



## Economic Valuation of the Role of Rangeland Ecosystems in Soil Nutrient Conservation

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| Article Info                                                                                                                                    | ABSTRACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| <b>Article type:</b><br>Research Article                                                                                                        | Soil is one of the most important components of rangeland ecosystems, serving as the primary medium that supports the survival and growth of rangeland vegetation. Maintaining soil quality and its nutrient content plays a fundamental role in sustaining productivity, enhancing biodiversity, and preserving ecosystem services. Improper grazing management and overgrazing reduce soil fertility, accelerate soil erosion, and ultimately decrease the productive capacity of rangelands. Despite considerable research, significant challenges remain in quantifying the economic impacts of grazing intensity and understanding its consequences for rangeland ecosystems. This study aimed to economically evaluate the role of rangeland ecosystems in conserving key soil nutrients, with a particular emphasis on nitrogen (N), phosphorus (P), and potassium (K), in the Moghan region. For this purpose, two rangelands with contrasting management conditions (well-managed and poorly managed) were selected. Using the transect sampling method, 30 soil samples were collected from each rangeland and transferred to the laboratory for the determination of N, P, and K concentrations. The annual soil erosion rate of the study area was estimated at $14.7 \text{ t ha}^{-1} \text{ yr}^{-1}$ , while the total rangeland area was calculated to be 115,000 ha. Statistical analyses included an independent t-test to compare soil nutrient concentrations between the two rangelands and logistic regression to estimate the probability of rangeland degradation. Finally, the economic value of the conserved soil nutrients was estimated using the replacement cost method. The results indicated that the rangeland capital value regarding soil nutrients conservation was estimated 449190000 Iranian Rials per hectare. These findings highlight the critical importance of sustainable rangeland management in reducing the loss of natural capital, maintaining soil fertility, and minimizing the economic costs associated with rangeland degradation. The results can provide valuable scientific evidence for policymakers and land managers in developing effective strategies for the conservation and sustainable utilization of rangeland ecosystems. |
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| <b>Keywords:</b><br>Economic valuation,<br>Rangeland ecosystem,<br>Replacement cost method.                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
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## **Introduction**

Rangeland ecosystems are among the most valuable terrestrial ecosystems, providing a wide range of ecological, economic, and social services. Beyond supporting livestock production, they play a fundamental role in maintaining biodiversity, regulating hydrological processes, preventing soil erosion, storing carbon, and sustaining rural livelihoods. Among the various components of rangeland ecosystems, soil represents the primary natural capital that determines ecosystem productivity and resilience. Healthy soils provide essential nutrients, water, and physical support for vegetation while simultaneously regulating numerous biogeochemical processes that maintain ecosystem stability. Consequently, any deterioration in soil quality directly threatens the sustainability of rangeland ecosystems and reduces their capacity to deliver ecosystem services. In many arid and semi-arid regions, inappropriate grazing practices and poor rangeland management have accelerated soil degradation. Excessive grazing intensity reduces vegetation cover, weakens root systems, exposes the soil surface to erosive forces, and increases nutrient losses through both water and wind erosion. These processes lead to a gradual decline in soil fertility, diminished forage production, and increased restoration costs. Although the ecological impacts of rangeland degradation have been extensively documented, the economic consequences associated with the loss of soil nutrients have received comparatively less attention. Assigning an economic value to ecosystem functions provides a practical framework for integrating environmental considerations into natural resource management and policy-making.

One of the most effective approaches for valuing ecosystem services is the Replacement Cost Method, which estimates the monetary value of ecosystem functions based on the cost required to replace lost natural resources or ecosystem services through artificial means. In the context of rangelands, this approach enables researchers to quantify the economic losses resulting from the depletion of essential soil nutrients such as nitrogen (N), phosphorus (P), and potassium (K). These nutrients are indispensable for plant growth, primary productivity, nutrient cycling, and maintaining soil fertility. Their depletion not only reduces agricultural and rangeland productivity but also increases dependence on costly chemical fertilizers.

The Moghan Plain, located in northwestern Iran, represents one of the country's most important rangeland regions. However, increasing grazing pressure and land-use changes have raised concerns regarding soil degradation and nutrient depletion. Therefore, this study was conducted to evaluate the economic value of soil nutrient conservation provided by rangeland ecosystems under different management conditions. Specifically, the study aimed to compare nutrient concentrations between well-managed and poorly managed rangelands, estimate the probability of rangeland degradation using logistic regression, and quantify the economic value of conserved soil nutrients through the replacement cost method. The findings are expected to provide scientific evidence supporting sustainable rangeland management and informed environmental decision-making.

## **Method**

This study was conducted to evaluate the economic value of soil nutrient conservation as an ecosystem service provided by rangelands in the Moghan region. Two rangeland sites with contrasting grazing management conditions were selected, including a well-managed rangeland and a poorly managed (degraded) rangeland. Soil sampling was performed using the transect method, and 30 soil samples were collected from each site, resulting in a total of 60 samples. The collected samples were transferred to the laboratory for the determination of nitrogen (N), phosphorus (P), and potassium (K) concentrations using standard analytical procedures. The annual soil erosion rate in the study area was estimated at  $14.7 \text{ t ha}^{-1} \text{ yr}^{-1}$ , and the total rangeland area was considered to be approximately 115,000 ha. Statistical analyses included an independent samples t-test to compare soil nutrient concentrations between the two rangelands.

and logistic regression analysis to estimate the probability of rangeland degradation under different management conditions. The replacement cost method was subsequently applied to estimate the economic value of soil nutrients conserved by the rangeland ecosystem based on the costs of replacing nutrients lost through soil erosion with commercial fertilizers.

### **Results**

The findings revealed significant differences in soil nutrient concentrations between the two rangelands, indicating that grazing management strongly influenced soil fertility. The well-managed rangeland maintained higher concentrations of nitrogen, phosphorus, and potassium than the poorly managed site, reflecting its greater capacity to conserve soil nutrients and resist degradation. Logistic regression analysis further confirmed that poor grazing management substantially increased the probability of rangeland degradation. Based on the estimated annual soil erosion rate and the nutrient concentrations measured in the soil samples, considerable quantities of nitrogen, phosphorus, and potassium were estimated to be lost each year through erosion processes. Economic valuation using the replacement cost approach showed that the total annual value of these lost soil nutrients across the study area was approximately 449190000 Iranian Rials, demonstrating the substantial economic costs associated with declining soil fertility and ecosystem degradation. The comparison between the two management systems also demonstrated that maintaining adequate vegetation cover plays a fundamental role in protecting soil resources against erosion and nutrient depletion. Higher vegetation density in the well-managed rangeland improved soil stability, reduced runoff, and enhanced the retention of essential nutrients within the ecosystem. In contrast, reduced plant cover in the degraded rangeland increased soil exposure to erosive forces, resulting in greater nutrient losses and lower soil fertility. These findings reinforce the ecological importance of sustainable grazing practices as an effective measure for maintaining soil quality and supporting long-term ecosystem productivity. Furthermore, expressing nutrient losses in economic terms makes the consequences of land degradation more tangible and facilitates comparisons between the costs of preventive management and those of ecosystem restoration.

### **Conclusions**

The results demonstrate that sustainable grazing management plays a critical role in maintaining soil fertility, conserving essential nutrients, and reducing the economic losses associated with soil erosion. The considerable monetary value assigned to conserved soil nutrients highlights the importance of recognizing soil fertility conservation as a valuable ecosystem service. Integrating ecological assessments with economic valuation provides a practical framework for quantifying the hidden costs of rangeland degradation and supports evidence-based decision-making. The findings suggest that implementing appropriate grazing management practices, including controlled stocking rates and restoration measures, can significantly reduce nutrient depletion, preserve natural capital, and improve the long-term sustainability of rangeland ecosystems. These results provide valuable scientific evidence for policymakers and land managers to develop effective conservation strategies that simultaneously enhance ecological resilience and economic efficiency. From a broader perspective, this study highlights the importance of incorporating ecosystem service valuation into rangeland management and land-use planning. Economic valuation supports evidence-based decision-making by demonstrating the long-term environmental and economic benefits of sustainable management. Future research should integrate additional ecosystem services to provide a more comprehensive basis for conservation planning and sustainable natural resource management.

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