our exploration, we aim to uncover the impacts of desertification, particularly in Djelfa's grazing areas, posing threats to livelihoods and altering ecosystems significantly. Highlighted in the Millennium Ecosystem Assessment ([MEA, 2005](#)), desertification stands out as a key peril affecting the well-being of impoverished populations, diminishing ecosystem services and human welfare. This aligns with Algeria's scientific research focus outlined in the [Journal Officiel \(2015\)](#), which emphasizes combating desertification, preserving nature and biodiversity, and promoting sustainable development. Legal provisions within this framework guide strategies for preventing major natural and technological risks.

2. Materials and methods

2.1 Observation and analysis of the territory

The steppe grazing lands, which serve as a source of sustenance for extensive livestock farming, have been the primary source of income for the local population since the existence of humans in this territory. Each one, in order to meet their own objectives, develops strategies based on their financial means ([Zemour et al. 2020](#)). However, not only that, but through the observation and analysis of the territory and the adoption of suitable tools, we can expand our understanding of this matter. Consequently, the identification of the risks and vulnerabilities caused by desertification becomes of utmost importance. To achieve this, and to make the task more operational, we have placed our focus on adopting a holistic approach. By defining the range of environmental goods and services provided by these grazing lands and identifying the beneficiaries of each service, we can gain a detailed understanding of the nature of current losses and those that may amplify in the future under the threat of desertification.

2.2 Presentation of Djelfa Province

Djelfa, situated in the central part of Northern Algeria, serves as a pivotal point connecting the four cardinal directions of the entire national territory. It occupies the central part of the three provinces of the Central High Plateaus (CHP) along with M'Sila and Laghouat ([Journal Officiel, 2010](#)). Djelfa is not only a key component of the central steppe but also represents the gravitational center of the steppe regions, encompassing a total of nineteen steppe provinces ([High Commissariat for Steppe Development, 1995](#)). It covers an area of 32,256.35 square kilometers and had an estimated population of 1,566,057 inhabitants as of December 31, 2018, resulting in a population density of 46.77 people per square kilometer ([Direction de la Programmation et du Suivi Budgétaires, 2019](#)). The province is divided into 12 administrative districts, each of which further comprises 36 municipalities. Djelfa shares its borders with nine other provinces ([Figure 1](#)): Médéa and Tissemsilt to the north, M'Sila and Biskra to the east, Laghouat and Tiaret to the west, and Ouargla, El Oued, and Ghardaïa to the south.

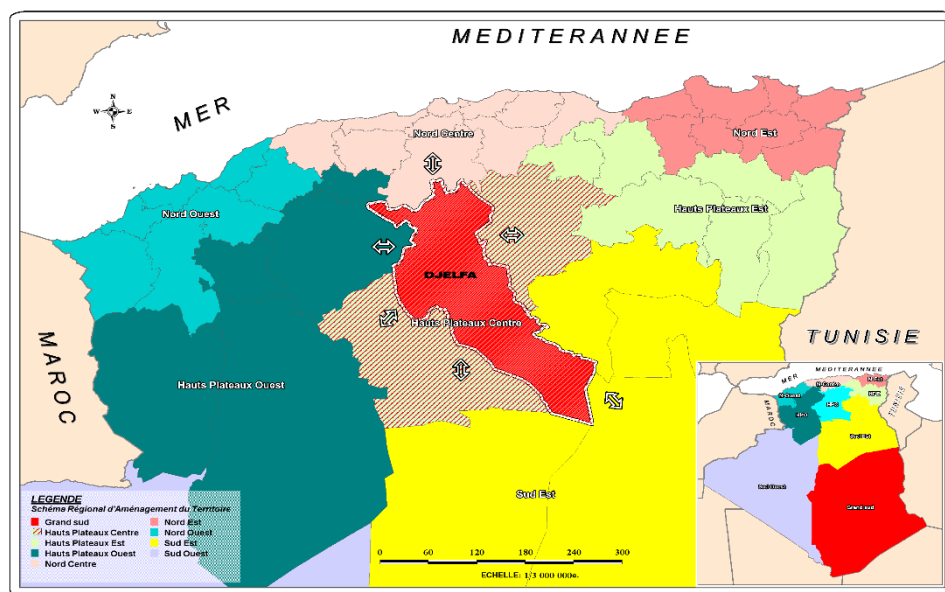


Figure 1. The Territory of Djelfa Province in its Regional Context.
Source: ([Direction de la Programmation et du Suivi Budgétaires, 2014](#))

3. Results and discussion

3.1 Importance of the province in pastoral activities

This territory serves as a hub for both people and animals and is considered the true heartland of pastoral activities. Commonly referred to as the "capital of the steppe," Djelfa naturally houses the central headquarters of the High Commissioner for Steppe Development (HCDS). This organization plays a pivotal role and has a wide-reaching impact across the entire steppe territory. It executes the national policy for integrated development of the steppe and pastoralism.

According to [Mekersi et al. \(2012\)](#), the High Commissioner for Steppe Development enhances coordination among various institutional actors operating in this space to ensure the coherence and effectiveness of the plans and programs carried out. Specialists consider it one of the key bastions in the fight against desertification. As stated by [Bedrani \(1993\)](#), the High Commissioner for Steppe Development is a unique institution, being the only one in all of North Africa and the Middle East that focuses on all grazing areas within a country.

It is quite evident that the evolution of livestock numbers varies across bioclimatic zones and among the various provinces of the country (Meguellati-Kanoun et al. 2018). Djelfa Province, with its diverse natural characteristics in agro-silvo-pastoral domains and ancient expertise in livestock farming, boasting a substantial livestock population (see Table 1), holds a significant position in the production of high-quality red meat, particularly the "steppe lamb," renowned for its gastronomic properties. Nevertheless, this region remains vulnerable to significant land degradation risks, including drought, desertification, overgrazing, and deforestation. As a result, various substantial efforts have been made in pastoral development and forestry activities that align with the fight against desertification (LCD), as well as the preservation and enhancement of the productive natural capital.

Table 1. Livestock production in Djelfa Province

Years	Designation	Livestock Farming				
	Species	Sheep	Goats	Cattle	Camels	Total
2019	Heads	3 456 000	406 000	30 400	1 250	3 893 650
	%	88.76	10.43	0.78	0.03	100
2009	Heads	2 517 000	340 450	27 870	6 380	2 891 700
	%	87.04	11.77	0.96	0.22	100
1999	Heads	2 285 300	221 200	25 413	3 900	2 535 813
	%	90.12	8.72	1.00	0.15	100

Source: [Ministère de l'Agriculture et du Développement Rural \(2019\)](#)

3.2 Desertification: The Genesis of a concept

The use of the concept of desertification dates back to the third decade of the 20th century. The term "desertification," attributed to [Lavauden \(1927\)](#), was coined based on his observations in North Africa. Indeed, he argued that in the entire area he had just mentioned, desertification, if I may say so, is purely artificial. It is solely the result of human activities and is relatively recent ([Lavauden, 1927](#)). Similarly, in a section of his work dedicated to combating encroaching desertification, he presents a fact based on accounts of the ancient capital of the Ghana Empire. He states that the Arab historian El Bekri described a situation amidst fertile fields, which was rediscovered in 1914 by Bonnel de Mézières in one of the most arid regions of Mauritania ([Lavauden, 1941](#)). These accounts inform us that this phenomenon is dynamic over time due to human interaction with nature, and more importantly, it must be fought against.

During the Earth Summit held in Rio de Janeiro in 1992, a new approach centered around "sustainable development" was adopted. This concept became central to numerous international cooperation programs and the objectives and implementation of several international conventions. The summit introduced Agenda 21, which included a new definition of desertification. The definition, found in the second paragraph of Chapter 12 of Agenda 21, states that: "Desertification is the degradation of land in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities." Efforts to refine this concept primarily aimed to expand the list of causes of this plight and recognized the diversity of triggering factors, notably, and in addition to human activities, the noteworthy inclusion being climatic variations.

The sustainable development approach played a crucial role in the formulation of several international conventions. The Convention on Biological Diversity was signed in Rio de Janeiro on June 5, 1992, as was the Convention on Climate Change. Additionally, the United Nations Convention to Combat Desertification (UNCCD) in Countries Experiencing Serious Drought and/or Desertification, particularly in Africa, was adopted in Paris on June 17, 1994.

According to the [United Nations Convention to Combat Desertification \(1994\)](#) convention, the parties recognized that, despite past efforts, progress in combating desertification and mitigating the effects of drought had been disappointing. They concluded that a more effective and sustainable approach was necessary at all levels. Consequently, the parties to the convention agreed to adopt a new definition of desertification. The term "desertification" was defined as the degradation of land in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities ([United Nations Convention to Combat Desertification, 1994](#)). This definition is identical to the one adopted at the Earth Summit in Rio de Janeiro on June 5, 1992, with the exception that the term "soils" was changed to "land." Indeed, the term "land" is a more accurate description of the impacts of desertification than the term "soils," as the convention's text clarifies that the term "land" encompasses the term "soils".

3.3 Rangelands in Algeria: A steppic trend

The Algerian steppe covers approximately 20 million hectares, with rangeland areas estimated at 15 million hectares, including alfalfa fields totaling 2.7 million hectares ([Direction Générale des Forêts, 2003](#)). Of the remaining 5 million hectares, they are divided as follows: 1.4 million hectares of forests, 1.1 million hectares of cultivated land, and 2.5 million hectares of unproductive land, consisting of bare soil, sands, and sebkhas ([Ministère de l'Aménagement du Territoire et de l'Environnement, 2003](#)). Additionally, in accordance with [Journal Officiel \(2010\)](#) concerning territorial planning and sustainable development, the steppe is considered one of the sensitive areas, defined as an ecologically fragile space where development actions must take its specificity into account.

The pastoral code of 1975, as outlined in articles 1, 9, and 10, specifies that rangeland areas in the steppe are state-owned. These areas encompass all natural grazing lands situated in the steppe zones, distributed according to isohyets, excluding lands under constant development either due to favorable natural conditions or installations allowing seasonal or permanent irrigation, as defined before the implementation of this ordinance. Therefore, rangeland areas consist of the following steppe zones:

Agro-pastoral substeppic zone, also referred to as the "lower semi-arid zone," is situated between isohyets of 300 and 400 mm. The northern steppe zone, known as the "upper arid zone with Tellian influence," falls within isohyets of 200 and 300 mm. The southern steppe zone, termed the "lower arid zone with Saharan influence," is located between isohyets of 200 and 300 mm. The pre-Saharan rangeland zone, designated as the "lower arid dayas region," lies below the 200 mm isohyet.

According to [Journal Officiel \(1995\)](#) regarding land use orientation, lands designated as pastoral or having pastoral purposes are defined as any rangeland covered with natural vegetation, whether dense or sparse, including plants with annual or multi-year vegetative cycles, as well as shrubs or forage trees, and is used for multi-year grazing of animals. Furthermore, the Agricultural Orientation [Journal Officiel \(2008\)](#) dedicates the chapter to provisions regarding rangelands, defining rangelands as any land covered by natural vegetation, whether dense or sparse, comprising plants with annual or multi-year vegetative cycles, along with shrubs and forage trees. According to scientists like [Benrebiha & Bouabdellah \(1992\)](#), rangelands are generally referred to as pastures formed by spontaneous vegetation and extensively exploited to feed livestock, primarily sheep in our case.

Based on these definitions, we can understand the location of rangelands, especially in the steppe ([Figure 2](#)). The most important component of rangelands is the natural vegetation with annual or multi-year vegetative cycles, along with shrubs and forage trees. Their natural purpose is for grazing livestock. Additionally, these lands are recognized for their fragility, so any development intervention in this space is expected to adopt a holistic approach to assess the overall framework of its sensitive characteristics.

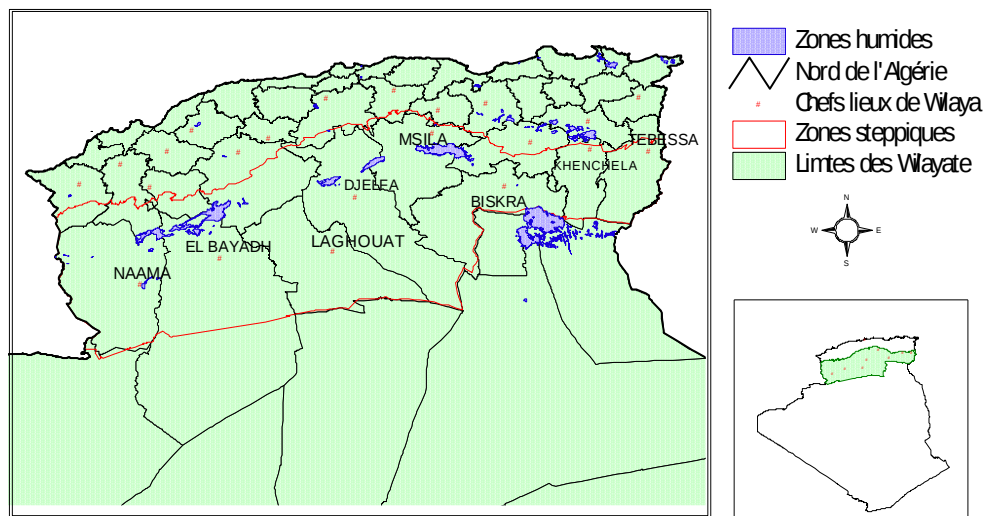


Figure 2. Administrative Boundaries of the Entire Steppe Region in Algeria. Source: High Commissariat for Steppe Development & Bureau National d'Etude de Développement Rural (2010).

3.4 The Djelfa region at the crossroads of rangeland desertification risk and livestock development

Land degradation, particularly through desertification, continues to advance. In fact, a desertification sensitivity map was created in 1996, covering 9 steppe provinces. Covering an area of over 13 million hectares (approximately 70% of the entire steppe region), this map made it easier to assess desertified lands and revealed the extent and intensity of this phenomenon. According to Bensuoiah (2004), in an effort to evaluate and pinpoint desertification, the Forestry Administration created the national desertification sensitivity map using remote sensing, which has become the fundamental tool for the strategy and planning of desertification combat in Algeria. Since monitoring desertification is a dynamic, non-static process, the desertification sensitivity map is intended to be updated. In 2009, a new map (Figure 3) covered 27 million hectares, including the 9 provinces previously studied, with the addition of 3 more steppe provinces affected by this phenomenon.

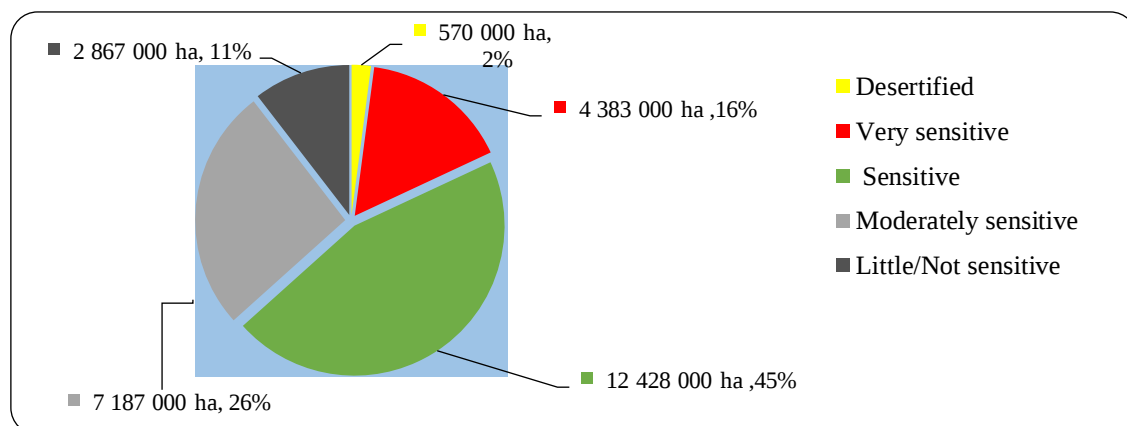


Figure 3. Result of the desertification sensitivity map in Algeria 2009, displaying proportions and areas in hectares.

Source: Office National des Statistiques (2015)

In the Djelfa Province, this concern takes on a grim magnitude and is evident through the effects of sand encroachment, reduced soil fertility, diminished vegetation cover, and migration movements. A representation in [Figure 4](#) better illustrates the situation based on the results of the desertification sensitivity map in Djelfa Province, depicting land classification according to the degree of sensitivity, in terms of area and proportions.

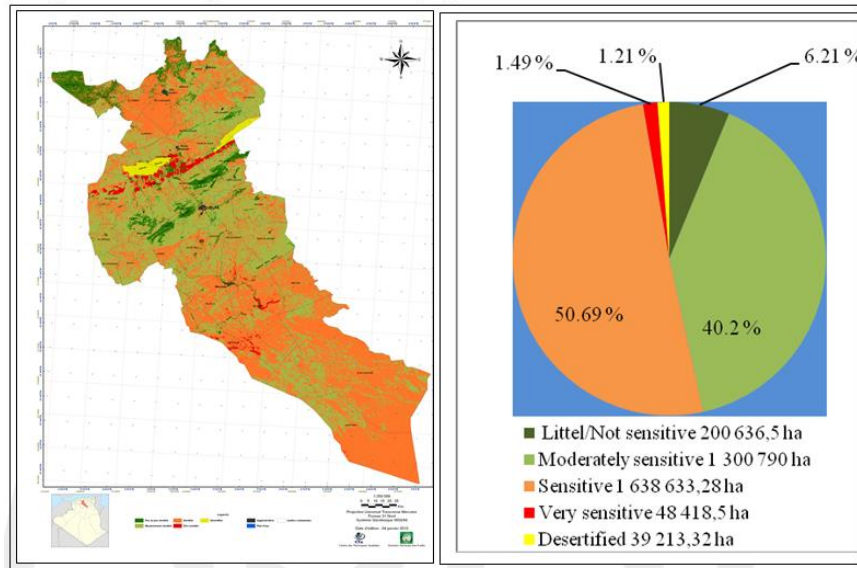


Figure 4. Desertification sensitivity map of Djelfa Province.
Source: [Centre National des Technologies et du Consulting \(2014\)](#)

3.5 Forage production in steppe rangelands

Estimating the productive potential of rangelands inevitably involves quantifying the environmental goods produced by this ecosystem. Production indicators for forage resources depend on the existing facies within the rangeland, which determine the average pastoral productivity (FU/ha). From this, the stocking rate (ha/equivalent sheep) is estimated, which also varies depending on ground cover and the floristic composition at the site.

In 2010, the High Commissioner for Steppe Development conducted a study on steppe rangelands in collaboration with Bureau National d'Etude de Développement Rural. According to this study ([High Commissariat for Steppe Development & Bureau National d'Etude de Développement Rural, 2010](#)), the average production per hectare is approximately 72.53 UF/ha. Annual species account for 70.32% of production, while perennials make up 29.68%, with an average production of 51.07 FU/ha for annual species and 21.53 FU/ha for perennials ([Table 2](#)).

Table 2. Production classes and global area percentages

Production Class (FU/ha)	Area (ha)	(%)	Total Production (FU)	(%)	Average Production per Hectare (FU/ha)
Moins de 50	9 562 784.69	44	404 185 555.39	26	42.26
50 à 100	9 523 115.18	44	830 499 140.85	53	87.21
100 à 200	2 457 600.01	11	307 114 757.59	20	124.96
Plus de 200	117 998.85	1	29 462 896.43	2	249.68
Global	21 661 498.7	100	1 571 262 353.26	100	72.53

Source: [High Commissariat for Steppe Development & Bureau National d'Etude de Développement Rural \(2010\)](#)

The displayed information highlights several important elements for understanding forage production in the steppe region. Firstly, 44% of rangelands provide a production of less than 50 FU/ha. Secondly, almost the same portion of rangeland areas yields an average production slightly exceeding 87 FU/ha/year, while the good rangelands (beyond 124 FU/ha) only make up a relatively small portion, not even reaching 12%. The observation is undoubtedly alarming and underscores the advanced state of degradation for a significant portion of the rangelands in the region.

In Djelfa Province, land degradation in rangelands is not an exception. According to statistics from the Ministry of Agriculture and Rural Development (MADR), the rangeland area was 2,138,100 hectares in 1998, decreasing to 2,122,428 hectares in 2010, and further reducing to 2,114,041 hectares in 2019. The loss during the period from 1998 to 2019 amounts to 24,059 hectares, with a deficit rate of nearly 1,100 hectares per year. While it's possible that some of the lost lands have undergone a change in use, desertification is also gaining ground.

Table 3 provides insights into the natural forage supply of rangelands in the Djelfa region. The first striking observation is that 84% of Djelfa's rangelands provide a production of less than 50 FU/ha, with a little over 60% yielding less than 10 FU/ha. Additionally, the remaining 16% of rangeland areas offer an average production of approximately 62.65 FU/ha/year. The conclusion here is straightforward: not only is the state of degradation already alarming, but it also surpasses other steppe regions.

Table 3. Rangeland production classes by degree of degradation

Production Class (FU/ha)	Area (%)	Average Production (FU/ha)
<10	61.38	8.03
10 à 30	20.03	26.38
30 à 50	2.73	49.01
> 50	16.20	62.65
Global	100.00	21.53

Source: [Centre National des Technologies et du Consulting \(2014\)](#)

3.6 Livestock grazing pressure in Djelfa Province

Livestock grazing pressure is expressed in terms of the number of hectares required to satisfy one sheep equivalent, with each sheep equivalent having dietary needs equivalent to 400 FU/year. Therefore, the distribution of rangelands based on natural forage production determines the classes of grazing pressure.

The justification for this vulnerability caused by desertification in the Djelfa region is further supported by Table 4. We can also illustrate the fragility of this ecosystem in terms of its inability to meet the total needs of the local livestock. The results of the High Commissioner for Steppe Development 2010 study specify grazing pressure classes in terms of pastoral value and phytomass, which are derived from quantitative and qualitative assessments of rangelands. An analysis of this table informs us that only 146 hectares are capable of supporting grazing pressure of less than 2 hectares per sheep equivalent, while the dominant area for livestock grazing pressure in Djelfa encompasses 1,328,635 hectares, capable of sustaining grazing pressure exceeding 8 hectares per sheep equivalent. This situation will certainly lead to negative repercussions, both on the environmental aspects of rangeland ecosystems and on livestock activity. This includes increasing pressure on the exploitation of existing natural resources, expressed, among other things, by overgrazing and a rising demand for livestock feed (in greens and/or concentrates). This observation benefits some (producers, sellers, and speculators) of livestock feed while posing a significant challenge for others (livestock farmers). Consequently, it results in additional expenses for feeding, maintaining, and developing herds, especially during difficult periods like prolonged drought, and requires substantial financial resources to restore degraded ecosystems.

The productivity (FU/ha), is estimated on the basis of the qualitative and quantitative evaluations of the vegetal production in (FU) on the unit surface of rangeland in one (ha), following which, and on the basis of the needs sheep unit at (400 FU), the charge is easily identifiable, it is expressed by:

$$\text{Stocking Rate (ha/sheep)} = \frac{\text{Pastorale productivity per hectare (FU/ha)}}{\text{Feed needs of the sheep unit (400FU)}}$$

Table 4. Livestock load classes in the Djelfa Province with the state of rangelands

State	Phytomass Class (kg MS/ha)	Area (ha)	Stocking Rate Class (ha/sheep)	Area (ha)
Excellent	1400 >	128 614	1<X<=2	146
Good	1100-1400	35 148	2<X<=4	269 362
Moderate	800-1100	105 343	4<X<=6	407 729
Degraded	500-800	84 609	6<X<=8	227 217
Highly degraded	500>	1 885 765	>8	1 328 635
Unclassified		552 330		

Source: [High Commissariat for Steppe Development & Bureau National d'Etude de Développement Rural \(2010\)](#)

Since each class of animal load occupies a given surface area, the total capacity of the territory in (sheep-equivalents) is therefore, the total of capacity of each class. Based on the preceding table and through straightforward mathematical calculations, one can deduce the estimated total capacity of the rangelands in (sheep equivalents). Consequently, it is evident that, in the best-case scenario (an optimistic calculation based on the center of each class), the entire Djelfa rangeland can only support:

$$\frac{146}{1.5} + \frac{269\,362}{3} + \frac{407\,729}{5} + \frac{227\,217}{7} + \frac{1\,328\,35}{8} \leq 370\,000 \text{ heads (equivalents-sheep)}$$

Furthermore, considering that the livestock population in the Djelfa province during the same period, according to [Ministère de l'Agriculture et du Développement Rural \(2010\)](#), consisted of 2,752,000 sheep, 337,000 goats, 29,100 cattle and 6,200 camels. Additionally, [High Commissariat for Steppe Development & Bureau National d'Etude de Développement Rural \(2010\)](#) clearly states that the average carrying capacity of the steppe is 1 head per 5.65 hectares, implying that the steppe can only support 3,836,794.22 heads. It thus becomes evident that the natural productive potential existing on the natural grazing lands, after estimating its quantification, is significantly insufficient to sustain the region's livestock.

3.7 The true dimensions of the risk of rangeland degradation

It is entirely misguided to limit the impacts of rangeland degradation solely to the provision of natural forage. This would undoubtedly be a false trail and seems to divert us from our objective. If plant biomass has captured the attention of the general public (the lion's share), especially those involved in livestock activities, it is because it is the most tangible in terms of high socio-economic profitability, especially during rainy years when abundant plant biomass is converted into animal biomass through the livestock production process (a significant source of income for the region's population).

In reality, the impacts of degradation are manifold and much more diversified than simply a reduction in natural grass. They demand specific attention. To properly assess the situation, we must accelerate our efforts and employ significant resources. Indeed, a comprehensive vision appears to be the most suitable approach to grasp the various dimensions of this ordeal. Relying on the identification of the component of the Total Economic Value (TEV) of all ecosystem services

provided by rangelands, as well as listing the beneficiaries associated with each environmental service, can provide us with a clearer and more comprehensive understanding of the entire picture that is under constant threat from desertification in the region.

Table 5. Components of the total economic value (TEV) and types of ecosystem services in steppe rangelands (Djelfa Region)

TEV	Services	Utilization
Use Value	Use Value Direct	Provision
	Use Value Indirect	Regulation
Non-Use Value	Heritage Value	Cultural
	Existence Value	Cultural

3.8 The most important ecosystem goods and services provided by rangelands and their primary beneficiaries

There is an extensive list of ecosystem goods and services supplied by steppe rangeland ecosystems. In the Djelfa region, these environmental assets are harnessed by humans, and each of these environmental assets serves to satisfy the needs of specific beneficiary groups, most of which derive benefits from nature without charge. These ecosystem services are classified based on their use value and beneficiaries, with the most significant ones being:

Use Value

Direct Use Value: Services related to the provision of natural forage. Indeed, rangelands offer a wide array of palatable plant species. The floral diversity in the region is extensive, comprising both annual and perennial species highly favored by livestock. The primary beneficiaries are the local livestock farmers. Additionally, rangelands also provide opportunities for engaging in sport hunting activities. The natural wealth of wildlife in rangelands, including small mammals and birds, bestows significance upon these areas as ideal locations for such sporting activities.

The aromatic and medicinal plants (AMP) sector identifies a development opportunity in rangelands, which represent an almost inexhaustible source of AMP and occasionally endemic plants. Traditional medicine, which has served generations past, attests to the use of these plants. Moreover, beekeeping activities in rangelands find ample pasture space for bees in this ecosystem, and the importance of this activity is emphasized by local beekeepers and transhumant herders. Additionally, the collection of truffles and certain mushroom varieties becomes a trend, particularly during rainy years.

The supply of firewood is also significant, even though the collected branches are primarily used for domestic purposes by livestock farmers. Artisanal activities, such as the use of Alfa as a widespread raw material in the creation of various decorative items and domestic utensils like containers, funnels, mats, etc., benefit local rural and urban populations as well as artisans.

Finally, the paper industry finds a crucial raw material in Alfa, which has been exploited since the inception of this industry. Collectors, transporters, and industrial producers all benefit from Alfa. These ecosystem services underscore the multifaceted importance of rangelands in the region, not only in supporting livestock but also in providing resources for various economic and cultural activities, contributing to the well-being of local communities.

Cultural services, among which the primary ones include recreational activities and ecotourism, are similarly provided by rangelands. The primary beneficiaries of these services are visitors, the local population, as well as travel agencies, tourism organizations, and discovery associations. As for the services related to spiritual values, due to the socio-cultural conditions of the local society, which demand respect and preservation of natural assets and the rational use of natural resources, the gifts bestowed by nature stimulate this sentiment in the younger generations. Moreover, these populations find a source of relaxation and inspiration on rangelands. Educational values are also present, particularly in terms of scientific research; rangelands serve as an open-air research laboratory for many natural and life sciences, as well as humanities, remote sensing, and more. Another significant educational value lies in the fact that rangelands have always symbolized a learning stage, characterized by the acquisition of traditional livestock techniques passed down from generation to generation, especially among the rural population. These teachings are of great importance for the sustainability of livestock activities and the transfer of this knowledge to others, which also holds significant weight.

Indirect Use Value: As long as vegetation cover remains dense, rangelands exhibit resistance against water erosion and desertification. Healthy rangelands serve as a source of both plant and animal diversity, leading to natural reserves for wildlife and flora, provided that these rangelands are managed sustainably. Under similar conditions, rangelands also represent an inexhaustible source of seeds, ensuring the continuity of the ecosystem. In addition to these benefits, rationally managed rangelands contribute to greener landscapes, enhancing the aesthetic appeal of the territories. Similarly, we can include the purification of air and water, as well as carbon sequestration by the vegetation present on rangelands, with the beneficiaries of all these services being the global population as a whole.

Non-use value

The non-use ecosystem services provided by rangelands primarily encompass heritage and existence values. Indeed, in the imperative to protect and preserve Mother Earth and its natural resources, there exists a strong connection between the beneficiary and the land. This connection is nourished and confirmed by belonging to a material and immaterial cultural heritage, where non-use values are passed down from one generation to the next. For example, the preservation of traditional tents and the livestock-raising techniques of transhumant communities (customs) are closely linked and are practiced exclusively on the territories of natural rangelands.

Furthermore, this ecosystem, given its specific pedoclimatic and biophysical characteristics, boasts its own floral and faunal diversity. This diversity translates into a variety of species, many

of which find their vigorous existence only within this natural environment. Consequently, rangelands also represent existence values, particularly for endemic species.

3.9 Impacts of desertification on ecosystem services in steppe rangelands: A real threat to humanity and the environment

Desertification represents a significant potential risk in steppe rangelands, driven by inappropriate human practices and climatic uncertainties. Indeed, the degradation of natural forage productivity has become increasingly pronounced, rendering rangelands incapable of supporting the growing livestock population. Faced with necessity, livestock farmers find themselves in a situation with limited maneuverability and their options often boil down to exerting repeated pressures on the ecosystem, hoping that it will endure as long as needed, or accepting additional burdens to sustain their livestock activities.

Contrary to their hopes, the logical and natural repercussions of this situation gradually become tangible and widely visible, particularly during periods of drought. Furthermore, all the environmental goods and services identified in rangelands (Table 5), along with the beneficiaries associated with each ecosystem service, appear to suffer the negative effects of desertification. These effects manifest as a quantitative and qualitative reduction in environmental services, leading to a general decline in the total economic value of the productive potential of rangeland ecosystems. Consequently, a logical consequence is a decrease in the list of beneficiaries.

As a result, we observe an increasingly evident exposure to socio-economic and environmental vulnerabilities, jeopardizing the overall well-being of the human population in this territory. Paradoxically, humanity itself serves as both the primary cause (trigger and facilitator) of desertification, and thus, it is compelled to confront these new challenges in the face of pressing circumstances.

3.10 Some aspects of public action in combating desertification

This longstanding situation has compelled public authorities to allocate substantial human resources, scientific expertise, and significant financial resources with the aim of restoring the ecosystem and maintaining human economic activity and well-being in this territory. In Algeria, just a few years after gaining independence (within less than a decade), an ambitious project was launched. This project spans an area limited by the country's eastern and western borders, with a width that can extend up to 30 kilometers. Known as the "Green Dam," it was initiated in 1970 and has been a source of inspiration for numerous similar initiatives worldwide. It serves as an emblematic project, continuously providing valuable lessons in both success and, at times, failure (Figure 5 and Figure 6).

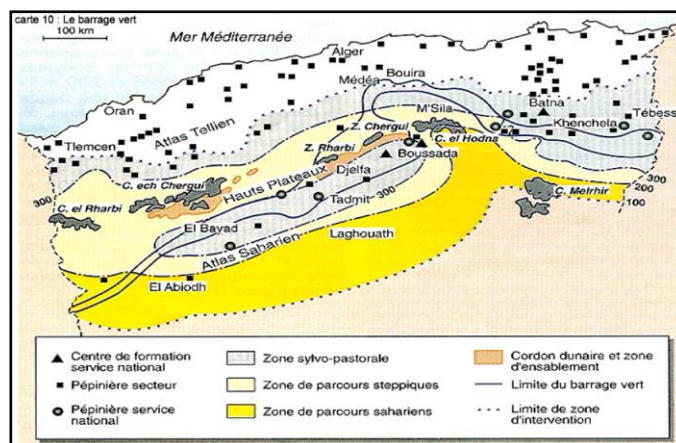


Figure 5: The Green Dam. Source: Journal Officiel (2010)

In the Djelfa province, as is the case across the steppe territories and high plateaus, young national service members are actively engaged in reforestation efforts. The High Commission of the National Army accomplished the reforestation of 19,100 hectares over 20 years. In 1990, the responsibility for this mission was transferred to the Forestry Administration, which successfully completed reforestation efforts covering 32,072 hectares (see [Table 6](#)).

Table 6. Summary of the green Dam Project in the Djelfa Province from 1970-2022

Years	Project Lead	Area Accomplished (ha)	Operations
1970-1990	High Commission of the National Army	19 100	Reforestation : 41 953 Dune Stabilization: 5 854
1990-2022	Forestry Administration	32 072	Pastoral Planting: 3 365
Total	-	51 172	-

Source: [Direction Générale des Forêts \(2022\)](#)

In 1994, the High Commission for Steppe Development (HCDS) initiated its first major program, titled "The Grand Pastoral Development Works." This program aimed to undertake various actions, including rangeland development and the rehabilitation of water points ([High Commissariat for Steppe Development, 1994](#)). This was achieved through pastoral planting, enclosure construction, and water point creation and restoration. Subsequently, numerous significant programs followed, resulting in 2,800,000 hectares of deferred grazing and over 400,000 hectares of pastoral planting across the steppe regions ([High Commissariat for Steppe Development, 2022](#)). These measures have the potential to enhance the productivity of moderately degraded or severely degraded rangelands up to 250 FU/ha and 600 FU/ha, respectively ([High Commissariat for Steppe Development, 2010](#)) (see [Figure 6](#)).

In the Djelfa province, the achievements related to these two techniques total 140,843 hectares (see [Table 7](#)), distributed as follows:

Table 7. Summary of enclosure and pastoral planting achievements in the Djelfa Province from 1994-2017

Years	Technique Employed	Area Achieved (ha)	Total (ha)
1994-2017	Pastoral Plantation	27 304	140 843
	deferred grazing	113 539	

Source: [High Commissariat for Steppe Development \(2017\)](#)



Figure 6a. Rangeland degradation



Figure 6b. Deferred grazing



Figure 6c. Deferred grazing



Figure 6d. Pastoral planting



Figure 6e. Pastoral planting

Source : [Direction Générale des Forêts \(2017\)](#)



Figure 6f. Green dam

Source: [Direction Générale des Forêts \(2017\)](#)

Figure 6: Difference between restored and desertified rangeland

4. Conclusion

Steppe rangelands are rich in ecosystem goods and services crucial for both humans and the environment. Yet, they face the threat of desertification due to human activities and natural factors. This vulnerability has led to reduced soil fertility, less vegetation cover, and a decline in essential biomass for livestock, impacting livelihoods in these regions. Overgrazing and increased costs for livestock farmers are clear consequences, particularly during prolonged droughts. Taking a holistic approach, we've identified the wide range of benefits these rangelands offer and their recipients. Understanding this helps us gauge economic value and assess the impacts of desertification on ecosystems and people. Desertification is a significant risk, causing a decline in environmental services and affecting both livestock activities and the well-being of local populations. Efforts to combat desertification have been ongoing since gaining independence, involving significant human, scientific, and material resources. However, individual contributions are crucial. Inappropriate practices harm the ecosystem and individuals themselves, emphasizing the need for reinforced efforts at a human level to ensure sustainable development and collective well-being.

Author's declaration and contribution

The authors certify that they have no conflicts of interest. Author contributions across all phases of this research article were diverse and crucial, spanning from idea inception and methodological refinement to data collection, analysis, manuscript drafting, critical review, project supervision, and highlighting a comprehensive collaborative effort.

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