

HUMAN ACTIVITY AND LAND DEGRADATION IN THE PIRSAATCHAY RIVER BASIN

Aygun Haghverdi 

Institute of Geography, Ministry of Science and Education of the Republic of Azerbaijan

*Yazışılan müəllif: aygun.hagverdi@bk.ru

NƏŞR TARİXİ:

Qəbul edilmə tarixi:

06.06.2026

Nəşr edilmə tarixi:

25.06.2026

KEYWORDS:

Pirsaatchay,
degradation, NDVI,
humus,
urbanization

SUMMARY

This article is devoted to the impact of settlement on soil degradation. The study area is the Pirsaatchay basin, which includes the administrative districts of Shamakhi, Gobustan, Hajigabul, Salyan and Garadagh. In these territories, settlement processes have been examined as one of the main anthropogenic factors exerting multifaceted impacts on soil resources. In the course of the research, statistical data were used, and satellite imagery was decoded using the ArcMap 10.8 software package. The results indicate that, as the Pirsaatchay basin has been a settlement area since ancient times, it has been exposed to intensive anthropogenic pressure. The expansion of settlements concentrated around economic activities has altered the natural composition of the soil cover, disrupted landscape structures, and consequently led to various forms of soil degradation. A comparison of the vegetation index (NDVI) maps across different years demonstrates that inefficient land use and anthropogenic impacts have caused the destruction of vegetation cover in the districts of Hajigabul, Salyan and Gobustan, with the exception of Shamakhi. This, in turn, has resulted in reduced soil productivity and increased degradation..

INTRODUCTION

From an ecological perspective, degradation is the process by which soil fertility declines as a result of the deterioration of vegetation cover and pasturelands, the transformation of forest ecosystems into shrublands, disruption of soil structure, and the reduction of humus reserves and exchangeable cations under the influence of natural, anthropogenic, and technogenic factors. The emergence of soil degradation is significantly affected by factors such as improper application of organic and mineral fertilizers, mining industry activities, discharge of wastewater from industrial enterprises, population growth, intensified erosion processes, non-compliant grazing of livestock, and inadequate implementation of irrigation practices.

Settlement has historically been one of the main factors contributing to soil degradation. Settlement processes represent a key anthropogenic factor exerting multifaceted impacts on soil resources. During the establishment of new residential areas, the soil cover undergoes mechanical alterations. Construction activities lead to the removal of the humus layer, disruption of the soil profile, and deformation of natural structures. This process weakens the agro-physical properties of the soil and reduces its productivity potential. Urbanization-related factors, such as increased traffic, operation of construction machinery, and daily human movement, further contribute to soil compaction. However, in the past, these impacts did not cause as significant concern among humanity as they do today. Currently, we are facing a new type of transformation in natural systems, where the environment cannot adapt to human interventions, leading to catastrophic and irreversible changes, including the destruction of soil and vegetation cover (FAO. (2015); Lal, R., & Stewart, B. A. 1990). Regarding this type of alteration in soils and soil resources, following Professor D. Montgomery (2007), it can be stated: “The planet’s soils are degrading and eroding faster than they are forming, and this is our fault”. In conventionally tilled fields, the net soil erosion rate (approximately 1 mm per year) leads, over the long term, to the degradation of a typical hillslope soil profile, with a timescale comparable to the lifespan of major civilizations.

According to recent studies, increasing urbanization and anthropogenic pressure significantly alter urban and peri-urban soils, often resulting in the degradation of productive soil resources and irreversible disturbances in soil ecological functions (Binner, H., Wojda, P., Yunta, F., et al. 2024).

In contrast, in no-till agricultural systems, erosion rates are maintained at levels closer to soil formation rates, indicating that such systems can provide a reliable foundation for sustainable agriculture (Montgomery D. R 2007).

Human impacts on the environment are not one-sided. Such impacts create crises through feedback loops, as the environment actively responds to human activities, leading to various socio-economic disruptions (Pimentel D., Elinor C., Hudson R., Rochereau S., Samis R. And etc. 1976). Currently, soil degradation has reached catastrophic levels: more than half of agricultural lands can be considered to have undergone some degree of degradation.

The study area encompasses the Pirsatchay basin and the administrative districts of Shamakhi, Hajigabul, Salyan, Garadagh, and Gobustan located within it. Across these districts, the total number of settlements is approximately 180. Compared to other regions of Azerbaijan, the overall density of settlements in these districts is relatively low. Settlement density ranges from 0.12 to 0.57 per 10 km², primarily due to desert and semi-desert conditions and the scarcity of freshwater resources (Mammadov R.M. 2015). Owing to limited employment opportunities, much of the population has migrated to suburban areas of Baku, Sumgayit, and Khirdalan. Nevertheless, within the study area, settlement development, the construction of infrastructure and roads, and human economic activities have had a notable impact on environment.

MATERIAL AND METHOD

In this study, a comprehensive methodological approach was employed to assess the impact of settlement on soil degradation. In the initial stage, existing scientific literature, statistical sources, and official data were analyzed to examine the physical-geographical characteristics of the study area, population distribution dynamics, and changes in soil cover. NDVI and other vegetation indices were applied to evaluate changes in soil cover, and comparative analyses were conducted using indicators reflecting the level of urbanization.

The research process also included structured interviews with the local population to gather information on land use practices, grazing intensity, settlement growth rates, and economic activities (Akpan U., Mawadri J., Asingwire D., Butt A. 2024; Dongmei Li, Dongyan W., Hong Li, Shuwen Z., Wenbo T. 2017). Thus, a multi-component approach integrating statistical, cartographic, GIS-analytical, and laboratory methods was applied, allowing a comprehensive investigation of both spatial and functional aspects of the mechanisms through which settlement influences soil degradation.

RESULTS AND DISCUSSION

The total number of settlements in the administrative districts within the Pirsatchay River basin is approximately 180. Due to desert and semi-desert conditions, as well as a shortage of freshwater, the settlement density in the area is low, ranging from 0.12 to 0.57 per 10 km². Furthermore, the lack of employment opportunities has driven a migration wave from these regions toward the suburban areas of Baku, Sumgayit, and Khirdalan (Hagverdi A. 2025). Within the Pirsatchay basin, there are approximately 70 settlements. The density of settlements in this area ranges from 0.17 to 0.77 per 10 km² (Table 1). Around industrial enterprises and industrial parks, both the number of settlements and the total population are higher (Budagov T. 2023).

The majority of the population in the districts belonging to the Pirsatchay basin is concentrated within this region, primarily due to the availability of freshwater resources. However, historically, socio-political and natural events in the area have negatively affected population settlement patterns and the development of urbanization.

Regarding the rural population, the soil and climatic conditions of the area, along with the recent development of labor-intensive agricultural sectors, have had a significant influence on population density. Several researchers analyzing recent statistical data note that the natural growth of the rural population in the administrative districts under consideration has declined, and despite the large number of settlements, most villages consist of medium and small-sized settlements.

Nevertheless, a comparison of settlement patterns over the years in the districts within the study area shows an increase in the number of settlements (Figure 1). This, in turn, intensifies anthropogenic impacts on the environment, particularly on the soil cover.

Table 1. Contemporary Characteristics of Settlements in the Pirsatchay Basin

Name of region	Total area (km ²)	All settlements		Including		
		Number	Density per 10 km ²	The area included in the study area, km ²	Number	Density per 10 km ²
Shamakhi	1670	59	0,57	1026	38	0,37
Gobustan	1369	33	0,25	426,6	14	0,33
Hajigabul	1640	25	0,16	493,6	8	0,17
Salyan	1600	49	0,31	32,2	1	0,32
Qaradagh	1080	13	0,12	91,4	7	0,77



Figure 1. Comparison of population settlement in 2000 and 2024 (in Gobustan)

Settlement processes—including the expansion of industrial and service sectors, the establishment of new residential areas, and the development of road infrastructure—have led to the reduction of arable lands and the loss of pasture and forest cover. These changes are also reflected in NDVI indicators. Therefore, NDVI maps prepared from satellite imagery of different years allow a spatio-temporal analysis of the impact of settlement on soil and vegetation. For this purpose, NDVI maps of the area for the period 2000–2024 were created using ArcMap 10.8 (Picture 2).

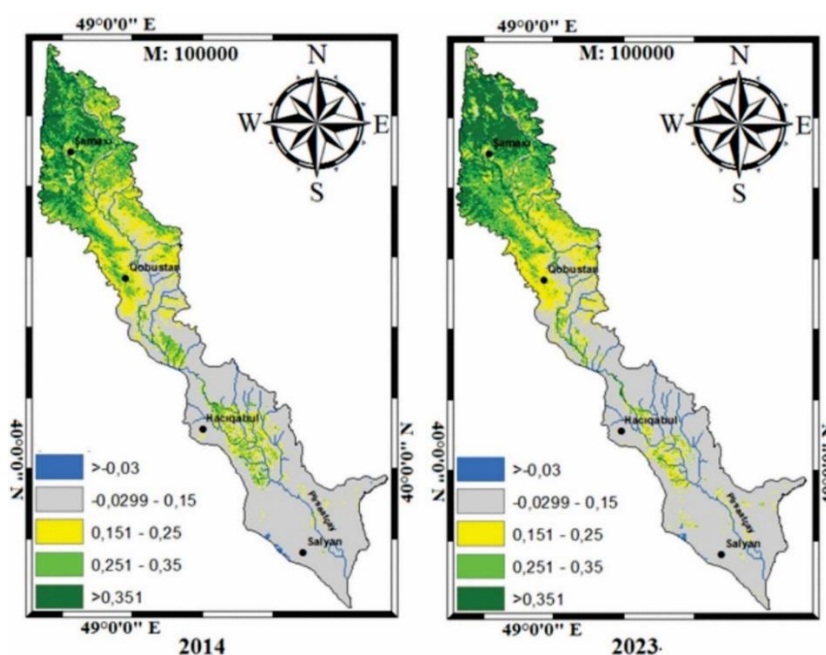


Figure 2. Normalized plant vegetation index in Pirsatchay basin.

Analysis of the maps indicates that the area of bare soils has increased and currently covers 0.25% of the total area. The proportion of areas classified as having very low vegetation cover has also risen, from 53.72% in 2014 to 55.32% in 2024 (Table 2).

With the increase in settlement, the load on pastures in the surrounding areas of settlements has exceeded normal levels, with indicators averaging 1.3–4.9 times higher. Over the last 20–25 years, the intensification of anthropogenic economic activities, coupled with the expansion of agriculture in zones with relatively dense population and areas of recreational and tourism importance, has transformed natural landscapes into anthropogenic ones. In the middle and lower arid and semi-arid bioclimatic zones of the Pirsatchay basin, ecosystem disruption and soil degradation are directly associated with settlement processes. Furthermore, research indicates that although a forest landscape had formed in the recent past, the subsequent expansion of human economic activities led to the development of grey, grey-brown, and darkish soils under steppe vegetation (Hagverdi A. A. 2025).

Table 2. Sectoral indicators for NDVI (for 2014-2023)

Year	Month	Indicators	Classification	Area	
				ha	%
2014	May	>-0,03	-	373,22	0,19
		-0,0299-0,15	Very weak	111596,1	53,72
		0,151-0,25	Weak	40101,91	19,31
		0,25-0,35	Mild	30527,73	14,69
		>0,35	High	25128,47	12,09
2024	May	>-0,03	-	253,13	0,25
		-0,0299-0,15	Very weak	115193,6	55,32
		0,151-0,25	Weak	34717,13	16,71
		0,25-0,35	Mild	26031,34	12,54
		>0,35	High	31532,23	15,18

CONCLUSION

Modern settlements in the basin are characterized by the expansion of infrastructure, including roads and residential areas, as well as increased human economic activities. These developments have significantly influenced the spatial distribution of the population, contributing to intensified anthropogenic pressure on soil and vegetation. Additionally, urbanization trends, coupled with industrial and service sector growth, have reshaped the land cover, leading to partial replacement of natural landscapes with anthropogenic ones. Settlement-related reductions in vegetation cover intensify soil erosion on slopes. Activities such as leveling soil for construction, leaving the soil exposed, and improper drainage of runoff increase erosion risk, particularly in foothill and sloped terrains. In areas near settlements, especially on southern and southeastern slopes used for moving livestock to summer pastures, the optimal structure of forested areas has been disrupted, and soils have undergone slight to moderate degradation. In these areas, weakened soil formation processes and erosion have significantly reduced soil layer thickness and organic matter content compared to normal conditions.

REFERENCES

- Akpan U., Mawadri J., Asingwire D., Butt A. (2024). Impact of refugee settlements on land degradation in Uganda, *Poljoprivredna tehnika*, 49(3):52-62, <https://doi.org/10.1080/10106049.2019.1704073>
- Binner, H., Wojda, P., Yunta, F., et al. (2024). A Systematic Review and Characterization of the Major and Most Studied Urban Soil Threats in the European Union. *Water, Air, & Soil Pollution*, 235, 494. <https://doi.org/10.1007/s11270-024-0728>

- Budagov T. (2023). Regions of Azerbaijan: Statistical collection /State Statistical Committee of the Republic of Azerbaijan Editorial staff chairman, 863 p.
- Dongmei Li, Dongyan W., Hong Li, Shuwen Z., Wenbo T. (2017). The Effects of Rural Settlement Evolution on the Surrounding Land Ecosystem Service Values: A Case Study in the Eco-Fragile Areas, China, International journal of Geo-Information, 6(2), p.49 <https://doi.org/10.3390/ijgi6020049>
- FAO. (2015). Status of the World's Soil Resources (SWSR) – Main Report. Rome: Food and Agriculture Organization of the United Nations.
- Hagverdi A. (2025). Analysis Of Anthropogenic Load On Soils Of The Pirsaatçay River Basin In Azerbaijan . Bulletin of Science and Practice. 11(7). 276-283 <https://doi.org/10.33619/2414-2948/116/34>
- Hagverdi A. A. (2025). The influence of natural factors on the process of soil formation (in the example of the Pirsaatçay basin). Modern Problems Of Ecology And Earth Sciences Ii International Scientific and Practical Conference of Young Scientists, Dedicated to the 180th Anniversary of the Founding of the Russian Geographical Society (Gomel, September 26, 2025) Conference Proceedings.
- Lal, R., & Stewart, B. A. (Eds.). (1990). Soil Degradation. New York: Springer.
- Mammadov R.M. (2015), Geography of the Republic of Azerbaijan, Regional geography: [in 3 volumes].
- Montgomery D. R (2007) Soil erosion and agricultural sustainability, Proceedings of the National Academy of Sciences 104(33), <https://doi.org/10.1073/pnas.0611508104>
- Pimentel D., Elinor C., Hudson R., Rochereau S., Samis R. And etc. (1976). Land degradation: Effects on food and energy resources. Journal of Science, Vol.194, № 4261, pp. 149-155 <https://doi.org/10.1126/science.194.4261.149>

XÜLASƏ

PİRSAATÇAY ÇAYI HÖVZƏSİNDƏ İNSAN FƏALİYYƏTİ VƏ TORPAQ DEQRADASIYASI

Aygün Haqverdi
AR Elm və Təhsil Nazirliyi Coğrafiya İnstitutu

Bu məqalə məskunlaşmanın torpaq deqradasiyasına təsirinə həsr olunmuşdur. Tədqiqat sahəsi Pirsaatçay hövzəsi olub, buraya Şamaxı, Qobustan, Hacıqabul, Salyan və Qaradağ inzibati rayonları daxildir. Bu ərazilərdə məskunlaşma prosesləri torpaq resurslarına çoxşaxəli təsir göstərən əsas antropogen amillərdən biri kimi tədqiq edilmişdir. Tədqiqat zamanı statistik məlumatlardan istifadə olunmuş, peyk təsvirləri isə ArcMap 10.8 proqram təminatı vasitəsilə dəşifrə edilmişdir. Nəticələr göstərir ki, Pirsaatçay hövzəsi qədim dövrlərdən məskunlaşma ərazisi olduğuna görə güclü antropogen təzyiqə məruz qalmışdır. İqtisadi fəaliyyətlər ətrafında cəmləşən yaşayış məntəqələrinin genişlənməsi torpaq örtüyünün təbii tərkibini dəyişdirmiş, landşaft strukturlarını pozmuş və nəticədə torpaq deqradasiyasının müxtəlif formalarının yaranmasına səbəb olmuşdur. Müxtəlif illər üzrə bitki örtüyü indeksi (NDVI) xəritələrinin müqayisəsi göstərir ki, qeyri-səmərəli torpaq istifadəsi və antropogen təsirlər Şamaxı rayonu istisna olmaqla Hacıqabul, Salyan və Qobustan rayonlarında bitki örtüyünün məhv olmasına səbəb olmuşdur. Bu isə öz növbəsində torpaq məhsuldarlığının azalmasına və deqradasiyanın artmasına gətirib çıxarmışdır.

Açar sözlər: *Pirsaatçay, deqradasiya, NDVI, humus, urbanizasiya*

РЕЗЮМЕ

ЧЕЛОВЕЧЕСКАЯ ДЕЯТЕЛЬНОСТЬ И ДЕГРАДАЦИЯ ЗЕМЕЛЬ В БАССЕЙНЕ РЕКИ ПИРСААТЧАЙ

Айгюн Гахверди

Институт географии, Министерство науки и образования Азербайджанской Республики

Данная статья посвящена влиянию расселения на деградацию почв. Область исследования — Пирсаатчайский бассейн, включающий административные районы Шамахи, Гобустан, Гаджигабул, Сальян и Гарадаг. На этих территориях процессы расселения рассмотрены как один из основных антропогенных факторов, оказывающих многостороннее воздействие на почвенные ресурсы. В ходе исследования использовались статистические данные, а спутниковые снимки были дешифрованы с применением программного пакета ArcMap 10.8. Результаты показывают, что Пирсаатчайский бассейн, будучи территорией расселения с древних времен, подвергался интенсивному антропогенному воздействию. Расширение населённых пунктов, сосредоточенных вокруг хозяйственной деятельности, изменило естественный состав почвенного покрова, нарушило структуру ландшафтов и, как следствие, привело к различным формам деградации почв. Сравнение карт индекса растительности (NDVI) за разные годы показывает, что неэффективное землепользование и антропогенные воздействия вызвали разрушение растительного покрова в районах Гаджигабул, Сальян и Гобустан, за исключением Шамахи. Это, в свою очередь, привело к снижению продуктивности почв и усилению процессов деградации.

Ключевые слова: Пирсаатчай, деградация, NDVI, гумус, урбанизация