

## Soil Protection: A Strategic Priority of the Soil Museum

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**Abstract.** Azerbaijan's soil resources constitute a vital part of the country's natural capital, playing a key role in maintaining ecological balance, supporting agricultural productivity, and ensuring sustainable development. However, growing anthropogenic pressures, ongoing land degradation, and climate-related impacts have increasingly threatened soil quality and functionality. This study explores soil protection as a strategic focus within the activities of the Soil Museum operating under the Institute of Geography. Although soil conservation has been among the museum's primary objectives since its establishment, its integration into the institutional framework of the Institute has significantly expanded its scope. Today, the museum functions not merely as a storage space for soil monoliths and scientific collections, but also as a scientific, educational, and informational center where soil is presented as an integral element of the geographical environment. The research particularly emphasizes that soil, as a fundamental component of geographical systems, is closely interconnected with climate, relief, water resources, vegetation, and human activities. This integrated geographical approach enhances the scientific value of the museum by enabling the study of soil diversity within the broader context of natural-territorial interactions that shape landscapes and ecological processes across Azerbaijan. Soil monoliths serve as effective tools for demonstrating soil diversity, environmental conditions, and degradation patterns. The results indicate that soil protection is not only a scientific concern but also a key element of environmental education, public awareness, and sustainable land use. From a geographical perspective, degradation levels vary across regions depending on relief, climate, irrigation practices, and human influence.

**Keywords:** soil protection, soil museum, soil monoliths, geographical ecosystems, land degradation, environmental education, Azerbaijan

### Introduction

Soil represents one of the most critical natural assets, forming the basis of terrestrial ecosystems, agricultural systems, and overall environmental stability (Mirzezadeh et al., 2025). Nevertheless, both the availability and quality of soil resources are steadily declining on a global scale. Unsustainable land management, industrial contamination, erosion, salinity issues, and climate change are among the primary factors accelerating soil degradation and reducing its productive potential (Ganieva et al., 2019; Shukurov et al., 2025b).

In Azerbaijan, these challenges are particularly pronounced due to the country's diverse physical-geographical conditions, including mountainous regions, arid plains, foothill areas, and humid subtropical zones (Mammadzada et al., 2025; Verdiyeva et al., 2025).

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Such environmental heterogeneity has led to the formation of highly diverse soil types, each characterized by distinct ecological roles, agricultural significance, and varying levels of vulnerability to human-induced pressures (Huseynova et al., 2024).

Rapid population growth, economic expansion, and increasing demands for food production have further intensified pressure on land resources (Ismayilova et al., 2025a). As a result, the amount of arable land per capita is gradually decreasing, while the risks associated with soil degradation continue to rise (Sadigov et al., 2026). Under these circumstances, the efficient use, systematic monitoring, and protection of soil resources have become pressing priorities from scientific, environmental, and socio-economic perspectives (Ismayilova et al., 2025b).

Beyond its role in production, soil functions as a vital component of the biosphere, contributing to the regulation of biogeochemical cycles, water dynamics, carbon sequestration, and the stability of ecosystems (Shukurov et al., 2025a). Therefore, soil conservation should be addressed through an integrated ecosystem-based approach that considers environmental, economic, and social dimensions simultaneously (Sadigov et al., 2025).

Within the research framework of the Institute of Geography, soil is examined as an inseparable part of the geographical environment, closely interacting with climate, relief, hydrological conditions, vegetation cover, and land-use systems. This interdisciplinary approach aligns with the strategic priorities of the Ministry of Science and Education of the Republic of Azerbaijan, which emphasize the advancement of scientific research, environmental awareness, and sustainable natural resource management (Nasirova et al., 2026).

In this regard, the Soil Museum gains particular scientific importance, as it not only ensures the preservation of soil collections but also facilitates the geographical interpretation of soil diversity, degradation processes, and environmental transformations across Azerbaijan.

## **Materials and Methods**

The present study is grounded in the analysis of soil types exhibited in the Soil Museum functioning within the scientific framework of the Institute of Geography. The museum's collection constitutes a valuable scientific resource for examining soil diversity, spatial distribution patterns, and degradation processes across Azerbaijan (Gurbanov et al., 2021). In line with the broader research agenda of the Ministry of Science and Education of the Republic of Azerbaijan, the museum acts as a specialized platform that supports the integration of soil research with geographical and ecological evaluations.

The research materials include:

- Soil monoliths obtained from various ecological and geographical regions of Azerbaijan, representing key soil types developed under diverse climatic and landscape conditions
- Soil samples analyzed through physical, chemical, and biological parameters that reflect soil formation processes, fertility status, and human-induced changes
- Archival documents, historical sources, and scientific publications related to soil classification systems and soil conservation practices
- Soil maps, landscape imagery, and supporting descriptive materials illustrating the spatial distribution of soils and associated environmental settings

Special emphasis is placed on monoliths that reflect both intact and degraded soil conditions. These include samples affected by erosion, salinity, and technogenic disturbances, providing an opportunity to evaluate contemporary soil protection issues across different geographical zones (Akhundova et al., 2025; Ismayilov et al., 2025). The study employs an integrated methodological approach

combining comparative soil analysis, morphogenetic evaluation of soil profiles, ecological and geographical assessment, museum-based scientific interpretation.

The methodology of this research relies on fundamental concepts of soil science while incorporating up-to-date ecological and geographical approaches, together with relevant practices adopted in soil museums in countries such as Russia and Moldova (Mammadova et al., 2026).

A key component of the methodology is the structured scientific presentation of soil monoliths. Each profile is supplemented with detailed explanatory information covering its origin, classification features, geographic setting, ecological characteristics, and the level of human impact (Fig. 1). From the standpoint of geographical analysis, soil monoliths are not treated solely as separate pedological units. Instead, they are viewed as representations of broader landscape dynamics, illustrating the interdependence between soil formation processes and factors such as climate, topography, vegetation, and land use patterns (Shukurov et al., 2026).



**Figure 1**  
*Soil monoliths collection*

## Results and Discussion

Soil performs a fundamental role in sustaining biological cycles, preserving biodiversity, and ensuring environmental balance within geographical systems. It serves multiple functions at once, acting as a natural filtration medium, a source and storage of nutrients, a substrate for plant development, and a regulator of both water movement and carbon sequestration. As part of the geographical environment, soil remains in constant interaction with climate conditions, terrain features, vegetation cover, and hydrological processes, which makes it a highly dynamic component in the formation and evolution of landscapes (Gahramanova et al., 2026).

At the same time, soil increasingly becomes a recipient of various anthropogenic pressures, including industrial pollutants, oil-derived contaminants, heavy metals, and agrochemicals. The accumulation of these substances not only results in contamination but also alters soil structure, decreases biological activity, and reduces its ecological effectiveness (Mammadova et al., 2024). The soil cover of Azerbaijan is distinguished by its exceptional diversity, which is closely linked to the country's complex physical-geographical structure. The interaction of altitudinal zonation, significant climatic

variability, and heterogeneous landscape conditions has resulted in the development of a wide range of soil-forming environments. These factors contribute to the formation of highly differentiated soil types with distinct morphological, physical, and ecological characteristics (Mammadova et al., 2026).

From a geographical perspective, Azerbaijan represents a unique natural system in which diverse soil types are distributed within a relatively limited spatial extent (Hasanova & Mammadova, 2023). Major soil groups represented in the museum collection include mountain-forest soils, steppe and semi-desert soils, subtropical soils, alluvial and irrigated soils. Each soil type demonstrates specific morphological, physical, and chemical properties that determine both its ecological role and agricultural potential. Their comparative representation within the museum allows observation of how geographical conditions directly influence soil genesis and functional characteristics (Mirzazadeh et al., 2025).

The Soil Museum functions as a specialized scientific unit within the Institute of Geography, where soil diversity is examined through the lens of geographical and ecological interactions, rather than being limited solely to classification-based approaches. Its main functions include: 1. Scientific function: preservation, systematization, and scientific interpretation of soil materials. 2. Educational function: training students, researchers, and specialists in soil science, geography and environmental studies. 3. Informational function: raising public awareness of soil conservation and land degradation issues.

The museum's collection includes soil monoliths representing major soil types and subtypes, samples of degraded and technogenic polluted soils, scientific literature, maps, archival materials, and historical records. A particularly important section is devoted to soil-contaminated soils of the Absheron Peninsula, where long-term industrial activity has visibly transformed soil morphology, chemical composition, and ecological functions (Akhundova et al., 2025). These materials provide valuable evidence for understanding anthropogenic transformation of landscapes.

Soil monoliths provide a direct visual representation of soil profiles and allow detailed analysis of: genetic horizons, soil formation processes, degree of degradation, anthropogenic transformations. From an educational perspective, soil monoliths play an important role in translating abstract pedological concepts into observable reality, allowing clear demonstration of structural variations among soil types, forms of degradation, and ecological adaptations. Moreover, monolith collections serve as a reference record of baseline soil conditions, providing a valuable foundation for future comparative studies aimed at assessing long-term environmental and landscape changes (Bunyatova et al., 2025).

The museum materials clearly reflect the major forms of soil degradation currently affecting Azerbaijan: erosion, salinization, overgrazing, industrial pollution. These processes lead to a decline in soil fertility, reduce the stability of ecosystems, and pose challenges for sustainable agricultural utilization. This confirms that soil protection must be integrated into wider environmental and territorial planning policies. One of the strategically important directions is the development of a national "Red Book of Soils", analogous to biodiversity conservation frameworks. This concept includes identification of rare and endangered soil types, protection of unique soil ecosystems, preservation of soil genetic diversity.

The scientific collections maintained by the Soil Museum serve as a valuable empirical foundation for soil classification, as they preserve representative soil profiles that could be subject to degradation or even loss in the future. From a geographical perspective, this effort also plays a significant role in recording environmentally vulnerable areas and enhancing the scientific basis for land conservation policies. The results of this study demonstrate the practical importance of strengthening the role of museum-based soil science within national scientific and educational priorities of Azerbaijan.

The study highlights the importance of integrating soil protection into national environmental and land-use policy, expanding museum-based environmental education, strengthening interdisciplinary links between soil science and geography, developing regional soil museums and scientific information centers. The Soil Museum may serve as a model for scientific communication, sustainable development strategies, public participation in environmental protection, preservation of natural scientific heritage.

## Conclusion

1. Soil conservation is recognized as a major scientific and environmental priority for ensuring sustainable development and maintaining ecological balance.
2. Within the structure of the Institute of Geography, the Soil Museum serves not only as a repository but also fulfills significant scientific and educational functions.
3. Soil monoliths constitute important research materials for studying soil diversity, spatial distribution, and processes of degradation.
4. The initiative to establish a national “Red Book of Soils” represents a crucial measure for the protection of rare soil types and the preservation of soil genetic diversity.
5. Increasing public awareness, promoting scientific knowledge, and applying geographical approaches to soil processes are key elements in developing effective soil protection policies.

## Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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