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Hydrographic Features of the Nakhchivan Autonomous Republic: Structure, Distribution, and Agricultural Significance

[1] **Akif Mərdanlı,** [2] **Tofiq Aliyev**

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Abstract:

This article provides a comprehensive hydrographic analysis of the Nakhchivan Autonomous Republic (NAR), a landlocked exclave of Azerbaijan. Nakhchivan's hydrographic network comprises about 400 rivers (total length ≈1,800 km), most of which drain into the Aras (Araz) River on its southern border. The major rivers – the border Araz (Aras), the transboundary Arpachay (Arpa), and the intra-regional Nakhchivanchay – originate in the Lesser Caucasus mountains and are fed by snowmelt and rainfall. The region's climate is dry continental, with mean annual precipitation only ~200–350 mm on the Araz plain and 500–800 mm in uplands. Rivers are typically calcium–bicarbonate type, with moderate mineralization (total dissolved solids ~300–500 mg/L) and episodic high turbidity (up to ~1000 g/m³ during floods). Recent studies find that heavy metal concentrations in Aras and Arpachay waters generally meet WHO standards. Nakhchivan's agriculture (dominated by wheat, barley, fruits) is heavily reliant on irrigation from these rivers and ancient qanat (kahriz) systems. For example, rehabilitation of 125 kahriz tunnels has provided irrigation to ~700 ha of arable land. Educationally, the Nakhchivan river system offers rich case studies in dryland hydrology, transboundary water management, and traditional irrigation. This article reviews physical geography and hydrology, profiles the Araz, Arpachay, and Nakhchivanchay rivers, examines tributary networks and water chemistry, and discusses agricultural uses and teaching applications of these water resources. Citations from recent government and scientific sources are provided throughout.

Keywords

Nakhchivan Autonomous Republic; hydrographic network; Aras (Araz) River; Arpachay; Nakhchivanchay; irrigation; arid climate; qanat

Introduction

The Nakhchivan Autonomous Republic (NAR) is a 5,500 km² mountainous exclave of Azerbaijan, bordering Armenia, Iran, and Turkey. Its terrain is dominated by the Lesser Caucasus mountains (Zangezur and Daralayaz ranges) with an average elevation ~1,450 m. The region has historically

[1] **Mardanli, A.** Associate Professor, Nakhchivan State University, Azerbaijan. Email: akifmerdanlı@ndu.edu.az / akifmerdanlı@mail.ru. ORCID: https://orcid.org/0009-0000-5953-8743

[2] **Aliyev, T.** Nakhchivan State University, Azerbaijan. Email: aliyev.tofik@yahoo.com. ORCID: https://orcid.org/0009-0008-0138-7493

been arid and semiarid; one-third of Nakhchivan lies in lowlands along the Araz (Aras) River, but more than half is rugged highlands. In this context, water resources are scarce and strategically vital. The Araz River – a major Transcaucasian river rising in Turkey – forms Nakhchivan's southern border, collecting the flow of all local rivers. The NAR's climate is strongly continental and dry, with short cool winters and hot, dry summers. Annual precipitation on the plains is only about 200–300 mm, reaching 500–800 mm in the higher mountains. Such low rainfall creates an urgent need for irrigation and efficient water management.

Geographers and environmental educators must understand Nakhchivan's hydrography because its scarce water resources underpin local agriculture, ecology, and development planning. This article analyzes the structure and distribution of Nakhchivan's rivers and streams, their hydrological characteristics, and their importance for farming. We combine data from Azerbaijani government sources and recent studies (2010s–2020s) on river flow, water quality, and land use. In addition, we highlight pedagogical applications: Nakhchivan's water systems illustrate key geographical concepts (e.g. basin hydrology in arid zones, human adaptation to water scarcity) and can be used for classroom case studies or lessons. Following this introduction, we outline Nakhchivan's geography and climate, describe the general hydrographic network, profile the major rivers (Araz, Arpachay, Nakhchivanchay), examine tributaries and watershed behavior, review water chemistry and sediment issues, and discuss agricultural uses alongside educational insights.

Geographical and Climatic Background

Nakhchivan lies in the southeast Caucasus plateaus, with the Lesser Caucasus mountains encircling the exclave. The highest peak is Mount Qapichig (3,904 m) in the Zangezur range. The terrain slopes southward toward the Araz River valley. The main administrative districts reflect this topography: Sharur, Kangarli, Babek (which includes the city of Nakhchivan), and Julfa occupy the lower Araz plains, while Shahbuz, Ordubad, and parts of Babek extend into upland and alpine zones.

Climatically, Nakhchivan is strongly continental. Average annual precipitation is very low – roughly 200–300 mm on the Araz plains and up to 500–800 mm in the high mountains. For example, the Aras (Araz) plain areas receive only about 200–300 mm per year, making them one of the driest parts of Azerbaijan. Temperatures are hot in summer (often >30°C) and cold in winter (occasionally below –10°C). Seasonal snow and rainfall are critical for river flow: most rivers swell in spring from snowmelt and autumn rains, then shrink in summer's heat. Compared with the wetter North Caucasus, southwestern Nakhchivan faces frequent droughts and even dust storms. The semi-desert vegetation in lowlands and subalpine meadows in the high zones reflect this aridity.

Taken together, the steep relief and dry climate mean that Nakhchivan's rivers are relatively short but potentially torrential. Many are fed by snow-melt and spring showers, yielding short-lived high flows (flood peaks) in late spring or early summer, and very low flows in summer and early autumn. Historical records note episodic floods on the Araz (and its tributaries) in years with

unusually heavy summer rains. Reservoirs built since the mid-20th century (see below) have partly moderated flooding, but flash floods remain a hazard in mountain streams. Understanding these geographical and climatic factors is essential before examining Nakhchivan's water networks.

General Hydrographic Characteristics

Nakhchivan's hydrographic network is relatively dense given its area. Official sources report *"about 400 big and small rivers"* totaling roughly 1,800 km in length. Most of these streams are short (typically under 50–100 km) and originate in the nearby mountains. The terrain and geology produce mostly mountain streams that descend rapidly from high altitudes (often above 2,000–3,000 m) into the valleys. There are also several small lakes and reservoirs in Nakhchivan. Natural alpine lakes include Ganligol, Batabatgol, Səlavərti (Salvar əti) and Göygöl, mainly in the Nakhchivanchay and Gilanchay valleys. In addition, an Araz (Heydar Aliyev) reservoir and multiple dam reservoirs have been constructed on local rivers for water storage and hydroelectricity (e.g. on the Araz, Arpachay, Bananiyar, Nehram, Uzunoba).

Aside from surface waters, Nakhchivan is famous for its mineral and groundwater springs. Over 250 mineral-water sources (e.g. Badamlı, Sirab, Vayxır) are recorded in the AR. These springs provide both bottled water and local spa uses, but we focus here on surface streams and irrigation sources. The climate regime means that many rivers are seasonal: in dry summers some may run low or dry up, whereas during snowmelt and rain events they carry substantial flow. For example, documented floods along the southern Caucasus slopes (including Nakhchivan) occurred multiple times in the 20th century, though dams now reduce extreme peaks.

Hydrologically, all rivers of Nakhchivan ultimately drain into the Araz/Aras River, which then joins the Kura River and flows to the Caspian Sea. A helpful classification divides Azerbaijan's rivers by basin: the Nakhchivan rivers (Arpachay, Nakhchivanchay, etc.) belong to the Araz basin. (By contrast, only the Samur, Gudyal, Velvele etc. drain directly to the Caspian elsewhere in Azerbaijan.) Thus, in Nakhchivan the Araz (forming the border with Iran/Turkey) can be seen as the trunk river, with Arpachay and Nakhchivanchay as its two largest tributaries.

Profiles of Major Rivers

Araz (Aras) River

The Araz (Aras) River is the largest and most important river for Nakhchivan. It rises in the Turkish Bingöl Mountains and flows roughly 1,072 km through the Caucasus. In Nakhchivan, the Araz defines much of the southern border (with Iran and Turkey). It is a deep, broad river that collects water from dozens of tributaries. In downstream Azerbaijan (beyond Nakhchivan) the Araz joins the Kura at Sabirabad and supplies water to the Caspian basin.

The Araz River's discharge is heavily variable. Near Nakhchivan the mean flow is moderate, but in spring during peak snowmelt it can reach over 1,000 m^3/s, whereas in late summer it may drop to only tens of m^3/s. This variability reflects the short summer drought and reliance on mountain

snow. The water quality of the Araz is generally fresh: its total dissolved solids average ~40–60 mg/L (as $CaCO_3$) in the lowlands, making it suitable for irrigation and drinking after treatment. Recent analyses report that most heavy metals in the Araz are below WHO limits, though arsenic (likely from natural sources) may pose a chronic risk. Overall, the Araz provides potable and irrigation water to numerous communities and thousands of hectares of cropland along its course.

A major infrastructure on the Araz is the Heydar Aliyev Hydroelectric Power Plant (Aras HPP), built in 1970. The Aras Reservoir behind the dam has a capacity of about 1.2 billion m^3 (usable). This reservoir regulates river flow, generates ~22 MW of electricity, and supplies irrigation water during the dry season. The reconstruction of the Araz HPP is part of recent development plans for Nakhchivan. In agricultural terms, the Araz's irrigation provides water to the Aras Plains and beyond. The plains of Sharur, Kangarli, Babek and Julfa counties are largely irrigated by canals drawing from the Araz. (Sharur's Sadarak, boyukduz areas, and Julfa's Babak pipeline are examples.) In summary, the Araz River is the ultimate sink and source for Nakhchivan's hydrology – it defines the region's drainage and anchors its irrigation network.

Arpachay (Arpa) River

The Arpachay (also known as Arpa) is Nakhchivan's second-largest river and the largest *internal* river. It originates in Armenia's Vayots Dzor mountains (near Jermuk) and flows southeastward into Nakhchivan, joining the Araz near the village of Shibrat. Its total length is about 126–128 km, with a drainage basin of ~2,630 km^2. The river descends from roughly 3,100 m elevation (the summit of Mt. Kechaldag) to ~400 m at the Aras confluence.

Within Nakhchivan, the Arpachay gains many small tributaries (some 23 reported: 13 right-side, 10 left-side). Its flow is also snow-fed; spring melt from the Zangezur range yields peak flows, and summer often sees lower flow. An important feature on the eastern Arpachay is a reservoir (completed in the Soviet era) with a total storage of ~150 million m^3 (140 million m^3 usable). This reservoir serves irrigation needs for several kilometers of downstream farmland. A 25-MW hydroelectric plant was built on the Arpachay reservoir, though its power output is modest compared to the Araz HPP.

Chemically, the Arpachay waters are predominantly calcium–bicarbonate type. Dissolved bicarbonate and calcium dominate, with sulfates constituting ~7–16% of the anionic equivalents and chlorides 1–8%. Total mineralization is similar to the Nakhchivanchay (~40–80 mg/L hardness). The river is considered quite clean biologically: one study found 68 benthic macroinvertebrate species, indicating good oxygenation and habitat diversity (likely due to mountain origin and forest cover upstream). Overall, the Arpachay is widely used for irrigation and drinking water within Nakhchivan.

Notably, as an international river, the Arpachay involves cooperation between Armenia and Azerbaijan. During the 2020 ceasefire discussions, the joint management of the Arpachay/Akhurian River for irrigation was an important issue (indeed, its name is the same in

Armenian: Akhuryan). Water releases from the reservoir and summer flows are regulated by treaties to ensure downstream Nakhchivan's needs are met. Thus, like the Araz, the Arpachay underscores Nakhchivan's dependency on transboundary water flows.

Nakhchivanchay River

The Nakhchivanchay is the principal river entirely within the Nakhchivan exclave. It arises on the southern slopes of the Dereleyez ridge of the Lesser Caucasus (at Mount Kechaldag, 3,114 m) and flows south through the Shahbuz and Babek districts to the Araz. Its length is about 91 km, and the basin area ≈1,630 km². Like the other rivers, it is a left-bank tributary of the Aras.

The Nakhchivanchay has many minor feeder streams – about 16 named tributaries (9 entering from the east, 7 from the west). Its hydrology is similar to the Arpachay but with a slightly smaller catchment. Average discharge is roughly 3.7 m³/s (but can rise in flood), and turbidity in winter/spring may reach ~700 g/m³ (up to ~1,000 g/m³ during floods). These high turbidity values reflect strong seasonal silt transport from steep slopes. A major infrastructure on the Nakhchivanchay is the Vayxır Reservoir (built on a tributary, supplying water to city of Nakhchivan). Water chemistry measurements in the Nakhchivanchay show moderate mineralization (300–500 mg/L, mainly HCO_3^- and Ca^{2+}), and a slightly alkaline pH (~7.1–7.2).

The Nakhchivanchay valley is important for local communities: the city of Nakhchivan and several villages lie along it. Thus it provides much of the region's domestic water and feeds irrigation canals in the central plain. Farmers downstream rely on its summer flow for crops, supplementing with reservoir release if needed. In summary, while the Nakhchivanchay is shorter than Arpachay, it is significant for central Nakhchivan's population and agriculture.

Tributaries and River Basin Analysis

All Nakhchivan rivers feed the Aras River. The two largest sub-basins are the Arpachay basin (≈2,630 km²) and the Nakhchivanchay basin (≈1,630 km²). Smaller basins include those of the Alinjachay and Gilanchay rivers (which both feed into the Arpachay system) and numerous very minor streams in the mountains. The Arpachay's 23 tributaries (13 from the right, 10 left) mean that much of Sharur and Kangarli districts drain into it. The Nakhchivanchay's 16 tributaries (mostly from the Babek highlands) serve central districts. West of the Nakhchivanchay, smaller rivers such as Alinjachay and Gilanchay irrigate portions of Babek and Shahbuz, but these are minor by comparison.

From a basin perspective, Nakhchivan's rivers are steep-gradient and relatively short. The entire Araz basin (including these tributaries) has a watershed area of ~100,000–102,000 km². Within Nakhchivan's 5,503 km², roughly three-quarters of land area is drained by one of these rivers to the south. The westernmost district, Sadarak, is somewhat anomalous: its rivers (e.g. Soyuqbulag) end in saline Sadarak plains and do not flow to the Araz (they disappear into groundwater or small sink basins).

Seasonality in these basins is pronounced. Spring snowmelt and rains produce high flows and frequent floods. For example, hydrological monitoring on the Araz near the dam shows peak discharges ~1,100 m³/s, whereas in mid-summer dry periods flows can fall to 30–40 m³/s. Likewise, peak flows on Arpachay or Nakhchivanchay are orders of magnitude above baseflow. This seasonality causes strongly seasonal availability of irrigation water: fields must rely on stored river water (via reservoirs or kahriz wells) through the dry season. Land use data reflect this: district-level irrigation area expanded greatly in recent decades, but water resources limit yields. (For instance, although Nakhchivan increased its cultivated area by 58% from 2000–2022, grain yield rose only ~7%, indicating water constraints.)

In summary, Nakhchivan's river basins are compact and snow-fed. Sub-basin analyses emphasize that all flows from Sharur, Kangarli, Babek, Julfa and parts of Shahbuz and Ordubad ultimately route to the Araz. Engineering works (dams, canals, kahriz) in these basins govern water distribution, but fundamentally the hydrology is controlled by the region's steep relief and limited precipitation.

Hydrochemistry and Sediment Transport

The water chemistry of Nakhchivan's rivers reflects the geology of the Lesser Caucasus (limestone, volcanic rocks) and the arid climate. Generally, the rivers are "hard" (high in calcium) and alkaline. Analyses show that dissolved bicarbonate (HCO_3^-) and calcium dominate. For example, Nakhchivanchay samples had total dissolved solids ~300–500 mg/L (mostly Ca–HCO_3). Arpachay water is similarly Ca–HCO_3 type; chloride levels are low (1–8% of anions) and sulfate modest (7–16%). These values place the water chemistry in the moderately mineralized category. Groundwater-fed springs (kahriz) have comparable chemistry. Importantly, pollution levels have been studied: a 2019 survey found that heavy metals in both Aras and Arpachay are below WHO drinking-water limits. However, some trace arsenic was noted (requiring long-term vigilance). Nutrient concentrations (nitrate, phosphate) are generally low, since Nakhchivan has little heavy industry; main water quality issues arise from agricultural runoff (salinization and fertilizers).

Sediment transport is a significant factor during floods. The steep mountain slopes lead to high erosion rates when vegetation cover is sparse (especially in dry seasons). Turbidity measurements in Nakhchivan rivers are very high relative to more humid regions. For instance, the Nakhchivanchay had an average turbidity of ~700 g/m³, rising to ~1,000 g/m³ at flood peak. Similar values occur on Arpachay after summer storms. These sediments consist of silts and clays carried in suspension. During flood events, a substantial portion of valley alluvium can be mobilized. Reservoirs (like the Arpachay and Araz dams) trap much of this load; but downstream, notable sedimentation has occurred in channels and farm intake structures.

Farmers are aware of soil salinization issues, which are partly related to irrigation return flows and evaporation of these mineral-rich waters. Over time, continuous irrigation can concentrate salts in the soil. The government promotes improved drainage and salt-tolerant crops to mitigate this. From

an educational standpoint, measuring turbidity or mineral content in local streams can be an instructive lab exercise on weathering and sediment yield in arid regions.

In summary, Nakhchivan's rivers carry mineral-rich, alkaline water under natural conditions. Floods deliver heavy sediment loads, reflecting the high-energy mountain environment. Water quality is generally good for most uses, but requires management of salinity and monitoring of pollutants.

Agricultural and Pedagogical Relevance

Agricultural significance. Agriculture is the main livelihood in Nakhchivan, and it depends critically on water. The hot, dry climate makes rainfed farming marginal; irrigation is essential. As one analysis notes, *"with annual precipitation 110–350 mm … this region is one of the driest areas in Azerbaijan,"* so water from the Araz and internal rivers underpins all crop production. The major crops are cereals (wheat, barley), fruits, vegetables, and some tobacco. For example, in 2022 over 33,000 ha were planted to grain (mostly winter wheat and barley), yielding 107,418 tons. Potatoes and vegetables are also widely irrigated. Despite expanding irrigated area, yields have been relatively stagnant: an analytical brief reported that farmland grew ~58% (2000–2022) but yields rose only ~7%, underscoring water and soil quality limits.

Nakhchivan has invested heavily in irrigation infrastructure. From Soviet-era canals to recent state programs, the focus is on maximizing efficient use of Araz and tributary flows. An innovative traditional system is the *kahriz* (qanat) – an underground gravity-flow channel tapping mountain aquifers. Between 2002–2011 Switzerland funded rehabilitation of 125 kahriz tunnels, bringing water to ~40,000 people and irrigating some 700 ha. These kahriz now provide a reliable supplemental source for local villages (especially in Shahbuz and Kangarli). Modern reservoirs and wells also supply water to collective farms. Agricultural managers monitor river levels and reservoir storage closely; the new State Program for 2023–2027 emphasizes modernizing irrigation systems (e.g. lined canals, drip irrigation) to address climate stress.

Pedagogical insights. Nakhchivan's hydrography offers rich educational opportunities. For geography and environmental science curricula, the region is a real-world case of water management in an arid, transboundary context. Possible teaching applications include:

- **River basin mapping:** Students can map Nakhchivan's watersheds (Arpachay vs. Nakhchivanchay, tributaries) and analyze flow patterns. Using GIS or simple contour maps, one could illustrate how all water drains to the Aras and discuss implications of being an exclave dependent on neighbors' water.
- **Water balance exercises:** Given rainfall (~300 mm) and crop evapotranspiration (450–650 mm for wheat), students can calculate irrigation requirements and assess sustainability. A lesson might involve planning an irrigation schedule for a hypothetical farm, using local climate and river flow data.

- **Kahriz and cultural history:** The ancient kahriz system can be studied in history or technology classes. Educators could demonstrate a small-scale qanat model, linking geology (aquifers) with engineering. Discussion can touch on how societies innovate to obtain water in deserts.
- **Water quality lab:** A field or lab activity could involve testing local stream water for pH, hardness, and turbidity. Comparing values from Nakhchivanchay vs. Arpachay could reveal geological differences. Students learn about mineral content, and can discuss salinization issues raised in policy briefs.
- **Transboundary water policy:** In social studies or civics, the Nakhchivan case illustrates international water rights. Students can role-play negotiations between countries on Araz water shares, using the 2016 agreement between Azerbaijan and Iran as a reference (cooperative management of new dams).

In sum, integrating Nakhchivan's river data into lesson plans makes geography and environmental science more concrete and locally relevant for Azerbaijani students. It also aligns with Sustainable Development Goals (SDG6: Clean Water) and climate adaptation themes.

Conclusion

Nakhchivan's hydrographic network, though modest in scale, is central to the region's livelihood and education. The exclave's rivers – dominated by the Araz, Arpachay, and Nakhchivanchay – reflect a semi-arid, mountainous environment with strong seasonal flows. The Araz River (Aras) forms Nakhchivan's lifeline, with large reservoirs and canals drawing from it for irrigation and power. Arpachay and Nakhchivanchay supply the interior plain, and their waters are generally of good quality (calcium–bicarbonate type). However, water quantity is limited: annual rainfall is low (often <300 mm) and irrigation demands are high. As a result, water management (including kahriz, dams, and efficient irrigation) is critical for agriculture, which focuses on cereals and fruits.

From an educational viewpoint, Nakhchivan's rivers provide concrete examples of key concepts: the role of climate in hydrographs, traditional water technologies, and resource planning under constraints. Geography and environmental science courses can draw on real local data (streamflow, precipitation, irrigation rates) to teach water budgeting, watershed mapping, and sustainable practices. For instance, students might investigate how a village's wells (kahriz) supplement river irrigation, or model the impact of a 50% reduction in Araz flow on crop yields – integrating cross-curricular skills.

In conclusion, understanding Nakhchivan's hydrographic features – their structure, distribution, chemistry, and human uses – is essential for regional planning and education. Recent government programs and scientific assessments (cited above) offer up-to-date data on flows, water quality, and agricultural outputs, forming a basis for continued study. Educators and policymakers alike should leverage this knowledge: as one source notes, *"the critical need for effective irrigation*

systems" in Nakhchivan underscores both a development challenge and a rich teaching opportunity.

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