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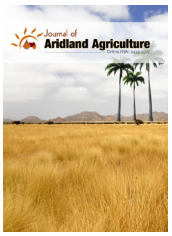

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Economic assessment of deferred grazing pasture system for rangeland restoration in steppe areas: A quantitative analysis

Benbader Habib[1,2]*, Mohamed Amine Benmehaia[3], Mohamed Saâdaoui[1], Mohamed Kacimi Elhassani[4], Adel Djoughlafi[2], Abdelghafour Doghbage[2], Hafidh Zemour[5], Walid Soufan[6]*, Muhammad Nazim[7], Fathi Abdellatif Belhouadjeb[2]

[1]Conservation, Management and Improvement of Forest Ecosystems laboratory, National Higher Agronomic School, Algiers 16004, Algeria, [2]Centre de Recherche en Agropastoralisme (CRAPAST), Djelfa 17000, Algeria, [3]Department of Agricultural Sciences, University of Biskra, Biskra, 07000, Algeria, [4]Laboratory of Organic Chemistry and Natural Substances, University of Djelfa, Djelfa 17000, Algeria, [5]ISTA, University of Larbi Ben M'hidi, Oum El Bouaghi, Algeria, [6]Plant Production Department, College of Food and Agriculture Sciences, King Saud University, Riyadh 11451, Saudi Arabia, [7]State Key Laboratory of Desert and Oasis Ecology, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China

ABSTRACT

Over the past three decades, substantial efforts have been made to implement public programs aimed at developing pastoral areas in Algeria. This study seeks to investigate the impacts of rangeland restoration projects, specifically deferred grazing, in the steppe regions. To achieve this objective, a comprehensive financial evaluation of pasture management techniques was conducted in the steppe. The study focused on identifying the most important ecosystem goods and services provided by deferred grazing project and the main beneficiaries compared with free-range grazing through observations in the areas concerned. Also, a detailed analysis of the cost structure for the deferred grazing technique, and four key criteria: Net Present Value NPV, Internal Rate of Return IRR, Invested Capital Recovery ICR, Profitability Ratio PR, and the productivity threshold for which breeders have an interest in using deferred grazing areas. Through scenario simulations, the financial profitability of these restoration projects was assessed by formulating various hypotheses. Additionally, the study evaluated the benefits of taking action to combat steppe land degradation. The results of the analysis yielded valuable insights into the economic implications of the restoration projects. Furthermore, this study draws important policy implications for the Algerian pastoral economy.

KEYWORDS: Beneficiaries, Ecosystem services, Performance indicators, Scenario simulations

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***Corresponding authors:**
Benbader Habib
E-mail: habib.benbader1@gmail.com
Walid Soufan
E-mail: wsoufan@ksu.edu.sa

INTRODUCTION

On the Earth's land surface, rangelands cover more than a third (Ojima *et al.*, 2020), Algerian rangelands occupy an area of 32 752 530 ha (MADR, 2019) or 13.75% of the total territorial area of 238 174 273 ha. These rangelands are full of a multitude of ecosystem services that translate into the benefits supplied to humans by nature, more precisely: the benefits people obtain from the ecosystem. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling and cultural services such as recreational, spiritual, religious and other nonmaterial benefits (MEA, 2003). The production of these services is increasingly deteriorating, leading to a drastic state of rangelands, and favoring the establishment of desertification, which is gaining more ground through various degradation factors (Habib *et al.*, 2024). Desertification is a major risk in Algeria, threatening not only the production of environmental services but also the economic and social aspects of the areas affected. Indeed, it significantly and often irreversibly reduces the ability of millions of people whose livelihoods depend on the natural plant and animal resources in the regions it affects (Bedrani & Elloumi, 1998). Therefore, according to MEA

(2005), desertification ranks among the greatest environmental challenges today and is a major impediment to meeting basic human needs in drylands. For example, Davies (2016) in the case of land degradation, even predicts that conflicts will intensify as the population grows and resources become scarcer, particularly in the context of climate change.

Desertification is land degradation in arid, semi-arid, and dry sub-humid areas resulting from various factors, including climatic variations and human activities UNCCD (1994). Indeed, In addition to the climate change that is beginning to occur (MATE, 2002; DGF, 2003; Aidoud *et al.*, 2011; Kanoun, 2016; Belhouadjeb *et al.*, 2022; Boukerker *et al.*, 2022), the counterproductive human activities established by modernization such as sedentarization and the disruption of traditional livestock farming, overgrazing, mechanized ploughing, and deforestation (MAP, 1974; Boukhobza, 1982, 1988, 1989; Aidoud, 1989; Bedrani, 1993; DGF, 1999, 2016; Bensouiah, 2004; MATE, 2007; Daoudi *et al.*, 2010; SNAT, 2010; Nedjimi & Guit, 2012; Hadeid *et al.*, 2015; ONS, 2015; Salemkour *et al.*, 2016; Djeddaoui *et al.*, 2017; Martínez-Valderrama *et al.*, 2018; Hammouda *et al.*, 2019; Boussaada *et al.*, 2022; Ouali *et al.*, 2023), the result will be very clear and visible: a serious decrease in production on rangelands natural forage. Indeed, according to (Nedjraoui & Bedrani, 2008) in 1968 the steppe rangelands already had an actual pastoral load twice as high as the potential load. In terms of rangeland productivity in Fodder Unit (FU), (HCDS, 1995; Nedjraoui, 2006) stated that in 1978, it was between 120 to 150 FU ha^{-1} $year^{-1}$, to decrease at 30 FU on degraded rangelands, and 60 to 100 on palatable pastures. In 1998 rangeland production was 10 times lower than livestock needs (Nedjraoui & Bedrani, 2008), and based on research for these steppe rangelands from 2001; gave an average productivity of 72.53 FU ha^{-1} (HCDS & BNEDER, 2010). Over the same period, the sheep herd stood at around 22.87 million head (MADR, 2010), rising to 31.13 million by 2021 (MADR, 2021). As a corollary of this situation, the retail price of sheep red meat has increased from 55 DZD kg^{-1} in 1977 (Nedjraoui, 2006), to over 500 DZD kg^{-1} in 2001 and almost 1 500 DZD kg^{-1} in 2019 (ONS, 2019), to stabilize at around of 2 500 DZD kg^{-1} at present. Consequently, due to an imbalance between forage production and livestock feed needs, livestock feed made up of natural and cultivated fodder, is undoubtedly one of the major constraints on the development of livestock farming (Hirche *et al.*, 2015; ONS, 2022). So on this fragile area, and on the basis of these indicators, the situation is alarming. We are no longer in the case of sustainable development (Hirche *et al.*, 2011). This region faces a multitude of socio-political challenges that shape its development and the livelihoods of its inhabitants: 1) Land Management and Ownership: Traditional land use practices historically governed the region, but changes in land ownership and the introduction of private property have led to conflicts over grazing rights and resource access among pastoral communities (Schmitz & Boussaïd, 2021). 2) Population Growth and Migration: The region has witnessed population growth, resulting in increased pressure on land and resources. Urbanization has led to the abandonment of traditional pastoral practices by some communities, contributing to the degradation of rangelands (Martínez-Valderrama *et al.*, 2018; Slimani & Aidoud, 2004). 3) Water Resource Management: Water scarcity is a significant issue in the steppe, impacting agriculture, pastoral activities, and human settlements (Benaradj *et al.*, 2020; Rahmani *et al.*, 2020). 4) Biodiversity Conservation: The steppe region hosts diverse flora and fauna, but unsustainable land use practices and human encroachment threaten its biodiversity. 5) Climate Change Adaptation: The steppe region is vulnerable to the impacts of climate change, including increased temperatures and more erratic rainfall (Benmehaia *et al.*, 2020; Alliouche & Kouba, 2023).

We are conscious that: the causes of rangeland degradation are complex in time and space and associated with interactions between pastoralists, governance and policy, and environmental factors (Bedunah & Angerer, 2012), and in aim of reversing this situation, and within the framework of integrated sustainable development in the areas concerned, in line with international commitments which aims at: 1) prevention and/or reduction of land degradation, 2) rehabilitation of partly degraded land, 3) and reclamation of desertified land UNCCD (1994). Algeria has developed several plans to combat desertification and land degradation, on the diversity of techniques used, deferred grazing emerges as an effective technique, easy to implement, inexpensive, and stimulates the role of biodiversity (MA, 1996; Boukli-Hacene, 2002; Amghar *et al.*, 2016; Kouba *et al.*, 2021, 2024). It should be noted that deferred grazing relies on the resilience of the ecosystem and its vitality, in particular on the presence of a minimum plant cover, and as long as the soil is deep, permeable and fertile, the results are favorable, especially under good climatic conditions. The perimeter is protected from humans and domestic animals for a period between 1 and 3 years, depending on the factors already mentioned, but generally for 2 years and more (CAEES, 1961; Smail, 1991; Hien *et al.*, 2004; Boukhnifer, 2008; HCDS, 2010).

Deferred grazing, a time-tested pasture regeneration technique, has been a long-standing practice, it is a technique for regenerating rangelands, traditionally practiced for centuries in steppe areas. Deferred grazing, commonly known as *Agdal*, seems to be well known by pastoral society and is part of ancestral know-how. Indeed, according to Le Houérou (1995), deferred grazing is a natural technique that allows us to protect a territory or a plot of land against humans and/or domestic animals, it is a well-known technique that was practiced for centuries by our ancestors such as *Agdal* in North Africa or the *Hema* system in the Near East and Arabia. Indeed, According to the National Action Programme to combat desertification in the Kingdom of Saudi Arabia (NAP, 2005) *Hema* is an ancient technique in the Kingdom, where its application is governed by tribal decisions, with customary organization determining the area, method of exploitation, and beneficiaries. Abandoned at the beginning of the second half of the twentieth century, set-aside is regaining its importance due to overgrazing and long cycles of repeated drought. (Haddad, 2014; NAP, 2015) stated that even before the appearance of Islam (7th century), *Hema* was governed by traditional institutions in the Arabian Peninsula to signify the setting aside of land to enable the regeneration and sustainable use of natural resources for

the benefit of communities living nearby. However, Muslim influence transformed private *Hema*, into a legal system that protected natural areas for greater collective benefit, negating the dominance of powerful chosen individuals.

In order to increase general well-being, operational responses are increasingly required to strengthen society's resilience in the face of global change and to provide economic responses to guide policy formulation and decision-making. This study aims to examine and detect the most important ecosystem goods and services provided by the deferred grazing technique and the main beneficiaries in restored areas compared with steppe-free grazing marked by deterioration in the productive potential of the biomass. The originality of our research also lies in the lack of studies that clarify the conduct of a complete quantitative assessment of ecosystem benefits using selected performance indicators for the analysis of pasture restoration projects, as well as the simulation process for assessing financial profitability with the establishment of a complete set of numerous hypotheses. This article also opens up numerous avenues of research, which should give greater importance to ecosystem goods and services in their various dimensions in the steppe region.

MATERIALS AND METHODS

Study Area

This study covered the entire steppe of Algeria, which stretches over 36 million ha of pastureland, of which 16 million ha is in the pre-Saharan region (MAP, 1984; HCDS, 1995). It is located between the isohyets 100 and 400 mm (Bedrani & Elloumi, 1998). The Algerian steppes with the pre-Saharan region (Figure 1) extend to 440 municipalities (Belhouadjeb *et al.*, 2022). The climate is dry in summer, harsh with little rainfall, and cold in winter (GGA, 1893; MAP, 1998; Abbas *et al.*, 2011; Benhizia *et al.*, 2021). The vegetation is based on Gramineae and/or perennial chamaephytes with a varied cortege of annual species (DPSB, 2014). Only livestock farming (sheep and goats) is able to make the most of this vegetation, on condition that it is mobile, so as to find his livelihood Côte (1996). Indeed, traditionally the steppe is considered a sheep production area HCDS (1995).

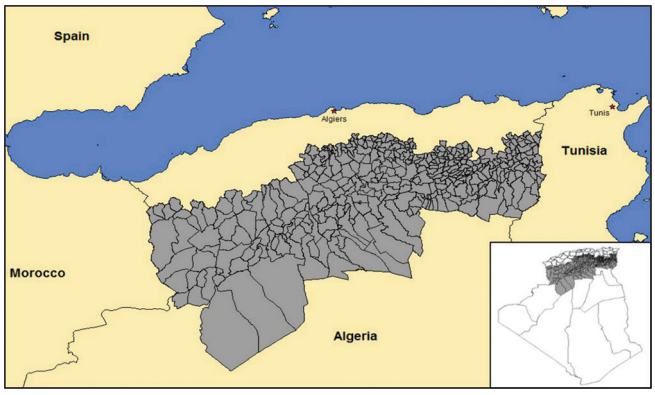

Figure 1: Algerian Steppe, data source: (Belhouadjeb *et al.*, 2022).

Data Collection

All the data on rangeland restoration projects are provided in a document of the (HCDS, 2010). The document gives an exploitation life of 5 years for deferred grazing. As for the time needed for upstream vegetation to recover, this is estimated at 2 years before exploitation, giving 7 year life cycle for the project, and productivity of 250 FU ha^{-1} $year^{-1}$. The discount rate used is 5.5%, the rate used by the Agriculture and Rural Development Bank (BADR) to calculate interest on agricultural investments. As for the price value of the FU, and because 1 FU=1 kg of barley, we bet on the local market price of 1kg of barley at 30 DZD according to our observations from the start of the project (DZD: Algerian dinars local currency, one USD is equivalent roughly to 135 Algerian dinars in terms of official exchange rate in 2023).

Detect The Most Important Ecosystem Goods And Services Provided By Deferred Grazing Project And The Main Beneficiaries

This task involves making observations on managed areas in order to deduce the list of goods and services provided by deferred grazing areas compared with free-range grazing. This list is then sorted according to the type of service and its use value, and the main beneficiaries of each service are also listed.

Selected Performance Criteria For Project Analysis

In the assessment of preservation projects utilizing a cost-benefit analysis approach, it is essential to consider a set of relevant indicators. However, conducting a comprehensive quantitative assessment of ecosystem benefits and losses can be challenging due to information limitations at various levels, as highlighted by Sukhdev (2008). As a result, a partial quantitative evaluation becomes necessary, and the following performance indicators are deemed most pertinent: Net Present Value (NPV), Internal Rate of Return (IRR), Invested Capital Recovery (ICR), and Profitability Ratio (PR).

For evaluating the economic profitability of public initiatives combating rangeland degradation, this study utilizes the NPV measurement. As projects have lifespans, determining the present value of costs and benefits at each stage during the project's lifecycle is essential. The formula applied is as follows:

$$NPV = \sum_{t=1}^{N} R_t (1+i)^{-t} - \sum_{t=1}^{N} I_t (1+i)^{-t} \quad (1)$$

Where R_t represents the cash flow generated by the investment, I_t is the cost at time t and i is the interest rate. The NPV provides an assessment of project acceptance or rejection and facilitates comparisons between benefits derived from different project alternatives.

The IRR denotes the discount rate (i) at which the NPV becomes zero (Boughaba, 2005), signifying the point of

equality between discounted income and expenditure. The IRR is determined through trial and error and offers insights into the project's financial viability. If the IRR exceeds the interest rate, the project is deemed acceptable; otherwise, it is rejected, indicating that the project's benefits do not cover the investments. The formula applied for calculation is:

$$I_0 = \sum_{t=1}^{N} R_t (1+i)^{-t} \quad (2)$$

Where I_0: investment

The Invested Capital Recovery ICR informs about the number of years required to recover both the investments and expenses incurred in the project. It determines the point at which positive cash flows begin to be recorded. This criterion favors investments with higher immediate cash flows (Bouchaib, 2001). To determine ICR, a linear interpolation is used.

Finally, the study employs the Profitability Ratio PR, which represents the ratio between discounted benefits and costs. This indicator expresses the value derived from dividing the sum of discounted cash flows by investments. Projects that accumulate higher cash flows relative to the investment receive favorability in decision-making.

$$PR = \frac{\sum_{t=1}^{N} R_t (1+i)^{-t}}{\sum_{t=1}^{N} I_t (1+i)^{-t}} \quad (3)$$

The significance of the PR lies in its ability to provide a rapid and straightforward response for project evaluations. If the PR>1, it indicates that discounted benefits outweigh costs, rendering the project profitable and favorable for implementation.

Scenario Simulation Procedure For The Deferred Grazing

The simulation process for evaluating the financial profitability of our project commences with the establishment of a comprehensive set of hypotheses, encompassing various scenarios throughout the project's duration. These scenarios revolve around variations in Fodder productivity of the deferred grazing perimeters in Unit per hectare (FU ha^{-1}), a variable that undergoes simulation. As the development technique's rational exploitation relies significantly on biophysical and climatic factors, the annual fodder production is inherently subject to their influence. The uncertain and uncontrollable nature of the future necessitates the identification of hypotheses that reflect potential disruptions in FU production caused by these factors.

Under these circumstances, this study endeavors to explore various scenarios concerning fodder production in pastoral areas. These scenarios are formulated as hypotheses, encompassing different annual production levels throughout the project's operational period. Throughout these scenarios, we maintain consistent production costs, discount rates, and FU prices to ensure accurate comparisons.

To evaluate the financial viability of each hypothesis, we recalculate the underlying financial criteria for all the scenarios. By analyzing these metrics for each production hypothesis, we gain valuable insights into the project's performance under varying conditions. The study's findings and analyses are presented in the form of an informative dashboard, offering clear visual representations for each hypothesis. It will provide a comprehensive view of the project's financial sustainability, allowing stakeholders to assess the potential outcomes for different production scenarios.

RESULTS AND DISCUSSION

The Most Important Ecosystem Goods And Services Provided By Deferred Grazing Perimeters And The Main Beneficiaries

From the moment we set foot on the deferred grazing perimeters, it turned out, according to our observations, that there was a larger and generously considerable list of goods and services provided by the deferred grazing perimeters (Table 1), compared to those of the free ranges (Habib *et al.*, 2024). This situation has led us to draw conclusions from the examination of the field.

- Firstly, the first point concerns the importance of the comparative advantages offered by deferred grazing technique. Indeed, an operator is well served in terms of the quality of ecological goods, and amply in terms of quantity compared to free ranges;
- Secondly, according to our observations during the interviews with the herders, the farming practice takes place in an atmosphere of tranquility, the resource persons justify this situation by the permanent presence of the guards and the limitation of the plots for each herder;
- Thirdly, the logic of the thing, and the fact of reconnecting ideas and events in its chronological context, mean that, in order to be able to analyze this new situation, we will have to take into account that the growth in supply will certainly generate a greater exploitation than before, which itself, and under rational conditions, will create in the demands, other secondary activities of services and the provision of substantial needs, which can only be initiated and strengthened if a good number of people do so, and it is from this it is clearly apparent, an enlargement in the list of beneficiaries (directly and/or indirectly), and an increase in the number of people in question.

Direct Use Value

The supply of natural fodder is certainly one of the most important environmental services targeted by public action and sought after by livestock farmers. It is quite clear that deferred grazing technique offers more natural grass in quantity and of better quality, which is greatly appreciated by breeders. Indeed, the productivity per hectare (UF ha^{-1}) is multiplied several times,

Table 1: The component of Total Economic Value and types of ecosystem service offered by deferred grazing perimeters in study region

Total Economic value		Services	Usage
Use value	Use value Direct	Provision	Low-cost fodder offer (FU)
			Supply of firewood
			A source of wealth for the municipality and the public treasury
			Promote the creation of micro-enterprises (transport, land registry, etc.)
			Boost the region's economy through direct or indirect involvement
			Possibility of exploitation of aromatic and medicinal plants (MAP)
			Job creation in rural areas
			Creation of non-agricultural income
			Mitigating the rural exodus to the city
			Fight against unemployment and rural poverty
			Honey production
			Sport hunting
			The supply of raw materials for artisanal activity (Alfa, Thymelaea, etc.,)
		Cultural	Ecotourism and recreation
			Spiritual values
			Educational values "research"
			Educational values: the acquisition of new techniques and skills
	Use value Indirect	Regulation	A reserve of standing fodder in case of drought calamity
			Fight against water erosion
			Combating desertification
			Creation of a new plant and animal atmosphere, which leads to natural reserves of wild fauna and flora
			An inexhaustible supply of seeds
			Mitigate the action of overgrazing
			Creation of greenery from an aesthetic point of view
			Water and air purification
			Carbon storage
Non-use value	Heritage Value	Cultural	Preservation of rangelands for future generations
			Installation and adoption of a participatory approach
			Maintenance and safeguarding of the rangelands, places of the traditional tent, and the breeding of transhuments (customs) for future generations
	Existence Value	Cultural	The re-emergence of species of pastoral interest once threatened by overgrazing

and the vegetation cover is very rich with a wide range of species palatable by the animal herd (formerly threatened by overgrazing and drought). The main beneficiaries of natural fodder are the herders whose activities are closely dependent on the availability of natural grass, as well as the entire economy of the region.

The few trees and shrubs on the rangelands of the region offer firewood, certainly in less quantity than the forest ecosystems, but capable of warming the pastoralists on the landlocked rangelands. It should be noted that even transhumant households in Algeria use butane gas cylinders, unless they are absent, the head of the household uses wood purchased or cut from nature.

In addition, the municipality and the public treasury will benefit from a fee paid for each operating campaign, the amount of which is set at one thousand dinars 1000 DZD ha^{-1} for each campaign. The distribution of the fee revenue is 70% for the municipality and 30% for the public treasury. The fee is more favorable to the municipalities; it aims at the good management of the routes put on the deferred grazing, and more motivation for the municipalities that are still hesitant in this approach.

One category of beneficiaries that we believe is crucial to count, the rural and urban local populations, will benefit from the sources of activity offered by deferred grazing project. Indeed, the activity of guarding these perimeters is a very valuable work opportunity in isolated rural areas where work is rare in scattered areas. The local urban populations in turn ensure the proper execution of these fodder perimeters and provide goods and services for the herders, as well as there are a multitude of activities assigned to this population: creation of micro-enterprises (transport, cadastre, etc.).

Deferred grazing perimeters also offer the possibility of hunting activities. Indeed, plant and animal biodiversity is further developed in these areas. The maintenance and development of nature, and the prohibition of all activities in this ecosystem, will qualify them as places that attract birds and small mammals, which are the preferred and crucially important animals for this kind of sporting activities. The main beneficiaries are rural and urban populations.

The aromatic and medicinal plant sector is certainly finding an opportunity for development. On the perimeters developed for deferred grazing, and because of its immensity, diversification, and also permanent guarding, deferred grazing perimeters presents an almost inexhaustible source of AMP and sometimes endemic plants, the main beneficiaries are the rural and urban populations. In addition, during good rainy years, truffle and mushroom picking on protected ranges becomes an occasional activity.

On the other hand, beekeeping also finds a real opportunity for development in the region. Indeed, the flora is well protected,

varied, prosperous, and above all abundant on all landscapes. The region's beekeepers and transhumant are the potential beneficiaries.

A craft activity, in turn, gains advantageous possibilities by putting it in deferred grazing perimeters. Indeed, the preservation and continuity of the cultural heritage are linked to the availability of raw materials, which favors the transmission of artisanal knowledge from one generation to its successor, the Alfa for example, and in addition to its interests in the paper industry, is of a very widespread importance in the production of certain artistic and traditional works: carpets, ropes, baskets, hats. The Thymelaea is used to make cord and broom, etc. The maintenance and transfer of the artisanal know-how of the ancestors found on the deferred grazing perimeters, a source of preservation of raw materials, therefore, the approach to the preservation of the cultural heritage identifies a source of prosperity. The main beneficiaries are the local rural and urban populations and artisans.

Cultural services are provided on the perimeters of the deferred grazing, the main ones being leisure activities and ecotourism. These activities are gradually being demanded given the pressures of modern life, and are increasingly being called upon as the landscape is accessible and has a rich and protected biodiversity. The main beneficiaries are visitors and rural and urban populations.

Spiritual value services are also identified. Indeed, the socio-cultural conditions of the native people of the steppe strongly encourage the maintenance of natural assets, especially if they are common goods; these same conditions also encourage the rational and fair use of natural resources. In addition, and on the geographical basis of its distance from modern life, the deferred grazing perimeters, also offer a source of relaxation and inspiration for those who seek a sense of tranquility.

Educational values, particularly in terms of scientific research, are certainly guaranteed by these developed perimeters. The deferred grazing perimeters offer a research laboratory in nature for those curious about science, especially natural and life sciences, human sciences, geography remote sensing, etc.

The other educational value, which seems to us to be of major and significant importance, is manifested in the acquisition of new techniques and skills for the rural and urban population. These lessons will be of decisive importance in the success and expansion of future similar projects, as well as the transfer of this knowledge to others. The idea here is not only about technical transfer, but it is a process of observation by others. A realization of the rules of the art and in rational conditions, undoubtedly stimulates the orientation of reflexivity of people who are still doubtful, such a realization would most probably have led to a demonstrative and spectacular objective, which manages to seduce the local population to contribute massively in this approach, and to encourage more the Communal People's Assemblies of the other municipalities and those populations that have not yet joined to do so, for "experience instructs more surely than advice" especially when it is a matter of a tangible and very palpable result, and observed by a professional's eye.

Indirect Use Value

These values are manifested by its functions in the regulation and maintenance of the ecosystem. The developed area contributes effectively to the fight against water erosion and desertification, as well as the creation of a plant and animal environment that will lead to natural reserves of wild fauna and flora. In addition, the almost inexhaustible supply of seeds can be added to this: the creation of greenery from an aesthetic point of view, air and water purification, and carbon sequestration, as well as the contribution to mitigating the action of overgrazing. The beneficiaries of these services are the entire population.

Non-Use Value

The preservation of rangelands, which are increasingly threatened by degradation for future generations, is necessarily one of the duties and responsibilities of the current generation. In addition, the approach adopted by the public authorities (participatory) seems to improve good environmental governance, and thus the use of new traditions and good practices in the management and use of the commons of nature. To optimize the sense of organization and duty/responsibility in the success and continuity of these development actions, this value is manifested by the contribution of all actors in the elaboration and execution of public action aimed at developing degraded grazing lands. The entire population benefits from these non-use values detected on the deferred grazing perimeters. These ecosystem services are referred to as heritage and existence values.

The safeguarding of local animal breeds, traditional tents, traditional medicine (treatment of grandmothers), and all the know-how of transhumant breeding (tangible and intangible customs and cultural heritage), these services are only exercised in a suitable territory; the perimeters of deferred grazing seem to offer this opportunity. On the other hand, the values of existence are particularly reflected in the reappearance of species of important interest in pastoral activity that were once threatened by overgrazing before public action. In short, a deferred grazing perimeter under rational conditions not only allowed a greater offer in ecosystem services, but it actually contributed to the genesis of a renaissance of steppe rangelands.

Analyzing The Cost Structure Of Deferred Grazing Controlled Pasture System

The economic assessment commences with a detailed analysis of the cost structure for the selected deferred grazing project in this study. Table 2 presents the cost structure for one hectare of controlled pasture system in the steppe.

Upon analyzing the results, it becomes evident that deferred grazing stands out as a straightforward and cost-effective technique, with production costs slightly exceeding 520 DZD.

Table 2: Structure of the costs of deferred grazing project for one hectare

Items	%	%
Wages		94
Specialized engineers	1.56	
Specialized technicians	3.14	
Attached officers	1.14	
Field technicians	1.88	
Guarding agents	84.08	
Engine drivers and mechanics	1.60	
Management and maintenance costs		6
Fuel and lubricants	1.65	
Spare parts	1.35	
Confluence and assessment fees	0.33	
Displacement fees	1.57	
Delimitation and materials	1.35	
Total	100	100

However, the breakdown of these costs reveals that a significant portion (94%) is allocated to salaries, while only 6% is attributed to management and maintenance expenses. Particularly noteworthy is the fact that the guarding component consumes nearly 85% of the production costs, underscoring the crucial role of this technique in generating employment opportunities in remote and isolated areas.

Calculation of Performance Criteria for Project Analysis

The Table 3 presents the financial indicators for controlled pasture investment, facilitating a comprehensive analysis of the main economic performances in the context of the steppe region. The calculated Net Present Value (NPV) for deferred grazing yields positive values (27027.45). These results unequivocally demonstrate the profitability of the technique. This favorable outcome can be attributed to a combination of factors. Firstly, the production costs per hectare are notably low, which further adds to its economic feasibility, making it financially viable. Additionally, the increasing demand for perimeters of deferred grazing plays a vital role in its economic success, coupled with the prevailing market price of the fodder unit (FU).

Furthermore, the Internal Rate of Return (IRR) for the deferred grazing investment is calculated to be (3.67), indicating that the project can tolerate an interest rate of 367% (if financed by a bank). This finding underscores the fact that deferred grazing serves as a moderate-risk investment option, making it a viable choice for loan financing. Additionally, the Invested Capital Recovery ICR for deferred grazing has been calculated to give a result of (2.1) years. This implies that the capital invested in deferred grazing is recovered within just two years after the project's initiation, directly after the first operation of exploitation. This result further highlights the advantageous nature of deferred grazing as an investment project.

Lastly, the estimated Profitability Ratio (PR) for the investment in deferred grazing is also calculated, and gives the value of (16.5), clearly indicating that the benefits derived from adopting this technique surpass the costs incurred by a staggering 16 times.

Table 3: Performance indicators for the deferred grazing controlled pasture investment

Indicators	Deferred Grazing
NPV	27027.45
IRR	3.67
ICR	2.10
PR	16.46

Furthermore, the breeders exploiting the deferred grazing zone are required to pay a fee of 1000 DZD ha^{-1}. Hypothetically, there exists a productivity threshold in FU ha^{-1}, where the monetary value of the FU produced equals the market reference price of fodder unit, i.e., 1000 DZD ha^{-1}/30 DZD FU^{-1} = 33.33 FU ha^{-1}. In this case, livestock farmers have an interest in utilizing deferred grazing perimeters as long as the productivity exceeds 33.33 FU ha^{-1}, without even considering the other ecosystem services produced by these developed perimeters. However, if the livestock farmers are obliged to pay 1050 DZD (50 DZD more for supervision rights), then the threshold for positive productivity for the livestock farmers increases to 35 FU ha^{-1}, i.e., 1050 DZD ha^{-1}/30 DZD FU^{-1} = 35 FU ha^{-1}.

Scenario Simulation Procedure For The Deferred Grazing Project

The Drawing upon these findings and analyses, scenario simulations was conducted to assess the financial performances under various hypotheses. Table 4 presents the results of different scenarios for each indicator. Notably, when considering deferred grazing as an investment generating only a fee of 1000 DZD ha^{-1} $year^{-1}$, regardless of its productivity in FU, and neglecting the improvement of ecosystem services resulting from this technique (i.e., excluding the reference price of 30 DZD in the calculation), the indicators consistently yield positive values, reaffirming the profitability of the investment.

Financial performances under various scenarios are also calculated in greater depth and on 15 hypotheses of productivity from 30 to 600 FU ha^{-1}, Table 4 gives some examples of scenario results.

The calculations made of the probable scenarios under different productivity (FU ha^{-1}); agree to illustrate the economic utility of deferred grazing project even at values below the expected productivity of 250 (FU ha^{-1}). On the basis of these calculations, we can confirm that the various results obtained support giving a dashboard with green signs (Figures 2-6), and underline the importance of the deferred grazing technique (Figure 7).

Indeed, with the development of productivity in the developed area, the first observation reveals a continuous increase in the calculated values of the Net Present Value (NPV), the Internal Rate of Return (IRR), and the Profitability Ratio (PR). Secondly, the Invested Capital Recovery (ICR) has a negative relationship with productivity growth, but most of the scenarios record an (IRC) of less than 3 years, which is a very encouraging indicator. For the calculated estimate of the monetary value of the fodder unit produced in the perimeter, our calculations also show a

Table 4: Scenario results for each financial indicator

Indicators	Scenario 3 (50 FU)	Scenario 5 (100 FU)	Scenario 7 (200 FU)	Scenario (33.33 FU). 0r (1000 DZD ha^{-1} $year^{-1}$)
NPV	4007.54	9762.54	21272.48	2089.25
IRR	1.11	1.97	3.18	0.71
ICR	2.95	2.26	2.12	3.02
PR	3.29	6.58	13.17	2.19

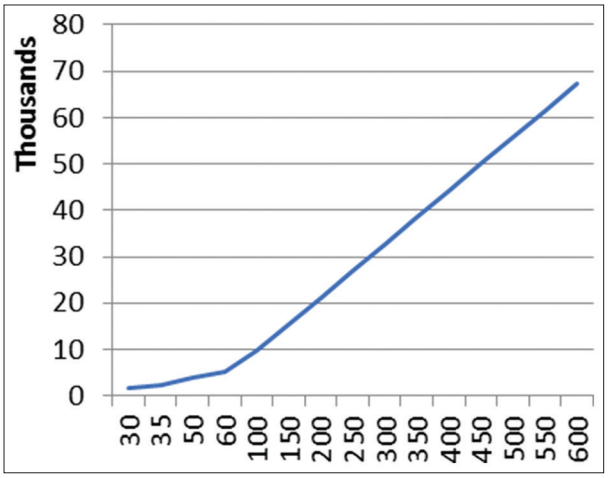

Figure 2: The different NPR values depending on Productivity (FU ha^{-1})

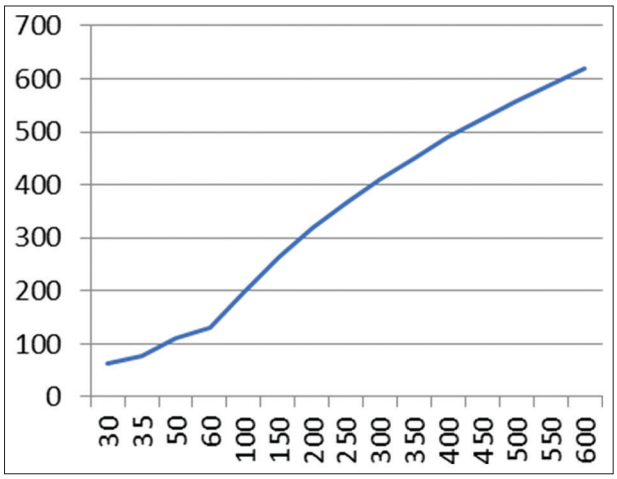

Figure 3: The different IRR (%) values depending on Productivity (FU ha^{-1})

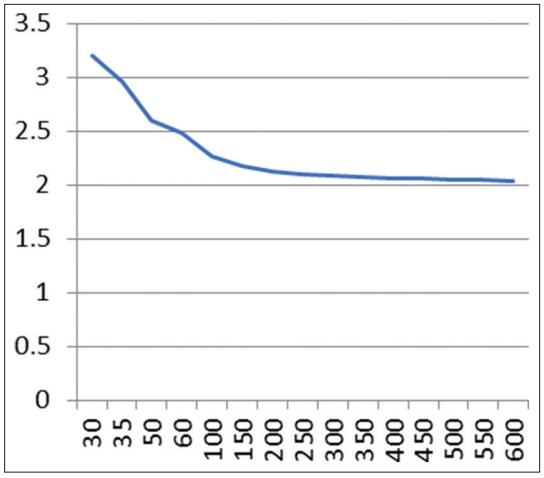

Figure 4: The different ICR values depending on Productivity (FU ha^{-1})

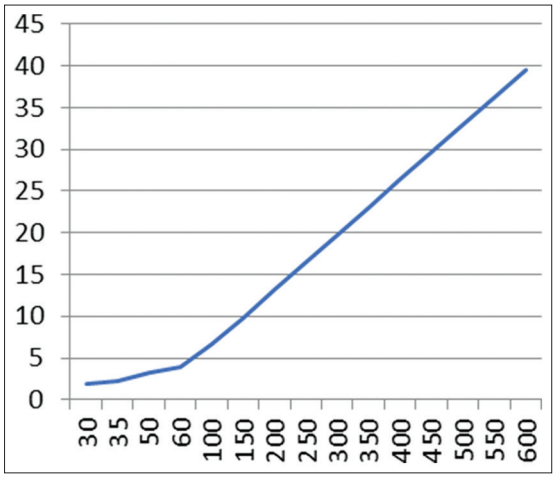

Figure 5: The different PR values depending on Productivity (FU ha^{-1})

price that decreases with the evolution of productivity, which allows a reduction in the production costs of the livestock farming activity. These simulations demonstrate that deferred grazing continues to be a financially viable and advantageous investment, even under different hypothetical scenarios. The positive outcomes highlight the robustness of this controlled pasture system, making it a promising option for rangeland restoration and sustainable development in the steppe region.

Finally, it is clear from this quest that the technique of deferred grazing offers a wide range of environmental goods and services, and a strengthening in the list of beneficiaries compared to the free range grazing, resulting in an increase in the total surplus of society. The insignificant amount of implementation as well as its structure, demonstrates the positive impacts on the socio-economic aspect, in particular the deployment of the workforce in rural areas, and a tangible response to the problem of natural fodder which is highly essential for the production of organic red meat, and with much lower costs than on the market. On the basis of the results of the calculation of performance indicators under different scenarios, the economic aspect is more supported, as the overall benefits generated by this public action far exceed the costs of its implementation, and at a minor duration, with a large capacity to cover the interest rates of the capital invested in the event of bank financing, In other words, the total economic value produced by installation of deferred

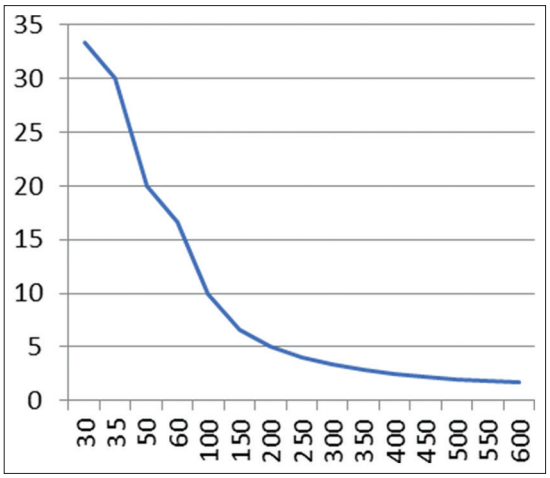

Figure 6: The different price 1FU DZD^{-1} values depending on Productivity (FU ha^{-1})

Figure 7: Deferred grazing in Djelfa area Source: HCDS

grazing project far outweighs the costs of degradation. Deferred grazing is therefore a strategic investment in the steppe, which offers a valuable opportunity to restore and improve degraded rangelands, combat desertification, and effectively increase the production of ecosystem goods and services.

CONCLUSION

This study aimed to undertake an economic assessment of investment in a crucial technique for controlling pastures in the steppe of Algeria, namely: deferred grazing. Through an analysis of project performance criteria and scenario simulations, we shed light on the financial profitability and potential benefits of these preservation projects.

The main findings highlight the viability and economic advantages of deferred grazing project. We observed that the controlled pasture system offers substantial benefits, ranging from increased fodder productivity to job creation in rural areas, and plays a crucial role in combatting land degradation and desertification. The positive Net Present Value and Internal Rate of Return for the investment highlight the profitability and potential for long-term economic gains. However, it is essential to acknowledge that our assessment only encompasses a portion of the full range of services provided by ecosystems, and there are likely benefits that remain unidentified. Despite our best efforts, we recognize that the complete assessment of ecosystem services and their quality may always remain elusive. Nevertheless, this study provides valuable insights into the economic implications of investing in rangeland restoration projects, which can inform decision-making and policy formulation.

The results of this study hold significant policy implications for sustainable land management and ecosystem conservation in the steppe of Algeria. The positive economic outcomes of the deferred grazing technique underscore the importance of investing in this initiative to mitigate land degradation and preserve valuable ecosystem services. Policymakers should prioritize supporting and promoting controlled pasture systems to enhance agricultural productivity, conserve biodiversity, and create job opportunities in rural areas.

While this study offers valuable insights, there are several limitations that need to be acknowledged. Firstly, the assessment of ecosystem services is inherently complex and may not capture the full extent of their value accurately. Additionally, the analysis primarily focused on the financial aspects, and other non-economic benefits, such as cultural and social values derived from rangelands, were not fully addressed.

As we move forward, there are several avenues for further research and exploration. Future studies could incorporate a more comprehensive assessment of ecosystem services, considering both economic and non-economic aspects, to better understand the full value of rangeland ecosystems. Additionally, evaluating the long-term ecological impacts of deferred technique could provide valuable information on their sustainability and effectiveness. Moreover, extending the analysis to other regions in Algeria and comparing different land management strategies could yield valuable insights for policy formulation and adaptive management approaches.

While there are inherent challenges in assessing the full range of ecosystem services, our findings underscore the potential benefits of preserving rangelands and inform the development of policies that promote sustainable land management practices. By recognizing the value of these preservation projects, Algeria can pave the way for a more resilient and ecologically sound future for its pastoral regions.

AUTHOR'S CONTRIBUTION STATEMENT

Conceptualization, B.H. and M.A.B.; methodology, B.H., M.A.B. and M.S.; software, B.H., M.A.B. and M.S.; validation, B.H., M.A.B., M.S., M.K.E., A.D., A.Do., W.S., M.N. and F.A.B.; formal analysis, B.H. and M.A.B.; investigation, B.H. and M.A.B.; resources, B.H., M.A.B. and M.S.; data curation, B.H.; writing-original draft preparation, B.H., M.A.B. and M.S; writing-review and editing, B.H., M.A.B., M.S., M.K.E., A.D., A.Do., W.S., M.N. and F.A.B.; visualization, B.H., M.A.B. and

M.S; supervision, B.H., M.A.B. and M.S.; project administration, B.H., M.A.B. and M.S.; funding acquisition, W.S., M.N. and F.A.B. All authors have read and agreed to the published version of the manuscript.

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