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Assessment of Cultural Ecosystem Services Potential in River Catchments in the Caucasus: Evidence From Dilijan National Park, Armenia

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The Caucasus region is recognized as a biodiversity hotspot. Nature conservation and nature-based tourism are promoted to preserve the region's vulnerable mountain ecosystems. Understanding the cultural value of the ecosystems and the services they provide is essential for conservation efforts. In our study, we use the case of Dilijan National Park, Armenia, to develop a framework to assess the potential of cultural ecosystem services. This framework can be adapted into various assessment matrixes calibrated for local cases in mountain regions. To make the assessment more comprehensive and the results spatially interpretable, we developed a 5-level scoring system using a set of criteria for 2 river catchments in Dilijan National Park. We then conducted an assessment of the rivers' ecological statuses under the condition of no visitors as a reference for further comparisons. To avoid biases, the scoring system for some aspects of the spatial assessment, such as the preference for land use/land cover, was justified using participatory methods. The results highlight a significant potential for cultural ecosystem services in areas where recreational amenities and infrastructure are close to rivers. The mixed-methods approach used for the overall assessment of the cultural ecosystem services potential indicated that, while visitors do exert some pressure on ecosystems, the impacts observed in the 2 catchment areas under study remained relatively low and fell within the carrying capacity of these vulnerable ecosystems.

Keywords: *ecosystem services; mountain streams; tourism; protected areas; Caucasus; Armenia; Dilijan National Park; mixed methods.*

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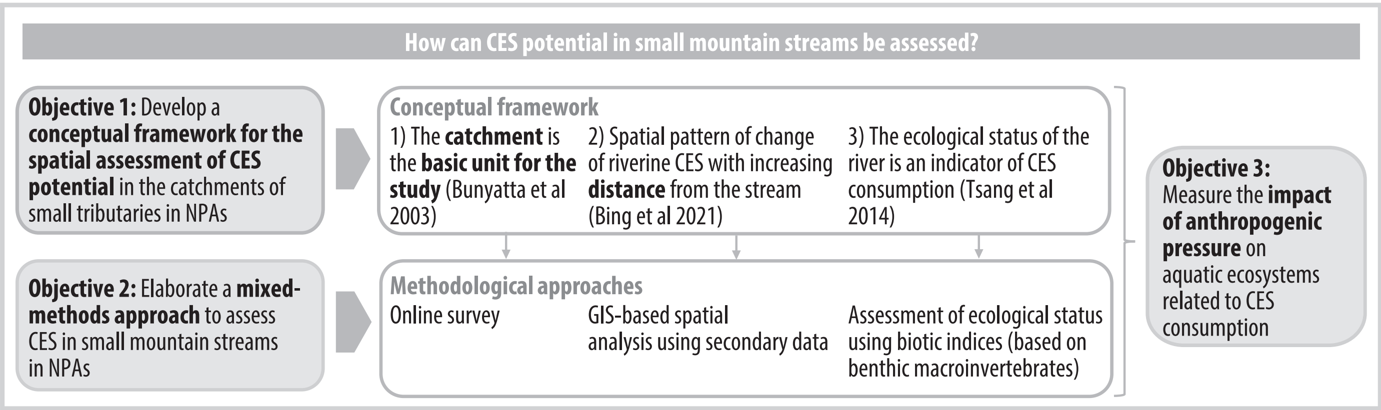
Introduction

The Caucasus region is recognized as one of the world's biodiversity hotspots for conservation priorities (Myers et al 2000; Kong et al 2021). With its high diversity of ecosystems (Fayvush et al 2023), Armenia, as one country in the South Caucasus region, is striving to develop nature-based tourism and recreation activities. Nature-protected areas (NPAs) are among the most popular tourism destinations worldwide (Andries et al 2021). In addition, during the last decade, the number of international tourists in Armenia has roughly doubled, and most of the newcomers prefer cultural tourism, followed by adventure tourism, business tourism, and nature-based tourism (TC 2019).

These protected landscapes and ecosystems provide particular cultural services (Plieninger et al 2013). The Millennium Ecosystem Assessment (MA 2005) defines ecosystem services (ES) as "nonmaterial benefits people obtain from ecosystems." Based on the work of MA (2005), Daniel et al (2012), Plieninger et al (2013), and Fish et al (2016), we refer to cultural ES (CES) as spiritual values, educational benefits, inspiration, aesthetic values, social relations, sense of place, belonging, cultural heritage values, recreation, and ecotourism value. CES must demonstrate a significant relationship between the ecosystem structures and functions specified in the biophysical domain and the satisfaction of human needs and wants specified in the medical/psychological/social domain (Daniel et al 2012). Aquatic ecosystems, particularly rivers, are vital for human wellbeing (MA 2005). They provide a range of CES that people consume both directly and indirectly (Ncube et al 2021). Although the MA (2005) provides a general framework for ES assessment, the definitions of most CES categories are vague (Plieninger et al 2013). Michaelis et al (2020) suggest a need for a more systemic assessment that includes sociocultural benefits from nature. Managing these services holistically safeguards rivers' sustainable use and acknowledges potential trade-offs and synergies across the entire river system, enhancing conservation efforts and community empowerment (Stosch et al 2017). Recognizing local ES use can enable the implementation of strategies that preserve ecosystem quality while respecting traditional resource use, benefiting both protected area management and community empowerment (Lim et al 2021). Valuing ES

FIGURE 1 Study design.



is a complex task that encompasses ecological, sociocultural, and economic dimensions (Mukherjee et al 2014). Participatory valuation is crucial, especially for CES, accounting for both material and nonmaterial values (Stosch et al 2017). Place-specific evaluation methods, incorporating local knowledge and values, are essential for sustainable development (Plieninger et al 2013; Gómez et al 2023), and involving stakeholders in aquatic ES assessments is vital for effective evaluation (Scemama et al 2022).

In particular, in Armenia, water holds profound cultural significance, with a rich associated history of reverence and legends; there is even a holiday, Vardavar, dedicated to it (Petrosyan and Bobokhyan 2015). Along every river in Armenia, especially by mountain springs, there are numerous designated picnic spots, highlighting the integral role of water bodies in leisure and recreation. Our case study region is Dilijan National Park in Armenia, which is a well-known tourist destination and recreation area because of its water bodies, forests, wildlife, mild climate, and mineral waters (Khanjyan 2004). During the summer months, thousands of people visit these locations for various recreational and cultural activities, leaving their footprint on ecosystems (Arzumanyan et al 2023). The flow of tourists also creates anthropogenic pressure and can negatively affect CES provision on a catchment scale (Taff et al 2019). Small mountain rivers, while culturally significant, also serve as indicators of anthropogenic pressure, highlighting the need for sustainable management and conservation efforts in NPAs (Liu et al 2020). These rivers are usually less impacted and impaired by human activities in Armenia (eg Asatryan and Dallakyan 2021; Asatryan et al 2023). However, there is some pressure from agriculture and household wastewater discharge in many areas. Hence, there is an urgent need to assess the potential of CES at their baseline state to find ways for sustainable governance of Dilijan National Park. The main research question of this study is: How can CES potential in small mountain streams be assessed? Thus, the objectives of our work were (1) to develop a conceptual framework for the spatial assessment of CES potential in the catchments of small tributaries in NPAs, (2) to elaborate a mixed-methods approach to assess CES potential in small mountain streams in NPAs, and (3) to measure the impact of anthropogenic pressure on aquatic ecosystems related to the consumption of CES. The latter objective is aimed at answering the question of to what extent the use of CES influences the carrying capacity of river ecosystems.

Material and methods

Study design

To develop the conceptual framework, we considered seminal articles by Daniel et al (2012), Plieninger et al (2013), Stosch et al (2017), and Michaelis et al (2020). The authors of these studies provide definitions of CES and advocate for the integration of various scientific disciplines, methods, and tools to assess and spatially represent CES, supporting better governance of socioecological systems (Figure 1).

Thus, for the assessment of CES potential in small mountain streams in NPAs in Armenia, we followed 3 main concepts:

1. Small streams are organically connected with the landscapes within their catchment; therefore, spatially, the catchment is the basic unit for the study (Bunyatta et al 2003).
2. The supply and demand of riverine CES at the catchment scale have a clear spatial pattern of change with increasing distance from the stream (Bing et al 2021). Thus, the distance from a stream within the catchment should influence the CES potential of the area.
3. From a holistic perspective, streams carry the aggregated impact of activities in the catchment; therefore, their ecological status indicates the health of the overall catchment (Tsang et al 2014).

Zoderer et al (2019) developed an approach for regional mapping of tourists' landscape preferences in geographically diverse areas from the perspective of ES. Based on the first concept of the framework and using this approach, we tried to integrate the preferences of visitors with the landscapes from an ES perspective. Specifically, we identified the perceived supply and sociocultural valuation of ES. Considering the second concept, we collected available spatial data and elaborated a set of criteria with a scoring system to conduct spatial analysis using ArcMap 10.5 software. Mapping is becoming a vital method for CES potential assessment (Nahuelhual et al 2016). The aim was to determine theoretically the range of CES potential in the catchment. As the work is performed for NPAs, we also set a limiting factor for the overall assessment, which was the accessibility of the site based on the availability of roads or trails and the distance from them. Following the third concept, we investigated the benthic macroinvertebrates in the streams and conducted an assessment of the ecological status using biotic indexes.

Case study: Dilijan National Park, Haghartsin and Gosh catchments

Dilijan National Park was established in 2002 based on a state nature reserve dating back to 1958. It covers an area of 240 km^2 and is one of the most forested areas in Armenia (Khanjyan 2004). Geographically, the park spans the Pambak, Areguni, Miapor, Ijevan, and Halab mountain ranges at elevations of 1070–2300 masl (ARMSTAT 2018). The Aghstev River and its main tributaries partly flow through the park's territory (Figure 2; Asatryan and Dallakyan 2021). Gosh and Haghartsin are relatively small tributaries, but both are well-known for their recreational and spiritual values. Unlike the Gosh catchment, where the village of Gosh with almost 1000 residents is located (ARMSTAT 2022), there are no settlements in most of the Haghartsin River basin, apart from around the river mouth. Thus, the Gosh River experiences anthropogenic pressure throughout the year, while tourism is the major stressor for the Haghartsin basin.

The flora in Dilijan National Park includes 902 species of vascular plants, including rare and endangered ones (Khanjyan 2004). Forests in the park consist of both deciduous and coniferous species (Morin et al 2021). The park is home to diverse fauna, with approximately 800 species of beetles, numerous reptiles, amphibians, fish, and about 150 bird species. Mammals, including red deer, brown bears, and foxes, thrive in the park (Galstyan 2017). There are several cultural monuments that are common tourist destinations, such as Haghartsin Monastery (10th–13th centuries), Goshavank (12th–13th centuries), Jukhtak Vank (11th–13th centuries), Matosavank (10th–13th centuries), and Aghavnavank (11th century) (Khanjyan 2004).

Data collection and analysis

The data were collected using a mixed-methods approach.

Spatial analysis: To map the potential of Gosh and Haghartsin catchments to provide CES, we collected the following spatial information and layers (Figure 3): terrain; hydrological system; roads; settlements; cultural and natural monuments, from the American University of Armenia, Acopian Center for the Environment (ACE n.d.); land cover/land use, from Sentinel-2 data (Sentinelhub n.d.); and tourist trails, hiking spots, and outdoor recreation objects (eg picnic areas), from Tavush Tourism Development Agency. To complete the geographic information system (GIS) database, we conducted field trips and updated the outdoor recreation objects layer to 1 July 2023. Then, we analyzed distance from the input categories, such as roads, rivers, and monuments, using the Euclidean distance method. This describes each cell's relationship to a source or a set of sources based on the straight-line distance (Liberti and Lavor 2017). To set the categories for this analysis, we considered both the terrain of the Gosh and Haghartsin catchments and interviews with local experts about the average walking speed in such an environment. As a result, we concluded that 2 km per hour was an average walking speed and reflected the period needed to cover various distances on this terrain. Thus, it was estimated that to cover 500 m, the average tourist would walk for 15 minutes, 1 km would take 30 minutes, and so forth.

We developed a methodology using a 5-level gradation where 1 is the highest potential of CES and 5 is the lowest. This followed the River Ecosystem Service Index methodological approach to the gradation of ES in river stretches (Podschun et al 2018; Pusch et al 2018; Becker et al 2022). In this, each ES is independently estimated using either capacity matrixes or indicator-based approaches, and then the results are distributed into 5 classes. We also considered the European Union Water Framework Directive (EU WFD) recommendation for estimating the health of river ecosystems using 5-level evaluation frameworks (European Union 2000).

In terms of aesthetic value, geomorphological features of river valleys are among the most important CES (Didukh et al 2015). However, they influence the availability of walking trails in the area, so the focus of recreation in Haghartsin and Gosh catchments is in the plain area near the rivers (mostly in floodplains or first terraces). Thus, we conducted a slope analysis in GIS using a digital elevation model of the catchments simulated from the contour lines (topography) layer using the Topo to Raster spatial analysis tool. Based on these results, we made a supervised classification and set the scores for each category. To avoid biases as much as possible, scores from 1 to 5 were given for some aspects of the spatial assessment; for example, the preference for land use/land cover or preferences for geomorphological features were justified using the survey method.

Because there is no natural monument in the catchment of the Haghartsin River, the number of assessment criteria differed between the Haghartsin and Gosh catchments. The overall assessment was conducted using a raster calculator by summing the scores of all criteria used and multiplying by the weight factor (Equations 1 and 2). We kept the weight of each factor equal; thus, the weight coefficient was 0.1 in the case of the Gosh catchment and 0.111 in the case of the Haghartsin catchment.

$$\text{CES for Gosh} = 0.1 * \Sigma \textit{criteria score} \quad (1)$$

$$\text{CES for Haghartsin} = 0.111 * \Sigma \textit{criteria score} \quad (2)$$

Social data collection (survey): To obtain empirical data, we applied surveys. In July and August 2023, through informal discussions with local guides, business owners, and residents, we identified tourism and leisure activities in our case study regions. The identification and interviews with 12 local experts were facilitated by the corresponding author, who is from the region and has worked as a hiking tour guide in Dilijan National Park. This information, along with the data derived from spatial analysis (eg relief types), was used to develop an online questionnaire survey to facilitate participatory validation of the criteria associated with the Haghartsin and Gosh regions (EcoServ n.d.). To ensure an

FIGURE 2 Topographic features of Dilijan National Park, and its location in Tavush Province.

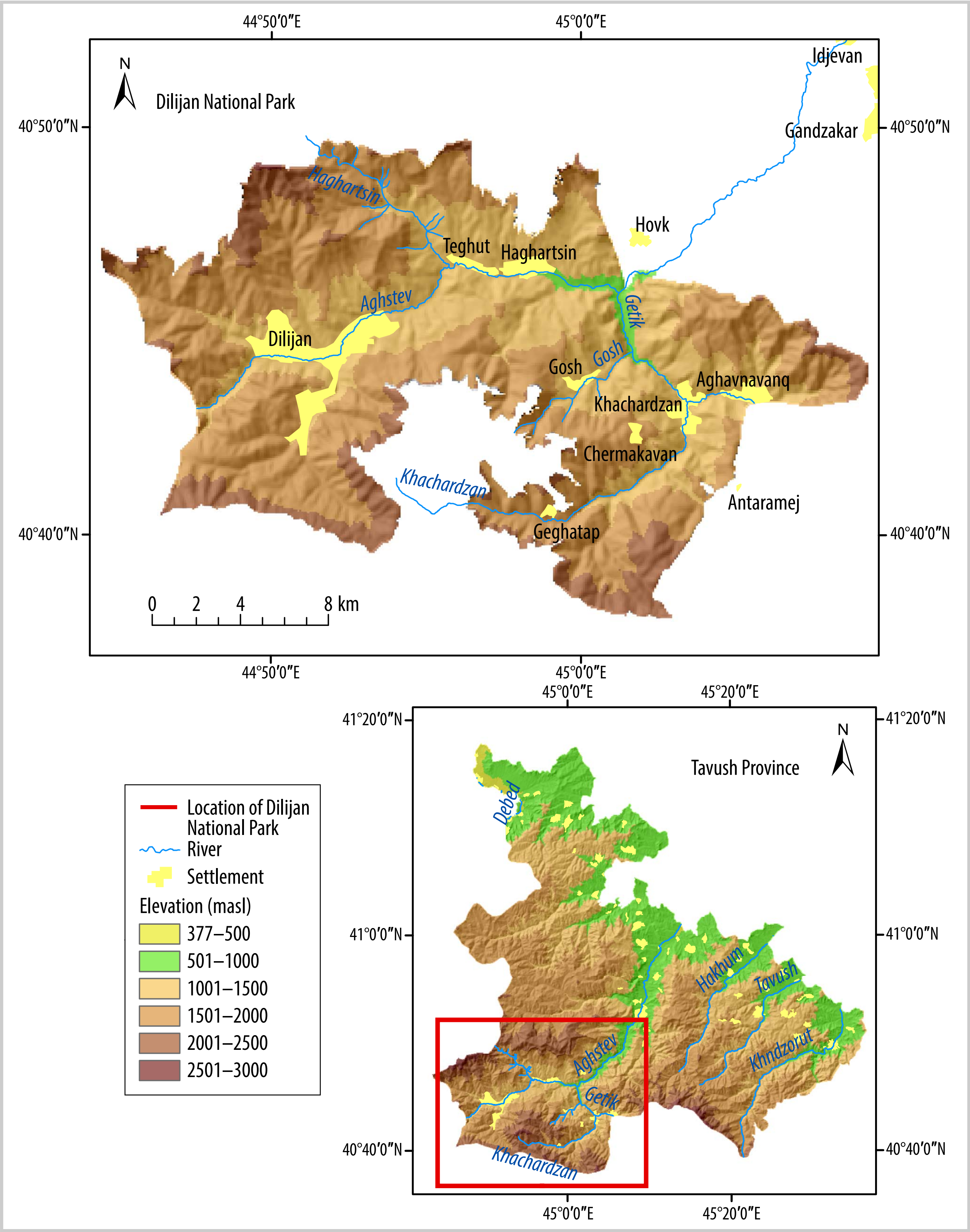
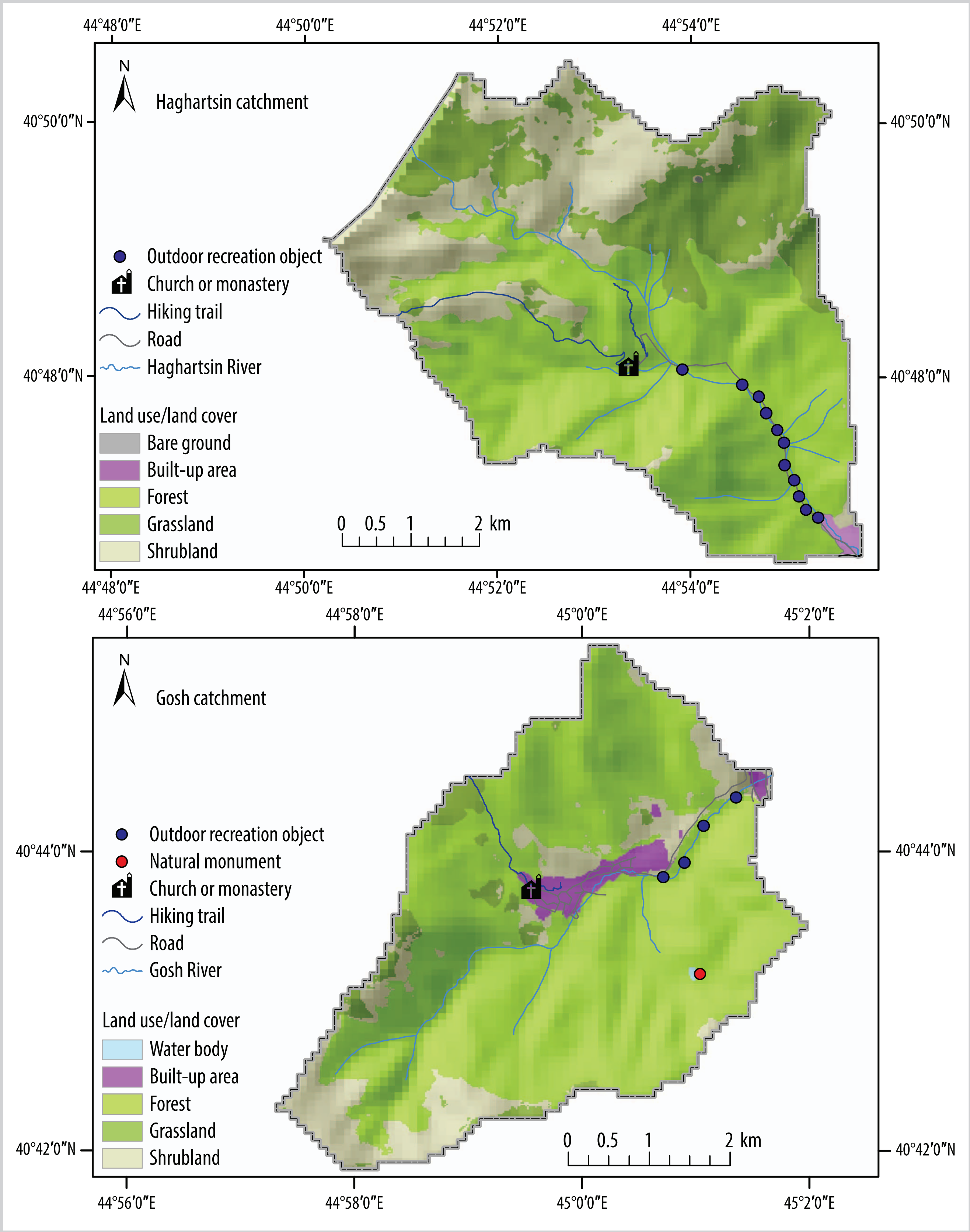


FIGURE 3 Spatial distribution of criteria used in CES assessment.



inclusive approach for different groups and individuals, the survey included closed and ranking questions in Armenian, English, and Russian. The aim of the survey was to

- Clarify the primary objectives motivating visits to the region;
- Examine the preferred relief forms when planning recreational activities within the region;
- Determine the favored settings for tourism and leisure activities: whether in natural wilderness environments or provided facilities (eg hotels, picnic areas, recreational sites).

In September and October 2023, the online survey was distributed on social media platforms, such as Facebook, and through professional mail groups and networks. The survey was distributed to people aged 18 and older who visited the Haghartsin and Gosh regions; there were no gender, nationality, occupation, or other limitations. The survey was completed by 141 respondents, with a clear consensus of preference being expressed by the majority of respondents.

Ecological status assessment: The EU WFD (European Union 2000) suggests 4 biological quality elements (BQEs) that indicate the ecological status of surface freshwater ecosystems. Among them, benthic macroinvertebrates (aquatic invertebrates larger than 1 mm) are the most preferred ones in the fast-flowing mountain waters of Armenia (Asatryan and Dallakyan 2021) and reflect well the impact of various stressors over an extended period (Birk et al 2012).

One sampling site was selected in each tributary near active recreation zones. The Haghartsin sampling site (40°48′04″N; 44°53′54″E) had an 1180 masl elevation. The substratum was mainly gravel, pebbles, and cobbles. The river width was about 3 m. The Gosh sampling site (40°43′51″N; 45°00′46″E) had a 1090 masl elevation. The substratum was mainly gravel and pebbles. The river width was about 2 m. To compare the results with the ecological status of the best available site in the drainage basin of the Aghstev River (Dallakyan and Asatryan 2021), we also investigated benthic macroinvertebrates in the Tandzut tributary (40°44′24″N; 44°37′18″E) where the sampling site was chosen at 1960 masl and the substratum consisted of pebbles, cobbles, and boulders. The width of the riverbed was 2 m. Benthic macroinvertebrates were collected following the main requirements of the AQEM project (AQEM Consortium 2002) in August 2020 and 2021 using a Surber sampler with a mesh size of 500 μm. Each sampling site was a 30 m long part of a river section, and from each site benthic macroinvertebrates were collected with 5 replications. The material was fixed in 96% ethanol and transported to the laboratory where identification of taxa was performed using the identification keys of, for example, Ivanov et al (2001) and Waringer and Graf (2011).

Although summer is the high tourist season in Dilijan National Park, there were almost no tourists in 2020 because of the COVID-19 pandemic. This enabled a baseline assessment of the ecological status and estimation of impact from tourism based on data for 2021.

To estimate the ecological status (Equations 3 and 4), we used the Biological Monitoring Working Party (BMWP) and average score per taxon (ASPT) indexes (Armitage et al 1983), where tolerance scores and ecological status classes were set following Wright et al (1993) and Leeds-Harrison et al (1996).

TABLE 1 Primary reasons for visiting and preferred relief forms for recreational activities in Haghartsin and Gosh regions.

Preference[a]	Primary reason for visiting	Preferred relief forms for recreation
1	Nature	River plain shores
2	Monasteries	Gentle slopes
3	Picnic	Slopes of medium steepness
4	Hiking	Inclined slopes
5	Adventure tourism	Canyon with vertical slopes

[a] Scale: 1 = most preferred, 5 = least preferred.

$$BMWP = \sum_{i=1}^{n} T_i \tag{3}$$

where T_i is a tolerance score for each taxon.

$$ASPT = \frac{BMWP}{N_{\text{taxa}}} \tag{4}$$

where N_{taxa} is the number of taxa in the sample.

According to the classification, good status refers to BMWP scores of 50–100 and ASPT scores of 4.1–4.49; very good status refers to BMWP scores of 100–149 and ASPT scores of 4.5–4.99; and excellent status refers to BMWP scores >150 and ASPT scores ≧5. All values less than the lower threshold of good status constitute serious degradation of the ecosystem. In addition, we used number of families (N_{family}), abundance (number of specimens in the sample), and percentage of Ephemeroptera, Plecoptera, and Trichoptera specimens that are common but intolerant to pollution in the sample metrics to describe the ecological status and its changes better.

Results

Survey results

The survey results shed light on the primary motivations behind visits to the region, preferred relief forms for recreational planning, and whether participants favored natural wilderness settings or human-provided facilities for tourism and leisure activities. The results indicated that the primary reason for visiting the Haghartsin and Gosh regions was the appreciation of nature, with monasteries being the second most common attraction. Picnicking came in third place, followed by hiking in fourth place. Adventure tourism and visiting relatives were not primary motivations for exploring this region (Table 1). When it comes to the preferred relief forms for organizing recreational and leisure activities in the Haghartsin and Gosh rivers valleys, respondents indicated that they preferred the flat parts, the river plain shores, followed by gentle slopes. Relatively less preferable options included slopes of medium steepness and

TABLE 2 Set of criteria and their parameters by scenario 1, where people prefer to have more "comfort" when visiting NPAs (Index 1), and scenario 2, where people prefer to be more in the wilderness when visiting NPAs (Index 2).

Criteria	Score						Validated through
	1	2	3	4	5	The assessment cannot be performed	
Valley slope angle (degrees) Index 1	0–5	5–10	10–20	20–45	45–70	—	GIS analysis and participatory validation
Valley slope angle (degrees) Index 2	0–5/45–70	5–10/20–45	10–20	—	—	—	GIS analysis and participatory validation
Land use/land cover (type) Index 1	Forest/built-up area/water body	—	Grassland	Shrubland	—	Bare ground	GIS analysis and participatory validation
Land use/land cover (type) Index 2	Forest/water body	—	Grassland	Shrubland	—	Bare ground/ Built-up area	GIS analysis and participatory validation
Distance from settlements (m) Index 1	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements
Distance from settlements (m) Index 2	>2000	1501–2000	1001–1500	501–1000	500	—	GIS analysis and personal measurements
Distance from rivers (m)	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements
Distance from roads (m)	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements
Distance from trails (m)	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements
Distance from spiritual and cultural monuments (m)	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements
Distance from natural monuments (m)[a)]	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements
Distance from hiking spots (m)	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements
Distance from outdoor recreation places (m)	500	501–1000	1001–1500	1501–2000	>2000	—	GIS analysis and personal measurements

GIS, geospatial information system.
[a)] Criterion used only for the Gosh River.

inclined slopes; canyons with vertical slopes were the least preferred relief type (Table 1). The survey results revealed that 72% or 102 respondents preferred to organize their leisure in natural wilderness settings, while 28% or 39 respondents preferred human-provided facilities, such as hotels, picnic areas, and recreational sites.

Spatial analysis

The results of the survey showed that people have different preferences in land use/land cover (landscapes). Thus, based on their preferences, we developed 2 indexes/scenarios to assess CES potential. The first scenario (Index 1) utilized the perception that visitors wish to have more comfort in terms of infrastructure and artificial objects nearby, while the second one (Index 2) reflected the needs of people who prefer to be in a wilderness far from settlements and anthropogenic objects. In both cases, the same spatial approach to the assessment was realized but with different arrangements of scores for some criteria (Table 2).

CES potential assessment: CES potential assessments based on Index 1 (Figure 4) and Index 2 (Figure 5) yielded similar results. Spatially, the highest potential was revealed near the rivers in the zones where one of the main attractions according to survey respondents—churches and monasteries—was located. Thus, in both cases, it was the

FIGURE 4 CES potential assessment based on Index 1.

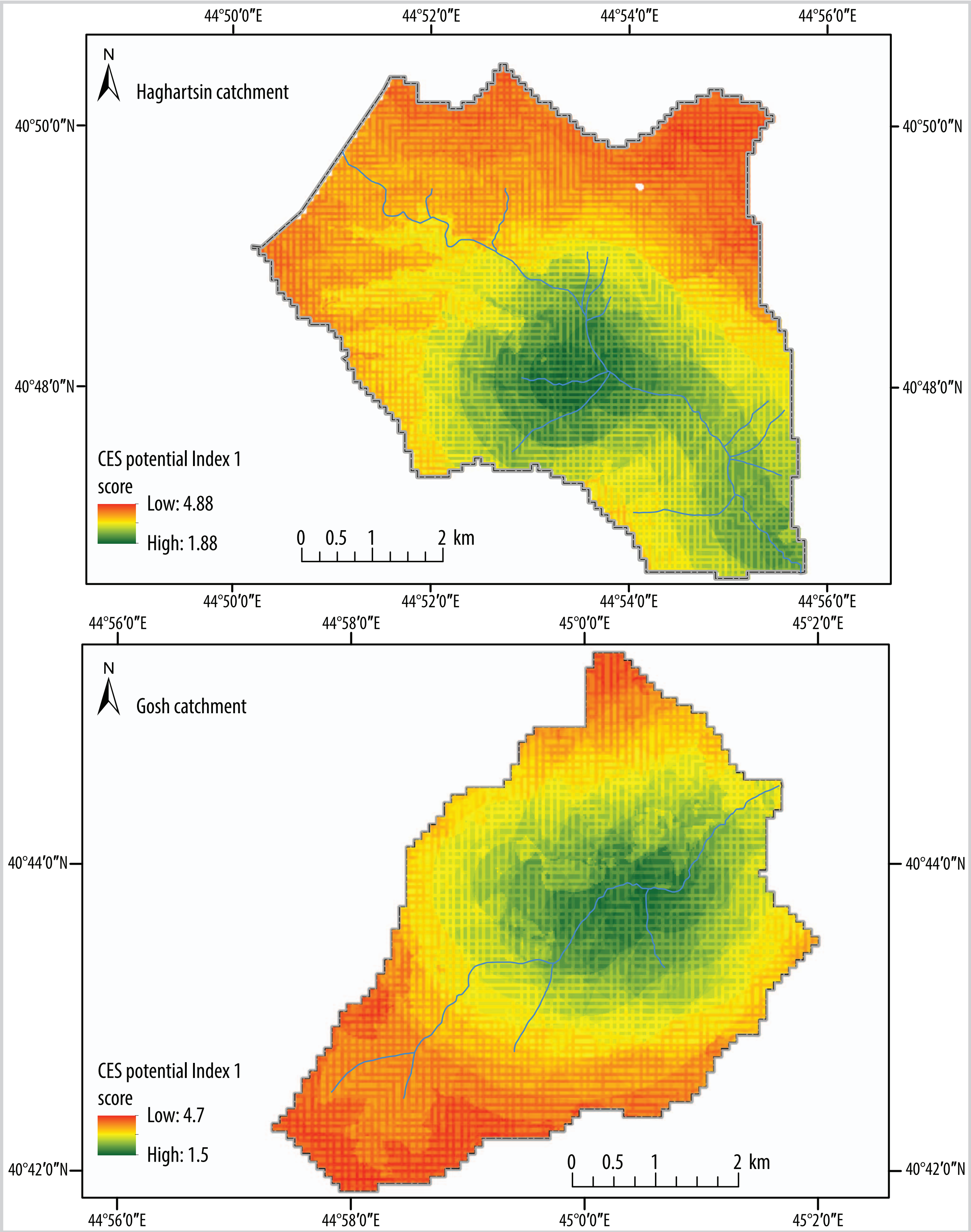


FIGURE 5 CES potential assessment based on Index 2.

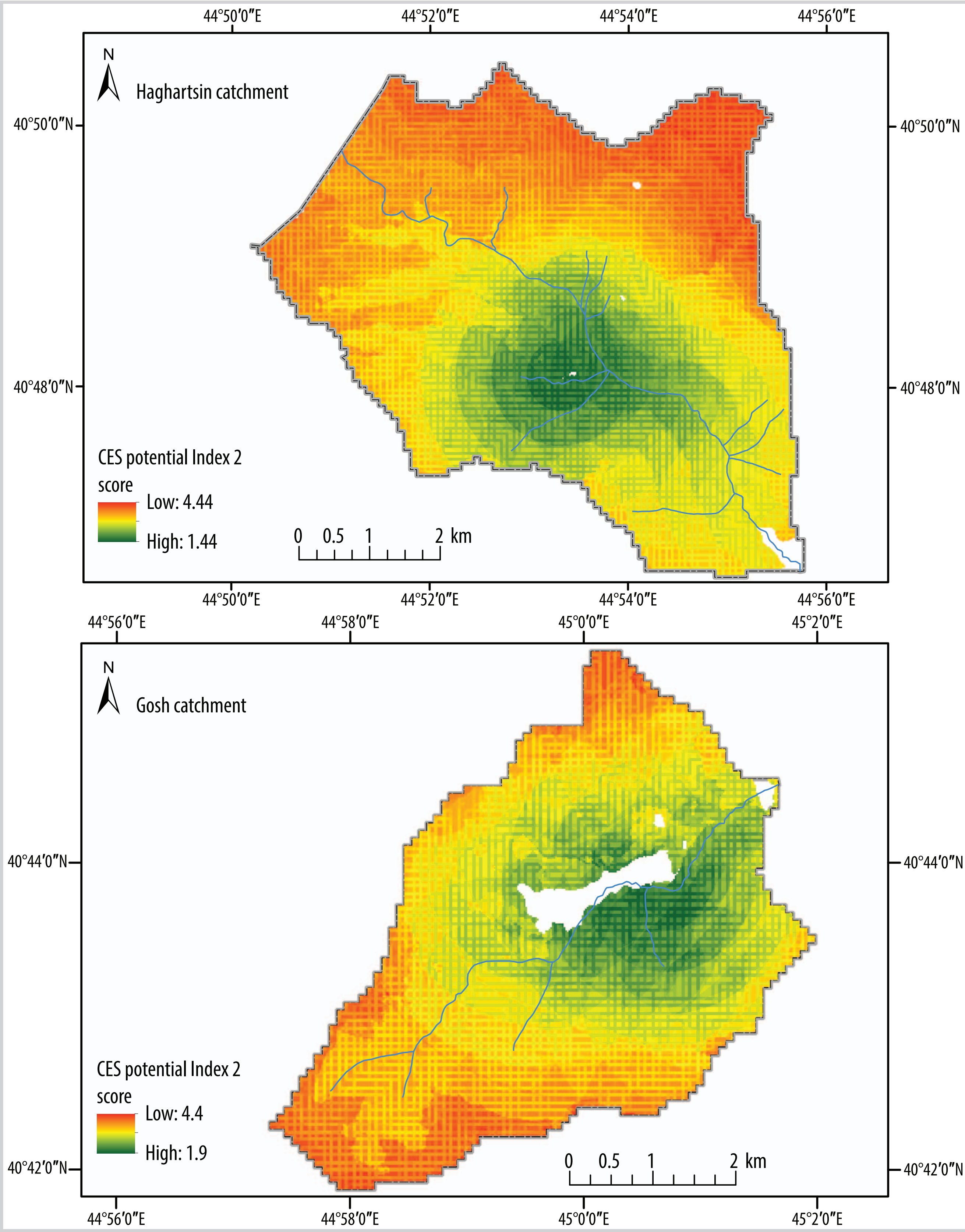


TABLE 3 Benthic macroinvertebrate structure and the main metrics related to the ecological status assessment.

Higher taxa/statistics	Family	Sampling site and year					
		Haghartsin		Gosh		Tandzut	
		2020	2021	2020	2021	2020	2021
Amphipoda	Gammaridae	28	73	30	11	0	1
Coleoptera	Elmidae	15	6	0	1	76	50
	Hydraenidae	0	5	10	12	2	6
Diptera	Athericidae	2	0	0	1	9	0
	Blephariceridae	0	0	0	1	0	0
	Chironomidae	1	4	0	4	1	1
	Dixidae	0	0	0	0	12	2
	Limoniidae	0	0	0	0	2	0
	Pediciidae	0	0	0	0	10	0
	Simuliidae	23	4	30	22	41	26
	Tabanidae	0	2	0	0	0	0
	Tipulidae	0	0	0	1	1	0
Ephemeroptera	Baetidae	46	94	12	28	92	36
	Heptageniidae	18	3	40	1	69	27
Hirudinea	Erpobdellidae	1	0	0	9	0	0
Isopoda	Asellidae	0	2	0	0	0	0
Neuroptera	Osmylidae	0	0	1	0	0	0
Oligochaeta		2	0	10	8	3	0
Plecoptera	Leuctridae	3	13	0	0	23	14
	Nemouridae	118	22	110	7	45	15
	Perlidae	0	0	0	0	1	1
	Perlodidae	2	0	1	1	13	3
Trichoptera	Glossosomatidae	0	1	0	0	2	4
	Hydropsychidae	17	5	30	3	3	3
	Lepidostomatidae	0	0	0	0	0	1
	Limnephilidae	2	0	0	0	7	3
	Polycentropodidae	0	0	0	0	1	0
	Rhyacophilidae	2	2	10	2	11	5
Tricladida	Dugesiidae	7	1	0	0	0	0
N_{family}		16	15	11	16	21	17
Abundance		287	237	284	111	424	198
% EPT		72.5	59.0	71.5	37.8	63.0	56.6
BMWP score		87	91	60	75	117	96
BMWP ecological status		Good	Good	Good	Good	Very good	Good
ASPT score		5.44	5.7	5.45	5.0	5.6	5.64
ASPT ecological status		Excellent	Excellent	Excellent	Excellent	Excellent	Excellent

Note: % EPT, percentage of Ephemeroptera, Plecoptera, and Trichoptera specimens that are common but intolerant to pollution in the sample.

middle course but with a slightly different score. In particular, when comparing the 2 indexes in the same catchment area, there is a slightly higher potential in the Haghartsin River drainage basin for those who prefer wilderness and a slightly higher potential in the Gosh River drainage basin for those who prefer more comfort and access to infrastructure. Human-made constructions and infrastructure generally have more impact on the potential of CES in the Gosh River.

Ecological status assessment: The structure of the benthic macroinvertebrate community at all sampling sites (Table 3) was typical of small streams in forested areas of Armenia. Species adapted for life on the stony substratum in high water velocities dominated in all stretches; however, their diversity and abundance among the sampling sites and over the years fluctuated more at the Gosh and Tandzut sites. At the same time, a decline in the share of species intolerant to pollution (Ephemeroptera, Plecoptera, and Trichoptera) occurred at all sampling sites but at a higher rate at the Gosh site. Here, we also recorded an increase in the number of fly (Diptera) taxa in 2021. All these changes constitute a worsening of ecological status, which was confirmed by a decrease in average tolerance score estimated using the ASPT index. Although there were some fluctuations in the BMWP score, no changes in the ecological status class were detected in Haghartsin and Gosh over the years. Good status showed the healthiness of the ecosystem, but it was one class lower than the best available site in the drainage basin of the Aghstev River in 2020.

Discussion

Following the main research question, our study was based on a mixed-methods approach to develop a conceptual framework for assessing the potential of CES within the catchment areas of small mountain streams. Using the case of Dilijan National Park, the study utilized spatial tools to develop 2 indexes for CES potential assessment, which revealed the main areas under anthropogenic pressure due to the use of CES. Then, we measured the ecological status of the most affected areas to answer the research question of to what extent the use of CES influences the carrying capacity of river ecosystems.

The results show that participatory assessment of nonmaterial cultural services, such as landscape preferences, proved to be useful, as highlighted by Stosch et al (2017) and Scemama et al (2022). The analysis also revealed that the potential for CES is notably higher in the zones where spiritual objects are situated. This observation highlights that the combination of natural landscapes with cultural objects strongly enhances the CES potential of these areas, which are likely to attract a higher influx of tourists. This raises the anthropogenic pressure on the environment. Consequently, it emphasizes the necessity for place-specific evaluations, as mentioned by Daniel et al (2012) and Gómez et al (2023), to ensure the sustainable management of NPAs. Our findings further highlight that regions with a more natural- and wilderness-oriented character, such as the Haghartsin region, have higher CES scores when compared with areas like Gosh, where human development occupies a substantial portion of the landscape. This disparity suggests that anthropogenic pressure is more likely to increase in wilder areas with the flow of tourists. Hence, it is crucial for the Dilijan National Park administration to take this factor into consideration when creating strategic development plans. These conclusions align with similar results achieved by Lim et al (2021), who advocate for the implementation of strategies that simultaneously preserve ecosystem quality and traditional natural resource use. Such an approach benefits both protected areas and the welfare of local communities (Lim et al 2021).

Michaelis et al (2020) and Stosch et al (2017) highlight the need for a more systemic assessment of CES for sustainable management of aquatic ecosystems. To address this gap, our study suggests combining different types of quantitative and qualitative data and involving stakeholders in aquatic ecosystem service assessments. Our study also utilizes the advantages of ES mapping as an important visualization tool for decision-makers, as highlighted by Daniel et al (2012). Thus, given the spatial approach developed within the assessment framework, the results can contribute to sustainable management of the national park, especially identifying the hotspots or problematic areas (Nahuelhual et al 2016).

Sustainable tourism development and management in NPAs requires constant monitoring of impacts (Miller and Ward 2005). In terms of CES, such impacts are limited yet essential to control. However, complexity arises from the subjective nature of data relating to CES and the lack of studies in “undisturbed” ecosystems. Thus, given the vulnerability of small mountain streams, it was essential to obtain some baseline data on BQEs for further development of hydrobiological monitoring systems in accordance with the EU WFD. Although the COVID-19 pandemic led to a global decline in tourism and had a negative impact on the economy of several countries (Gössling et al 2020), it also created a unique opportunity for such an estimation because of the temporal cutoff in tourism flows. Our study used this opportunity by measuring the anthropogenic impact on river ecosystems, and the results demonstrated that tourism in the territory of Dilijan National Park at this level does not exceed the carrying capacity and thus is sustainable. However, more detailed environmental monitoring involving soil, forest, aquatic ecosystems, and biodiversity should be conducted in NPAs considering the growth of tourist flows in the face of increasing urban stress, climate change, and demand for nature-based tourism.

Conclusion

This paper elucidated how a mixed-methods approach, combining GIS methods in visualizing and analyzing spatial data, a qualitative survey, and a bioindication method, was useful in assessing the CES potential and the effects of CES consumption of small mountain streams in Armenia. The results, which integrate tourists’ motivation and landscape preferences with spatial proximity to aquatic ecosystems and their ecological status, provide practical implications for the sustainable governance of Dilijan National Park. At the same time, the results and applied mixed-methods approach serve as an example for the Caucasus region and other mountainous NPAs with similar landscapes globally. The integrated perspective, which takes into account subjective perceptions, place-specific circumstances/settings, and the ecological status of the selected rivers, allowed us to address the subjective and intangible nature of CES. The study uses the case of Dilijan National Park, which is one of the most intensively used NPAs within Armenia. Therefore, we believe that our approach applies to other NPAs in the Caucasus region. However, a limitation is the different preferences of tourists regarding the criteria we used. However, giving case-specific weights to the criteria will make it possible to amend the results at a local level.

We encourage colleagues to apply and further develop our framework in different parts of the world to derive a more comprehensive understanding of the CES potential of aquatic mountain ecosystems under different cultural and natural circumstances. Furthermore, we hope that our study contributes to a more comprehensive evaluation and monitoring of mountain river ecosystems by policymakers and therewith integration into NPA management practices. The focus on CES can further contribute to an improved assessment and integration of all ES of upland rivers worldwide.

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