Coğrafiya elmləri / Geographical Sciences

GEOGRAPHICAL ANALYSIS AND ASSESSMENT OF NATURAL RESOURCE POTENTIAL IN KARABAKH AND EASTERN ZANGEZUR

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Abstract. The presented article analyzes the natural resource potential of the Karabakh and Eastern Zangezur economic-geographic regions of the Republic of Azerbaijan using a comprehensive geographical approach. The region's complex topography, climatic characteristics, rich water resources, vertical soil-landscape stratification, unique forest and biodiversity assets, and strategically vital mineral deposits are evaluated through the prism of contemporary developmental requirements. The research utilizes comparative-geographical, statistical analysis, landscape-indication, and systems approach methodologies. The findings indicate that the region possesses a rich natural resource foundation, presenting exceptional opportunities for the development of agriculture, ecotourism, green energy, and the mining industry. At the same time, the severe anthropogenic impacts and long-term ecological damage (ecocide) inflicted during nearly 30 years of military occupation are documented. The paper outlines scientific and practical recommendations for the rational exploitation of natural resources, the implementation of the "green energy zone" concept, and the restoration of ecological equilibrium in the liberated territories.

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Introduction

The Karabakh and Eastern Zangezur regions stand among the most unique and resource-rich natural-geographic territories of Azerbaijan by virtue of their geographical position, geological structure, geomorphology, and bioclimatic attributes. Encompassing the southeastern segments of the Lesser Caucasus mountain system, Karabakh Range, Volcanic Plateau, and the adjacent foothill and sloping plains, this territory has historically served as an attractive area for intensive economic activity. The region's intricate topography, altitude - dependent climatic diversity, dense hydrographic network, and fertile soil cover establish a robust natural baseline for multi-sectoral agrarian and industrial development.

Over recent decades, the region experienced one of the most severe ecological and humanitarian crises in contemporary history. During more or less 30 years of military occupation, unregulated anthropogenic pressures, military operations, and illegal economic exploitation induced profound structural transformations and ecological devastation (ecocide) within the natural complexes. Landmine contamination, extensive deforestation, and the heavy-metal contamination of river systems severely compromised the regional natural resource potential.

Following the liberation of these territories in 2020, large-scale restoration and reconstruction initiatives were initiated. The declaration of Karabakh and Eastern Zangezur as a "Green Energy Zone" by the Azerbaijani state necessitates a comprehensive re-evaluation of natural resources based on sustainable development principles. From this point of view, the systematic geographical assessment of the current state of this natural resource potential remains one of the highly critical imperative across geographical, economic, and ecological sciences.

Research object and methods

The object of this study comprises the natural and resource potential of the Karabakh (Aghcabadi, Aghdam, Barda, Fuzuli, Khojali, Khojavand, Shusha, and Tartar districts, and Khankendi city) and Eastern Zangezur (Jabrayil, Kalbajar, Qubadli, Lachin, and Zangilan districts) economic-geographic regions.

The research process was incorporated both traditional and innovative methodological frameworks native to modern geographical science:

Comparative-geographical analysis: utilized to evaluate and compare the qualitative and quantitative parameters of resources distributed across different altitudinal belts and landscape zones.

Landscape-indication approach: **e**mployed to ensure that natural landscape components were studied not in isolation, but as interconnected, unified geosystems.

Data sources included fundamental publications of the Azerbaijan National Academy of Sciences, data repositories of the Ministry of Ecology and Natural Resources, official reports from the State Statistical Committee, National Atlas of the Republic of Azerbaijan, and satellite remote sensing data provided by various international organizations.

Discussion

Physio-geographical and topographic characteristics of Karabakh and Eastern Zangezur.

The geomorphological architecture of the region is highly intricate. The territory primarily spans the mountainous systems of the Lesser Caucasus (Murovdağ, Karabakh, Shahdağ, Zangezur, and Daralayaz ranges), the Karabakh Volcanic Plateau, and the sloping plains extending from the mountain foothills toward the Kur-Araz lowland. The altitudinal amplitude drops to 100–200 meters above sea level along the Araz River plains (Zangilan, Jabrayil), while exceeding 3,500 meters at the highest summits (e.g., Mount Qapıcıq at 3,904 m and Mount Camışdağ at 3,724 m). This pronounced altitudinal gradient drives a classic vertical zones of natural landscape belts.

Tectonic-denudational landforms dominate the mountainous areas, whereas accumulative landforms prevail across the lowlands. Although high topographic fragmentation and deep river valleys impose accessibility and transport challenges, they simultaneously present invaluable assets for recreation, tourism, and hydropower generation.

The climate varies in accordance with the topography. A semi-desert and moderate-warm climate with dry winters prevails in the lowland and foothill zones; a moderate-warm climate with dry summers characterizes the medium-altitude mountains; and a cold alpine-tundra climate with dry winters dictates the high-mountain zones. Annual precipitation ranges between 300–400 mm in the plains and 700–900 mm across the medium to high-mountain belts. This rich climatic diversity fosters diverse biocoenoses and establishes a versatile agro-climatic baseline suitable for cultivating both thermophilic and cold-resistant agricultural crops.

Water resources and hydropower potential analysis. The Karabakh and Eastern Zangezur region is one of the most critical zones for the formation of Azerbaijan's water resources, accounting for approximately 20–25% of the country's internal freshwater reserves. The region's dense, high-discharge hydrographic network features vital transboundary and local rivers, including the Tartarchay, Hakarichay, Bargushadchay, Okhchuchay, Basitchay, Khachinchay, and Kondalanchay.

The substantial gradients of these mountain rivers play a decisive role in fuelling the renewable (green) energy sector. The integration of existing infrastructure, such as the Sarsang reservoir (on the Tartarchay), Khudafarin and Qiz Qalasi reservoirs (on the Araz river), and the Sugovushan reservoir, yields significant economic dividends. Furthermore, the restoration and systematic commissioning of dozens of small hydropower plants (SHPPs) along these mountain streams ensure regional energy self-sufficiency.

Water resources remain vital for agricultural irrigation—particularly across the cotton and grain fields of the low-lying Karabakh plains and for securing ecologically clean drinking water for the population. Groundwater assets, including the artesian basins of the Karabakh plain and the ancient subterranean water systems of the foothill zones, require specialized monitoring and conservation.

However, water resource analysis highlights acute environmental challenges. The Okhchuchay and Basitchay rivers, which originate beyond the national border in Armenia, suffer from severe heavy-metal contamination due to toxic industrial effluents discharged from the Qajaran copper-molybdenum and Qafan ore-processing complexes. This transboundary pollution poses a critical threat to the aquatic fauna of the Araz river and, consequently, the Caspian Sea basin.

Soil and agro-climatic resources. The regional soil profile strictly conforms to the laws of vertical stratification. While grey, grey-meadow, and chestnut soils span the lowlands toward the Kur-Araz Lowland, brown mountain-forest and brown-forest soils characterize the foothill and medium-altitude belts, yielding to alpine-meadow soils in the high-mountain zone.

These fertile soil resources underpin multi-sectoral agricultural development. The diverse agro-climatic sub-regions of Karabakh and Eastern Zangezur offer distinct specialization profiles:

Lowland and foothill zones (Aghdam, Fuzuli, Jabrayil) - the warm agro-climatic conditions are ideal for grain cultivation, cotton farming, viticulture, horticulture, and sericulture.
Medium and high-mountain zones (Kalbajar, Lachin, Shusha): the presence of expansive subalpine and alpine meadows drives optimal conditions for meat-and-dairy livestock farming, apiculture, and specialized cold-hardy fruit cultivation.

Conversely, unsustainable land management, extensive deforestation of shelter-belts, widespread wildfires, and severe mine contamination during the occupation period triggered acute water and wind erosion, resulting in widespread soil degradation. Accelerating mine clearance and implementing comprehensive land reclamation programs stand as immediate priorities.

Regional biodiversity assets. In terms of flora and fauna, Karabakh and Eastern Zangezur represent one of the most (biodiverse) havens not only within Azerbaijan but across the broader Caucasus ecoregion. Prior to the occupation, forests covered approximately 22–25% of the territory, dominated by oak species (Oriental oak, Araz oak), hornbeam, beech, linden, and ash, alongside numerous relict and endemic species. Notably, the Basitchay State Nature Reserve in the Zangilan district hosts Europe's largest natural Oriental plane (*Platanus orientalis*) forest, representing a natural monument of global significance.

The region serves as a native habitat for diverse and rare fauna, including the Caucasian leopard, Bezoar goat, Asiatic mouflon, brown bear, and dozens of protected avian species.

Anthropogenic impacts. Unfortunately, during the 30-year period occupation, forest reserves were systematically exploited. Valuable timber species were logged and extracted for construction and furniture industries, and thousands of hectares of forest were deliberately incinerated under a scorched-earth strategy. This severely contracted biodiversity habitats and pushed several species toward regional extinction. To reverse this damage, the state is currently restructuring strictly protected nature reserves (including Basitchay, Qaragöl, and Dashalti) and executing large-scale afforestation campaigns.

Metallic deposits: The region is renowned for its industrial-scale reserves of gold, copper, molybdenum, zinc, lead, and mercury.

Mineral resources and ore deposits. The Karabakh and Eastern Zangezur economic regions are richly endowed with subsoil assets, specifically metallic ores and non-metallic mineral deposits. Geologically, the territory is situated within the highly productive metallogenic province of the Lesser Caucasus.

- *Gold:* The Soyudlu (Zod) and Qizilbulaq deposits in Kalbajar, alongside the Vejnali deposit in Zangilan, hold substantial commercial value.

- *Copper and polymetals:* The Damirli copper-porphyry deposit in the Tartar (Aghdərə) district possesses extensive industrial reserves.

- *Mercury:* Large-scale reserves are concentrated in the Shorbulaq and Aghyataq deposits within the Kalbajar and Lachin districts.

Non-metallic minerals and building materials. Marblized limestone (Khankendi, Shusha, Aghdam) sawn stone, clays, cement raw materials, and ornamental stones (obsidian) are widely distributed. These materials provide a crucial domestic raw-material base for ongoing accelerated infrastructure and regional reconstruction (Rustamov & Kazimova, 2020).

Mineral water resources. The thermal and mineral springs of Kalbajar (Istisu), Shusha (Turshsu, Shirlan), and Lachin (Minkand) are famous for their therapeutic uses not just in Azerbaijan but all around the world. Although mineral resources play a significant role in the economic revitalization of the region, the implementation of “green mining” standards, waste management practices, and the minimization of ecological damage during future exploitation processes constitute indispensable requirements. The spatial differentiation of the landscape structure within the study area is directly conditioned by the interaction between the complex geomorphological structure, the regularities of vertical zonation, and climatic conditions (Ismayilov et al., 2025). The compiled “Landscape map of Karabakh and Eastern Zangezur” (map 1) clearly demonstrates the geographical distribution of 12 principal landscape types and subtypes, ranging from semi-desert zones to nival-rocky belts across the region.The analysis of the map indicates that the geosystems of the area are sharply divided into two major groups according to their morphological structure: mountainous landscapes and plain landscapes.

1. Xerophytic and subnival geosystems of the high mountainous zone: The subnival rocky landscapes (1), situated at elevations above 2500–3000 meters within the peak zones of the Murovdagh, Zangezur, and Shahdagh mountain ranges, are characterized by intense frost weathering and physical denudation processes. Below this zone, alpine and subalpine meadows (2, 3) constitute the dominant landscape background of the Kalbajar and Lachin districts,

as well as the Karabakh volcanic plateau. These meadows possess rich phytomass formed under conditions of high humidity and represent the principal basis of the region's livestock-breeding potential.

2. Mountain-forest and forest-steppe landscape complexes: Mixed beech and hornbeam-oak forests (4), which form the ecological core of the region, create extensive belts along the humid slopes of the middle mountainous zone. On the steep slopes of the Shusha, Khojaly, Kalbajar, and Lachin districts, forests also perform significant moisture-regulating and soil-protective functions. Descending toward the lower mountainous zone, particularly along the southern slopes, increasing aridity of the climate leads to the formation of arid forests and shrub-forest landscapes (5, 8). These xerophytic shrub communities, distributed within the low mountainous areas of Jabrayil and Zangilan, constitute unique cenoses adapted to conditions of moisture deficiency.

3. Transitional and plain landscape structures: Forest-steppe and steppe landscapes (6) dominate within the transitional zone toward the foothill sloping plains. Moving further toward the Kura-Araz lowland and the plains along the Araz River (Aghdam, Fuzuli, Jabrayil, Aghjabadi, and Barda), increasing climatic aridity completely transforms the landscape structure. Here, arid steppes (10) and semi-desert landscapes of accumulative plains (12) occupy extensive territories. Within the floodplain zones of river valleys, however, hydromorphic and tugay forests (11) acquire an intrazonal character due to the proximity of groundwater levels to the surface, thereby forming distinctive ecological corridors.

The analysis clearly demonstrates that both vertical zonation (changes in climate and vegetation with increasing altitude) and north-south asymmetry (more rapid aridization of southern slopes) constitute the principal factors determining the landscape structure of the region. The regularities governing the differentiation of the mountainous and plain landscape complexes of Karabakh and Eastern Zangezur, as well as their ecological and economic potential, are systematically presented in the following table (table 1).

Table 1

Eco-economic characteristics of mountainous and lowland landscape systems in Karabakh and eastern Zangezur

Altitudinal belt /zone	Landscape type	Geographical distribution	Key ecological and economic characteristics
High-mountain *(Xerophytic & Subnival)*	Subnival rocky landscapes	Peak areas of Murovdağ, Zangezur, and Shahdağ ranges (>2500–3000 m)	Dominated by intense frost weathering and physical denudation processes
High-mountain *(Meadows)*	Alpine and subalpine meadows	Kalbajar and Lachin districts, Karabakh Volcanic Plateau	Characterized by high moisture levels and rich phytomass; serves as the primary base for regional animal husbandry
Medium-mountain *(Forests)*	Mixed beech and hornbeam-oak forests	Humid and steep slopes of Shusha, Khojali, Kalbajar, and Lachin districts	Represents the region's ecological core; performs critical moisture-regulating and soil-protecting functions
Low-mountain *(Arid Zones)*	Arid forests and forest-shrub landscapes	Low-mountain zones of Jabrayil and Zangilan districts, primarily southern slopes	Driven by climatic aridization; features unique xerophytic coenoses adapted to chronic moisture deficits
Foothill *(Transitional zone)*	Forest-steppe and steppe landscapes	Transitional zones leading to sloping foothill plains	Dominant landscape type forming the spatial transition between mountainous and lowland systems
Lowland *(Steppes)*	Dry steppes	Kur-Araz lowland and plains along the Araz river (Aghdam, Fuzuli, Jabrayil, Aghcabadi)	Broad lowland plains formed under increasingly arid and dry climatic conditions

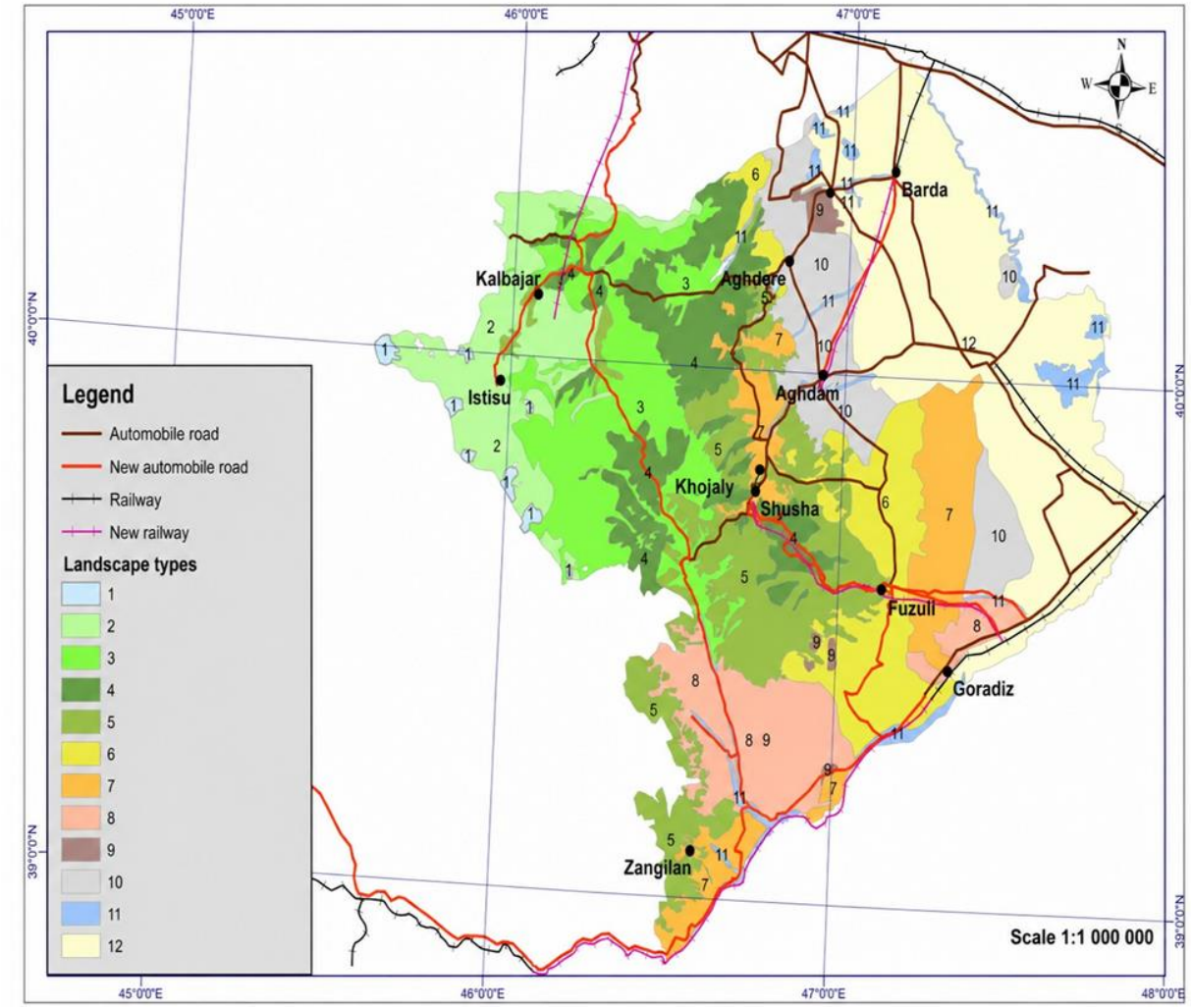
Lowland *(Semi-desert)*	Semi-desert landscapes of accumulative plains	Corresponding arid segments of the Kur-Araz and Araz river plains	Extensive lowlands where the landscape structure undergoes complete aridization
Lowland *(Intrazonal)*	Hydromorphic and tugai forests	Floodplains and alluvial terraces of river valleys	Sustained by shallow groundwater tables independent of the regional arid climate; functions as vital green ecological corridors

Source: Compiled by the authors.

The map 1 makes it possible to evaluate not only the natural boundaries of different landscape units, but also the degree to which they have been subjected to anthropogenic transformation.

During the 30-year period of occupation, the most severe degradation was recorded in the beech and hornbeam-oak forests (4) as well as in the Tugay forests along the Araz river (11). The analysis of satellite imagery and monitoring materials demonstrates that the large-scale fires occurring within the arid mountain-forest and shrub-land landscapes destroyed the upper fertile soil layer, thereby sharply intensifying processes of arid denudation and gully erosion. Consequently, the natural restoration potential of the landscape in many areas has been reduced to a minimum.

This geographical picture demonstrates that all infrastructure projects and the implementation of the "Green Energy" strategy within the region must be planned with mandatory consideration of the degree of sensitivity of the landscapes reflected in map 1.



Map 1: Landscape Map of Karabakh and Eastern Zangezur
Source: Prepared by the authors.

Legend

1. Subnival rocky landscapes
2. Alpine meadows
3. Subalpine meadows
4. Mixed beech and hornbeam–oak forests (middle and partly high mountainous zones)
5. Arid forests and forest-shrub landscapes (lower and middle mountainous zones)
6. Forest-steppe, steppe, and mountain-meadow landscapes (lower and middle mountainous zones)
7. Forest, shrub-meadow, and forest-steppe landscapes within accumulative plains.
8. Arid forests, forest-shrub, and shrub-steppe landscapes (lower mountainous zones)
9. Arid denudational semi-desert landscapes (lower mountainous areas and intermontane valleys)
10. Dry steppes and xerophytic steppe landscapes of denudation–accumulation plains
11. Hydromorphic and Tugay forests (within accumulative plains)
12. Semi-desert landscapes of accumulative plains

Conclusion and recommendations

The comprehensive geographical analysis conducted demonstrates that the economic-geographical regions of Karabakh and Eastern Zangezur possess a rich and unique natural resource potential. The region's water, soil, forest, biodiversity, and mineral resources will serve as significant drivers in the economic development and diversification of Azerbaijan as a whole.

Nevertheless, the severe ecological consequences of the occupation period necessitate a sensitive approach to the utilization of natural resources. In order to ensure the sustainable development of the region, the implementation of the following measures is considered appropriate:

- Accurate inventory and monitoring of landscapes: conducting regular electronic mapping and ecological monitoring of all natural resources, particularly land and water resources, through the application of modern Geographic Information Systems (GIS), satellite technologies, and drones.
- Ensuring safety: accelerating the process of complete clearance of agricultural and tourism zones, as well as forest fund territories, from mines and unexploded military ordnance.
- Sustainable exploitation (Smart approach): implementing closed-cycle and environmentally friendly technologies within the mining industry; applying advanced irrigation systems (drip irrigation) that prevent erosion in agriculture. Development of the "smart village" and "smart city" concepts.
- Transboundary cooperation and legal framework: undertaking measures within the framework of international environmental law to prevent the pollution of transboundary waters such as the Okhchuchay River.
- Restoration programs: scientifically grounded restoration of natural landscapes, protected areas, and destroyed forest belts in order to recover the region's former biodiversity

In conclusion, the rational and sustainable utilization of the natural resource potential of Karabakh and Eastern Zangezur, while preserving ecological balance, guarantees both the strengthening of Azerbaijan's economic power and the transformation of these territories into one of the world's most advanced green energy and ecological welfare zones.

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QARABAĞ VƏ ŞƏRQİ ZƏNGƏZURUN TƏBİİ RESURS POTENSİALININ COĞRAFİ TƏHLİLİ VƏ QİYMƏTLƏNDİRİLMƏSİ

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Xülasə. Məqalədə Azərbaycan Respublikasının Qarabağ və Şərqi Zəngəzur iqtisadi-coğrafi rayonlarının təbii resurs potensialı kompleks coğrafi yanaşma əsasında təhlil olunur. Ərazinin mürəkkəb relyefi, iqlim xüsusiyyətləri, zəngin su ehtiyatları, torpaq və landşaft örtüyünün yüksəklik qurşaqlığı, özünəməxsus meşə ehtiyatları və bioloji müxtəlifliyi, eləcə də strateji əhəmiyyətli faydalı qazıntı yataqları müasir inkişaf tələbləri baxımından qiymətləndirilir. Tədqiqatda müqayisəli-coğrafi və statistik təhlil üsullarından, landşaft indikasiyası metodundan və sistemli yanaşmadan istifadə edilmişdir. Əldə olunan nəticələr göstərir ki, region kənd təsərrüfatının, ekoturizmin, yaşıl energetikanın və dağ-mədən sənayesinin inkişafı üçün geniş imkanlar yaradan zəngin təbii resurs bazasına malikdir. Bununla yanaşı, otuz ilə yaxın davam etmiş hərbi işğal dövründə ərazinin məruz qaldığı güclü antropogen təsirlər və uzunmüddətli ekoloji zərər, o cümlədən ekosid halları göstərilir. Məqalədə işğaldan azad olunmuş ərazilərdə təbii resurslardan səmərəli istifadə, "yaşıl enerji zonası" konsepsiyasının həyata keçirilməsi və ekoloji tarazlığın bərpası istiqamətində elmi və praktiki tövsiyələr irəli sürülür.

Açar sözlər: *Qarabağ, Şərqi Zəngəzur, təbii resurs potensialı, su ehtiyatları, bioloji müxtəliflik, faydalı qazıntılar, yaşıl enerji*

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