

Riparian biodiversity of the Kura River and its role in ecosystem services and local green economy development

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ABSTRACT

Riparian ecosystems along the Kura River combine riverine vegetation, wetlands, fish communities, birds, mammals and reptiles within a narrow ecological corridor that supports both biodiversity and human well-being. This study develops an academic synthesis from an author-prepared research project on the fauna and flora of the Kura River and interprets its findings through ecosystem-services and local green-economy perspectives. The source project identified Tugai forests, reed and aquatic vegetation, fish, migratory and resident birds, semi-aquatic mammals and reptiles as characteristic components of the riverside system, while emphasizing declining water levels, pollution and flow regulation by dams as major pressures. The study combines this original material with recent research on Azerbaijan's Tugai forests, riparian restoration and Kura-related ecosystem services. Results show that riparian biodiversity is economically relevant because it contributes to bank stabilization, habitat continuity, water regulation, fisheries potential, recreation and nature-based tourism. Degradation therefore represents not only an ecological loss but also a weakening of natural capital that supports local development. The analysis indicates that restoring river-floodplain connectivity, protecting Tugai vegetation, improving pollution control, maintaining environmental flows and supporting low-impact recreation can generate joint ecological and economic benefits. The paper concludes that Kura riparian biodiversity should be treated as productive natural infrastructure within Azerbaijan's green-economy transition, while future work should add standardized field inventories, habitat mapping and ecosystem-service valuation.

INTRODUCTION

Riparian zones are among the most multifunctional parts of river systems because they connect flowing water, floodplains, soils, vegetation and terrestrial habitats. Their ecological value is expressed through biodiversity, bank protection, nutrient cycling, habitat connectivity and hydrological regulation. Their economic value is less visible but equally important: healthy river corridors can support fisheries, agriculture, recreation, tourism and the long-term stability of land and water resources. For this reason, riparian biodiversity can be interpreted as a form of natural capital rather than as an environmental feature separate from economic development.

The Kura River is especially important in this context. It is the largest river system crossing Azerbaijan and supports extensive lowland landscapes, settlements and productive activities before reaching the Caspian Sea. The original research project by Imanli and Ismayil examined the fauna and flora associated with the Kura riverside and organized the system into several components: Tugai forests, wetland and aquatic vegetation, fish communities, riverside birds, mammals and reptiles. The project also identified declining water levels, pollution and dams as pressures capable of weakening this ecological structure.

Recent research confirms that Azerbaijan's Tugai forests are ecologically distinctive riparian ecosystems whose composition depends on flooding, shallow groundwater, alluvial soils and salinity conditions. They provide habitat for diverse plant and animal

communities while also performing functions such as bank stabilization and local microclimate regulation (Gurbanov et al., 2026; Ahmadova, 2026). These functions create a direct bridge to green economy thinking because natural systems can reduce environmental risk and sustain economic activities without requiring continuous replacement by engineered infrastructure.

This study therefore asks three questions: (1) which biodiversity components are emphasized in the original Kura River research project; (2) how do these components contribute to ecosystem services and local economic value; and (3) which management actions can protect riparian natural capital while supporting green-economy development? The analysis does not treat the educational project as a standardized biodiversity census. Instead, it preserves the authors' observations and thematic structure, verifies major ecological mechanisms against recent literature and develops an ecosystem-services interpretation suitable for an interdisciplinary journal.

LITERATURE REVIEW

Tugai forests are the core riparian vegetation type of the Kura lowlands. Gurbanov et al. (2026) describe them as intrazonal ecosystems characterized by multilayered vegetation and strong dependence on hydrological regime, groundwater conditions and soil salinity. Dominant and characteristic groups include *Populus*, *Salix*, *Ulmus*, *Alnus* and *Tamarix*. The same study emphasizes that river regulation, intensive water abstraction, agricultural expansion,

deforestation, overgrazing, invasive species and climate change have reduced the extent and ecological integrity of these forests.

Field-based research from the Kura riparian zone in Agjabadi provides additional evidence. Qurbanov and Ahmadova (2024) documented poplar–willow–tamarisk communities on alluvial-meadow soils and argued that conversion of riparian forests to agricultural land can contribute to salinization and desertification. Their work is particularly relevant to the present study because it links plant-community structure with the need for ecological management and restoration in the Kura corridor.

Restoration research also shows that Tugai recovery cannot be reduced to tree planting alone. Ahmadova (2026) argues that effective restoration requires re-establishing the coupled river–floodplain–groundwater processes that support recruitment and long-term vegetation persistence. In economic terms, this matters because poorly designed restoration can consume resources without recovering the ecosystem functions that justify investment.

The Kura–Aras basin has also been examined through an ecosystem-services lens. Flores and Abbasov (2015) assessed freshwater ecosystem services in relation to hydropower and other water-dependent uses, demonstrating that water management decisions involve ecological as well as economic trade-offs. More recently, Zeynalova and Asgarova (2026) showed that the Kura riverfront in Mingachevir has potential for green tourism through waterfront landscapes, fishing, birdwatching and recreation, while stressing that ecological monitoring, resource-efficient services and waste management are necessary if tourism growth is to remain sustainable.

Together, these studies support a natural-capital framework for riparian biodiversity. Vegetation, wetlands and wildlife are not isolated conservation objects; they form a service-producing system whose condition affects erosion control, landscape quality, ecological connectivity, fisheries and recreation. This framework provides the basis for interpreting the original student project within a green-economy context.

MATERIALS AND METHODS

The study used an integrative qualitative design based on a 13-page educational research presentation prepared by Zahra Imanli and Farah Ismayil in 2026. The original project, titled 'Kür Çayı Ətrafında Fauna və Flora', aimed to examine plant and animal communities associated with the Kura River and to identify ecological threats and conservation measures. Its structure covered the river's geographical setting, Tugai forests, tree and shrub species, wetland and aquatic vegetation, fish, riverside birds, mammals and reptiles, current environmental pressures and selected conservation responses.

The source material was coded into four analytical categories: biodiversity components, ecosystem functions, major pressures and conservation responses. Plant and animal examples were retained when they were explicitly named in the source project. However, the project's visual labels describing relative fish abundance were not treated as measured population statistics because no sampling protocol or underlying dataset was supplied. The analysis therefore focuses on presence, ecological role and management relevance rather than on abundance estimates.

To strengthen academic interpretation, the source project was compared with recent peer-reviewed and institutional evidence on Azerbaijan's Tugai forests, riparian restoration, ecosystem services and sustainable riverfront tourism. No new field sampling, laboratory analysis, wildlife census or monetary valuation was conducted. The resulting study is a structured synthesis intended to preserve the

original research contribution while avoiding unsupported quantitative claims.

RESULTS AND DISCUSSION

Biodiversity structure of the Kura riparian corridor

The original project presents the Kura riverside as a vertically and horizontally connected ecological corridor. The vegetation component begins with Tugai forests and identifies white willow, white poplar, Tugai oak, oleaster and tamarisk among characteristic woody plants. Wet and slow-flowing zones are represented by reed beds, water lilies and other dense shoreline vegetation. These habitats create structural diversity from the river edge to the floodplain and provide feeding, breeding, shelter and movement spaces for wildlife.

The fauna section identifies fish, birds, mammals and reptiles as complementary parts of the system. The source project names sturgeon, carp, pike-perch and other fish; grey heron, black pelican, pheasant and purple swamphen among birds; and otter, nutria, wild boar, river turtle, water snake, wolf, fox and jackal among mammals, reptiles and predators. These records should be interpreted as an educational inventory rather than a verified species census, but they correctly emphasize the ecological diversity associated with river, wetland and woodland habitats.

Recent botanical studies support the project's emphasis on the Tugai zone. Gurbanov et al. (2026) found high species diversity and multilayered structure in Kura-basin riparian communities, while Qurbanov and Ahmadova (2024) documented poplar–willow–tamarisk formations in the Agjabadi sector. This agreement between the educational project and field literature strengthens the interpretation of riparian vegetation as the physical framework supporting much of the corridor's biodiversity.

Tugai forests as natural infrastructure and ecosystem-service providers

The source project describes Tugai forests as green corridors that protect riverbanks from erosion and provide shelter for animals. These functions have direct ecosystem-service significance. Vegetation can stabilize alluvial banks, reduce soil loss, create shade, maintain habitat continuity and contribute to local microclimate regulation. Ahmadova (2026) similarly identifies bank stabilization, habitat connectivity, biodiversity support and microclimate regulation as important Tugai functions.

From a green-economy perspective, such functions can be understood as natural infrastructure. When riparian buffers reduce erosion or maintain habitat, they help preserve the productive condition of land and water without requiring equivalent engineered interventions. This does not mean that ecological functions can always be assigned a simple monetary value, but it does mean that their degradation can create real costs through bank instability, poorer water quality, habitat loss and reduced recreational attractiveness.

Table 1. Riparian biodiversity components and their ecosystem-service and green-economy relevance

Biodiversity component	Ecosystem-service and green-economy relevance
Tugai forests and riparian trees	Erosion control, habitat connectivity, microclimate regulation, landscape quality and restoration value
Wetland and aquatic vegetation	Bird nesting habitat, wetland structure, aesthetic value and nature-based recreation
Fish communities	Food-web function, fisheries potential, recreational fishing and indicators of aquatic condition
Riverside birds	Biodiversity value, birdwatching potential and indicators of wetland habitat quality

Biodiversity component	Ecosystem-service and green-economy relevance
Mammals and reptiles	Habitat-integrity value, ecological connectivity and conservation-based recreation

The original project identifies three principal pressures: declining water levels, pollution and dams. Reduced flow can affect floodplain moisture, wetland persistence and the hydrological conditions required by Tugai vegetation. Pollution can reduce habitat quality for aquatic organisms and weaken the recreational and aesthetic value of the river corridor. Dams and flow regulation can modify natural hydrology and interrupt fish migration. These pressures are mutually reinforcing because hydrological alteration can make riparian ecosystems more sensitive to pollution and climate stress.

The literature confirms this multi-pressure interpretation. Gurbanov et al. (2026) identify reservoir construction, river regulation, water abstraction, agricultural expansion and climate change as important drivers of Tugai degradation. Qurbanov and Ahmadova (2024) further show that land conversion and inappropriate restoration approaches can weaken the ecological resilience of riparian forests. Biodiversity management therefore requires attention to the hydrological system, not only to individual species.

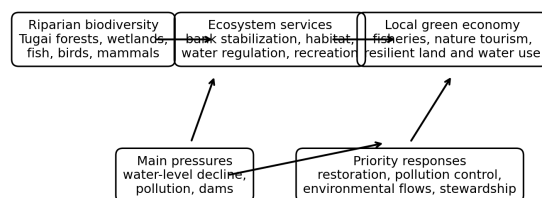


Figure 1. Conceptual pathway from Kura riparian biodiversity to ecosystem services and local green-economy value

Figure 1 summarizes the central relationship developed in this study. Riparian biodiversity produces ecosystem services, those services support locally relevant economic functions, and environmental pressures can weaken both. Restoration, pollution control, environmental-flow management and stewardship can reverse part of this pathway by protecting natural capital before ecological losses become higher social and economic costs.

Local green-economy opportunities linked to riparian biodiversity

Local green-economy value can emerge through several channels. First, healthy fish habitats can support renewable fishery and recreational-fishing opportunities when extraction remains within ecological limits. Second, bird-rich wetlands and visually attractive riverfront landscapes can support low-impact recreation, birdwatching and nature tourism. Zeynalova and Asgarova (2026) show that the Kura riverfront in Mingachevir already has potential for boating, fishing, birdwatching and other river-oriented tourism, but that ecological monitoring and resource-efficient services are essential for sustainability.

Third, restoration itself can be viewed as green investment. Re-establishing native riparian vegetation, controlling erosion, improving waste management and protecting floodplain connectivity can strengthen natural infrastructure while creating demand for ecological monitoring, nursery production, restoration work and environmental education. The economic objective is not to commercialize every ecosystem component, but to maintain the ecological assets on which resilient local development depends.

Conservation priorities and study limitations

The evidence supports five practical priorities: protect remaining Tugai forest fragments; maintain hydrological conditions that allow floodplain and wetland habitats to function; reduce untreated waste and chemical pollution; preserve fish-migration and habitat connectivity where possible; and expand community stewardship and environmental education. Protected-area management and artificial propagation can contribute to species conservation, but they should complement rather than replace river-corridor restoration and pollution prevention.

The study has important limitations. The original research project is an educational presentation rather than a standardized field inventory. Species presence was not verified through a reproducible sampling protocol, and the relative fish-abundance graphic was not accompanied by raw data. No habitat-area measurements, population trends or monetary ecosystem-service values were generated. Future research should combine georeferenced vegetation plots, bird and fish surveys, water-quality monitoring, habitat mapping and valuation of recreation, erosion protection and other ecosystem services.

CONCLUSIONS

The Kura River's riparian biodiversity forms a connected natural-capital system rather than a collection of isolated species. The original research project highlights Tugai forests, wetland vegetation, fish, birds, mammals and reptiles as characteristic elements of this corridor, while identifying water-level decline, pollution and dams as major pressures. Recent literature supports the ecological importance of Tugai vegetation and shows that its persistence depends on river–floodplain hydrology, groundwater and appropriate restoration. The green-economy implication is clear: protecting riparian biodiversity also protects services that support land stability, fisheries, recreation, nature tourism and resilient water-dependent livelihoods. Conservation should therefore be designed as investment in natural infrastructure. Priority actions include Tugai restoration, pollution prevention, environmental-flow and connectivity management, low-impact tourism, ecological monitoring and public stewardship. Because this study is qualitative, the next stage should integrate field biodiversity inventories with ecosystem-service and local economic data so that conservation priorities can be evaluated through both ecological and development criteria.

AUTHOR CONTRIBUTIONS

Z.I. and F.I. contributed the original research concept, source collection, biodiversity inventory, visual synthesis and preliminary assessment of Kura riparian flora, fauna, ecological pressures and conservation measures. A.J. contributed supervision, methodological framing, academic structuring, ecosystem-services and green-economy interpretation, and writing—review and editing. All authors reviewed and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

DATA AVAILABILITY

This study is a qualitative synthesis of an author-prepared educational research project and published literature. No new biological sampling, laboratory water-quality dataset, wildlife census or monetary ecosystem-service valuation was generated. The descriptive source material supporting the synthesis is contained in the authors' original research file.

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