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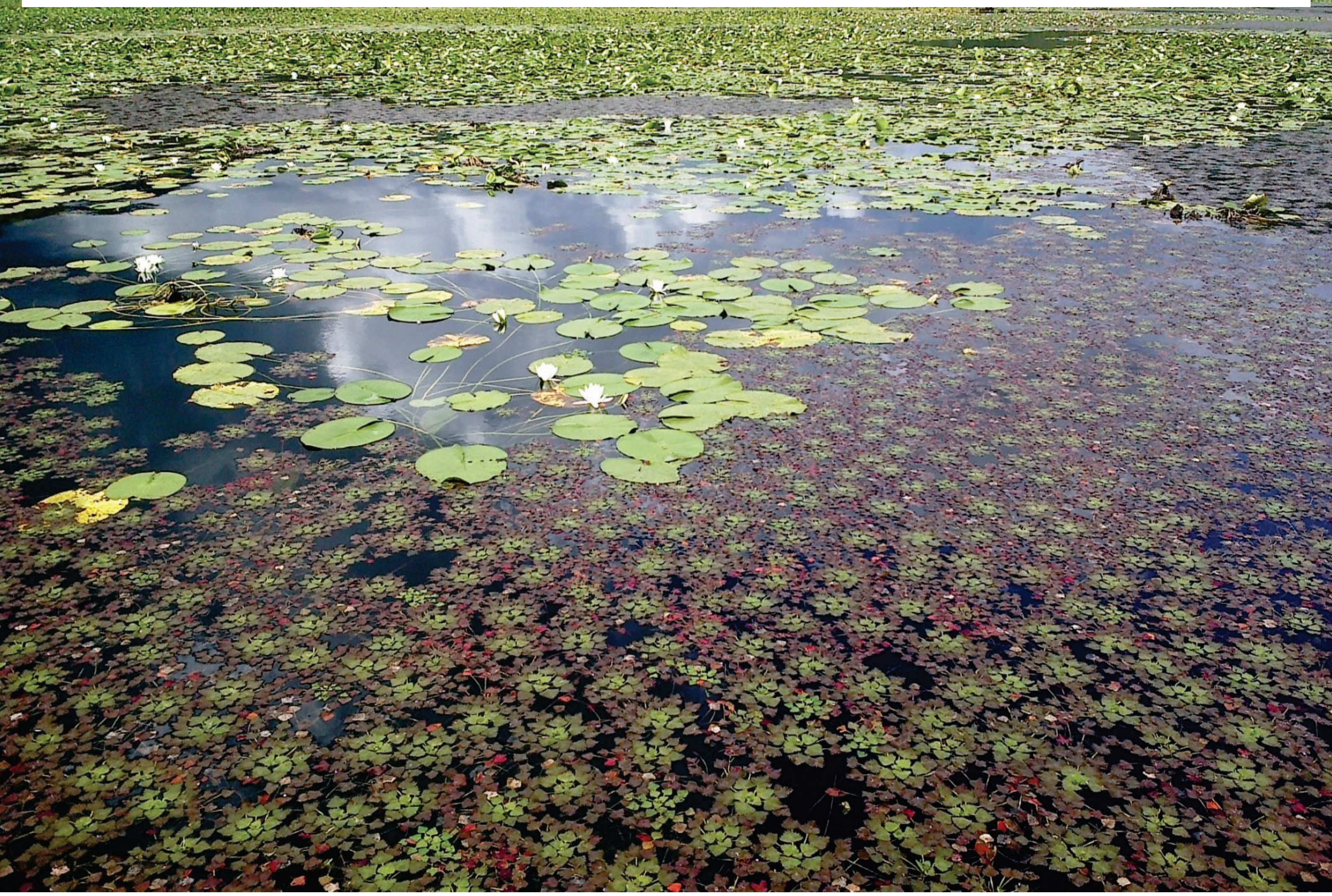

Shorezone Functionality
Skadar/Shkodra Lake

Implementing the EU Water Framework Directive in South-Eastern Europe

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Contents

Foreword

The EU Water Framework Directive (WFD) sets a framework for the management of surface and ground waters within the territory of the Union, with the aim to preserve or achieve their good ecological and chemical status. Significant progress has been made in recent years by Albania, FYR of Macedonia[1] and Montenegro not only towards transposing the WFD into their national legislation but also implementing it in parts of their river basins, including the sub-basins of Lakes Prespa, Ohrid and Shkodra/Skadar.[2] As a result of this joint transboundary endeavour, the so-called initial characterization of the three lakes has been achieved in 2015, with support of German Development Cooperation and other development partners. The present document marks another important milestone in WFD implementation – the assessment of hydromorphological status. This comprises a mixture of hydrological and morphological assessments.

Whilst the biological, chemical and physico-chemical elements are concerned primarily with the quality of the aquatic environment, hydromorphology is concerned with its physical nature. It examines the physical size of the water body itself as well as the shore/riparian zone – depth variations, surface areas, substrate composition, water inflow, abstractions/discharges, outflow, residence time, water level etc. For classification purposes, a water body can only be considered to be of good or even high ecological status if there are no or very limited hydromorphological alterations from its reference status, and if lake shore functionality is not seriously diminished, e.g. by urban encroachment and the concomitant extension of impervious surfaces.

Within the EU, different methodologies have been applied to assess the hydromorphology of lakes. The approach pursued in the present study – the Shorezone Functionality Index (SFI) – was first developed in Italy and has in the meantime been adopted by several European countries. Even though the SFI has been developed primarily to inform water management, it is of more general importance to all kinds of spatial planning taking place within lake sub-basins, including physical and landscape planning and zoning designations for protected areas. Moreover, it provides a status quo baseline and benchmark against which to measure future developments. The SFI will, therefore, enable planners and developers to take informed decisions for the sake of the sustainable development of the lake areas, to which all riparian countries are committed.

The authors of the study are acknowledged not only for the quality of their work but also for demonstrating that, in water resources management, more comprehensive and meaningful results can be achieved through transboundary collaboration.

Dr Ralf Peveling
Program Manager CSBL

[1] Upon decision of the General Assembly of the United Nations in 1993, Macedonia is provisionally referred to as "The former Yugoslav Republic of Macedonia", pending settlement of the difference that had arisen over its name. For the ease of reading and without prejudice, henceforth the name Macedonia is used..

[2] The names Shkodra and Skadar are used together or interchangeably.

1 THE SHOREZONE FUNCTIONALITY INDEX

1.1 Introduction

Lakes are extremely important. They are a source of freshwater and provide resources such as fish and support services such as water transportation, recreation and tourism.

Today, mitigating nutrient losses caused by anthropogenic nonpoint source pollution is particularly important for improving the water quality of a great number of the world's freshwater lakes. Relationships between land use and in-lake water quality have been observed, which means the whole drainage basin should be considered when managing nutrient loadings in lakes (Nielsen et al. 2012). For example, chemicals – nitrogen and phosphorus being prime examples – that are originally applied to the land for agricultural purposes can work their way into lake waters and, once present, will actively (and often negatively) affect the trophic-evolutionary processes of these waters (Premazzi and Chiaudani 1992; Chapman 1996).

The lake's riparian vegetation plays an important role as a buffer that helps to protect the aquatic ecosystem against degradation caused by human activities (Dosskey et al. 2010). Studies by Osborne and Kovacic (1993) have shown that the riparian zone can efficiently intercept nutrients emanating from nearby agricultural areas, diminishing by over 90% the nitrogen and phosphorus content of both the superficial and sub-superficial waters flowing into the water body.

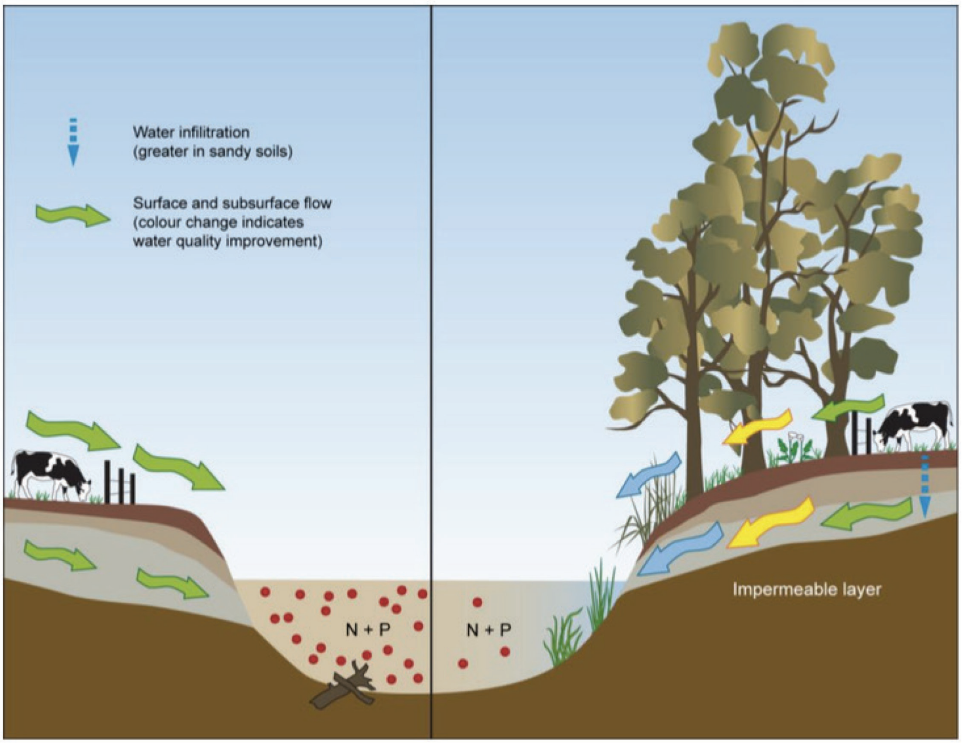


Figure 1. Nutrient interception by riparian vegetation (Dosskey et al. 2010)

The shorezone is a transition zone (ecotone) between a lake and its surrounding territory that can perform important ecosystem services, such as regulating nutrient inputs and protecting against nonpoint source pollution, ensuring the maintenance of ecological processes, providing food and habitat for organisms, and protecting the shoreline from erosion (Figure 2).

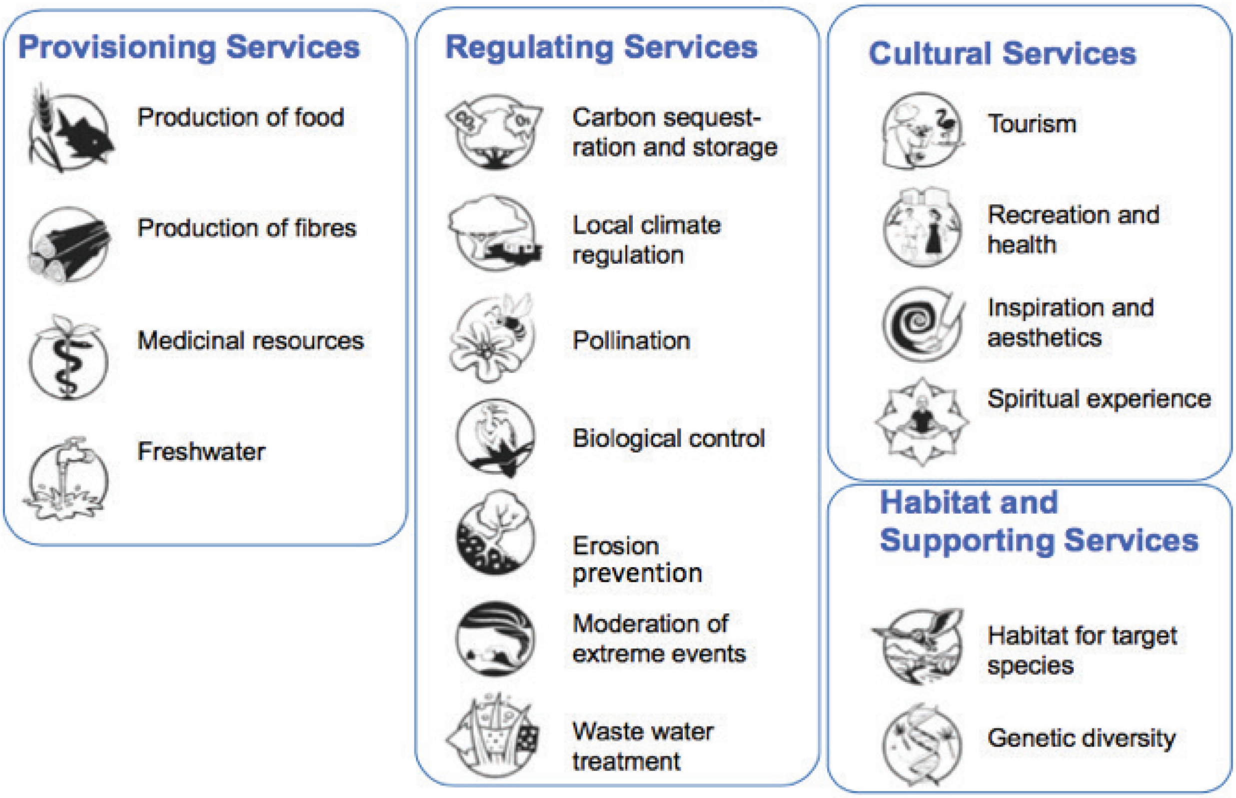


Figure 2. Examples of ecosystem services (TEBB 2012)

While the structure and extension of the shorezone are influenced by the area in question's topography and climate and the geological composition of its soil, the shorezone's water fluxes, nutrient and sediment inputs, and diffusion of animal and plant species are influenced by the lake's riparian vegetation. When unregulated lake-shore developments are built without sufficient planning authority oversight (a problem that particularly affects transboundary lakes) the functional shorezone can therefore be negatively affected.

1.2 The Shorezone Functionality Index

Understanding and evaluating the functions of the lake's shorezone provides the basis for creating a set of indicators that can be used to evaluate shorezone functionality, and it also supports and guides land planning policies and management choices. Furthermore, the need for a new index was also supported by the Water Framework Directive 2000/60/CE which, to determine ecological quality, requires that the evaluations of biological elements and the evaluation of hydromorphological elements be considered in conjunction.

The Water Framework Directive (WFD) 2000/60/CE defines the elements of quality (EQ) for classifying the ecological state of water bodies of any typology. Among the EQ to be determined are biological elements and hydromorphological elements that, for lakes, consist of the hydrological regime (quantity and dynamics of the water flow, water percolation and residence time) and the lake's morphology (variations in depth, characteristics of the substrate and shore structure) (CIS Wetlands Working Group 2003).

The Shorezone Functionality Index (SFI) was developed in Italy in 2004 by a working group of the Italian Agency for Environmental Protection and Technical Services (APAT), which was coordinated by the Provincial Agency for Environmental Protection (APPA) of the Autonomous Province of Trentino, Italy.

The SFI was originally created as the counterpart to the already existing Fluvial Functionality Index (Siligardi et al. 2007) and was tailored to Alpine lakes. Subsequently, it has been employed by (a) the European AlpLakes Project to assess lakes in Italy's Lombardy region, (b) the European SILMAS project to assess the lakes along the Alpine Arch (Italy, Austria and Slovenia), (c) the European Eulakes Project, albeit in modified form, to assess the large lakes of central Europe (Austria, Italy, Hungary and Poland) and (d) the University of Villarica, Chile, to train professionals with the Environmental Ministry (Ministerio de Medio Ambiente).

When using the SFI, morphological, structural and biotic parameters are evaluated in the field from an ecological perspective: biotic and abiotic factors are used to evaluate the buffering capacity of riparian vegetation, the complexity and artificiality of the shoreline, anthropogenic uses of the surrounding territory, and the way inputs from the watershed enter the water body.

This semeiotic index is easily surveyed, evaluates the state of the environment and assists in identifying the causes of deterioration by looking beyond the waterbody itself to include all the surrounding territory and drainage basin topography. The index not only provides baseline information on the status of the lake, but can also be used to support decision-makers tasked with planning environments adjacent to lakes and with managing lake water resources.

1.3 Methodology

To develop an initial overall understanding of the status of the lake, the first step of the SFI process involves reviewing existing literature on the hydrogeomorphological characteristics of the lake and its drainage basin and on the pressures and current issues affecting these features.

The whole length of the lake is then surveyed, with surveyors navigating alongside the shore to gather information on the ecological parameters (typology, width, continuity and/or interruption of the riparian vegetation), socio-economic parameters (land use, presence of infrastructure, etc.) and other abiotic parameters (steepness, concavity, shore artificiality, etc.).

Every time a change in one of these parameters is identified, a new form is completed and a new homogeneous shorezone is identified. In this way, the whole of the lake's shorezone is divided into different stretches with similar characteristics.

The data collected in the field is processed using the Shorezone Functionality Index software package (SFINX02) which determines the functionality value for each homogeneous stretch. There are five different categories of functionality, ranging from bad to high (Table 1), as suggested by the WFD 2000/60/CE.[3]

[3] Editors' note: Contrary to the WFD classification system, whereupon any ecological status less than high (i.e. good, moderate, poor and bad) is considered to be caused by human activity (and should be reversed to the extent possible if less than good), low shorezone functionality may result from either natural causes or human activity. Only in the latter case measures can and should be taken to improve functionality. Nonetheless, even shorezones whose natural functionality is low (and therefore cannot be enhanced) require measures such as sustainable land use practices in the shoreline hinterland to prevent pollutants from being discharged into the lake unimpededly.

Table 1. Functionality levels, category names and reference colours

Level	**Category**	**Colour**	**Water Framework Directive**
I	High	BLUE	Acceptable
II	Good	GREEN	
III	Moderate	YELLOW	Not acceptable except where it is caused by natural processes
IV	Poor	ORANGE	
V	Bad	RED	

Of all the parameters collected in the field, only nine are actually processed using the software: shore artificiality, vegetation cover, presence of interruption within the lake's shorezone, concavity of the shore profile, presence of reeds, presence of arboreal species, presence of road infrastructure, heterogeneity of arboreal vegetation, and presence of non-hygrophilous species. These parameters were selected based on the results of an artificial neural network analysis (ANN), carried out during the development of the index. The ANN showed that these parameters had the greatest influence over the results because of their numerical weight. The remaining parameters are still, however, very important for the report and can also be used to develop the index in future.

The nine parameters are configured as a classification tree (Figure 3), which shows the level of functionality (described as a sum of the percentages of each functionality level) of each homogeneous stretch.

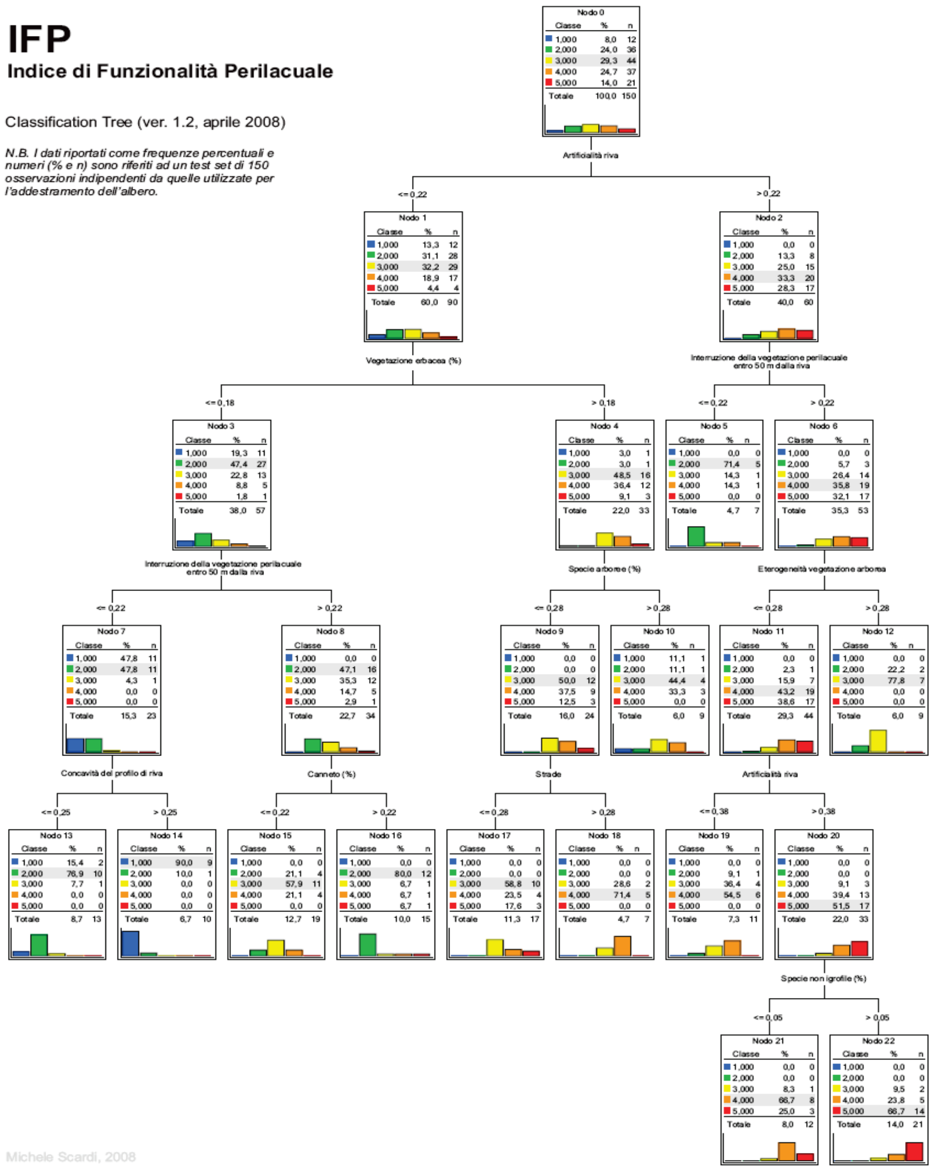


Figure 3. The classification tree produced by the SFI software

The classification tree is run for each homogeneous stretch to obtain the final functionality value. Each leaf (box) of the tree indicates the probability that the stretch will fall into one of the five categories. The higher probability percentage will determine the final level of functionality (Figure 4).

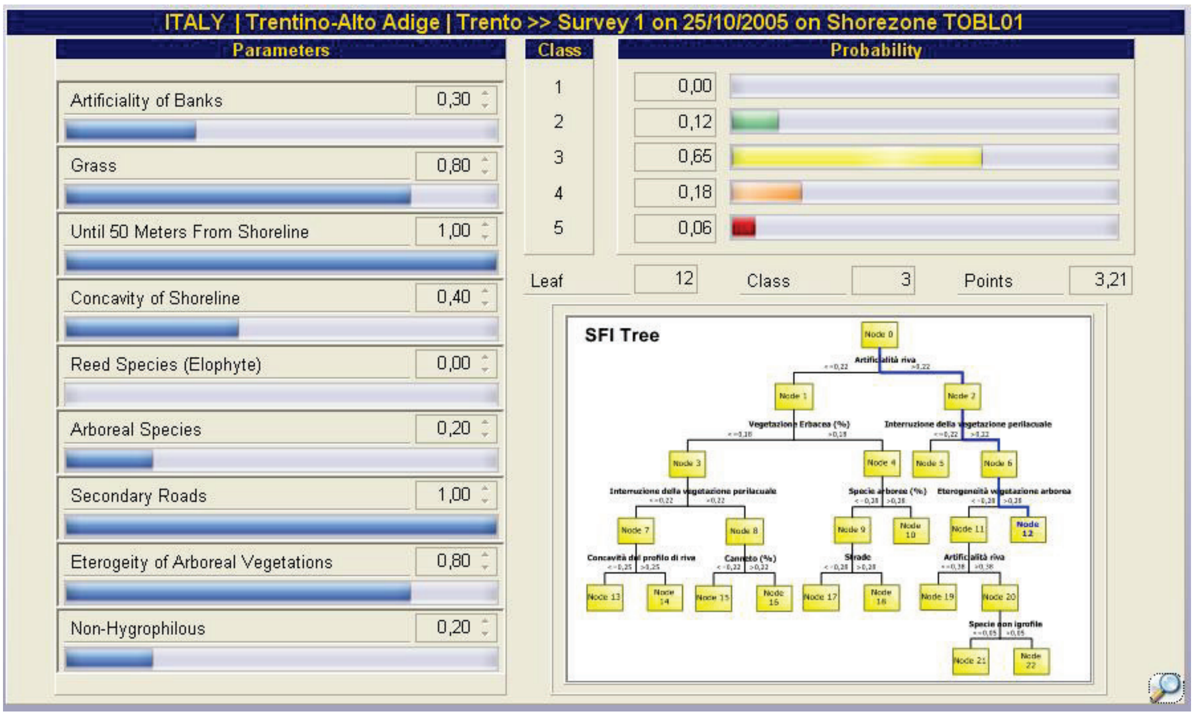


Figure 4. Example of the results output by the SFINX02 software package for a given homogeneous stretch

The results and parameters are then transferred to a GIS platform, which makes it possible to create thematic maps of the parameters surveyed, to carry out spatial analyses, and to identify which locations are weaker or stronger and which are in greater need of or are more suited to restoration actions. The SFI maps are very important as they provide initial direct visualisations of the general status of the lake's shorezone – e.g. indicating the location of remaining areas of high functionality (blue colour) (Figures 5 and 6).

The length of each homogeneous stretch, and therefore of the total lake perimeter for each category, can also be calculated using GIS.

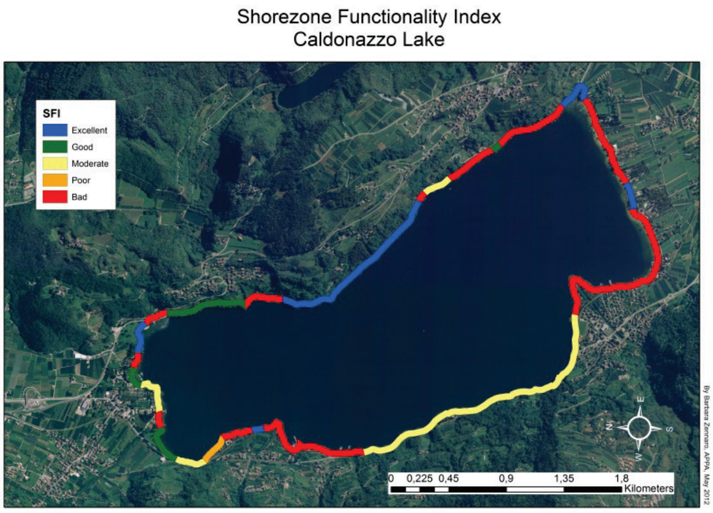


Figure 5. Map showing the Shorezone Functionality Index results for Caldonazzo Lake, Italy, which provides an initial direct visualisation of the status of the lake

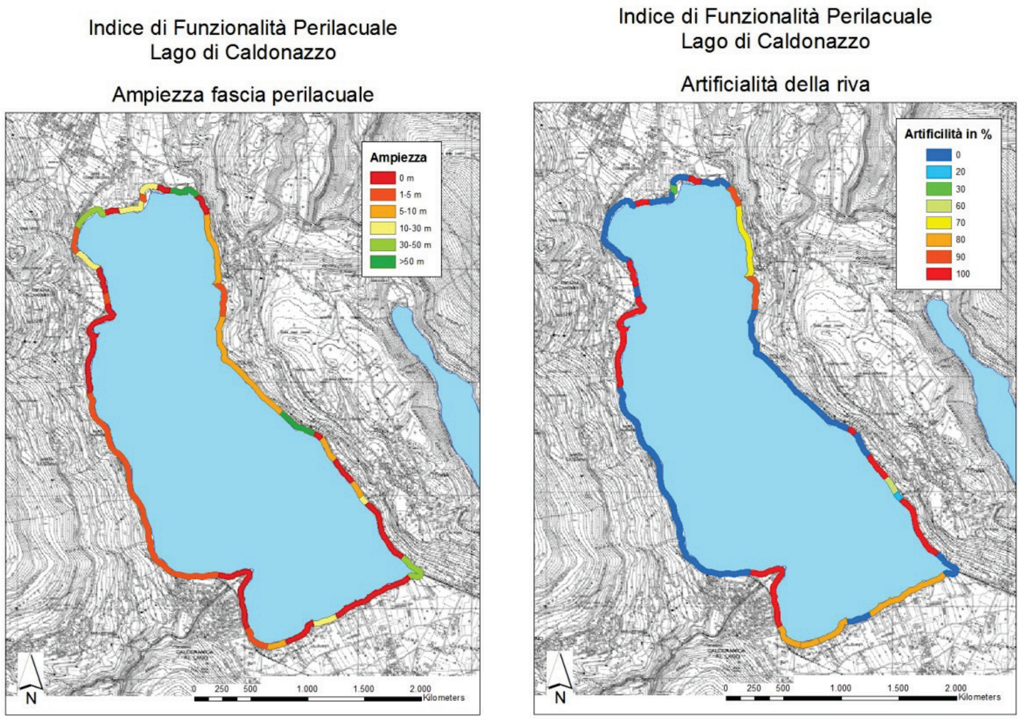


Figure 6. Thematic maps for Caldonazzo lake, with the left-hand map showing the width of the shorezone (red = 0 m, green = more than 40 m) and the right-hand map showing the artificiality of the shorezone (red = wholly artificial, blue = wholly natural)

It is important to keep in mind that the shores naturality and functionality are two different concepts. Therefore, a location with a wholly natural shorezone may, in certain cases, have low levels of functionality (see also Footnote 3). For example, steep cliffs that descend directly into the water and have little or no riparian vegetation are often unable to perform any good ecological functions.

1.4 The Shorezone Functionality Index as a management tool

The potential of the SFI method lies in its ability to produce a synthetic value for the shorezone functionality of a lake. With the SFI approach, it is possible to complete studies on the internal dynamics of a lake, which are often altered by productive activities, recreation and tourism. By basing a lake's shorezone management on the concept of its functionality, the human uses of the lake can be reconciled with its environmental protection, which facilitates ecologically sustainable urban and rural planning and watershed management. Lake managers and stakeholders can use these results to develop a sustainable ecosystem-based approach to watershed management (Figure 7).

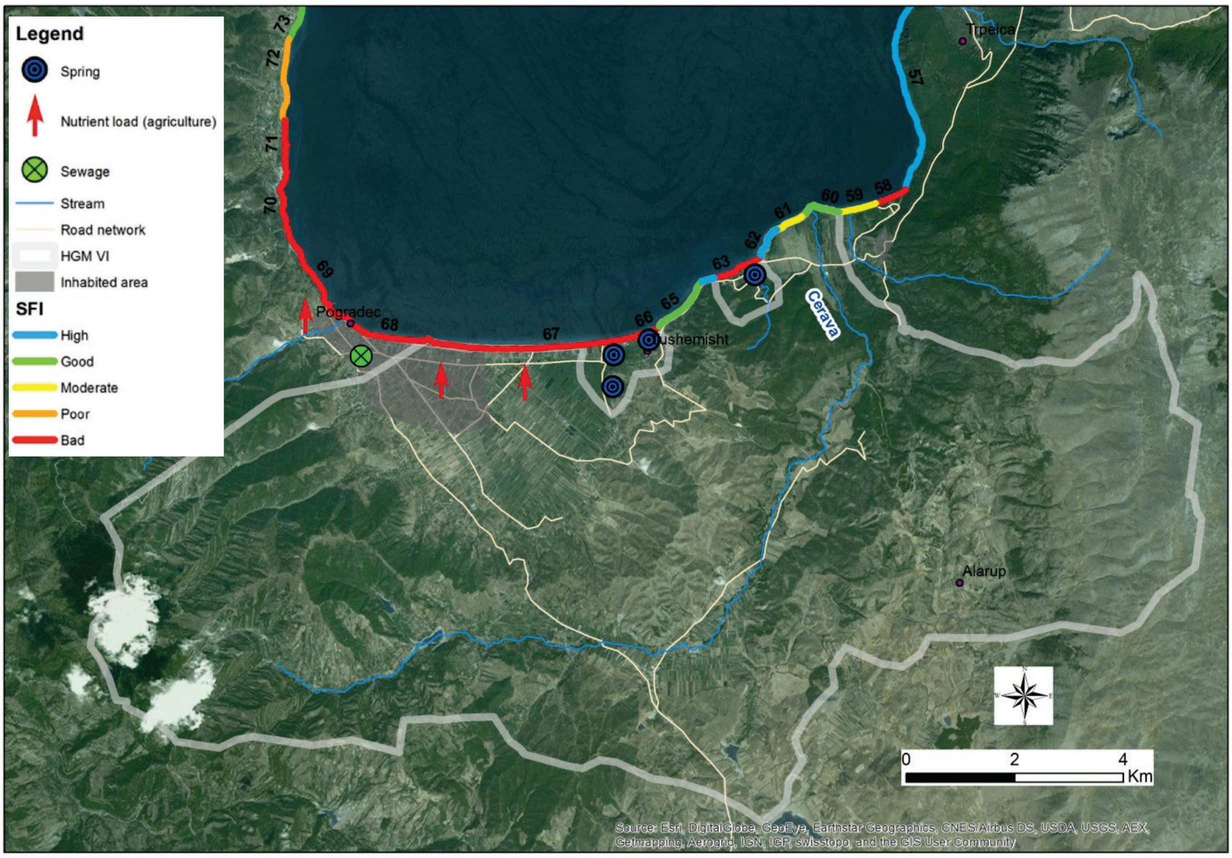


Figure 7. Example of an identified hydrogeomorphological (HGM) area at Ohrid Lake, Albania. The map shows the boundary of the HGM area (grey line), the presence of environmental stressors (i.e. the nutrient load from agriculture), hydrological factors (streams and springs), and the values produced when applying the Shorezone Functionality Index

The results of the SFI, which are relatively economical and quick to obtain, provide an immediate general picture of the state of the shores around the lakes. This differs to earlier indices, which were only representative of specific points along the shore. The SFI results can also be used to easily identify the locations of and action needed in potential restoration sites (using the SFINX02 software, different scenarios can be modelled for a specific area and, by changing determinate parameters, it is possible to foresee the impacts public or private activities may have on the waterbody) as well as the locations of protected areas, sites of important economic value and so on.

The SFI responds to the current need, arising from the requirements of the 2000/60/CE directive, to develop new indices capable of assessing the hydromorphological elements of lake ecosystems, including riparian zones. Future SFI reports on the same lake can also be used to track changes in the shorezone over time. Under this project, a number of different output formats have been developed for end users – be they managers, local stakeholders or tourists – which include the SFI report, the SFI thematic maps and the SFI brochure.

The **SFI report** describes the status of the shores around the perimeter of a given lake, providing useful information on its level of functionality. Managers and stakeholders can then use this information to ensure the proper management of the lake's shores, to identify restoration sites and to test and determine which lines of action will make the restoration work a success. Alternatively, the report can simply be used as a baseline study for benchmarking future developments. [4]

[4] For similar reports on Lakes Ohrid and Prespa, see Blinkov et al. (2017 a) and Blinkov et al. (2017 b), respectively.

The SFI report describes the lake and all the homogeneous stretches identified. The way in which it is written ensures that the results are comprehensible to readers who may not be familiar with the Index or the lake. It highlights the shorezone's weaknesses and strengths and indicates specific actions required to improve the lake's functionality. The report covers the following areas:

- Introduction to the Shorezone Functionality Index
- The lake's location, origin and history
- Results, statistical analysis and management recommendations
- Application of the Shorezone Functionality Index (description of each homogeneous stretch with photos, SFI results and specific recommendations where applicable).

SFI thematic maps can be created for each parameter collected in the field. A shapefile containing this information is created for each lake and for each SFI study. When the results are imported into a GIS environment, geospatial and geostatistical analyses can be performed. For example, SFI studies carried out on a specific lake in two different years can be compared to extract information on changes in the shore functionality over time.

The **SFI brochure**, which is usually made available in both English and the local language, was developed as a way of communicating SFI results to the general public. The brochure briefly describes the methodology and the lake's main categories, and provides a summary of the statistical results and management suggestions.

2 SKADAR/SKHODRA LAKE

2.1 Location, origin and watershed

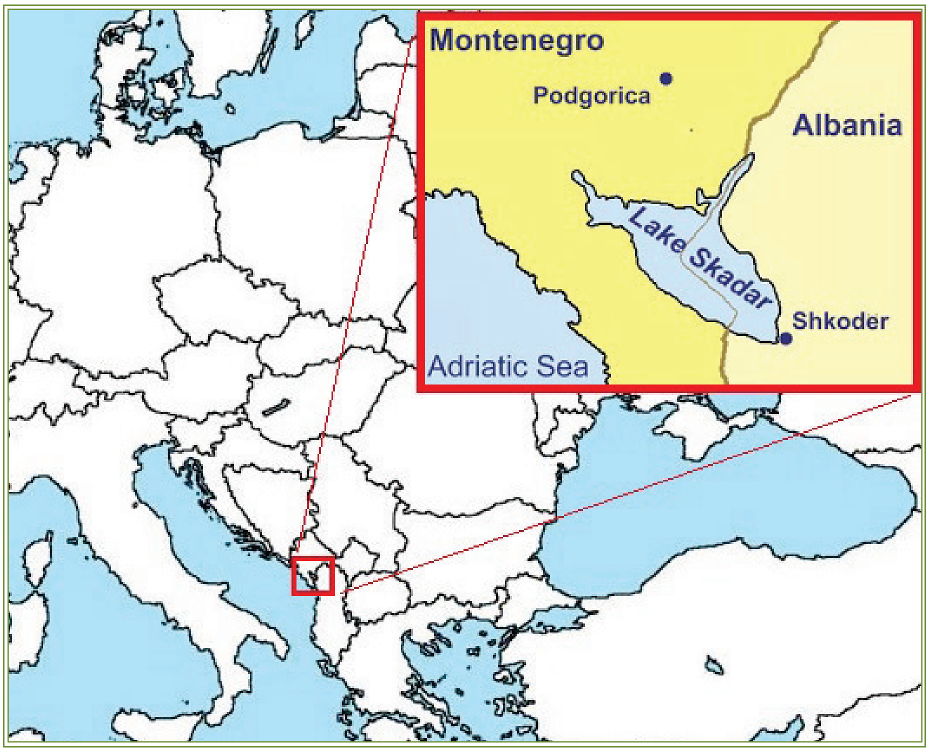


Figure 8. Location of Skadar/Shkodra Lake in Europe

Skadar/Shkodra Lake is a transboundary lake shared by Montenegro and Albania and is located in the karstic terrain of the south-eastern Dinaric Alps (Figure 8). According to the delineation set out in the Water Framework Directive (WFD), the entire catchment area of Skadar/Shkodra Lake falls within Ecoregion 5 – Dinaric Western Balkans (Figure 9).

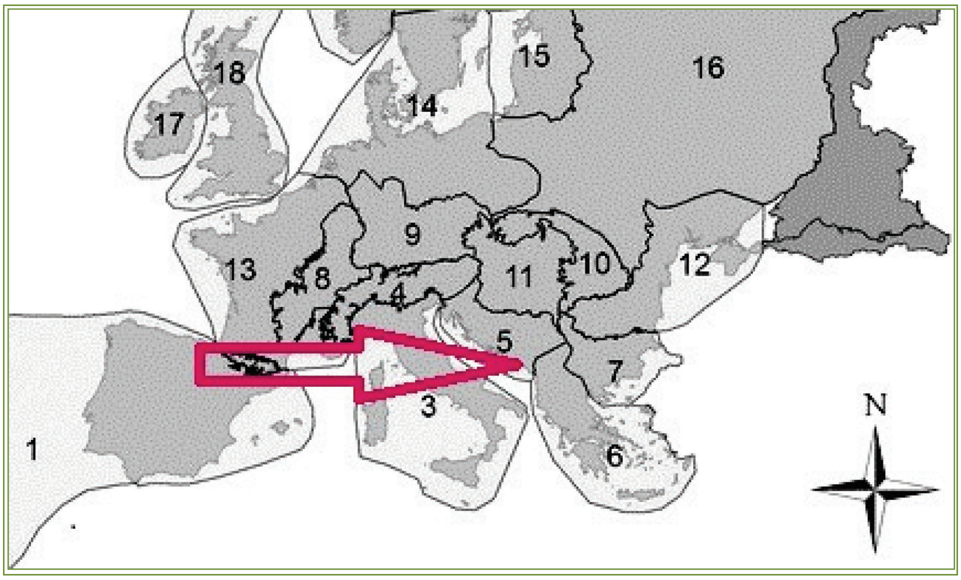


Figure 9. Position of Skadar/Shkodra Lake on the map of European ecoregions (Ecoregion 5 – Dinaric Western Balkans)

Figure 10. Drainage basin of Skadar/Shkodra Lake marked on a 1:200,000 topographical map

The basin (Figure 11) is a depression running northwest–southeast, parallel to the Adriatic coast. The Zeta Plain in Montenegro extends northward from the lake, and the Albanian Alps rise up to its east. The lake coast is flat on these northern and eastern sides. The southwestern coast is defined by the ridges of the Sutorman, Rumija and Tarabosh Mountains, and is therefore steep and rugged. It is this mountainous zone that separates the lake from the Adriatic Sea. The only outflow from the lake is the Bojana/Buna River, which for most of its length also forms the border between Montenegro (MNE) and Albania (AL).

Figure 11. 3D view of the Skadar/Shkodra Lake sub-basin (Google Maps 2016)

Skadar/Shkodra Lake has only existed in its present form since the second half of the 19th century. In 1846–48, the Drin River, which had previously flowed towards the Adriatic Sea, changed course of its own accord, joining the Bojana/Buna River near Shkodra city (Hidrologjia e Shqipërisë 1985). Gravel, sand and other material carried by the Drin River during high-flow periods formed a barrier downstream of the original small lake, which resulted in raising the lake's water level by several metres and flooding peripheral farmland. Today, the original channel of the Drin River has a different name, Drini i Lezhës, which remains completely separate from the Drin River. The Drin joins the Bojana/Buna River a short way downstream of Skadar/Shkodra Lake and continues along the border of Montenegro and Albania until it debouches into the Adriatic Sea.

Two main groundwater bodies can be distinguished in the drainage basin: karst alluvium to the west, south-west and north-east of the lake and porous aquifer (limestone and dolomite) mainly in the Zeta Plain in Montenegro and south of the lake (Figure 12). The groundwater in Zeta Plain stretches from the valley north of Podgorica, the mouths of the Zeta and Morača Rivers and the Ćemovsko, Zagoričko, Dinoško, Tološko and Lješko valleys to Skadar/Shkodra Lake. The area of this last aquifer is therefore around 158 km^2 and its thickness when charged with water varies from 20 m to 60 m, with the northern section being thicker. Elevations of the water table in this area vary from 35 m above sea level in the northern section to 10 m above sea level in the southern section. As a result, groundwater flows southwards from the northern part of the lake (Eftimi 2010).

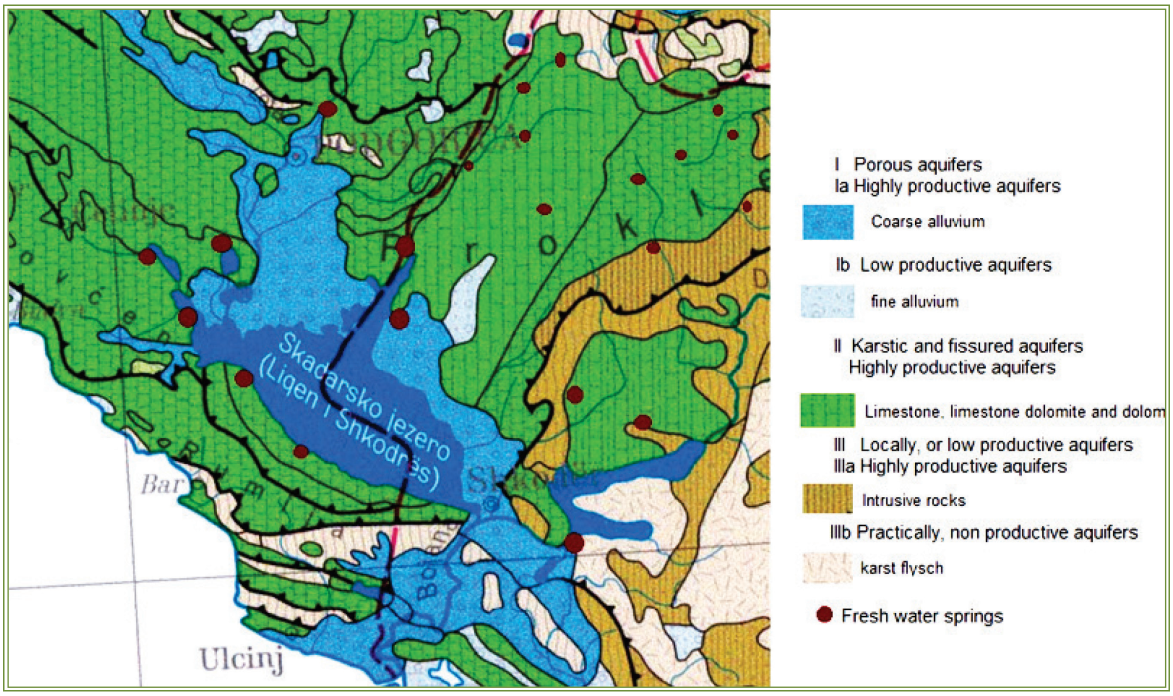


Figure 12. Simplified hydrogeological map of the Skadar/Shkodra Lake and Buna/Bojana River area (adapted from Eftimi R. 2010)

The lake area falls within a zone where major earthquakes of up to IX on the Mercalli–Cancani–Sieberg (MCS) scale are expected.

2.2 General form of the lake

The SFI Form 1 presented in Table 2 summarises Skadar/Shkodra Lake's morphological, climatic and physical characteristics.

Table 2. Characteristics of Lake Skadar/Shkodra according to SFI Form 1

General characteristics

	Indicator	Typology
CENERAL CHARACTERISTICS	Origin	Tectonic
	Type	Natural large
	Location	Lowland
	Latitude (north)	42°19′45′′ N – 42°03′15′′ N
	Longitude (east)	19°04′45′′ E – 19°28′45′′ E
	Altitude of the lake	6.5 metres above sea level
	Average altitude of the catchment basin	770 meters
	Main geological type of the substrate	Calcareous/ sedimentary

Morphological characteristics

	Indicator	Typology
MORPHOLOGICAL	Area of drainage basin (DB)	5,450 km² (4,350 km² MNE and 1,100 km² AL)
	Shoreline length	268.6 km
	Area of lake (LA)*	353–525 km² (355 MNE and 170 AL)
	Volume*	1.75–4.25 km³
	Maximum depth	8.1 meters (sub-lacustrine springs up to 60)
	Average depth	4.4–8.1 metres
	Structure and substrate of the lake bed	Muddy

* Variations due to changing water level

Climatic characteristics

	Indicator	Typology
CLIMATIC	Precipitation	2,430 mm/year
	Average max. January temperature	8 degrees Celsius
	Average max. July temperature	32 degrees Celsius

Other characteristics

	Indicator	Typology
OTHER	Average residence time	0.35 years
	Tributary/effluent capacity	Tributary: 245 m³/s Effluent: 320 m³/s
	Spring/groundwater	60 m³/s
	DB/LA relationship	12.3
	Water-level changes	Yes
	Thermic cycle	Amictic
	Summer transparency (Secchi disk)	2 metres
	Trophic classification	Mesotrophic

Climatic elements

The climate type of the Skadar/Shkodra basin is Mediterranean. However, the mountain range running between basin and sea inhibits the maritime influence, and there is continental influence from the north. In general, winter and autumn are wet, spring is variable and summer is dry.

Annual rainfall stands at around 2,430 mm in the lake zone and 2,000 to 3,200 mm in the drainage basin. The monthly precipitation pattern comprises a rainy period with humid climate in October–March and a summer period with an arid climate in April–September. Humidity levels are 65% to 80% (and are even higher in winter). Summer temperatures and sunshine duration result in high evaporation levels. In the warmest months (July–August), evaporation stands at around 180–230 mm, which is five to six times higher than in the winter months. On average, thunderstorms occur on 50 days each year, usually during the summer (Water Basis of Montenegro 2001).

Table 3. Precipitation on Skadar/Shkodra Lake (blue) and its catchment area (brown) in mm (Water Basis of Montenegro 2001)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot
Karuc	243	229	188	156	102	66	39	61	140	222	310	277	2033
Orahovo	277	249	210	191	137	101	58	86	145	239	338	315	2344
Podgor	357	327	285	244	145	88	54	73	163	286	402	412	2837
R. Crnojevica	284	261	223	184	120	75	43	68	154	244	355	347	2357
Virpazar	315	285	236	197	122	78	38	70	157	245	343	351	2437
Limljani	338	305	252	215	130	78	45	59	159	270	370	376	2597
Ckla	298	286	231	188	119	82	42	59	149	259	364	344	2422
Cetinje	402	373	326	248	161	100	65	90	189	314	482	466	3214
Danilovgrad	248	239	194	166	117	87	46	70	141	232	340	300	2180
Nikšić	200	201	166	152	94	57	75	131	201	307	290	697	2070
D. Morakovo	209	199	167	163	124	113	69	88	140	201	307	290	2070
Man. Morača	210	208	163	162	121	92	58	75	130	198	290	276	1983

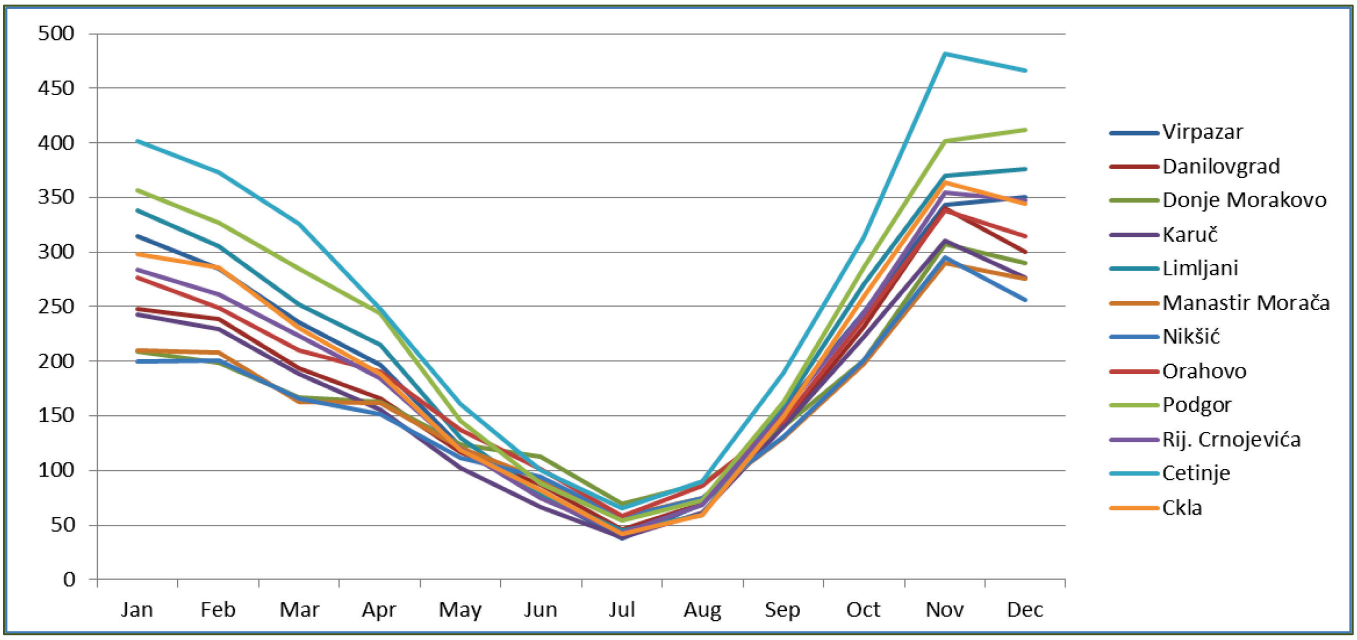


Table 4. Precipitation at the Albanian section of Skadar/Shkodra Lake in mm (Albania Hydrometeorological Institute)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot
Alb. station	243	200	180	174	126	67	42	70	179	230	274	280	2065

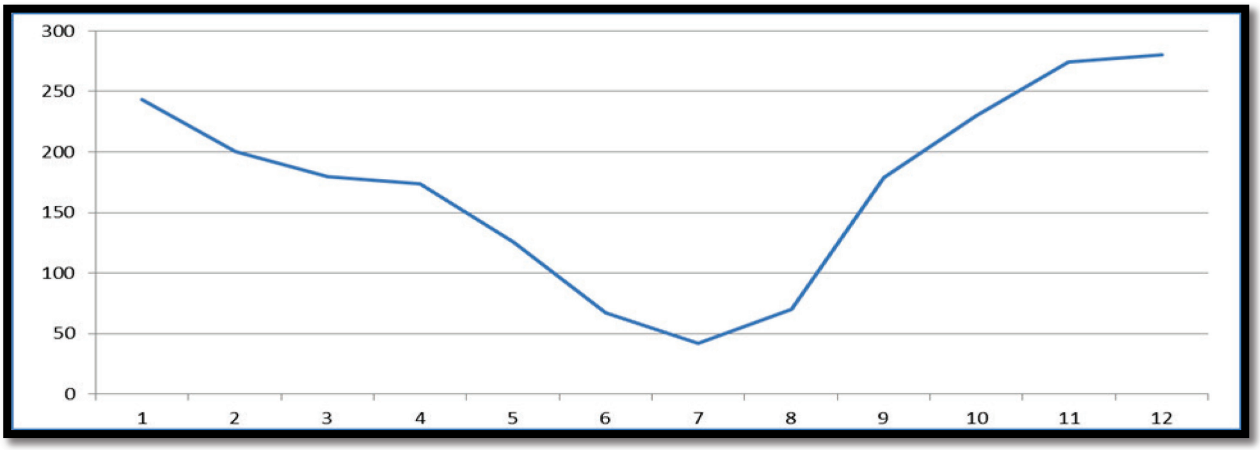
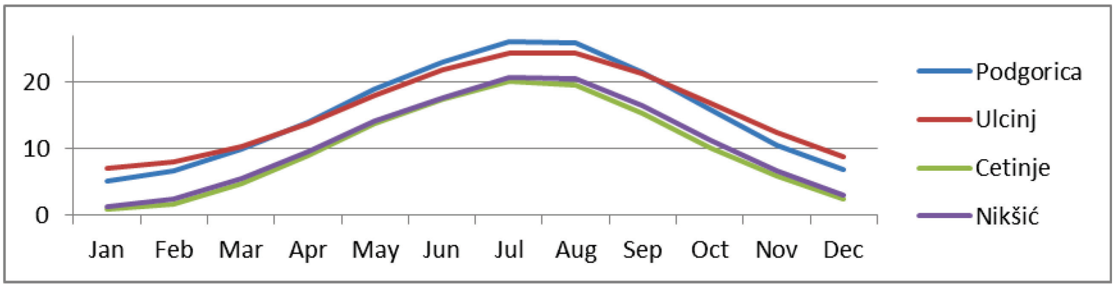


Table 5. Average monthly and annual air temperatures in °C (Water Basis of Montenegro 2001)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Ulcinj	7.0	8.0	10.4	13.8	17.9	21.8	24.4	24.3	21.2	16.9	12.4	8.8	15.6
Cetinje	0.8	1.7	4.7	9.0	13.7	17.5	20.1	19.5	15.3	10.1	5.8	2.4	10.0
Nitsic	1.3	2.4	5.5	9.6	14.1	17.7	20.7	20.4	16.4	11.3	6.7	3.1	10.8
Podgorica	5.1	6.6	9.9	14.0	18.9	23.0	26.1	25.8	21.5	15.8	10.5	6.8	15.3



The thermal regime of north-west Albania is quite complex and depends on the territory's landforms and proximity to the sea and on the masses of air that circulate above it. The map of average annual air temperatures shows that the southern direction of the isotherms strongly coincides with the direction of the region's mountain ranges. Also, as one moves towards the north and east, the temperature values decrease. This can be explained by the close relationship between geographical latitude and solar radiation (about 1°C for one degree of latitude) and the increasing distance from the sea. The annual distribution of air temperature is typically Mediterranean, with maximums in July or August (39.8°C) and minimums in January (13°C).

Table 6. Average monthly air temperatures in °C recorded at Shkodra Station from 1951 to 1980 (Albania Hydrometeorological Institute)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alb. station	5.0	6.5	9.5	13.5	18.0	22.0	24.6	24.7	20.0	15.7	10.9	6.9

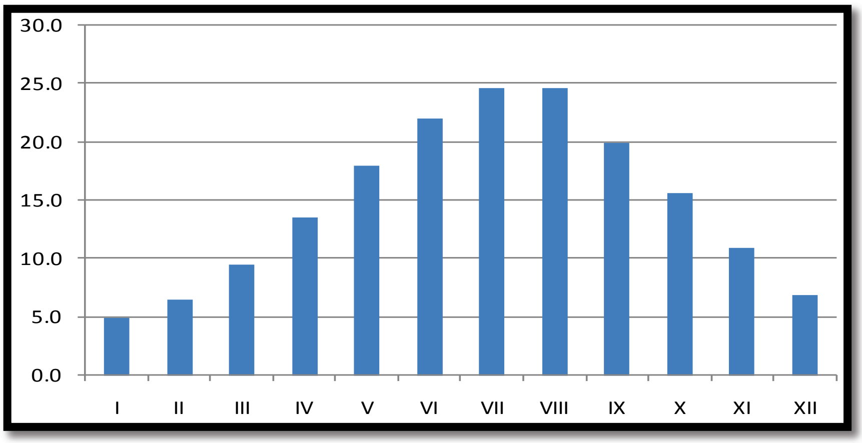


Table 7. Average evaporation levels in the basin in mm (Water Basis of Montenegro 2001)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min	28	41	68	95	128	160	200	183	126	80	48	30	1197
Mean	34	47	73	97	132	168	213	196	134	88	52	36	1270
Max	41	53	78	99	135	179	236	217	142	93	60	43	1334

(Evaporation from the lake is estimated to make up 70% of the overall evaporation from the basin.)

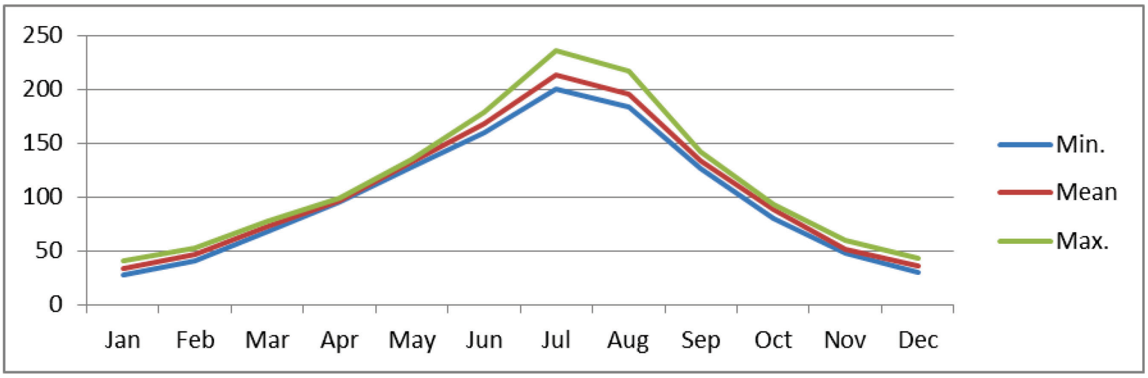
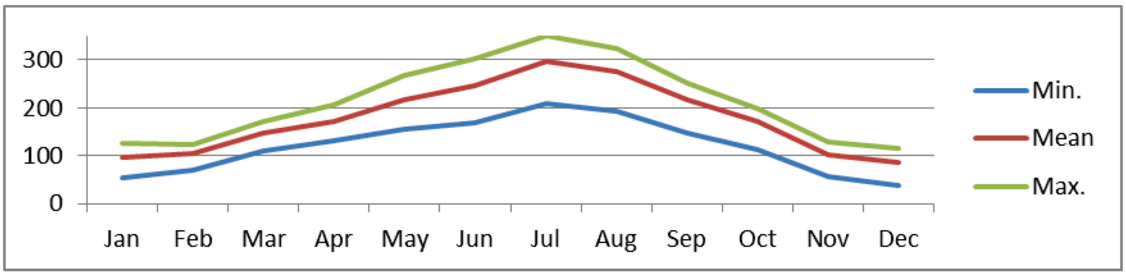


Table 8. Number of hours of sunshine per month (Water Basis of Montenegro 2001)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Min	53	71	111	131	156	169	208	194	147	113	58	38	1410
Mean	98	104	147	171	216	246	296	276	216	171	102	87	2123
Max	126	123	172	205	267	301	351	324	252	199	130	115	2560



The winds usually blow either from the northern or southern quadrants. The wind from the north, the *Sjevernjak*, is dry, strong and permanent, and generates high waves on the south-western coast. Several kinds of southern wind usually bring higher temperatures and precipitation. The *Južnjak* wind is the strongest, coming in bursts and generating high waves. Local winds will arise depending on certain conditions, especially when the waters warm up in summer. When the sky is clear in summer wind directions can change throughout the day: during the day the *Danik* blows from the south-west, during the night the *Nocnik* blows from the north, and in the morning there is the southward wind *Sjeverika.* These winds are moderate in strength and do not generate high waves (Water Basis of Montenegro 2001).

Table 9. Wind maximum speed, average speed and wind frequency (Vmax= m/s, V= m/s, Freq. = %) (Water Basis of Montenegro 2001)

Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S
V_{max}	24.0	29.0	16.0	13.4	10.8	17.0	17.0	21.0	15.0
V	4.8	5.3	3.3	3.0	3.3	3.0	3.8	4.0	2.9
Freq	10.0	9.1	1.5	1.5	0.7	1.3	1.6	8.0	7.3

Direction	SSN-W	SNW	NWS-NW	NW	NWN-NW	NNW	NNN-W
V_{max}	9.1	8.1	12.6	6.2	14.0	17.8	20.0
V	2.9	2.7	2.9	2.4	3.6	3.8	3.8
Freq	1.5	1.1	1.2	0.5	1.5	1.8	3.8

In Albania the most common wind directions are north-easterly and south-easterly. However, Korça has predominantly south-westerly winds while the area of Shkodra Lake is dominated by easterly winds. The north winds are cold throughout the country because they come down from higher latitudes. South winds are also observed throughout the country but they are warm. The east winds mainly blow from the country's interior towards the sea coast, whereas the west winds are local and blow particularly during the summer when the differences between sea water temperatures and inland air temperatures are more pronounced. During the cold half of the year (October–March) and especially during the winter months, the prevailing winds come from the continent (east, north-east or north). Air temperatures are therefore lower on the continent compared to those above the sea. Winds coming from the sea predominate during the warm half of the year, when seawater temperatures are cooler than those on land. In mountainous areas, such as northern Albania, topography has an important influence on wind direction. This can be illustrated by the prevailing wind directions recorded at various weather stations located in the surrounding valleys and mountains. Wind speed depends on different parameters, including season, terrain and location of the station (Climate of Albania 1987).

Table 10. Annual distribution of wind directions (%, line 1) and annual average wind speeds (m/s, line 2) for Shkodra Lake station (Albania Hydrometeorological Institute)

Quiet	N	NE	E	SE	S	SW	W	NW
60.8	0.6	2.3	10.5	7.1	5.8	4.3	5.2	3.4
-	1.5	4.0	4.7	4.4	4.8	3.7	3.3	3.4

Hydromorphological elements

When its water levels are at their lowest, the lake covers an area of 353 km^2 and has a volume of 1.75 km^3; when they are at their highest, the lake covers 525 km^2 and has a volume of 4.25 km^3. The difference between minimum and maximum volumes is therefore 2.50 km^3. At its lowest elevation, the lake bed sits at about 2.50 m below sea level (making the lake a crypto-depression) and has an average depth ranging from about 4.4 m to 8.10 m.

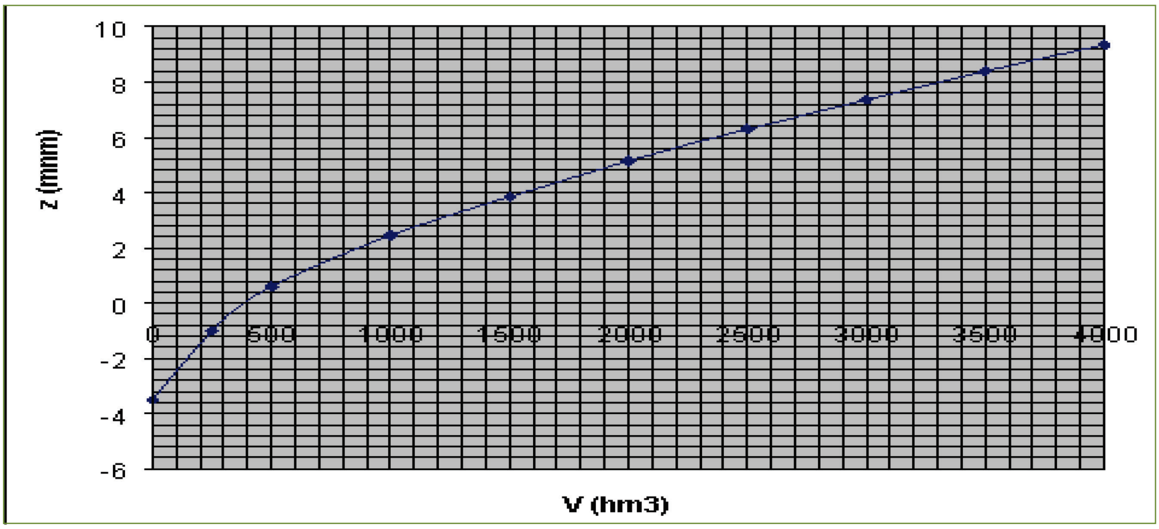


Figure 13. Relation between total volume (x-axis) and water level (y-axis, in metres above sea level) of Skadar/Shkodra Lake (Water Basis of Montenegro 2001)

Figure 14. The main tributaries of Skadar/Shkodra Lake

The main tributary of the lake is the Morača River, which itself has two tributaries: the Zeta and Cijevna/Cemi Rivers. The 99-kilometre long Morača flows through Montenegro's capital city of Podgorica, drains about 32% of the Montenegrin territory and provides 62% of the lake's water (Radulović 1997). Other important tributaries are the Crnojevica, Orahovstica, Karatuna and Baragurska Rivers on the northern coast of the lake in Montenegro, and the Përroi i Thatë, Rjolska and Vraka Rivers in Albania. Smaller streams flow into Skadar/Shkodra Lake from its western side. Together, all these tributaries contribute 11% of the total water input (see Table 11 on the water balance).

Groundwater from the Zeta Plain and karst springs (in the south-western and north-eastern sections of the lake) provide about 18% of the inflow into the lake (Figures 15 and 16).

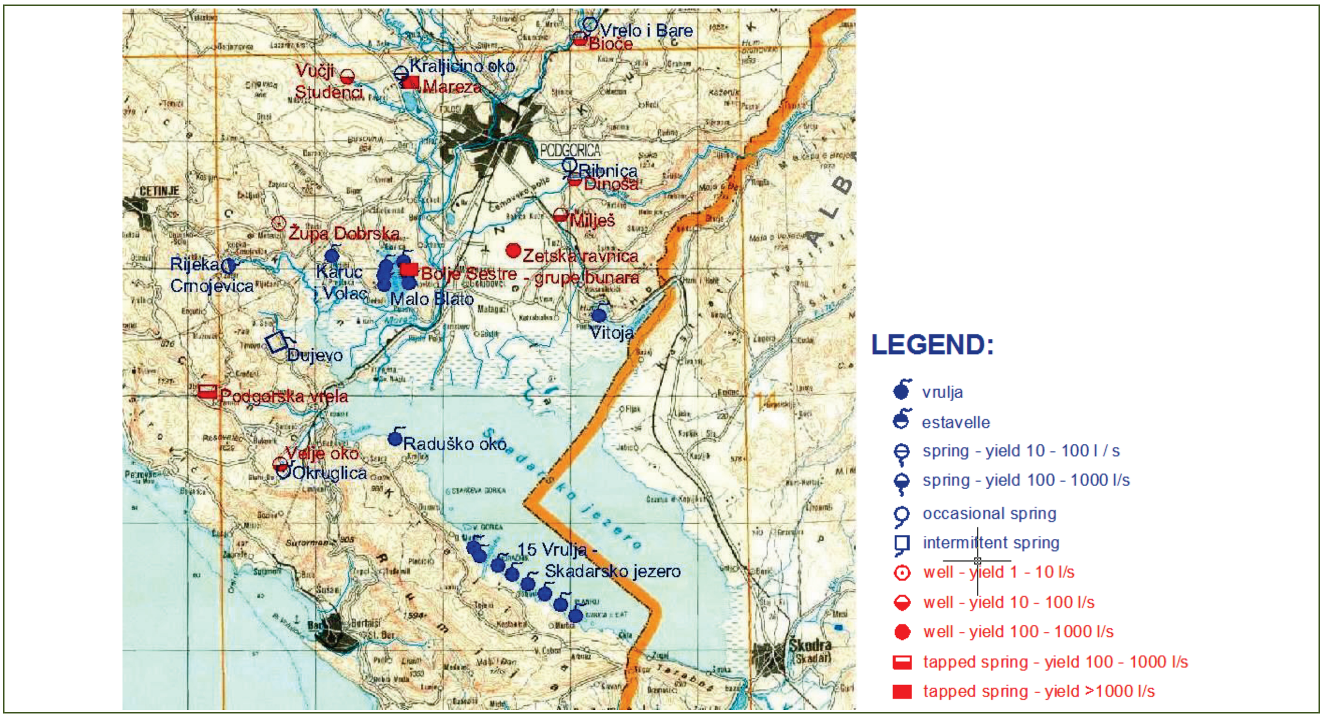


Figure 15. Springs and wells on the Montenegrin side of Skadar/Shkodra Lake
(Atlas of Waters of Montenegro 2010)

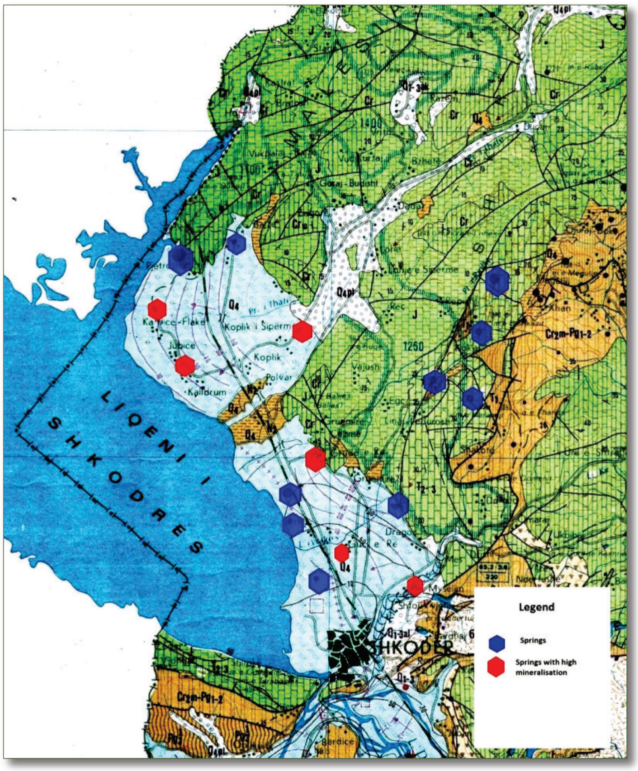


Figure 16. Springs and wells in the Albanian section of Skadar/Shkodra Lake
(Hydrogeological Map of Albania 1:200,000, Albanian Geological Service)

Water-mass movements are turbulent, caused by the influx of water from underwater karst springs and streams, or are superficial linear and thus depend on the wind direction and strength.

The only effluent from the lake is the Bojana/Buna River, which flows through Albanian territory for about 18 km and then forms the border between Montenegro and Albania at a distance of about 25 km.

Approximately 1.5 to 2 km downstream of the lake lies the confluence of the Bojana/Buna River and its major tributaries, the Drin River, which has a catchment area of 14,173 km^2.

In periods of high water, the Drin River slows the outflow from the lake and, in exceptional cases, some of the Drin's waters flow towards the lake. On the Drin River in Albania there are significant accumulations of alluvium that, given their size, could significantly alter the water regime of the lake and the Bojana/Buna River.

Table 11. Water balance of Skadar/Shkodra Lake in m^3/s (Radulović 1997)

Σ water inflow	335	100%
Precipitation	30	9%
Morača	210	62%
Rijeka Crnojevića	9	3%
Orahovštica	5	1%
Crmnica	4	1%
Other basins	17	6%
Sublacustic springs	60	18%
Σ water outflow	335	
Bojana/Buna	–320	95%
Evaporation	–15	5%

Table 12. Discharge of the Bojana/Buna River and its tributaries (Cullaj et al. 2005)

	Observation/monitoring station	Average discharge (m^3/s)	Observation period
Drin River	Before confluence with Bojana/Buna	352	1990–91
Bojana/Buna River	Skadar/Shkodra Lake outlet	320	1990–91

Table 13. Average values of the mean monthly and annual flows in Skadar/Shkodra Lake's tributaries in Montenegro in m^3/s (Water Base of Montenegro 2001) (also shown as diagram)

River	Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Morača	Pernica	27.42	27.83	30.46	49.34	57.51	29.27	9.74	6.59	10.44	25.14	46.58	41.63	30.16
Zeta	Dukl. Most	22.44	23.44	24.84	33.13	23.87	9.60	2.26	1.22	4.09	14.38	30.72	31.95	18.50
Zeta	Danilovgrad	113.34	110.41	104.77	109.25	79.27	43.28	21.98	15.04	26.35	61.25	122.26	134.69	78.49
Morača	Zlatica	79.69	77.03	73.60	90.69	78.41	36.14	9.90	4.61	14.07	43.67	94.88	99.89	58.55
Morača	Podgorica	214.94	213.30	203.77	236.01	200.47	103.52	40.86	27.13	50.64	124.19	253.93	274.06	161.90
Cijevna	Trgaj	26.94	28.10	26.80	39.52	41.61	22.93	7.85	4.56	8.15	19.06	36.42	36.34	24.86
Crnojeviča	Brod. Nijva	9.93	9.43	8.00	6.50	4.67	2.13	1.16	1.12	2.21	5.76	10.68	12.26	6.15
Orahovstica	Orahovo	5.65	5.37	5.01	4.29	2.55	1.06	0.37	0.23	0.73	2.12	5.32	6.12	3.23

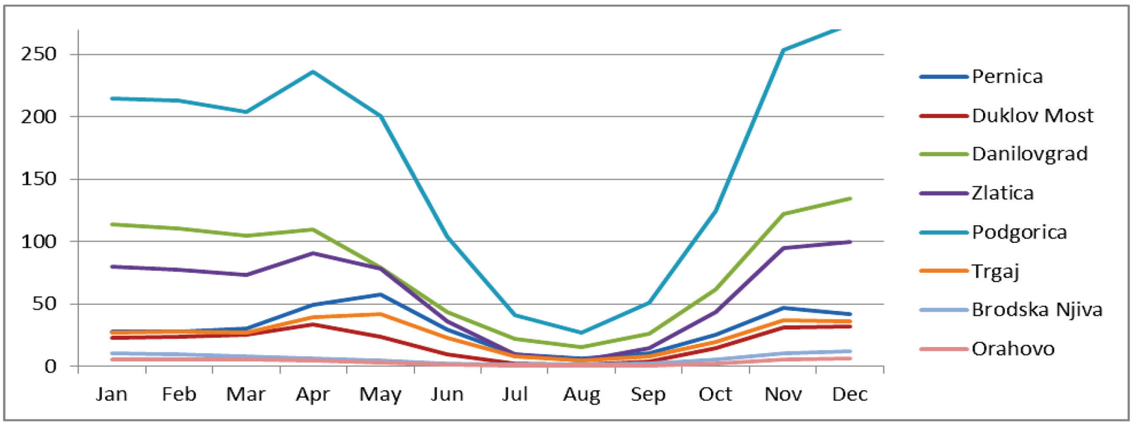


Table 14. Mean monthly and annual flows (a) from Skadar/Shkodra Lake into the outflow (*Bojana/Buna River*) (b) from Drin River (*Drini Bahcallëk)* and (c) at the confluence of the Drin and Bojana/Buna Rivers (*Joint Buna)* in m³/s

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Bojana/Buna River	576	442	403	372	363	296	169	92	65	154	372	350	320
Drini Bahcallëk	493	459	446	507	490	293	155	104	141	228	396	501	351
Joint Buna	1069	901	849	879	853	589	324	196	206	382	768	851	671

Table 15. Water levels (in meters a.s.l.) of Skadar/Shkodra Lake recorded at Plavnica hydrological station (Water Base of Montenegro 2001)

Lowest observed value	4.54 (1952)
Average minimum	5.16
Average value	6.52
Average maximum	8.51
Maximum observed value	Natural: 9.86 (1963) Anthropogenic: 10.42 (2010)

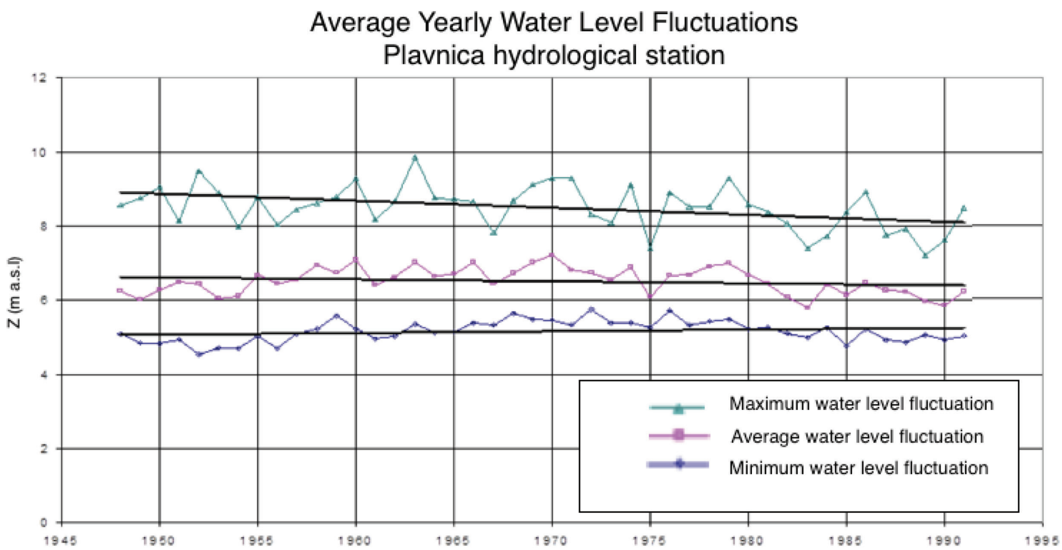


Figure 17. Trends in the characteristic water level (meters above sea level) of Skadar/Shkodra Lake recorded at Plavnica hydrological station (Water Base of Montenegro 2001).

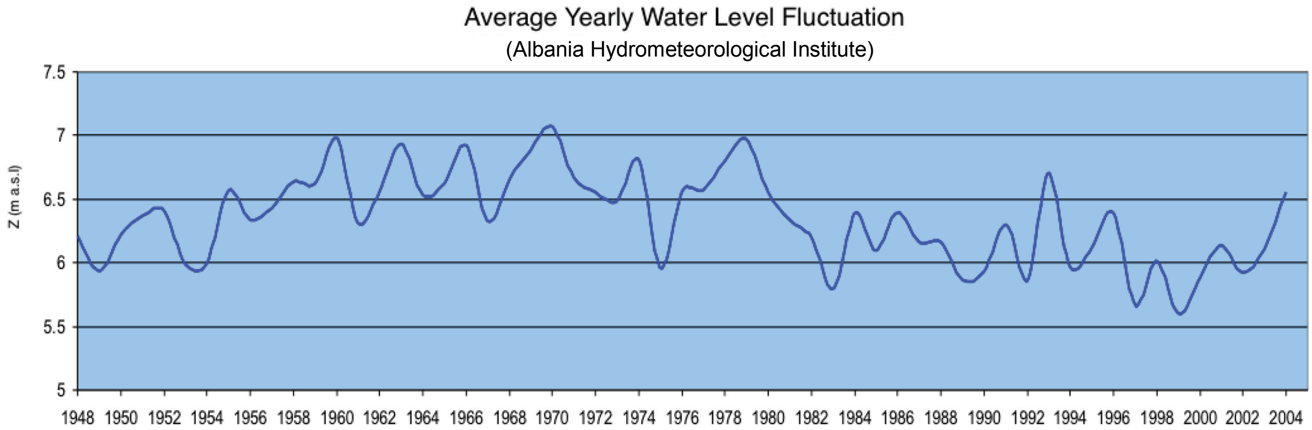


Figure 18. Average yearly fluctuation (meters above sea level) for Skadar/Shkodra Lake from 1950 to 2004 (Albania Hydrometeorological Institute)

2.3 Development issues

2.3.1 Development issues in Montenegro

The Skadar Lake basin is an important area historically and, given it has been inhabited since ancient times by people whose main activity has been subsistence farming, it is a centre of local heritage. Later, when the lake became larger, fishing also became an important part of the local economy.

The largest settlement on the Montenegrin side of the lake is Virpazar, with 350 inhabitants. In addition, there are around 20 other smaller settlements around the lake. Podgorica, the capital of Montenegro, lies on the Morača River and is about 25 km upstream of the lake shore.

Land use in the inner basin comprises agriculture, tourism and food processing (i.e. the fish processing plant in the town of Rijeka Crnojevića). In the wider catchment area, there are also metallurgical industries, namely the aluminium plant in Podgorica and the ironworks in Nikšić, which are among the most serious polluters of the lake.

Aside from the diffuse pollution caused by agriculture, the largest inflow of nutrients comes from Podgorica's wastewater treatment plant (WWTP). Of the annual 10.2 million m^3 of wastewater generated in the area of Podgorica, this treatment plant processes only 60%. The remaining 40% is discharged without treatment. The lakeside settlements Virpazar and Vranjina have built their own WWTPs. However, the town of Cetinje, which is located in the catchment area of the Rijeka Crnojevića tributary, does not have a WWTP, which means that pollution enters the tributary at its headwaters (Šundić, R. 2012).

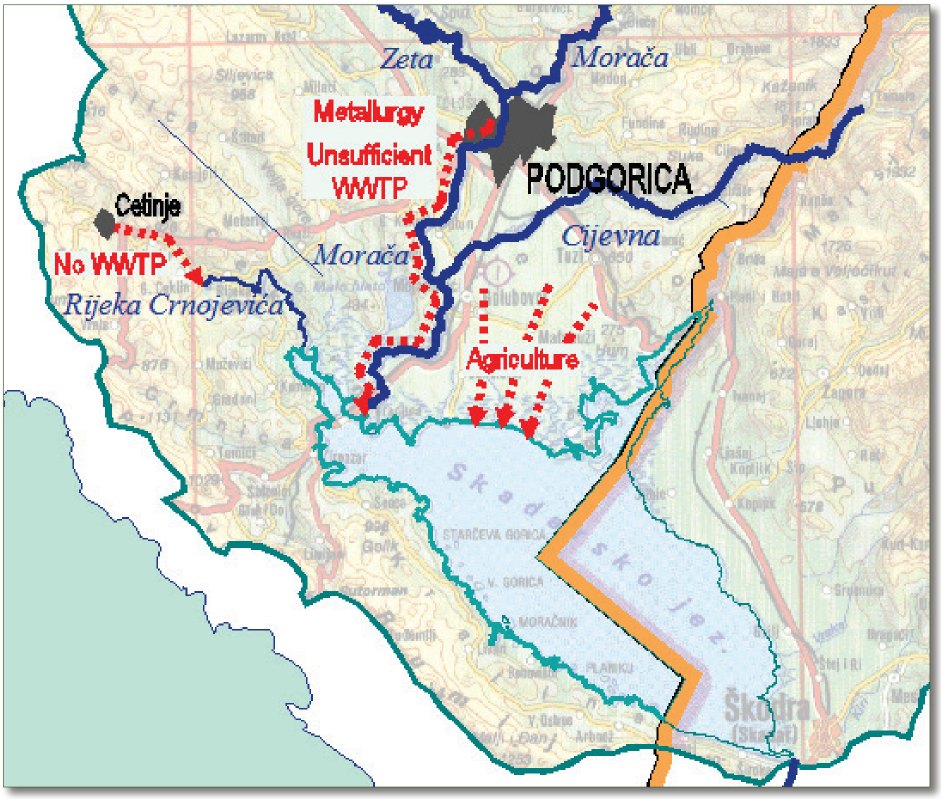


Figure 19. The main pollution pressures on the Montenegrin side of the lake

The entire shoreline of Skadar Lake in Montenegro is incorporated into Skadar Lake National Park.

Conservation status of the lake

Skadar Lake was designated as a national park area in 1983 (IUCN Management Category II) and, since 1995, it has featured on the Ramsar list of wetlands of international importance.

Figure 20. The territory of Skadar Lake (Skadarsko Jezero) National Park

Skadar Lake National Park contains 7,800 ha of permanently inundated land, 5,200 ha of intermittently inundated land, and 812 ha of bird reserve (REC 2003).

The lake harbours 279 bird species, some 90% of which are migratory species of international importance. A rare species of pelican nests on the lake. There are more than 50 species of fish, 15 of which are endemic. The region's flora is diverse: within the borders of the national park alone there are some 1,400 plant taxa (species and subspecies), more than 30 rare plant species and several nationally and/or internationally endangered species.

In terms of nature protection, there are three categories of reserve within the park:

- natural area under special protection (Pančeva Okaand Manastirska Tapija)
- natural area under general protection (Grmožur Island)
- natural area under protection (Crni Žar, Omerorova Gorica, Karuč, Djurovački Školj, and the bleak spawning area).

Floods

Due to the limited capacity and gentle gradient of the Bojana/Buna River channel, in times of high water the discharge from the Drin River prevents Skadar Lake from discharging into the Bojana/Buna and ultimately into the Adriatic Sea. Consequently, Skadar Lake's water levels rise, leading in exceptional circumstances (which are often exacerbated by anthropogenic factors) to flooding in areas deep into the hinterlands north of the lake.

Figure 21. The territory around Skadar/Shkodra Lake that was flooded in winter 2010/2011, when high waters were augmented by the release of water from dams on the Drin River (Water Directorate of Montenegro, 2011)

Table 16. Characteristics of transboundary aquifers (GEF 2014)

	Montenegro	Albania
Area (km^2)	~ 460 (karst aquifer) ~ 200 (shallow aquifer below Zeta Plain)	~ 450
Water uses and functions	25–50% for drinking water supply, <25% for irrigation, industry and livestock	50–75% for irrigation, <25% for drinking water supply, industry and livestock; the remaining goes naturally to the base flow and the support of ecosystems
Number of inhabitants	~ 270,000	~ 172,000
Water uses and functions	Groundwater comprises 30% of the total water use. 25–50% of the groundwater is used for irrigation, <25% for drinking water and industry, and the remaining maintains the base flow.	Groundwater comprises 60–70% of the total water use. 75% of the ground-water is used for irrigation, <25% for drinking water and livestock, and the remaining maintains the base flow.
Pressures	Insufficient urban waste and wastewater management. Hazardous waste from industry, particularly the aluminium industry in Podgorica and steel industry in Nikšić (Zeta River basin). Agriculture in the Zeta Plain.	Population increases in areas near the lake, particularly on the northern side, coupled with insufficient urban waste and wastewater management has led to increases in both water demand and pollution. Agriculture-related pollution is also a problem.
Problems related to groundwater quantity		Increased demand for water due to agriculture and urbanisation. Overuse of flowing artesian wells.
Problems related to groundwater quality	The shallow Zeta Plain aquifer is becoming polluted. Groundwater quality monitoring is currently limited. This monitoring needs to be extended to cover the whole basin and a joint database should be created for the two states.	Point source and diffuse (agrochemicals) pollution.

2.3.2 Development issues in Albania

The outflow of Shkodra Lake through the Bojana/Buna River is affected by high-water levels in the Drin River, which often results when water is released from dams upstream. Under certain conditions, the Drin's waters can even flow back into the lake, thereby significantly raising its water level (Academy of Sciences of Albania 2015). This phenomenon mostly occurs from December to February, but can also occur in other periods, depending on the quantity of water released from the hydropower dams (Vau i Dejes), which, in turn, depends on rainfall levels and electricity demand. Alterations in the water-level-fluctuation patterns of the lake exert pressure on its ecosystems as well as on local agriculture and microclimates. Shkodra Lake is defined as a shallow floodplain lake with regular and extensive flooding of its low-gradient areas. The floodlands are an essential habitat for maintaining the overall biodiversity of the lake. The flood regime – the timing and amplitude of changes in water levels – is an important factor for successful fish spawning. However, the increased frequency and intensity of floods in the Skadar/Shkodra–Bojana/Buna area has, in recent years, given rise to detrimental socio-economic effects in the region. The latest bout of flooding was the most severe recorded in the last 80 years.

While these phenomena do need to be researched more deeply, it is believed that they result from the combined effects of

- flow variability caused by both natural and anthropogenic factors (extreme weather phenomena, water releases from the dams on the Drin River);
- the accumulation of alluvium in the tributaries of the Drin and Bojana/Buna (in the case of the Drin, this is due to the river's decreased sediment transport capacity, which results from the control of outflows from upstream dams; in the case of the Buna/Bojana, this is due to the gentle gradient of the riverbed);
- the blockage of the natural secondary channels of the Bojana/Buna River in the delta area on the Albanian side of the lake, and peak flows that exceed the capacity of the main (existing) channel; and
- poor maintenance of irrigation channels and flood control facilities in Albania.

Climate change and variability leading to an increase in the frequency of extreme precipitation events is a possible explanation for the recent and serious flooding events experienced in the area. After all, similar 'localised' floods are becoming more frequent around the world and many scientists attribute these events to the changing climate (Academy of Sciences of Albania 2015).

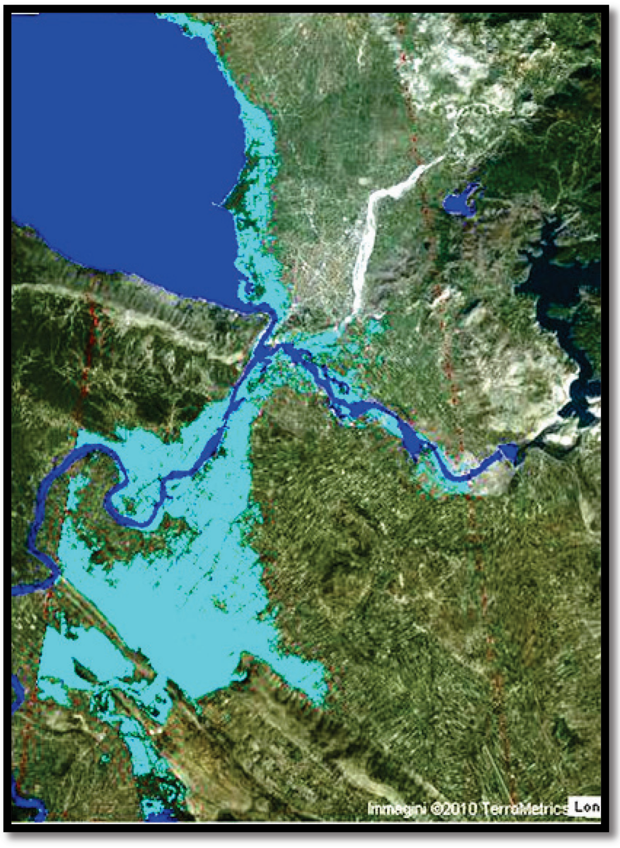


Figure 22. Floods in Albania 2010 (Relief Web, Albania Flood 2010)

Even though Skadar/Shkodra Lake receives pollutant loads, the water quality appears to remain reasonably good due to its high renewal rate of 2–2.5 times per year. Inappropriate wastewater management results in pollutants entering the hydrological system of Skadar/Shkodra Lake and the Bojana/Buna River. Improvement of related infrastructure in Shkodra is underway. The pollution entering the lake on the Albanian side is due to the absence of wastewater treatment, insufficient solid waste management and agricultural runoff. Sewage from Shkodra city is collected in holding facilities and then pumped into the

Drin River a short distance upstream of its confluence with the Bojana/Buna. Occasional failures of the sewerage system can result in spill overs that threaten the lake's water quality. The discharge of wastewater affects the Bojana/Buna River all the way down to its delta, and when the Drin's waters are high or there is flooding this wastewater ends up in the lake. Efforts to improve the solid waste management system in both countries, which include the construction of sanitary landfills, are ongoing (Cullaj, A. 2005)

Land cover

In all, 23% of the total area of the Albanian section of the drainage basin of Skadar/Shkodra is used for agriculture. Forests cover an area of 225.3 km^2 (23% of the total land area) and are well developed in the Albanian Alps. Urban areas take up only 1.2% of the land (according to the Corine land cover maps). Shkodra city is the most built-up area and its industrial zone extends north of the city.

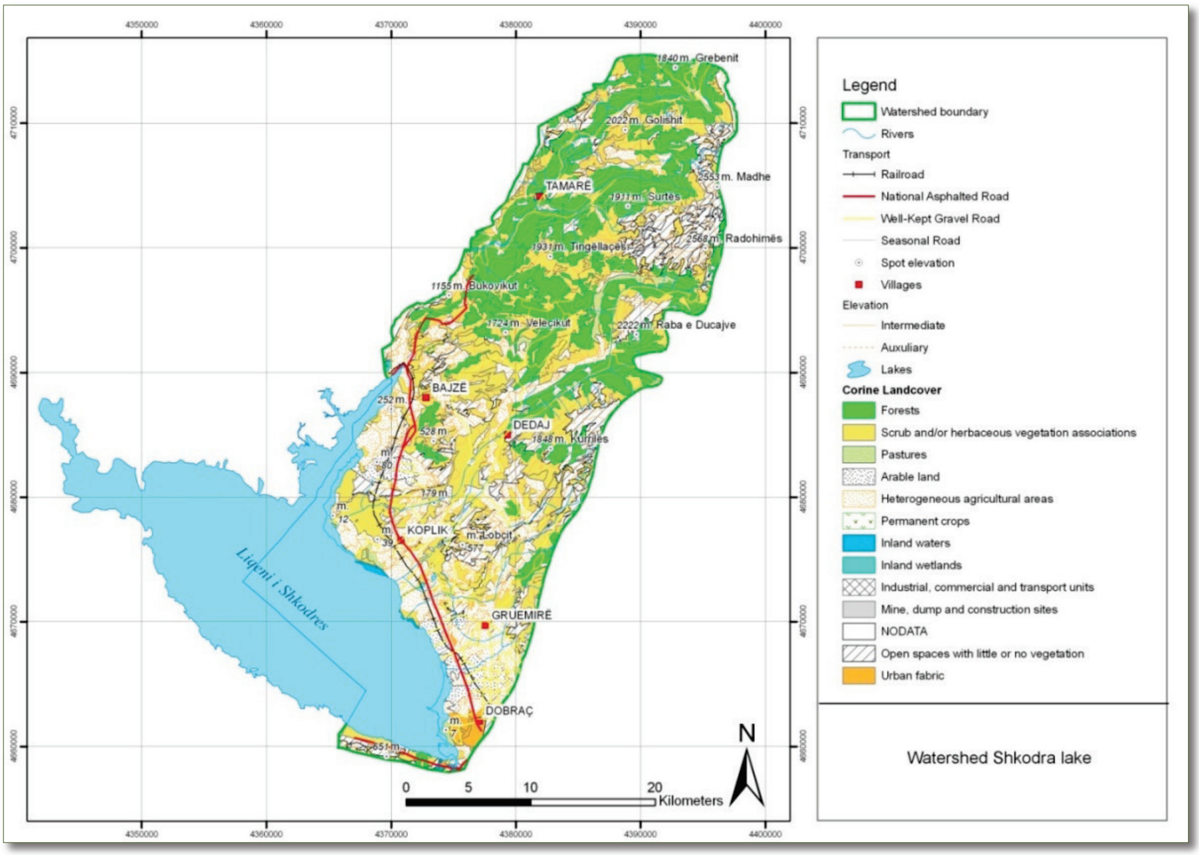


Figure 23. Land cover in the Albanian section of the Skadar/Shkodra Lake basin (Corine land cover map)

2.4 LAKE MANAGEMENT

Skadar/Shkodra Lake is a transboundary lake located across Montenegrin and Albanian territory.

2.4.1 Lake management in Montenegro

The management of Skadar/Shkodra Lake in Montenegro, as laid down in the Regulation on Waters of Importance for the Republic (Official Gazette of Montenegro, no 9/08 and no 28/09), is the duty of the Water Directorate of the Ministry of Agriculture and Rural Development, which also specifies how water is to be monitored. The monitoring is carried out by the Montenegro Institute for Hydrometeorology and Seismology.

Responsibility for the environmental protection of the lake falls to the Montenegro Environmental Protection Agency of the Ministry of Sustainable Development and Tourism.

As laid down in the Regulation on the Method for Determining the Boundaries of Water Lands (Official Gazette of Montenegro, no 25/12), the territory designated as 'water land 'is that falling within the boundary of the highest recorded water level (according to Montenegro's Water Law, 'water lands' are the 'beds and banks of watercourses, lakes, coastal waters, reservoirs and other surface water'). The water land of Skadar/Shkodra Lake is "important to the republic of Montenegro" as stated in the Water Law.

2.4.2 Lake management in Albania

Competences

The competent national body for water quality monitoring is the Ministry of Environment (MoE), while the Ministry of Agriculture, Rural Development and Water Administration (MARDWA) is in charge of water administration.[5] The country's Law on Water regulates matters related to:

- surface waters, including watercourses, lakes, reservoirs, springs and groundwaters;
- riparian lands and wetlands, including water protection and conservation, and protection against the harmful impacts of water;
- water management structures and services;
- organisational arrangements and the financing of water management; and
- the manner, conditions and procedures with which water can be used or discharged.

The main law covering lake management issues in Albania is the Law on the Integrated Management of Water Resources No 111/2012, which is fully harmonised with Directive 2000/60/EC of the European Parliament. This Law aims to protect and improve water environments and water resources, ensuring their rational exploitation, fair distribution and protection from pollution, and it provides for the establishment of the central and local institutional frameworks required to implement national management and administration policies. According to this law, all of the Republic of Albania's water resources, including its lakes, are state-owned and must be administered by state bodies. The main central authorities for the administration and management of water resources are the Council of Ministers, the National Water Council, MARDWA, MoE and the Technical Secretariat of the National Water Council.

The **Council of Ministers** (CoM), through the Prime Minister's Office, adopts bylaws proposed by the National Water Council on water management and approves the composition and functioning of the Technical Secretariat of the National Water Council. The CoM also approves the composition of the National Water Council and regulates its operations, and it appoints a special commission for the management of transboundary waters. The CoM approves river basin management plans following their approval in principle by the National Water Council, and it approves the National Strategy for Water Resources Management

The **National Water Council** is the central decision-making body responsible for the management of water resources. The National Water Council is the inter-ministerial body chaired by the Prime Minister.

[5] Reform of water administration ongoing at the time of publication of the present report

The **Ministry of Environment**, in collaboration with line ministries, develops and implements policies, strategies, programmes and projects aimed at ensuring the integrated management of water resources and the quantitative and qualitative preservation and further consolidation of these resources. The **Ministry of Agriculture, Rural Development and Water Administration** is tasked with the main duties involved in managing the nation's water bodies.

The **Prime Minister's Office**, in collaboration with line ministries, develops and implements policies, strategies, programmes and projects aimed at ensuring the integrated management of water resources and the quantitative and qualitative preservation and further consolidation of these resources. The Ministry of Agriculture, Rural Development and Water Administration is tasked with the main duties involved in managing the nation's water bodies.

At the local level, the authorities tasked with the management of water resources are the River Basin Councils and the River Basin Agencies. The Technical Secretariat of the National Water Council is the executive organ of this Council. River Basin Councils, which are responsible for managing water resources in given basins at the local level, report to the Technical Secretariat of the National Water Council. River Basin Agencies, which are set up in each watershed, are embedded in the central government structure.

Protected areas

Law No 9806 of 6 June 2002 on Protected Areas provides the legal basis for the management of protected areas in Albania. It provides the framework for the designation, conservation, administration, management and sustainable use of protected areas and their natural and biological resources. The law itself pays special attention to the management of water areas and other natural resources within protected areas. It also provides the legal basis for the designation of administrative structures and management committees for certain categories of protected area. It also defines the procedures for setting up and operating the management committees.

Monitoring and research

Monitoring is conducted to determine the effectiveness of park management. Water monitoring programmes are essential for assessing the main sources of pollution and eutrophication that are altering and changing the current and potential ecological status of the lake ecosystem. Discharges from tributaries flowing into these ecosystems must also be monitored. A detailed monitoring plan for physical and chemical parameters is provided in the framework of the transboundary monitoring system. Based on the archival data of the Institute of Hydrometeorology, a programme to monitor lake water levels is in place (with water gauge measurements taken every two or three days). The monitoring of water quality and ecological status of water bodies on the Albanian side of the lake has been conducted since 1951 under the responsibility of different state institutions.

Currently, the Fishery Inspectorate is responsible for monitoring the lake's fish stocks. The most recent (2013-2015) and comprehensive assessment of fish assemblages of Lake Skadar/Shkodra has been conducted with support of GIZ (Mrdak et al. 2017). State-owned forests and pastures are managed by central government, whereas the forests and pastures defined as common property are managed by the commune authorities.

Access to the shoreline

The lake's shoreline is state property. Should any part of the shoreline be included in a privately owned plot and should the owner of this plot decide to develop this section of shoreline, the state is empowered to nationalise the section to maintain access. According to Albanian law, access to the riparian belts of lakes is free. As such, local governments are obliged to ensure continued free access to these belts.

3 RESULTS AND CONCLUSIONS

3.1 Hydrogeomorphological areas

Six main hydrogeomorphological (HGM) areas have been identified. They are characterised by different geological, hydrological and morphological factors. These factors represent either an advantage for or a limitation to the natural growth of a functional shorezone and, in cases where anthropogenic pressures do not represent the major limiting factor, the SFI results often reflect the nature of the HGM areas.

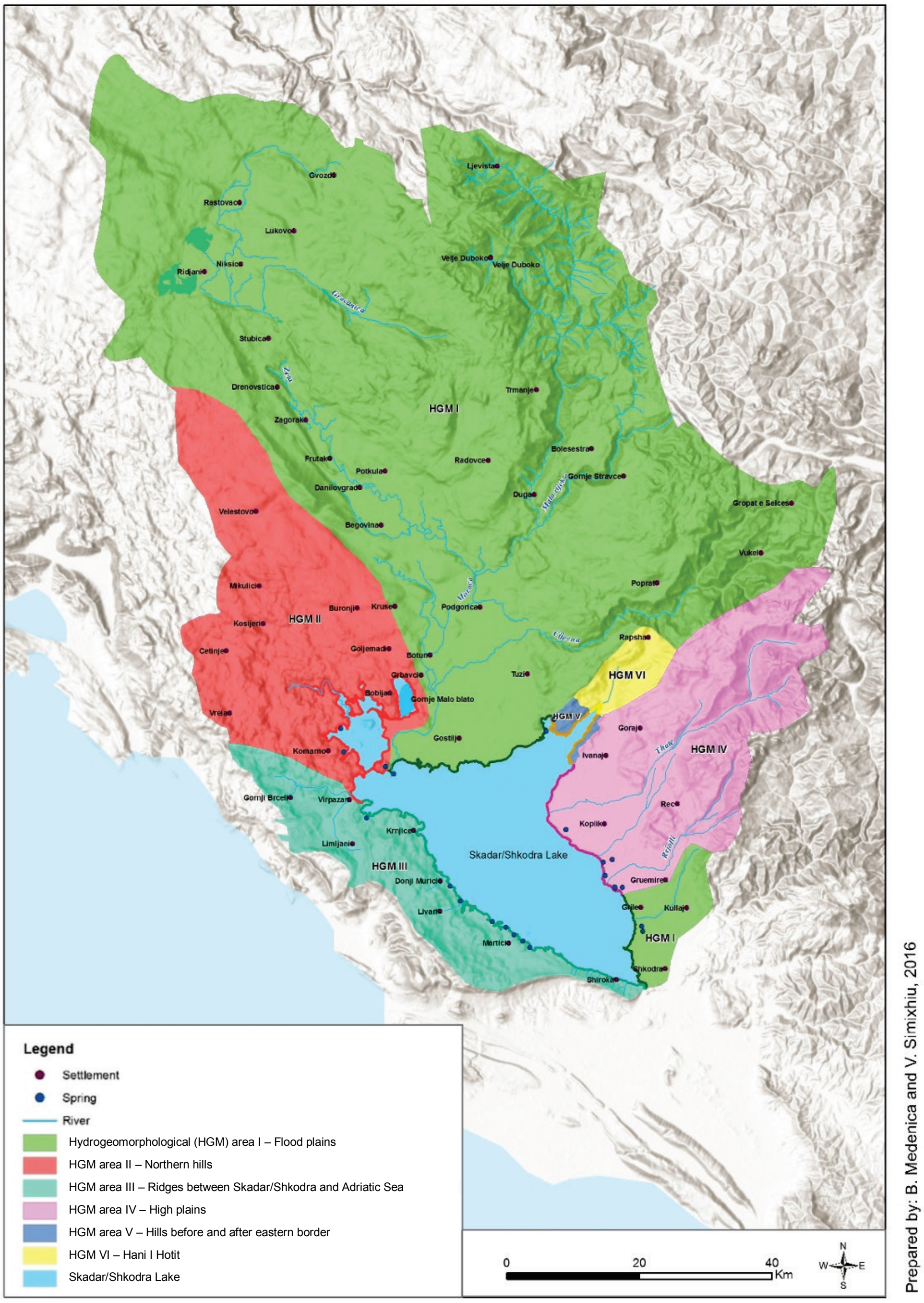


Figure 24. The six main HGM areas

Table 17. The content of stretches and hydrological catchment areas in different HGM areas

HGM area	Drainage basin (km²)	Shore length (km)	Drainage basin:shore ratio	Stretch number ID
I – Floodplains	3,357	48.1	69.8	9–15 and 156–163
II – Northern hills	634	108.3	5.8	16–110
III – Western ridges	290	66.4	4.4	111–156
IV – High plains	545	23.2	23.5	179–164
V – Eastern hills	14	18.0	0.7	1–9 and 179–181
VI – Hani i Hotit	57	3.5	16.3	182–183

The ratio between the HGM drainage area and the HGM shore length shows which HGM areas are most likely to be affected by different types of land use (Table 17). Water draining from HGM areas I and IV, both of which comprise flat land, is more likely to collect nutrients on its way and deposit them along a relatively short section of shoreline.

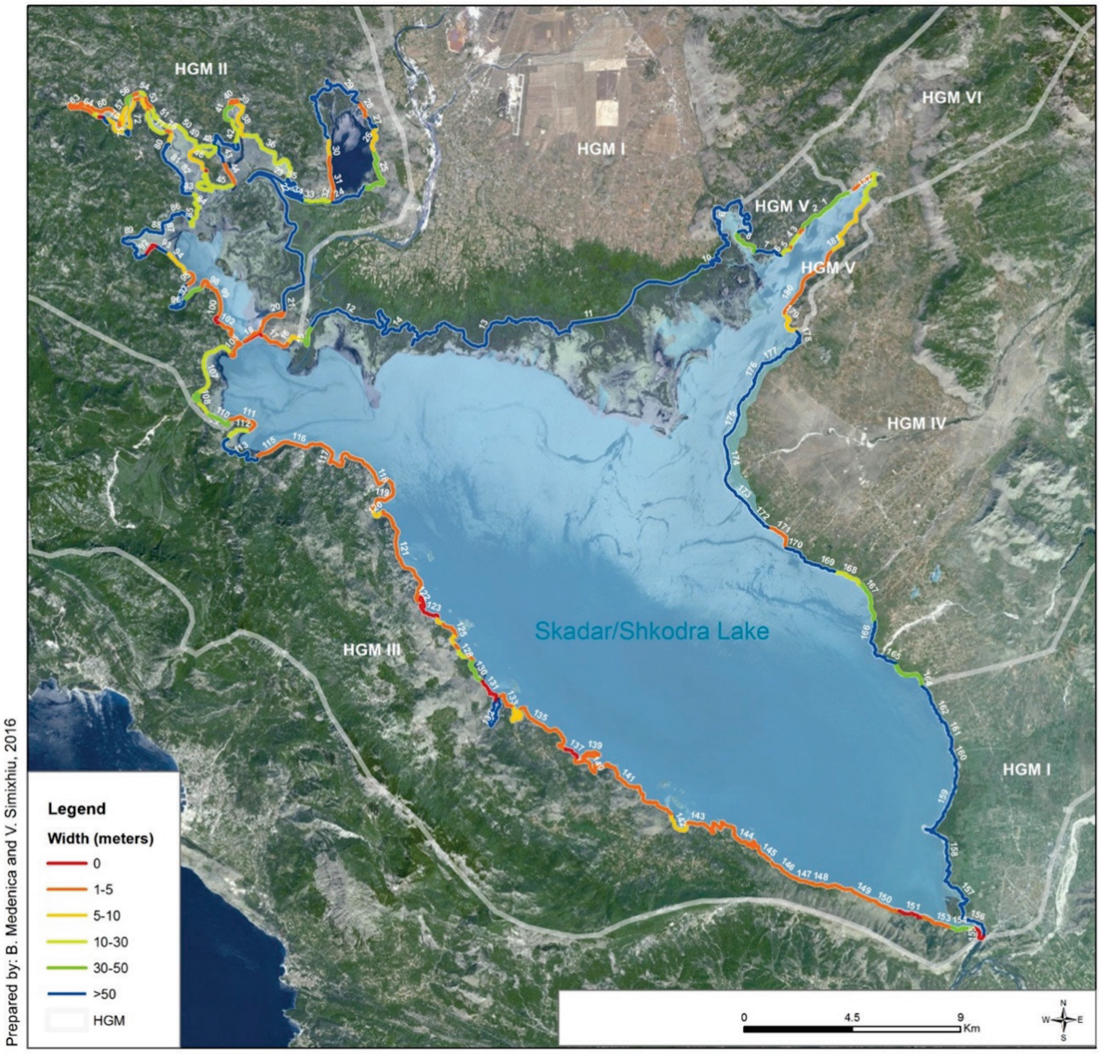


Figure 25. Width of the functional shorezone

The correlation between SFI parameters and hydrogeomorphological factors is represented by the width of the functional shorezone (Figure 25). In HGM area III, for example, the rugged steep terrain along the shore limits the growth of the riparian vegetation.

3.1.1 HGM area I – Flood plains (Montenegro and Albania)

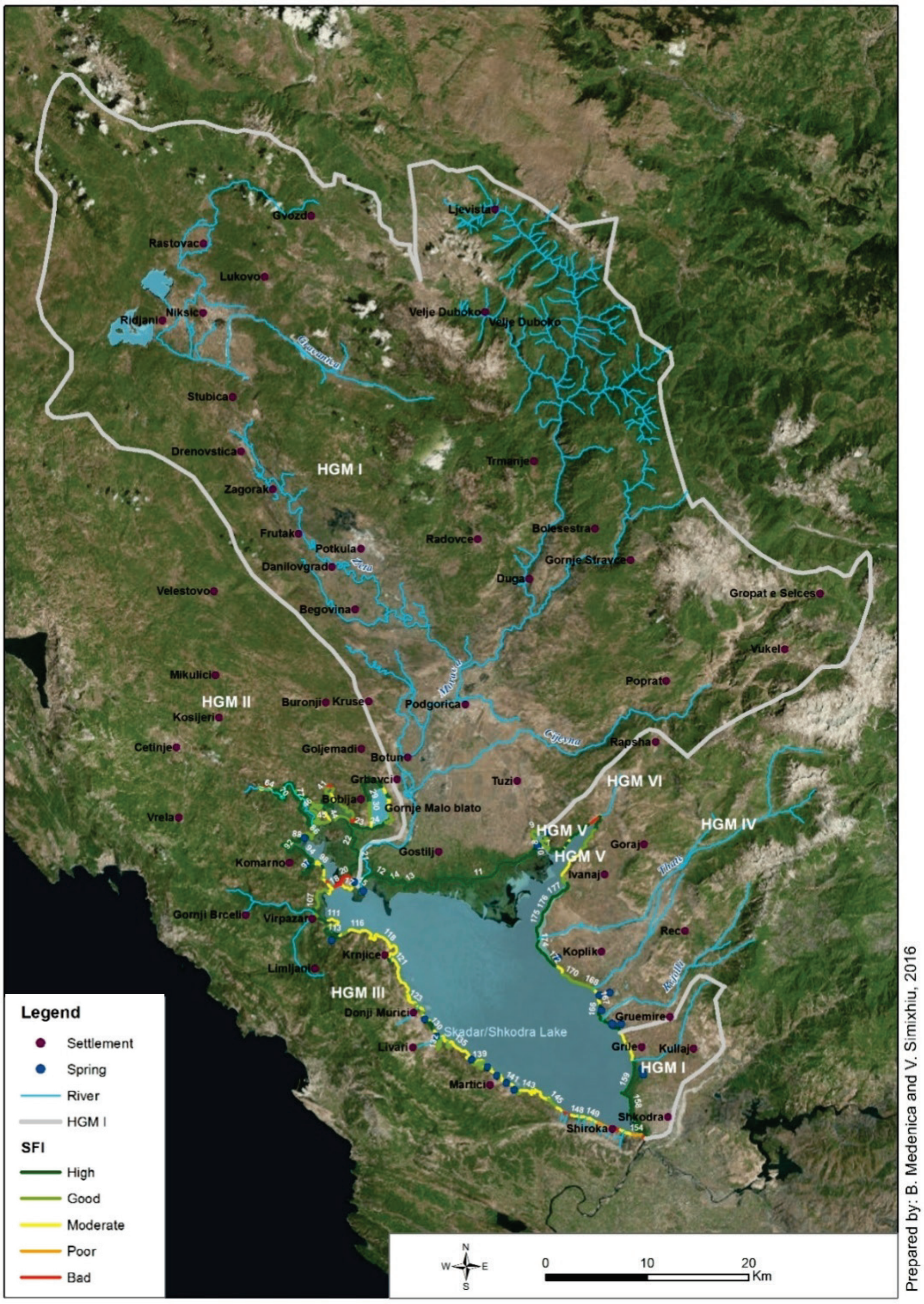


Figure 26. Catchment area of HGM area I – Flood plains (Montenegro and Albania)

HGM area I is split between two different locations around Skadar/Shkodra Lake: in the Zeta Plain in Montenegro and to the north of Shkodra city in Albania. These areas are characterised by the presence of a porous aquifer (limestone and dolomite) and comprise low-lying land that is regularly affected by lake inundations.

As these areas are prone to flooding, people tend not use them and the riparian vegetation can grow undisturbed. On the Montenegrin side, small family farming plots are present in areas close to the main Podgorica–Vranjina road, but they are only used seasonally. The only permanent structure along the shore here is the Plavnica tourism complex.

Due to the low elevation of the shore, reed beds can extend for hundreds of metres toward the lake, which further enhances the lake's shorezone functionality. Shorezone typology 1 is typical in this area.

Figure 27. HGM area I in Montenegro – Functionality category 1

The Montenegrin shoreline of HGM area I is designated as the Pančeva Oka special nature reserve and it is particularly important for avifauna.

Figure 28. Example of a functionality category 1 shorezone in the Montenegrin section of HGM area I

Morača River, the main tributary, flows into the lake from the Zeta Plain. This river provides 62% of the lake's water and its nutrient load can seriously affect the lake's ecological status.

Fortunately, the shorezone functionality in this HGM area is high, meaning it has a high capacity for nutrient removal. In addition, it provides a variety of habitats for aquatic and terrestrial fauna.

Figure 29. Alluvial area located near the mouth of Morača River in the Montenegrin section of HGM area I

Figure 30. Functionality category 1 in the Albanian section of HGM area I

The Albanian section of HGM area I is located just to the west of Shkodra city. As anthropogenic disturbance is absent in this zone, the riparian vegetation can grow undisturbed and the shorezone functionality is high. It therefore has a high capacity for nutrient removal and provides a variety of habitats for aquatic and terrestrial fauna. As such, it represents an important buffer zone that is capable of filtering out some of the pollution emanating from the city.

Figure 31. Example of a functionality category 1 shorezone in the Albanian section of HGM area I

3.1.2 HGM area II – Northern hills (Montenegro)

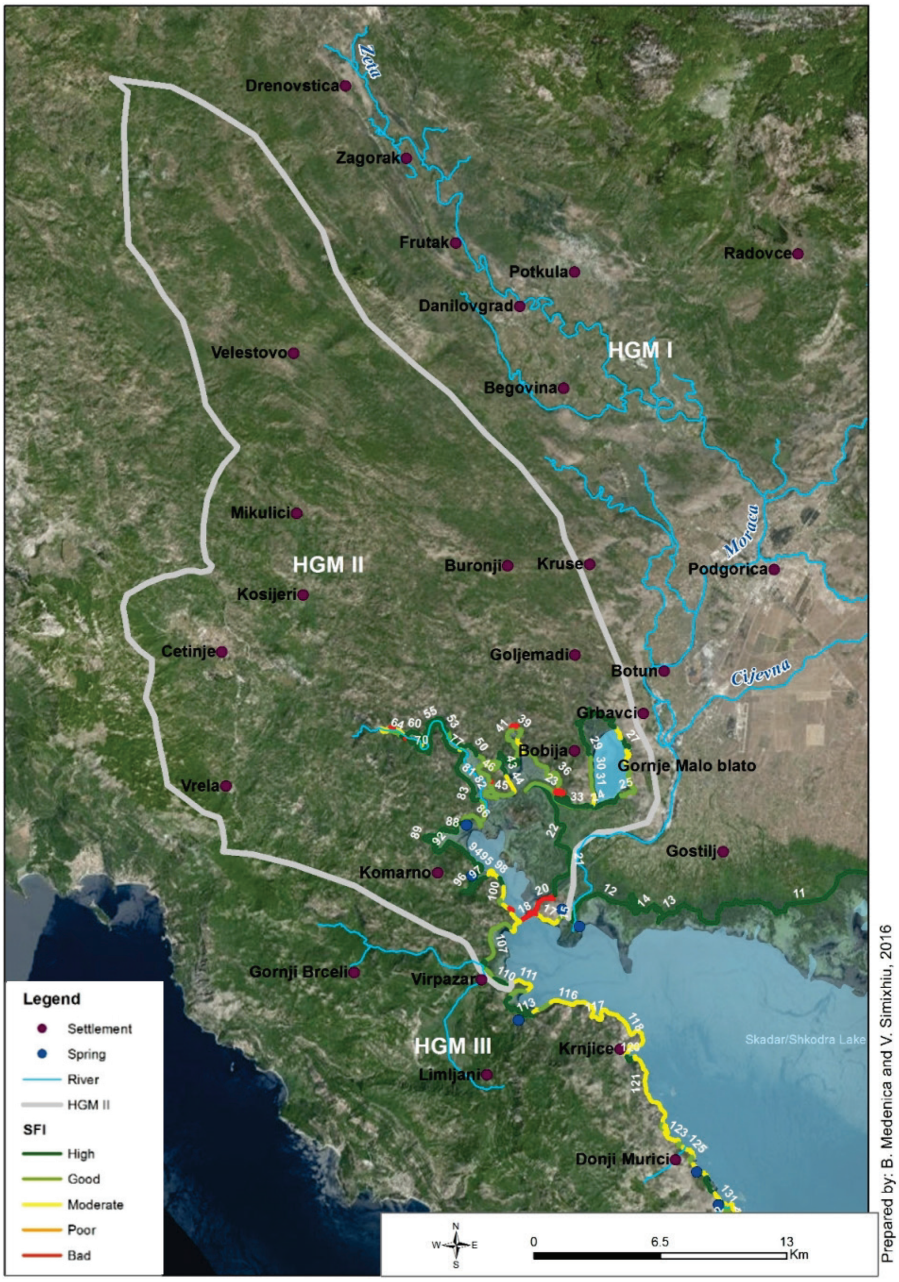


Figure 32. Catchment area of HGM area II – Northern hills (Montenegro)

HGM area II runs north-west from the lake and comprises hilly terrain that drops steeply down to the lake. The area has a natural belt of riparian vegetation of limited width (10 to 30 m wide), which sometimes includes reeds in the littoral zone.

The steeply sloping shorezone affects the growth of riparian vegetation, which can only thrive close the shoreline in a belt a few metres wide.

The limited width of the functional zone sometimes reduces the functionality level, which varies between category 1 (high) and category 2 (good).

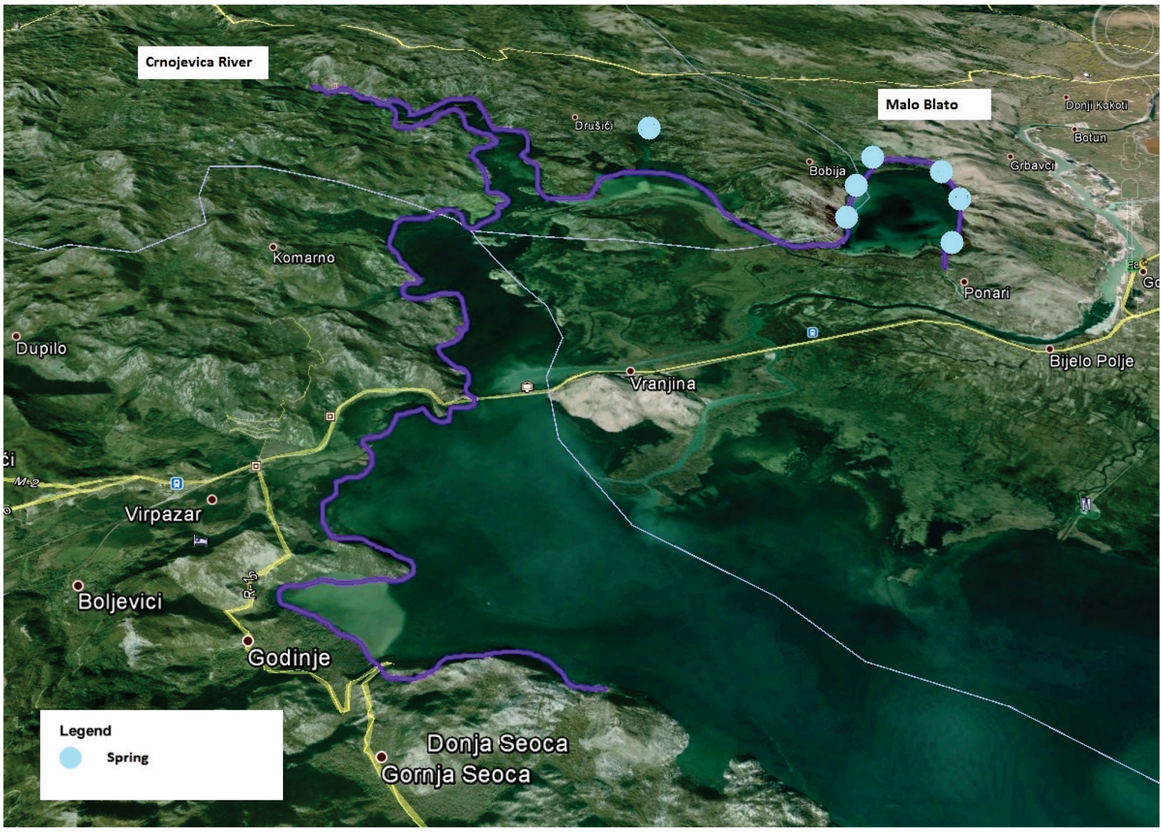


Figure 33. The terrain and main springs in HGM area II, Montenegro

The main tributary in this area is the Crnojevica River, which enters the lake at Crnojevica town, the most north-westerly point of the lake. The source of the river is a spring located 2.5 km to the south-west of Rijeka Crnojevića town. The headwaters of the river are polluted by wastewater emanating from Cetinje, a town lacking wastewater treatment facilities that is located in the river's upper catchment area (Šundić 2012). Other important sources of water in this area are the springs located in Malo Blato, on the north-eastern side of HGM area II. These springs provide a significant amount of the water required for the drinking water system that supplies communities along the entirety of Montenegro's lake coast.

Figure 34. Example of a functionality category 1 shorezone in HGM area II

Figure 35. Example of a functionality category 2 shorezone in HGM area II

3.1.3 HGM area III – Western ridges

HGM area III comprises the ridges of the Sutorman, Rumija and Tarabosh Mountains, which extend southwards from Montenegro into Albania and separate the lake from the Adriatic Sea. These mountains are steep and rugged and have experienced heavy deforestation, especially on the Albanian side. On the Montenegrin side, there are still consolidated oak forests that also contain hornbeam and ash trees, whereas on the Albanian side the hills appear largely bare and there are only two consolidated oak forests, located near the border with Montenegro.

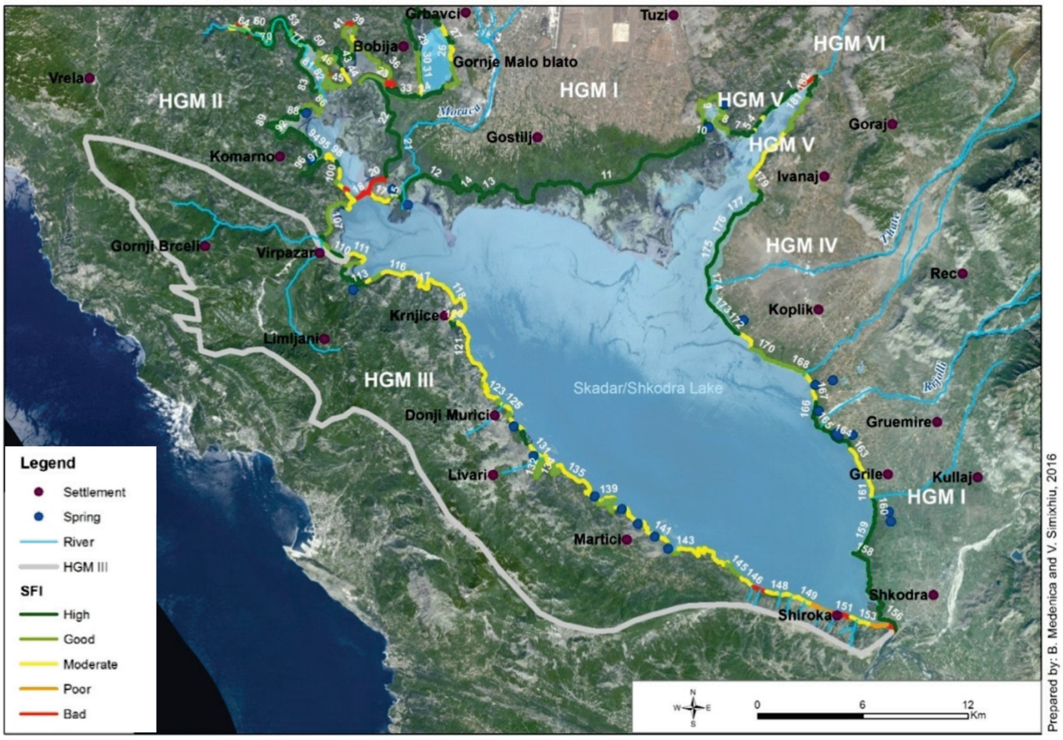


Figure 36. Catchment area of HGM area III – Western ridges between Skadar/Shkodra Lake and the Adriatic Sea (Montenegro and Albania)

Numerous springs are present along this shore and they constitute the main source of water input from this area (Figure 37).

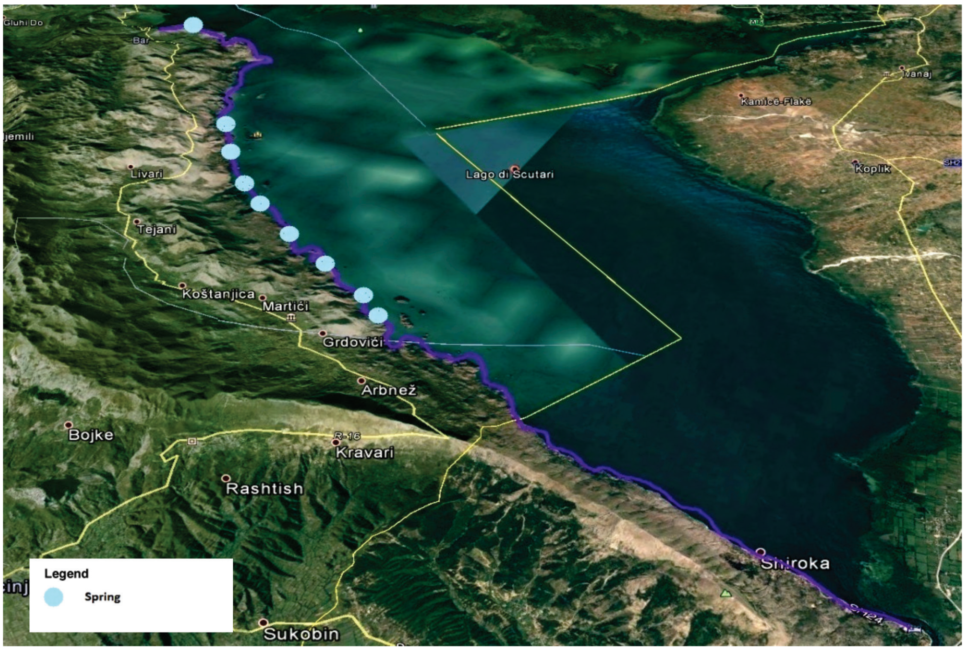


Figure 37. The terrain and main springs in HGM area III

The sloping topography of the shore affects the growth of riparian vegetation, which can only grow close the shoreline in a belt a few metres wide, and because the slope continues below the waterline, reeds cannot grow in this area. All these factors limit the width of the functional shorezone to a few metres. The filtering capacity of this shorezone is therefore limited, as is its capacity to provide habitats for aquatic and terrestrial fauna.

In this HGM area the functionality is naturally moderate (typology 3). The functionality therefore does not depend on human intervention – which in this area is insignificant – but rather is determined by the natural status of the environment. Shorezones with these characteristics (high naturality and low SFI values) are particularly vulnerable because they have limited resilience and reduced homeostatic capacity and are thus less able to cope with pressures as and when they arise. On these shores, a minor stressor can therefore generate major environmental problems.

Figure 38. Example of a functionality category 2 shorezone in the Montenegrin section of HGM area III

Figure 39. Example of a functionality category 3 shorezone in the Albanian section of HGM area III

3.1.4 HGM area IV – High plains (Albania)

Figure 40. Catchment area of HGM area IV – High plains

HGM area IV is located on the Albanian plains to the east of the lake, close to the settlement of Koplik.

Figure 41. HGM area IV – High plains

These plains are slightly higher than those found in HGM area I and are therefore not subject to periodic flooding from the lake. While the area is mainly used for agriculture, some tourism infrastructure is also present along the shore.

This area typically falls into shorezone category 1, but lower SFI values are also present due to the higher levels of human disturbance (width limited by adjacent farmland and tourism infrastructure).

Figure 42. Example of a functionality category 1 shorezone in HGM area IV, Albania

In this area, reeds are not as frequent as in HGM area I. Closer to the town of Koplik, agriculture extends very close to the shore, which limits the width of the functional shorezone and reduces SFI values (moderate and good).

The main tributaries are the Vraka River and the Përroi I Thatë (dry river). The latter flows close to the town of Koplik and, as the name suggests, is dry during most of the year. The Syri i Sheganit spring is also located in the north-east of this area.

Figure 43. Example of a functionality category 3 shorezone in HGM area IV – Bare soil and limited shorezone width

This area's proximity to the pristine HGM area I landscape, which is easily accessible by car, makes it a great launch pad for ecotourism trips, in particular birdwatching visits.

3.1.5 HGM area V – Eastern hills (border area between Albania and Montenegro)

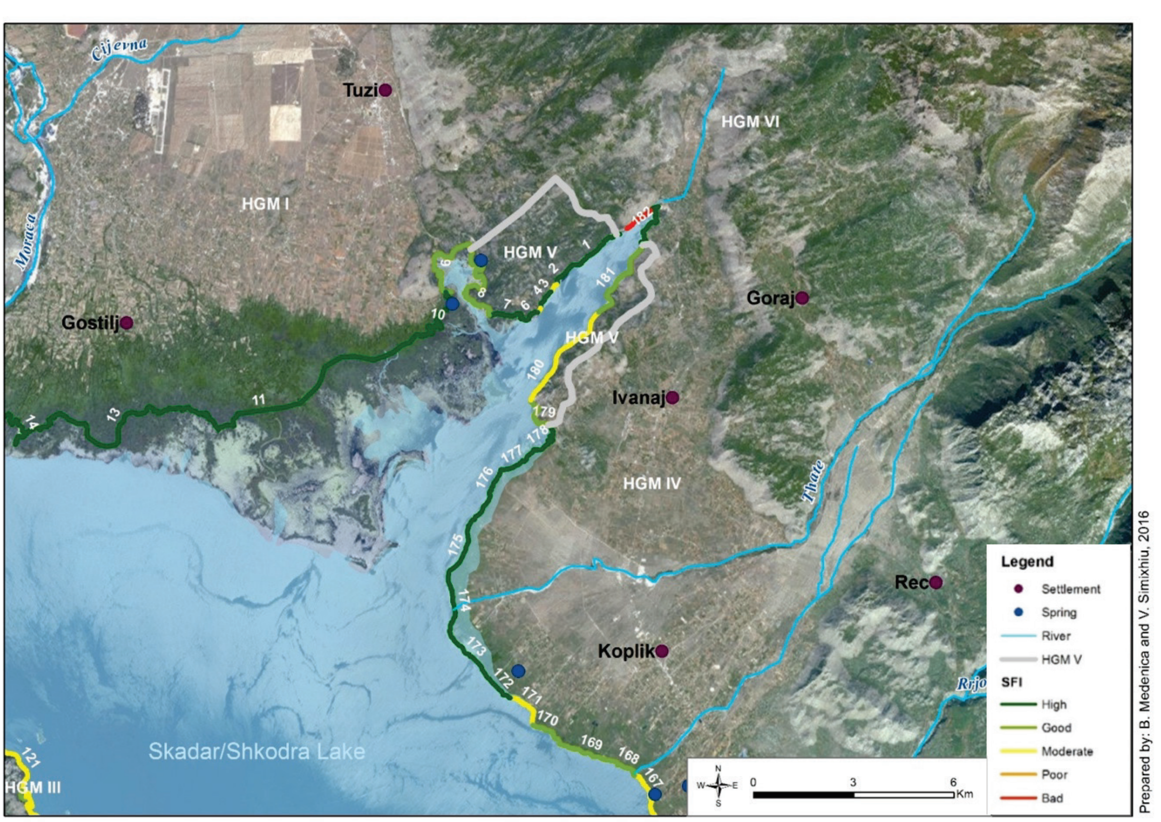


Figure 44. Catchment area of HGM area V – Eastern hills (Montenegro–Albania border area)

Close to the eastern border between Albania and Montenegro, a small hilly ridge separates the lake from the surrounding territory. On the Albanian side the hill is mainly bare and there are no signs of human presence, while on the Montenegrin side the main road that connects the border with Podgorica runs along the shore limiting the width of the shorezone.

In both cases the sloping topography of the shorezone limits the growth of riparian vegetation, which can only grow close the shoreline in a belt a few metres wide. Rather than being continuously present, reeds are generally concentrated in bays. The hills differ from the ridges found in HGM area III as the lake is quite shallow in HGM area V. This allows reeds and other aquatic plants to grow, which increases the width of the functional shorezone.

The Montenegrin section of the lake in this area is typically classified as shorezone typology 1, as the shallower waters enable more vegetation to grow. The Albanian side is, however, typically classified as typology 2 or 3, as riparian trees are mainly replaced by scattered shrubs and the surrounding territory is less verdant.

Figure 45. Example of a functionality category 1 shorezone in the Montenegrin section of HGM area V

Figure 46. Example of a functionality category 3 shorezone in the Albanian section of HGM area V

3.1.6 HGM area VI – Hani i Hotit (Albania)

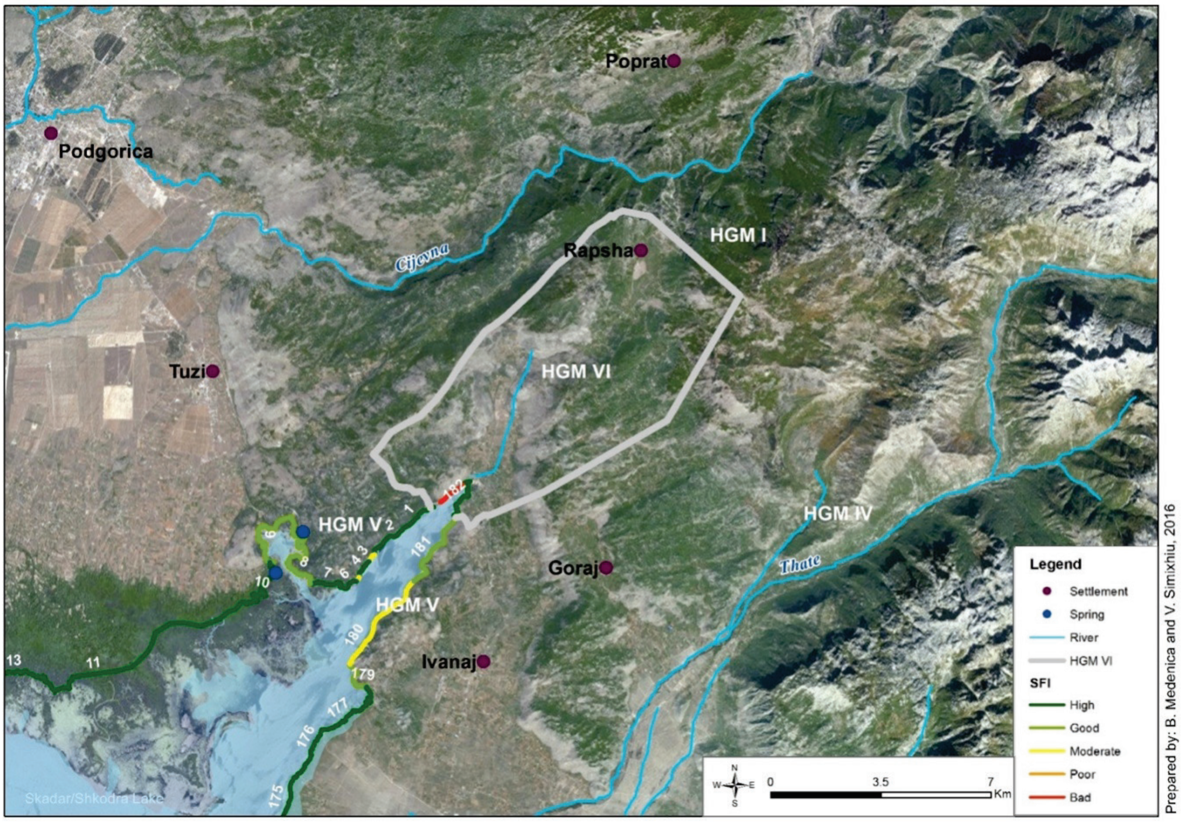


Figure 47. HGM area VI – Hani i Hotit, Albania

HGM area VI is located close to Albania's eastern border and comprises the small plain of Hani i Hotit. This area has only one homogeneous stretch, which is characterised by marshland (category 1). Different to HGM area V, the surrounding territory is flat and is farmed by several families who have plots here.

Figure 48. Example of a functionality category 1 shorezone in HGM area VI, Albania

3.2 Main shorezone typologies

Most of the shorezones of the lake display excellent or very good functionality, with homogeneous stretches carrying out different ecological functions such as nutrient removal from surface runoff that enters the lake, protection against shore erosion and habitat provision for aquatic and terrestrial species. In general, there are four different types of shore along Skadar/Shkodra Lake. They are determined by the presence of riparian vegetation, the gradient of the shorezone and the level of human intervention.

3.2.1 Typology 1: wide belt of riparian vegetation

Typology 1 is characterised by a thick belt (> 50 metres wide) of riparian vegetation (shrubs and trees), sometimes accompanied by reeds in the littoral zone. It provides high levels of complexity and functionality (SFI = 1) and is typically found in HGM areas I-A and I-M (where A = Albania and M = Montenegro).

Figure 49. Example of a typology 1 shorezone: riparian vegetation (shrubs and trees), with or without reeds, more than 50 m wide, natural, with a high level of complexity and functionality

3.2.2 Typology 2: narrow belt of riparian vegetation

The most common typology, covering around 70% of the lake's perimeter, comprises a natural belt of riparian vegetation with limited width (generally 10 to 30 m wide), sometimes accompanied by reeds in the littoral zone.

The width of the riparian belt, compared to typology 1 where the surrounding territory is generally flat, is naturally reduced due to the slope of the shorezone. The growth of the terrestrial riparian vegetation is therefore limited to the area closer to the shore. The presence of reeds in the littoral zone increase the overall areas considered as functional.

The reduced width of the functional zone results in lower functionality, and the SFI results vary between category 1 (high) and category 2 (good).

Typology 2 is typically found in HGM areas II-M, V-A, V-M, mostly in the northern and north-western parts of the lake.

Figure 50. Example of a typology 2 shorezone: riparian vegetation (shrub and trees), with or without reeds, a width of 10 to 30 m, 100% natural, and a good level of complexity and functionality

3.2.3 Typology 3: thin layer of shrubs

The third typology, which covers more than 20% of the lake's perimeter, comprises stretches without any level of artificiality but with lower levels of functionality due to the limited width (10 m wide) of the riparian vegetation. The vegetation in these stretches usually consists of very narrow bands of shrubs and small trees.

The sloping topography of the shorezone limits the growth of riparian vegetation, which can only grow close the shoreline in a belt a few metres wide. Also, because the lake deepens sharply close to the shore, reeds cannot develop in these stretches.

The limited growth of riparian vegetation is also, in certain stretches, due to high levels of anthropogenic pressure, such as uncontrolled grazing, that have occurred in the areas in question. This typology falls into the moderate SFI category (SFI = 3) and it is typically found in HGM areas III-A and III-M, which are mostly located on the western side of the lake.

Figure 51. Example of a typology 3 shorezone: the shrubs have low functionality, the shorezone is less than 10 m wide

3.2.4 Typology 4: reeds followed by bare soil/crops

Typology 4 is characterised by a belt of reeds followed by bare soil or market gardens planted almost to the shoreline. This typology is only present in HGM area 4-A, which is the only area where intensive cultivation occurs so close to the lake.

The SFI results are in the moderate category (SFI = 3) because, despite the lack of riparian vegetation on land, the reeds are still able to carry out some nutrient buffering functions and to provide habitat to local fauna.

Figure 52. Example of a typology 4 shorezone: reeds and bare soil, low level of complexity and functionality

3.2.5 Typologies 5 and 6: bare soil/grass and artificial shorezone

The fifth and sixth typologies, covering around 7% of the lake's perimeter, comprise natural areas with bare soil/grass, or partially or wholly artificial shorezone. They are usually found in areas with strong anthropogenic impact (mortar-bonded walling enclosing private gardens or main traffic routes and railway lines, parking areas, farmed land, etc.) or in tourism areas (artificial beaches).

A mortar-bonded wall along the shorezone reduces its functional width to zero, limiting the buffering capacity of the riparian zone and interrupting its ecotone role between aquatic and terrestrial environments. Typologies 5 and 6 are found mostly in semi-urbanised or urbanised areas, which appear in a dispersed form all around the lake and in a concentrated form in the north-western section and the southern end of the lake.

When reeds are present in typology 5 and 6 littoral zones, as they sometimes are, the overall shorezone functionality improves. The SFI categories here are nevertheless poor and bad (SFI = 4 and 5).

Figure 53. Example of a typology 5 shorezone: artificial

The survey's study of tourism infrastructure (gangways, facilities, cycle lanes, campsites, beaches, piers, etc.) revealed that its presence usually coincides with the presence of artificial shorezone.

The area considered for this parameter runs inland from the shoreline for 200 metres and the value is given as a percentage of presence of tourism infrastructures, such as beaches, hotels, pedestrian and bicycle paths (0% = absent; 100% = present along the whole stretch), weighted according to the ecological impact the infrastructure has on the shorezone (e.g. a beach has a stronger impact than an unpaved hiking trail).

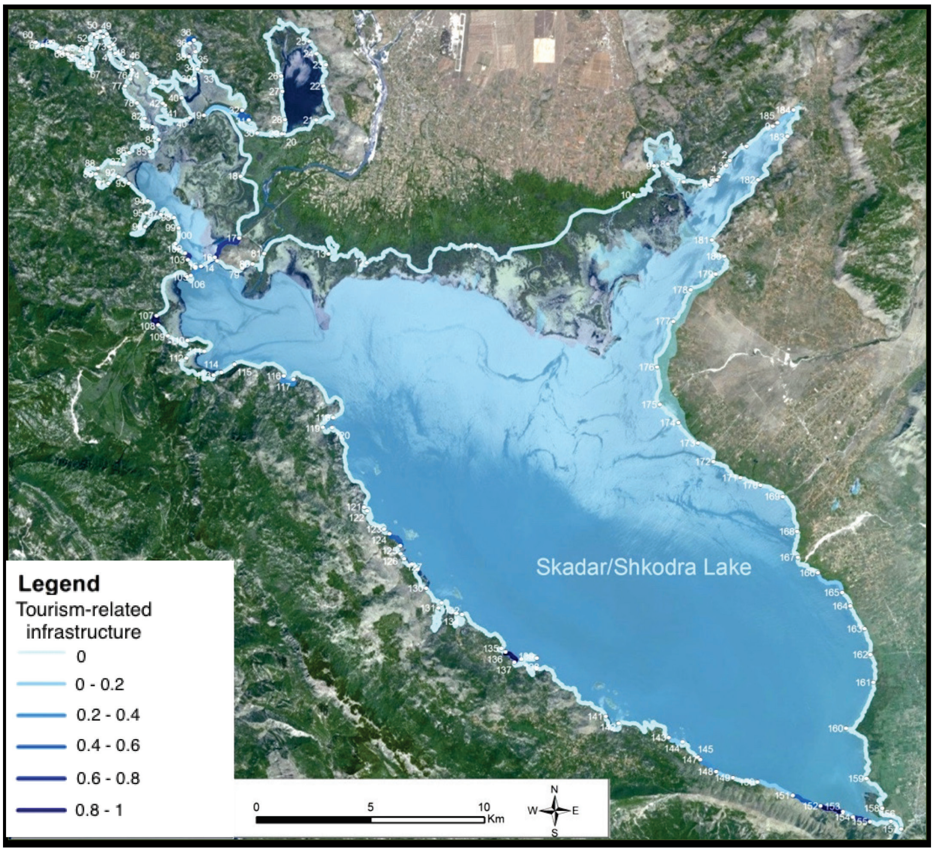


Figure 54. Tourism infrastructure (%)

3.3 SFI of the lake as a whole – Montenegro and Albania

3.3.1 SFI software results

The entire lake shoreline – i.e. the combined Montenegrin and Albanian shorelines – is about 268.6 km long. During fieldwork, 183 homogeneous stretches were identified, each distinguished by a unique set of characteristics.

The results show that about 46.0% of the total perimeter of the lake falls into the high category, 23.4% into the good, 24.8% into the moderate, 0.9% into the poor, and 4.9% into the bad (Figure 56).

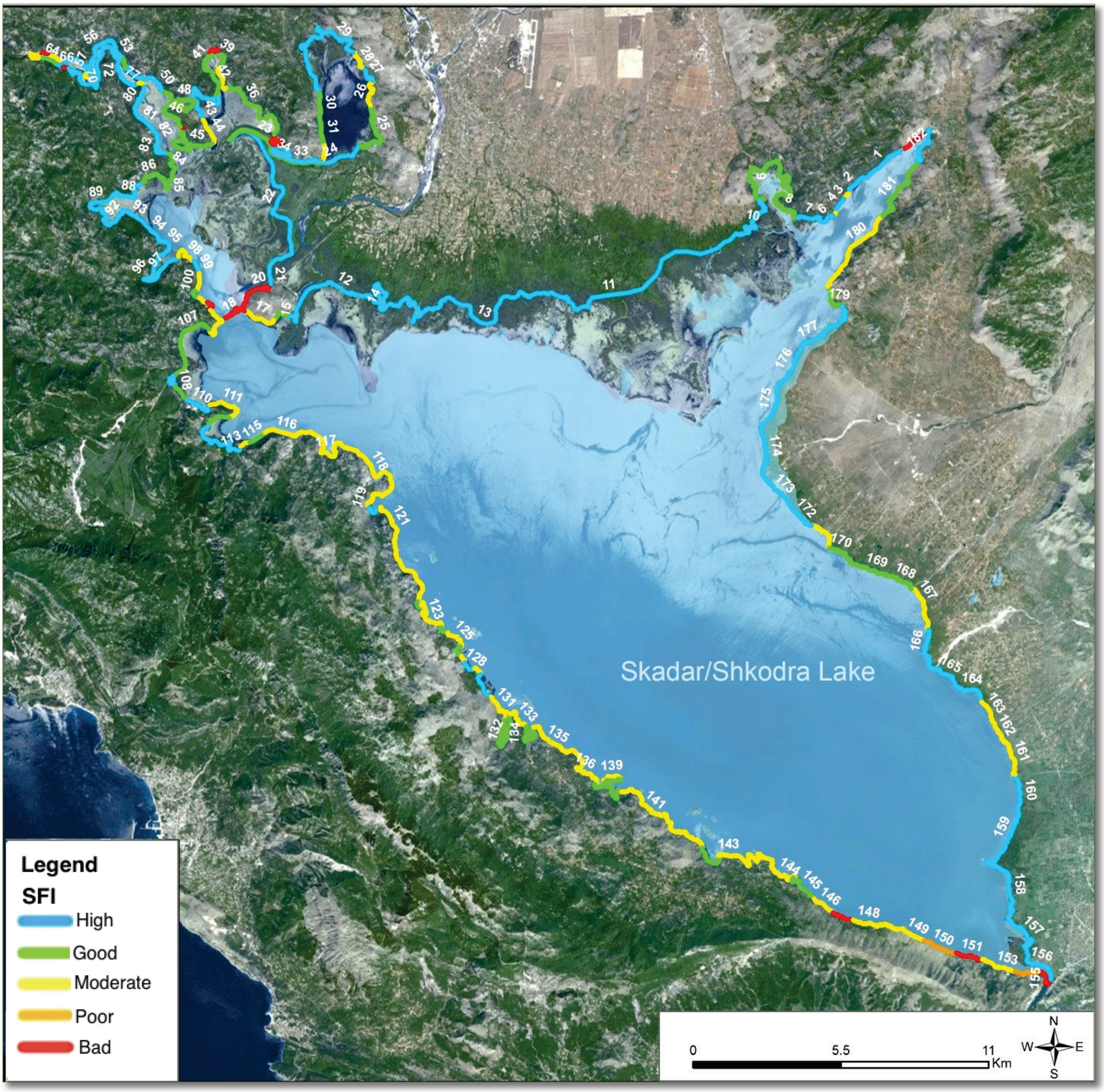


Figure 55. Shorezone Functionality Index for the whole of Skadar/Shkodra Lake
(Montenegrin and Albanian territories combined)

Table 18. Total number, length and percentage of length of sections with various SFI values (Montenegrin and Albanian territories combined)

SFI value	No of stretches identified	Total km	Percentage
1 - high	77	123.5	46.0
2 - good	39	62.8	23.4
3 - moderate	51	66.5	24.8
4 - poor	2	2.5	0.9
5 - bad	14	13.2	4.9
TOTAL	183	268.6	100.0

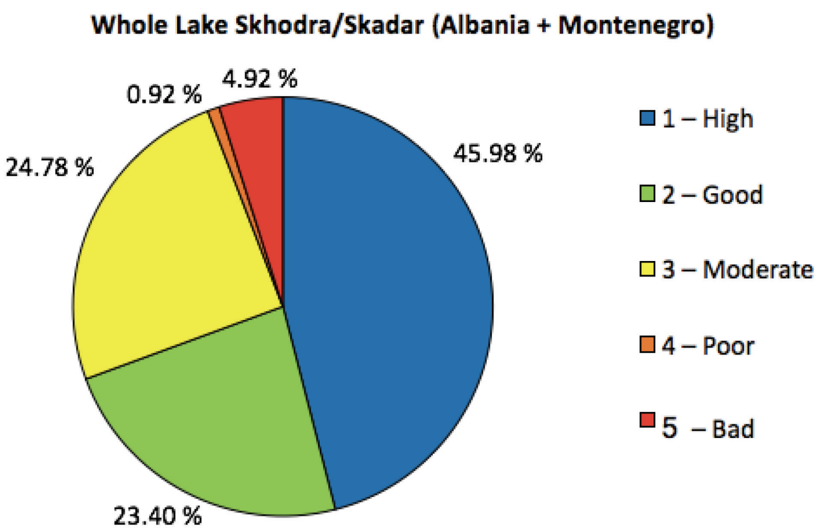


Figure 56. Shorezone Functionality Index percentages for Skadar/Shkodra Lake as a whole (Montenegrin and Albanian territories combined)

SFI category 1 – high

In all, 77 stretches (46.0% of the whole perimeter of the lake or 123.5 km) are categorised as having a 'high' shorezone functionality. Together they occupy the largest area of the lake shoreline and comprise continuous hygrophilous arboreal-shrub and reed vegetation. Most of the high-category shoreline is concentrated along the northern and eastern sections of the lake, corresponding to those areas already determined to have a higher level of naturality (HGM areas I, II and IV).

SFI category 2 – good

A large area of the lake's shorezone is categorised as 'good' (39 stretches comprising 62.8 km or 23.4% of the total perimeter). Here, the shoreline has consistent cover of predominantly dense native hygrophilous vegetation, but it has a limited functional width. Shoreline categorised as good is found in the north-western and, to some extent, south-western sections of the lake (HGM area II).

SFI category 3 – moderate

A total of 51 stretches, comprising 66.5 km or 24.8% of the total perimeter, are categorised as 'moderate'. The stretches that fall into this category are mostly dominated by a very narrow band of chaste trees (*Vitex agnus-castus*), or are rocky terrain with high naturality but low functionality. Shoreline categorised as moderate is usually found in the south-western and southern sections of the lake (HGM area III).

SFI category 4 – poor

The software categorised only two stretches as 'poor'. They are both located at the southern end of the lake on the Albanian side in areas dedicated to tourism (HGM area III). Together they comprise 2.5 km or 0.9% of the total perimeter of the lake.

SFI category 5 – bad

Only 14 stretches, comprising 13.2 km or 4.9% of the total shorezone, lack functionality. These are areas that have experienced a high level of anthropogenic impact, particularly the shoreline of the urban area in the north-western section of the lake on the Montenegrin side and in the tourism area at the southern end of the lake in Albania (HGM areas II and III).

3.3.2 Shorezone land use

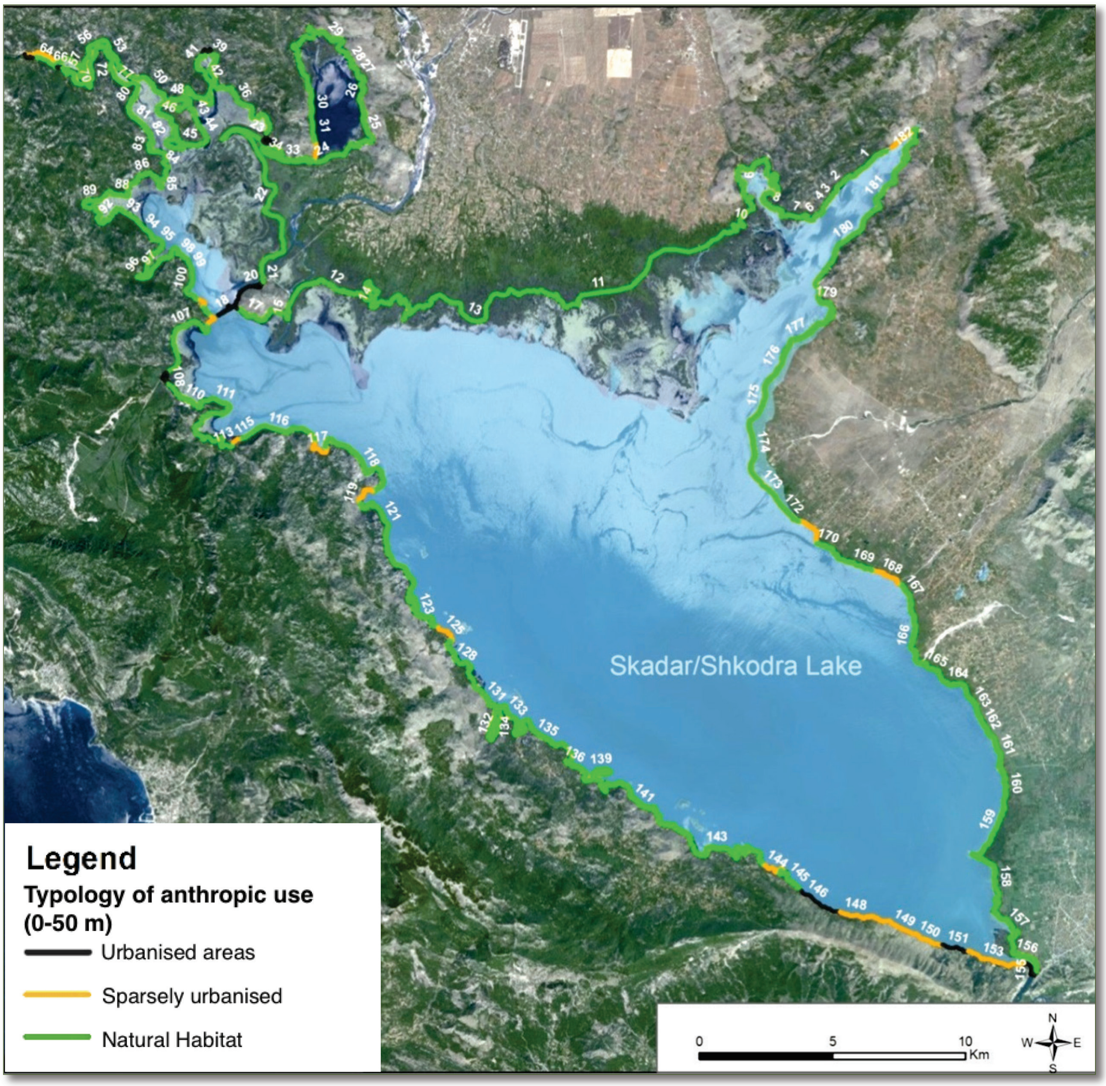


Figure 57. Anthropogenic use of the shorezone (from the shoreline to 50 metres inland)

Information on the types of anthropogenic use of the lake shorezone (from the shoreline to 50 metres inland) and of the surrounding territory (from the shoreline to 200 metres inland) was also collected during the survey.

As shown in Figure 57, most of the shorezone appears to be in natural state. Sites of sparse urbanisation, fields under cultivation (yellow) and urbanised areas (black) are easy to discern. It should be noted that this parameter looks at the overall status of the homogeneous stretch identified, and that the SFI value corresponds to the most prevalent typology in that stretch. If a one-kilometre-long homogeneous stretch contains a small urbanised area and this settlement does not impact on its surrounding environment, it will be assessed using the 'presence of interruption' parameter. An interruption is any intervention or work that in any way can reduce, affect, or limit the functionality of the vegetation in the lake shorezone, for example house gardens, vegetable plots, parking areas or other infrastructures.

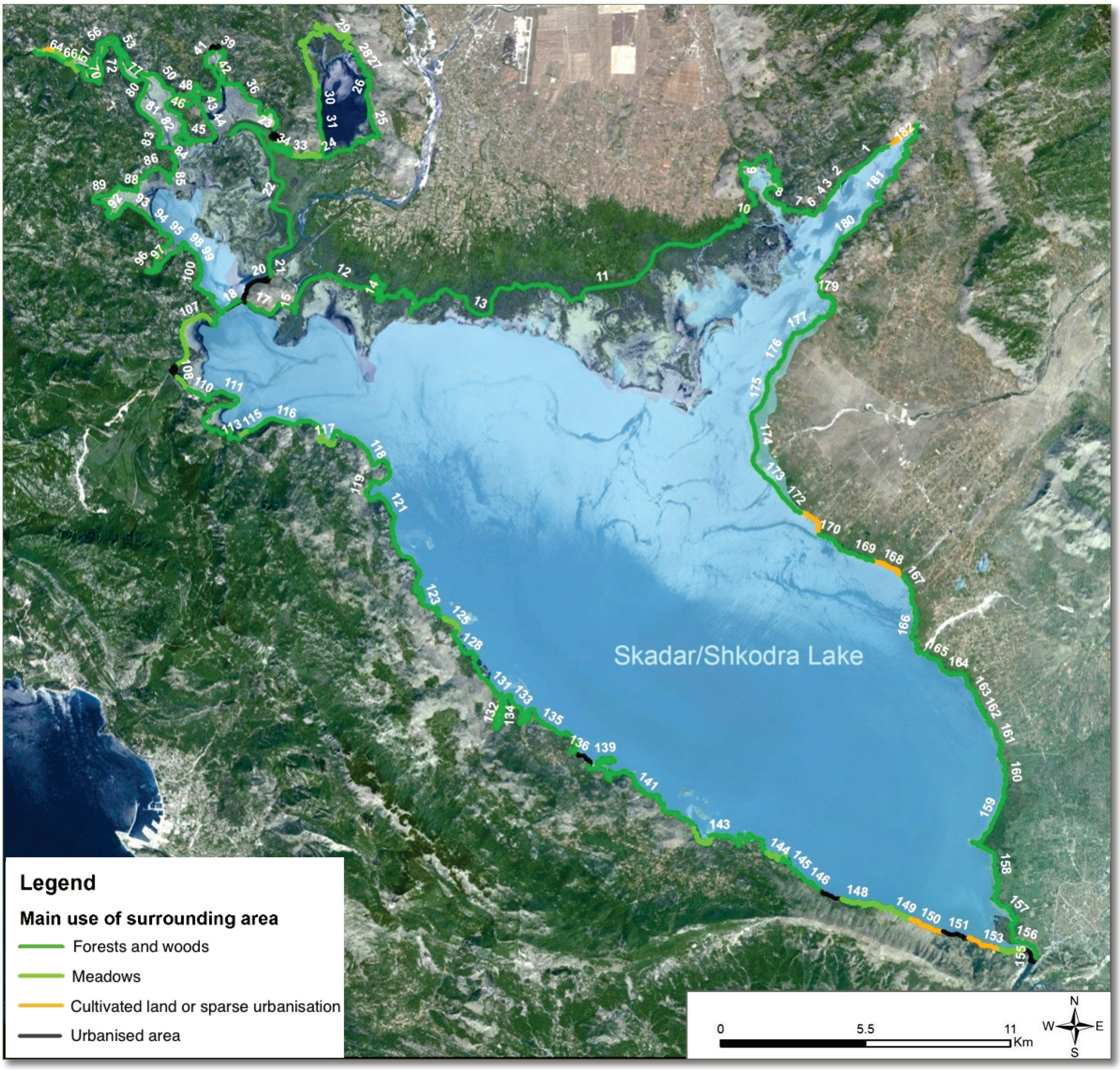


Figure 58. Anthropogenic use of the surrounding territory (0 to 200 metres inland from the shoreline)

The map of the main uses of surrounding areas reflects, in part, the data shown on the map of main types of anthropogenic use. Figure 58 describes the prevalent human activities occurring in the area running from the shoreline to 200 metres inland. It therefore indirectly indicates any repercussions on the shorezone's functionality occurring as a result of the modification of the surrounding soil that can increase the input of nutrients, organic matter and pollutants, and can change the natural permeability of the soil. The prevalent human use present in each identified homogeneous stretch is adopted as the use for that stretch.

Most of the shorezone comprises pristine environment (dark green line) or a balanced co-presence of human activities and natural environment (light green line). Only a few sections are under intensive cultivation or are tourism or urbanised areas (orange and dark grey line).

3.3.3 SFI results for Montenegro

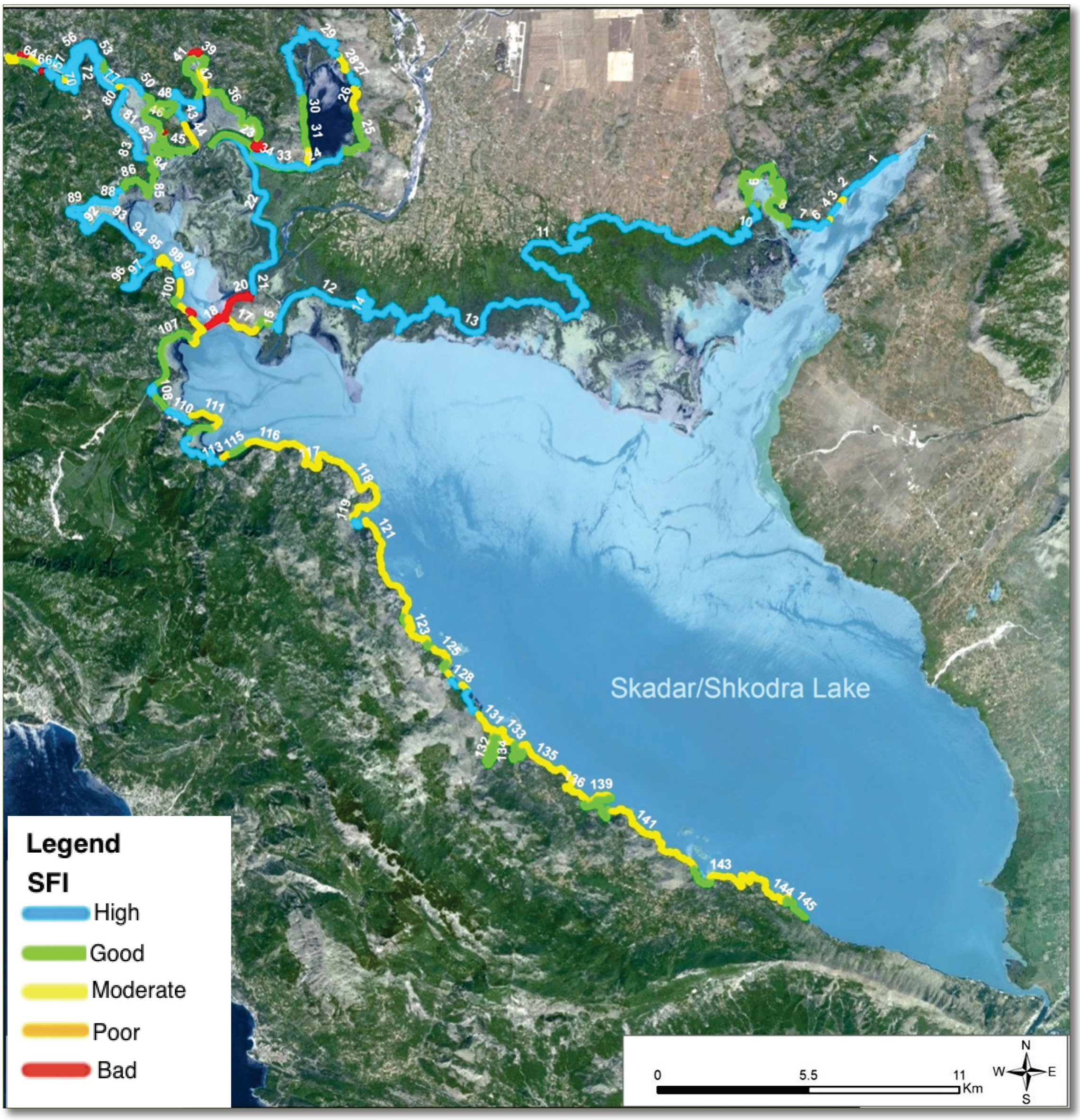


Figure 59. Shorezone Functionality Index for the Montenegrin side of Skadar Lake

The shoreline of the Montenegrin side of the lake is 208.8 km long and contains 145 homogeneous stretches.

When applied to the Montenegrin section of the lake's shoreline, the software provided the following results: the largest share, 45.0% of the total perimeter of this part of the lake, is categorised as high; 26.2% is good; 24.3% is moderate; and 4.5% is bad. No stretch falls into category 4 – poor.

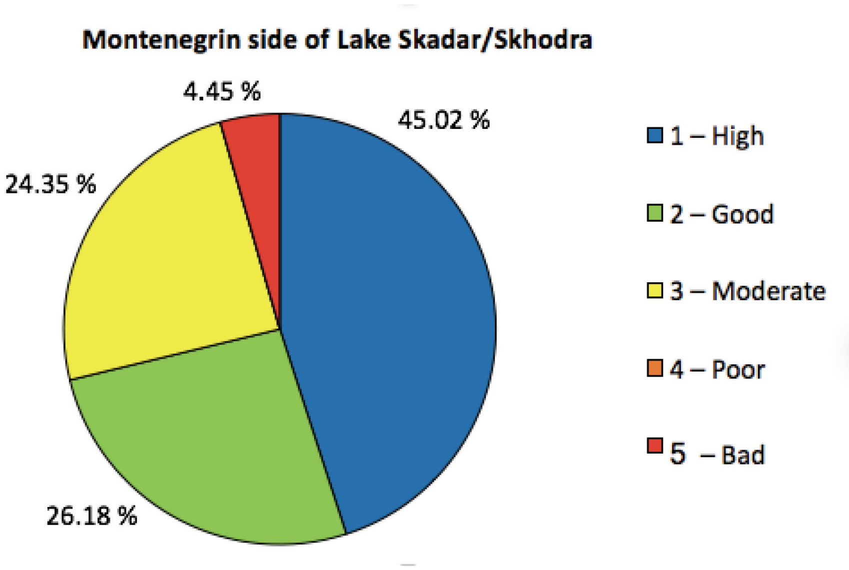


Figure 60a. Percentages of the SFI values for the Montenegrin side of Skadar Lake

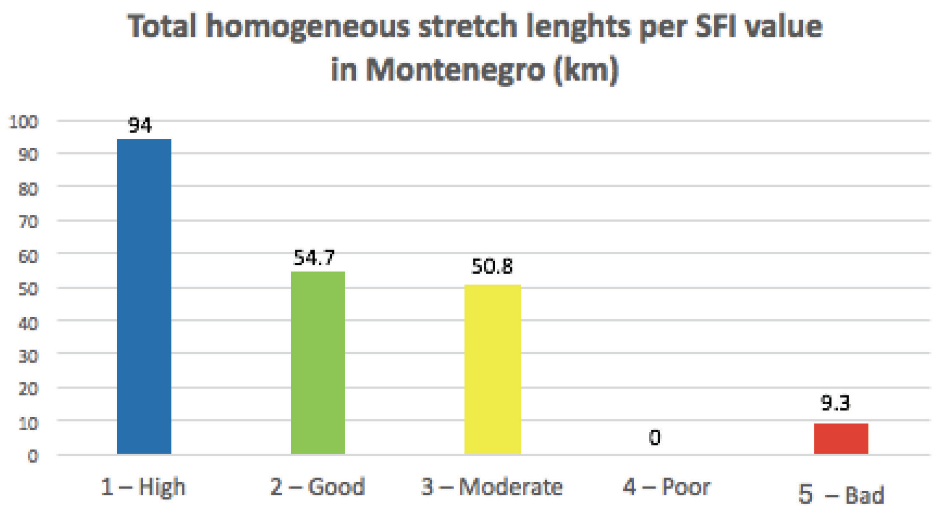


Figure 60b. Shorezone Functionality Index per length (kilometres) for the Montenegrin side of Skadar Lake

In all, 61 stretches of Montenegrin shoreline (45.0% or 94 km) were determined to fall into SFI category 1 (high value). Together these stretches make up the largest area of the Montenegrin lakeside and contain continuous hygrophilous arboreal-shrub vegetation, continuous reed belts, no infrastructure and no tourism activities.

Table 19. Total number, length and percentage of length of sections with various SFI values (Montenegrin territory)

SFI value	No of stretches identified	Total km	Percentage
1 - high	61	94.0	45.0
2 - good	34	54.7	26.2
3 - moderate	40	50.8	24.3
4 - poor	0	0	0
5 - bad	10	9.3	4.5
TOTAL	145	208.8	100.0

Most of the category 1 shoreline in Montenegro is concentrated in (a) the north, from Podhumski Zaliv Bay to Plavnica, which is in HGM area I, and (b) the north-western section of the lake, around Poseljanski Zaliv Bay and the natural area of Rijeka Crnojevića (Šanik, Pavlova Strana, Rudina, Prevlaka), which is in HGM area II.

On the northern shore of the lake (from Humsko Blato through Podhumski Zaliv Bay to Plavnica) the shore land is flat, so fewer very long homogenous stretches can be observed that are predominantly in category 1. This is due to the uniform shape of the shoreline and the uniform physical and relief conditions (flat and extremely long and wide shorezone) of the north shore.

Category 1 areas are mainly found in the northern part of the lake where the environment is more pristine, these is less urbanisation, and there is a wide belt of white willow (*Salix alba*) mainly interspersed with narrow-leafed ash (*Fraxinus oxycarpa*) and wide reed beds along the shoreline, adjacent to the tree line.

Figure 61. Example of the flat, non-urbanised shore in the northern part of the lake that is classified as SFI category 1

In the Humsko Blato and Podhumski Zaliv Bay area, two sites are designated as special nature reserves requiring a high level of protection: Pančeva Oka and Crni Žar. Because of the richness of the biodiversity found in these areas, the conservation of these sites is of major importance, both nationally and internationally. As such, we consider this area to be free of infrastructure and tourism (except visits undertaken for scientific research, bird watching, etc.) and thus of the impacts they engender.

A large area of the lake's Montenegrin shorezone (34 stretches, about 26.2% or 54.7 km) is classified as SFI category 2 (good). It is characterised by consistent shoreline that is predominantly covered by dense native and mainly hygrophilous (arboreal-shrub and reeds) vegetation, which grows without interruption along the lake shore. A large part of the category 2 shoreline is found in (a) the north-west, in the natural area of Rijeka Crnojevića (Šanik, Pavlova Strana, Rudina, Prevlaka), which is in HGM area II, and (b) the northern part of the lake (Podhumski Zaliv Bay to Plavnica), which is split between HGM areas I and V. Also, a large number of category 2 stretches are found in bays situated in the south-western part of the lake where the shorezone is flat or has a very gentle gradient, and contains hygrophilous arboreal-shrub vegetation and very well-developed wet reed vegetation.

Figure 62. Example of a natural shorezone with good functionality that is classified as SFI category 2

In all, 40 stretches, or 24.3% of the lake's Montenegrin shorezone (50.8 km), is classified as SFI category 3 (moderate). The stretches that fall into this category are usually found in the south-western part of the lake in HGM area III. Even though fully natural, the majority of the shoreline in this part of the lake has a lower level of functionality because the riparian vegetation has a limited width. It is generally formed by a very narrow band of shrubs and small trees (mostly chaste trees), separated with small areas of bare rock. For this reason, although there is a 'total absence of artificiality', these stretches' levels of functionality mean they can only attain SFI category 3. This is due to the steepness of the shore's topography and the nature of the substrate that prevents functional riparian vegetation growing in wider belts upland.

Figure 63. Example of a natural shore zone with lower functionality that is classified as SFI category 3

No stretches of the lake's Montenegrin shoreline were classified as SFI category 4 (poor). In all, 10 stretches, comprising 4.5% or 9.3 km of the total Montenegrin shoreline (208.8 km), do not have any functionality and are thus classified as SFI category 5 (bad). They are concentrated in areas experiencing strong anthropogenic impact, especially along the shorelines of the villages of Virpazar, Vranjina, Rijeka Crnojevića, Karuč and Dodoši, and in the north-western section of the lake, which belongs to HGM area II.

Figure 64. Example of an area experiencing strong anthropogenic impact and having poor functionality (SFI category 5)

3.3.4 SFI results for Albania

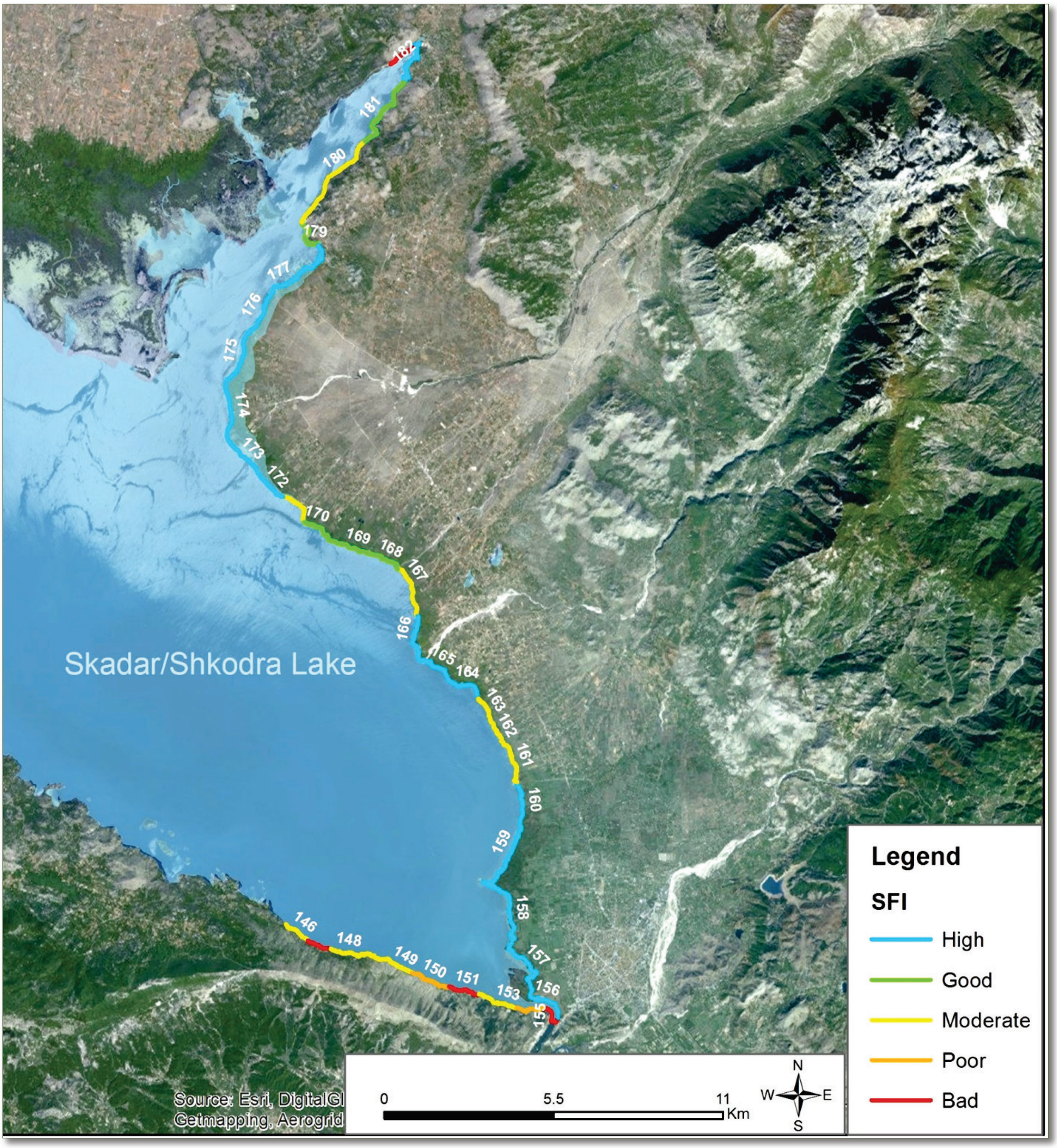


Figure 65. Shorezone Functionality Index for the Albanian side of Shkodra Lake

The shoreline of the Albanian side of the lake is about 59.7 km long and composed of 38 homogeneous stretches defined according to the diverse features they contain that determine their functionality.

Table 20. Total number, length and percentage of length of sections with various SFI values (Albanian territory)

SFI value	No of stretches identified	Total km	Percentage
1 - high	16	29.4	49.3
2 - good	5	8.2	13.7
3 - moderate	11	15.7	26.3
4 - poor	2	2.5	4.2
5 - bad	4	3.9	6.5
TOTAL	38	59.7	100.0

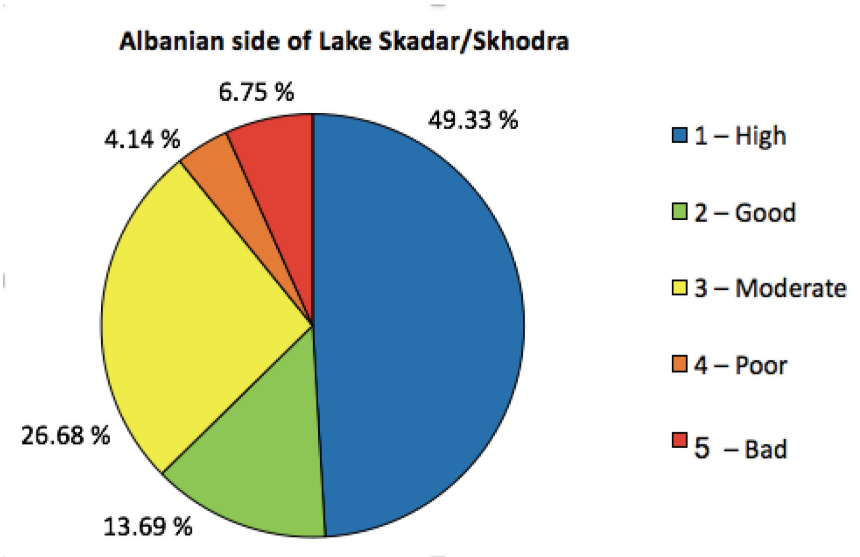


Figure 66a. Percentages of the SFI values for the Albanian side of Shkodra Lake

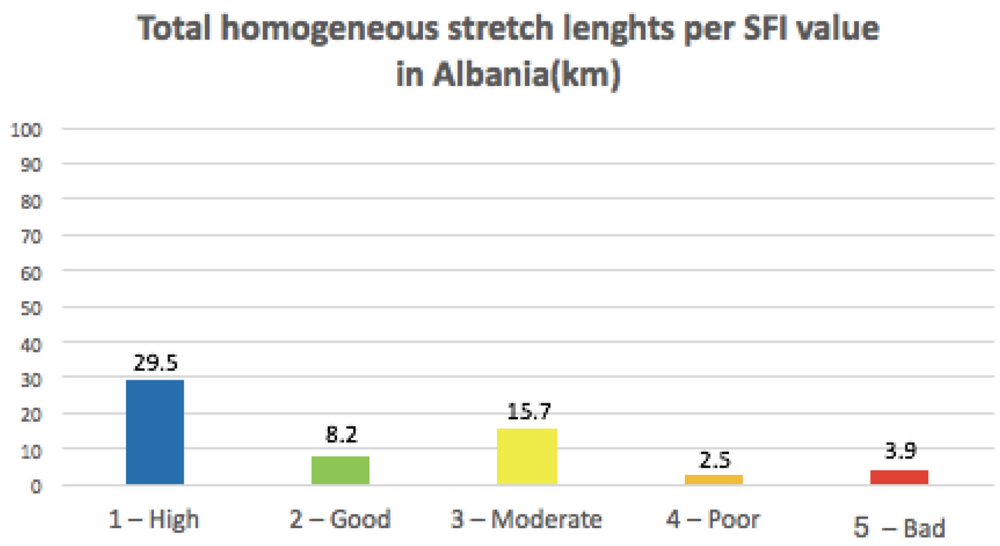


Figure 66b. Shorezone Functionality Index per length (kilometres) for the Albanian side of Shkodra Lake

Category – high

The majority of the lake's Albanian shoreline – 49.3% of the total shoreline or 16 homogenous stretches – is classified as SFI category I (high). These are clustered in three groups of contiguous stretches (nos 156–160, 164–166 and 172–178) except for stretch no 182, which is bordered by two stretches that fall into other SFI categories.

These stretches are found in HGM areas I-A and IV, which are areas of plain. They are covered with continuous hygrophilous arboreal-shrub vegetation and have wide and continuous belts of reeds.[6] Anthropogenic impacts in these areas are negligible: there is no infrastructure or significant tourism activity. Most of the category 1 shoreline in Albania is concentrated in the north-eastern part of the lake. However, one group of stretches is located in the south-eastern part.

Category – good

Only a small area of the shorezone is classified as category 2 (good). The five stretches falling in this category total 8.2 km in length and make up only 13.7% of the overall Albanian shoreline. Three of the stretches are grouped (nos 168–170) in the middle part of the Albanian shoreline in an area of high plain (HGM IV). The other two (nos 179 and 181) are located in the hilly area that starts in Syri i Sheganit and ends at Vukpalaj-Bajze, with the two stretches separated from each other by the Skajc hills (HGM V-A).

The main factor hindering functionality in stretches 179 and 181 is the limited shoreline where the hills begin. Meanwhile, in stretches 168–170 it is the impact of villages situated near the shore that impairs functionality. That said, anthropogenic impact remains very low in these stretches. In general, the stretches are characterised by consistent shoreline that predominantly contains hygrophilous vegetation and reed belts.

Category – moderate

In all, 11 stretches, comprising 26.3% or 15.7 km of the Albanian shoreline, are classified as SFI category 3 (moderate). Five are situated in the tourism area of Zogaj-Shiroka (stretches 146, 148, 149, 152 and 153). Three other stretches (161–163) are situated near the Vraka River, while the remaining three lie further away in the north-eastern part. Among the category 3 stretches, nos 146 and 180, which fall in HGM area III-A, are mainly natural areas. However, they are hilly and lack significant functional vegetation. The other stretches falling in HGM area IV experience moderate impact from tourism activities or agriculture occurring near the shoreline.

Category – poor

Only two stretches, comprising 4.14% or 2.47 km of the Albanian shoreline, are classified as category 4 (poor). Both are found in the tourism area of Shiroka village where terrestrial vegetation is scarce, the reed belt is insufficient, and human impacts are significantly high. There is some infrastructure in the shorezone of stretch 150 and a landfill site is located very near stretch 154. They both fall in HGM area III-A.

Category – bad

[6] Editors' note: Reed grasses can have detrimental or beneficial effects on ecosystems. The vast stretches of reed in the north-eastern floodlands towards the Zeta Plain effectively reduce nutrient input into the lake. However, the absorption of nutrients also leads to an encroachment of reeds, thereby degrading the (former) ecological status of this part of the lake. In contrast in the south-western part, reeds are also common but more widely dispersed. Here they are considered as beneficial because they add structural diversity, provide important spawning and breeding habitats for fish and birds, respectively, and reduce nutrient load.

Four stretches, comprising 3.9 km or 6.5% of the total Albanian shorezone, are classified as category 5 (bad). Three of these stretches (147, 151 and 155) lack any functionality and are situated around the tourism area of Zogaj-Shiroke in HGM area III-A. The remaining stretch is located in the north-eastern part of the lake, alongside the border with Montenegro. All those stretches experience very high anthropogenic impact such as roads running alongside the shoreline, different kinds of buildings, logging and reed cutting, and non-functional tree planting, to name but a few.

Conclusions

- The functionality of the majority (60%) of the Albanian shoreline is classified as either good or high. The high functionality areas are mainly situated in the north-eastern part of the shoreline but also close to Shkodra city in the south-eastern part of the lake.
- It is interesting to note that stretches classified as category 2 and especially category 1 tend to be grouped contiguously (156–160, 164–166, 172–178,168–170) or close to each other (179 and 181).
- Only six stretches were classified as either poor or bad. Except for the stretch located at the north-eastern end of the lake (by the border with Montenegro), all the other stretches with very low or no functionality are found in the Zogaj–Shkodra zone where urban infrastructure is present. Furthermore, these stretches are separated from other stretches with moderate functionality.
- While areas with moderate functionality are dispersed all over the shoreline, they are most common along the south-western part of the lake (Zogaj–Shiroke).

3.3.5 Expert judgement of the SFI results

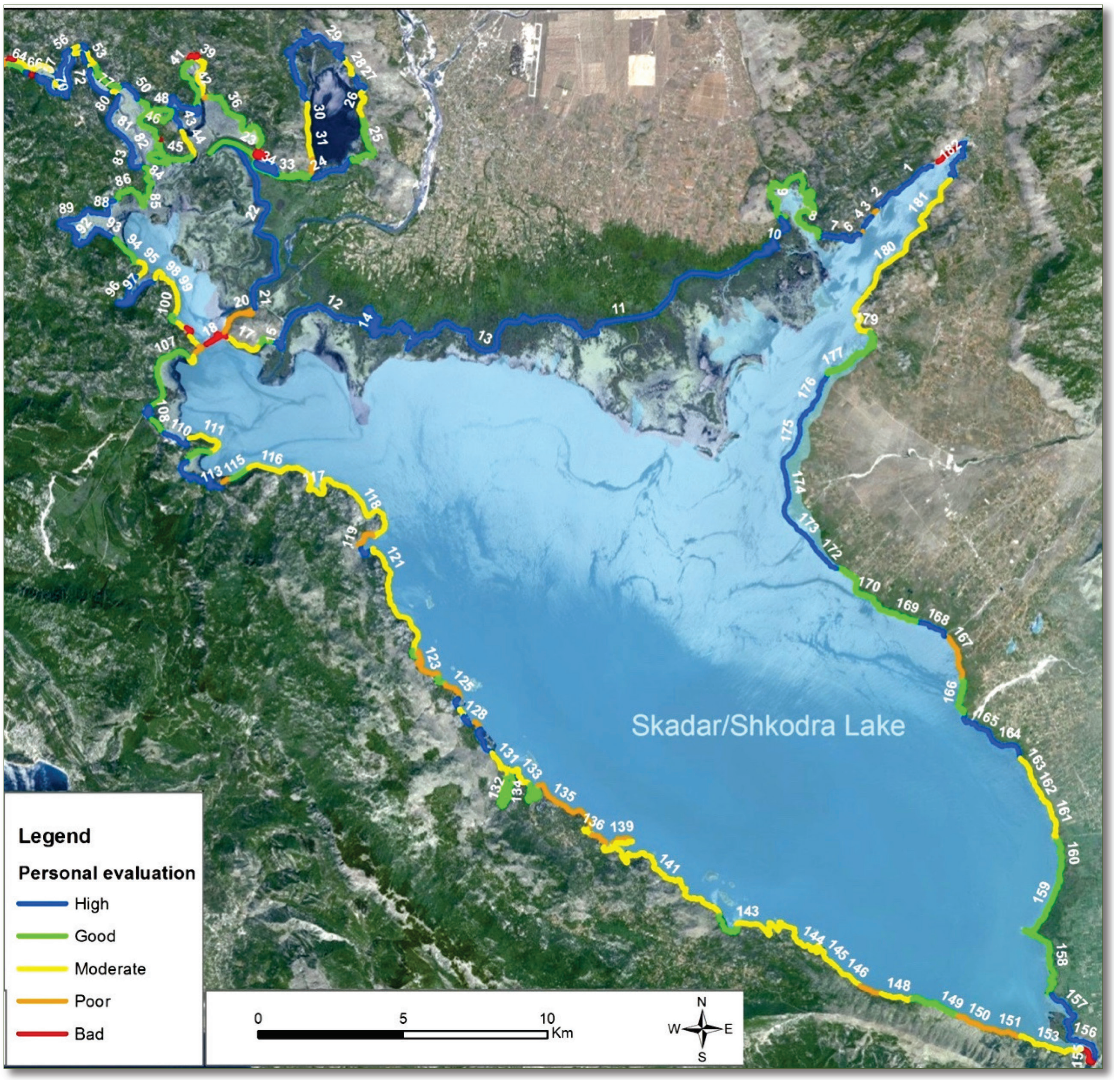


Figure 67. Shorezone Functionality according to expert judgement (Montenegrin and Albanian sides)

After compiling the form and examining each main parameter with the help of the SFI software, Montenegrin experts conducted their own assessment of shorezone functionality of all homogeneous stretches surveyed, based on expert judgement. This data was used to further develop and validate the SFI method (Table 21).

Table 21. Total number, length and percentage of length of sections with various SFI values, determined through personal evaluation, for the Montenegrin side of Skadar Lake

SFI value	Total km as per SFI results	Total km as per expert assessment	Approx. difference (km)
1 - high	123.5	106.6	- 17
2 - good	62.8	65.6	+ 3
3 - moderate	66.5	67.2	+ 1
4 - poor	2.5	20.3	+18
5 - bad	13.2	8.9	- 5

3.4 Management recommendations

3.4.1 Common recommendations

Restoration and/or protection

- The entire lake should be considered as a living organism. Its protection should be maintained in Montenegro and extended to the Albanian side as well.
- While it may ultimately be desirable to extend protection to the entire lake, areas of high functionality (HGM area I) and importance for the conservation of species and also habitats of national and/or community interest (Natura 2000) should be prioritised.
- The remaining natural forest in Albania should be preserved and protected, and reforestation projects should plant native trees.
- Grazing near the shoreline should be restricted. Maintaining a 30-metre (or wider) belt of riparian vegetation/reeds is recommended near river estuaries and springs to ensure effective nutrient removal.
- Protecting a functional shorezone – and thus an effective buffer against diffuse pollution – is particularly important near Malo Blato (in HGM area II), where a significant water intake for the regional drinking water supply system of the whole Montenegrin lake coast is located. Other important shorezones to be protected are
  - the shorezone in HGM area I, as a buffer against pollution coming from the surrounding territory and due to its importance as a nesting site;
  - the shorezone in HGM area II, for both its buffer function as well as its high ecotourism potential; and
  - the high- and good-status stretches in HGM areas III and IV, as they could provide safe resting areas for aquatic and terrestrial fauna migrating along the lake.

Planning and further research

- Urban planning should maintain and enhance shorezone functionality as much as possible and should emphasise the desirability of a shoreline that is continuous and healthy. Impervious surfaces should be avoided and native vegetation preserved and replanted. Some stretches will either be naturally more vulnerable or suffer from interruptions in continuity. These should therefore be subject to limits on construction and strict pollution controls.
- Development should be geared towards small-scale, sustainable ecotourism and services, preferably making use of already existing facilities, including beaches.

Infrastructure measures

- Adequate wastewater treatment facilities are urgently needed for urban centres and treatment capacity should be installed to all new tourism developments.
- Town and country planning policy should stipulate landscaping and design that supports the shorezone functionality and therefore the good status of Skadar/Shkodra Lake. Such policy should be based on the following principles:
  - Avoid artificial greenery (or exotic species) in the shorezone, and preserve or plant native vegetation.

- Avoid the construction of impermeable walling or surfaces in riparian zones. Where walling is required, build permeable walls with rocks and timber that do not interrupt the continuity between the terrestrial and aquatic environments.
- Preserve the continuity of the healthy shoreline as much as possible.
- In stretches that are not functional or have poor functionality, the status of the surrounding territory plays an important role. Particular attention should therefore be paid to possible polluting inputs in these areas and its prevention (e.g. prioritise natural areas over cultivated/fertilised areas).
- In stretches that are naturally vulnerable (e.g. rocky shores or narrow vegetation belts), which are commonly typology 3 and typology 4, limit construction and maximise pollution control.

In decision-making processes relating to the human uses of particular sections or locations of the coast of the lake, it is advised to follow the specific recommendations provided for each stretch in Chapter 4.

3.4.2 Recommendations for Montenegro

1. The preservation of the natural component (belts of reeds and white willow woods) in the northern and north-western part of the lake (HGM area I-M), especially in the Podhumski Bay area, is recommended. This is because these high-functionality components can act as buffers for any superficial water that may flow into the lake from the surrounding territory. Also, as these areas are strictly controlled nature reserves, the preservation of their natural environment is necessary.

2. The development of the lake should be centred around the concept of sustainable tourism, and the development process should involve the local population. Before local people are brought into the process, they must first be educated about the importance of the lake ecosystem and about the types of tourism (preferably ecotourism and village tourism) and services that could be developed in the lake area. Development should focus on sites that are already occupied:

- HGM area II – Poseljani, Rijeka Crnojevića, Karuč, Dodoši and Žabljak Crnojevića
- HGM area III-M – Ckla, Murići and Virpazar
- HGM area I-M – Vranjina and Plavnica (small-scale tourism facilities only)

In small fishing villages, existing facilities could be restored, vernacular architecture maintained and small-scale ecotourism facilities developed.

3. Particular attention should be paid to the point sources of pollution that may significantly affect the ecological state of the lake – namely the basin's most significant urban centre, Podgorica (HGM area I), and the wastewaters from Cetinje, which pollute the Rijeka Crnojevića River (HGM area II). The construction of adequate wastewater treatment plants must therefore be planned for the urban areas that lie within the coastal zone – namely Vranjina, Rijeka Crnojevića, Karuč and Dodoši. Treatment plants should also be built to manage the wastewater produced by new tourism-related facilities (or other point sources of pollution). Given that Skadar/Shkodra Lake's main source of pollution is the Morača River, it is recommended to retain the healthy functional shorezone that runs from the village of Vranjina to Kom Monastery (HGM area I).

4. Attention should also be paid to preserving the Malo Blato area (in HGM area II) because the Bolje Sestre spring is a major contributor to the regional drinking water supply system, which supplies the whole coast on the Montenegrin side of the lake. It is recommended to retain the present functional shorezone, which works as a buffer strip that inhibits the diffusion of pollution. It is also recommended to establish a monitoring station at this location to record specific data on the site's water and environment in real-time.

5. National park management should continue to focus on preserving the park's natural habitats (management of rare and endangered types of habitat and species of flora and fauna). It is recommended to monitor and record the negative impacts arising from intentional or unintentional human activities. Suggested actions include limiting grazing along the shoreline.

6. Individuals of exotic plant species have been observed during fieldwork. It is therefore recommended to monitor the distribution and spread of alien invasive species, and to draw up action plans for their eradication. The use of local flora is recommended in restoration/new-development work.

7. Biški Rep peninsula is an ecologically important area. As such, in addition to the appropriate design of the complex planned for this site, it is also recommended to install an information centre that educates visitors about the importance and richness of the lake's ecosystem and how best to minimise their impact.

3.4.3 Recommendations for Albania

1. Near the mouths of rivers that debouche into the lake on the Albanian side, the protection of reeds and natural riparian vegetation is advised, as these areas are more affected by the pollution carried by these rivers. A riparian vegetation belt at least 30 metres wide should be established/maintained, as this is the minimum width capable of efficiently removing excess nutrients.

2. In the areas of land around the lake that are subject to flooding, it is recommended to protect the existing vegetation and leave the area in its natural state. Developing these areas is expensive and the loss of ecological services will also result in economic losses.

3. Few beaches around the lake perimeter have been identified. We therefore recommend the further development of those beaches already impacted by tourism, and the protection of currently undeveloped beaches.

4. Developing tourism is an important way of increasing the use of the lake and realising its strong future potential as a tourist destination. Tourism developments should be focused on the villages of Shiroka and Zogaj and on the inadequate tourism infrastructure in the other parts of the lake that already impacts on the shorezone.

5. Heavy deforestation in the past has denuded the ridge that separates Skadar/Shkodra Lake and the Adriatic Sea. The two remaining consolidated oak forests located near the border with Montenegro, which also contain hornbeam and ash tree, show how this area would have been prior to deforestation. These forests protect the soil from erosion, limit runoff into the lake and provide other important ecological functions. It is therefore recommended to preserve and protect these existing forests and, whenever reforestation projects occur, to prefer the planting of tree species present in them (mainly oak, but also hornbeam and ash) to the planting of exotic species.

6. The shorezone close to the village of Grile has a moderate level of functionality because of the farming methods practised there. This stretch has good potential for tourism infrastructure development, such as kayak hire centres, because of its proximity to the main road and to a pristine stretch of shoreline that is rich in birdlife.

4 SFI APPLICATION FOR SKADAR/SHKODRA LAKE

The SFI for Skadar/Shkodra Lake project was implemented according to the methodology laid down in *Lake Shorezone Functionality Index (SFI) – A tool for the definition of ecological quality as indicated by Directive 2000/60/CE* (Siligardi et al. 2010).

The fieldwork was carried out under the supervision of Barbara Zennaro (an SFI expert) who, for the first few days of fieldwork, focused on the intercalibration of the different teams (including the Macedonian team for Prespa Lake and Ohrid Lake) to ensure the highest possible level of consistency between the work undertaken on the two sides of the lake.

Fieldwork activities

The fieldwork on the Montenegrin side was carried out between 4 June 2016 and 23 July 2016 by Dr Sead Hadžiablahović (Botanist), Dr Danka Petrović (Botanist) and Biljana Medenica (GIS expert). The boat was provided by Skadar Lake National Park (National Parks of Montenegro) and the first three days of fieldwork were supervised by the SFI expert Barbara Zennaro.

The fieldwork on the Albanian side was carried out on 7 and 8 June and on 28 August 2016 by Klodian Zaimi (Hydromorphologist), Orjeta Jaupaj (Botanist), Dhimiter Peci (Botanist) and Valbona Simixhiu (GIS specialist). On 28 August an additional day of fieldwork was carried out with Barbara Zennaro to check the intercalibration of results with the Montenegrin team.

The lake survey was carried out by boat. Both the Albanian and Montenegrin teams were equipped with maps, a GPS-enabled camera and a tablet installed with relevant applications. An individual SFI sheet was completed for each identified stretch, and pictures and coordinates of the stretch were taken. Later, all data from the SFI sheets were transferred into the SFI software and the final SFI result for each stretch was calculated.

The evaluation of the whole shoreline of the lake shows that the Montenegrin shore contains 145 homogeneous stretches and the Albanian shore 38. Each homogenous stretch is determined mainly by the different levels of human pressure, the presence of exotic and/or hygrophilous species, and the hydromorphological conditions for runoff.

For each homogenous stretch, an ID card was prepared containing the following information:

- Field form number
- Length of homogeneous stretch
- Delineation
- SFI result
- Personal evaluation
- Description of stretch
- Notes
- Map with location
- Representative photo
- SFI classification tree (produced using the software).

4.1 Homogeneous stretches 1–183

Individual homogenous stretch descriptions are supplied in digital form on a USB flat card (see sleeve in back cover).

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6 Appendix

6.1 Glossary of terms

Shorezone

The area that includes the littoral (maximum depth of one metre) and riparian zones, and extends inland up to 50 metres from the shoreline, with the exception of interruptions or particular lake morphology that may limit its width – see Figure 68 (Siligardi et al. 2010).

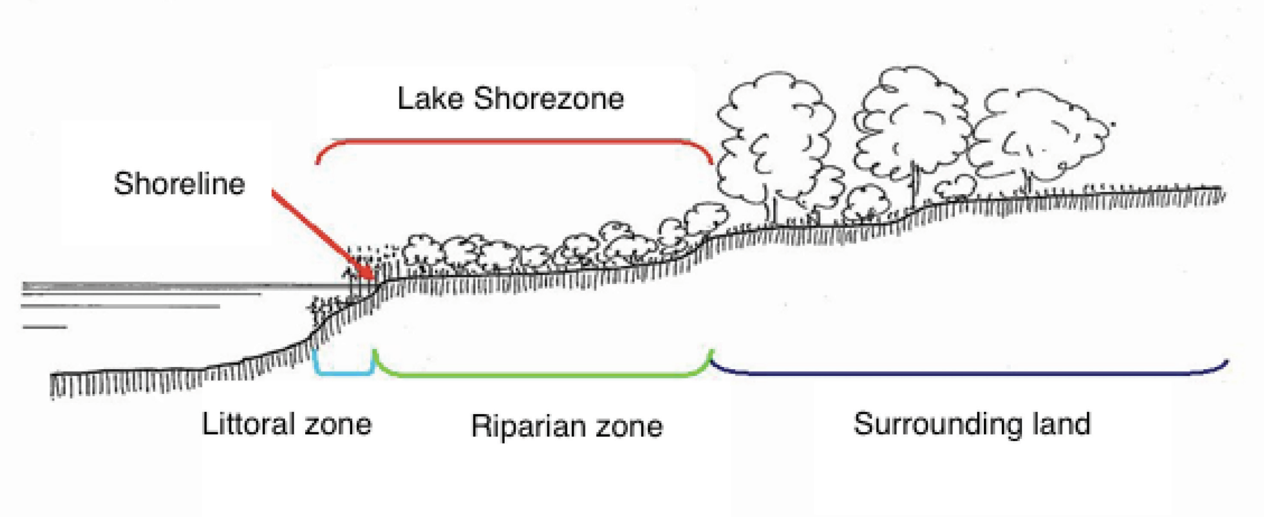


Figure 68. Structure of the lake shorezone

Riparian zone

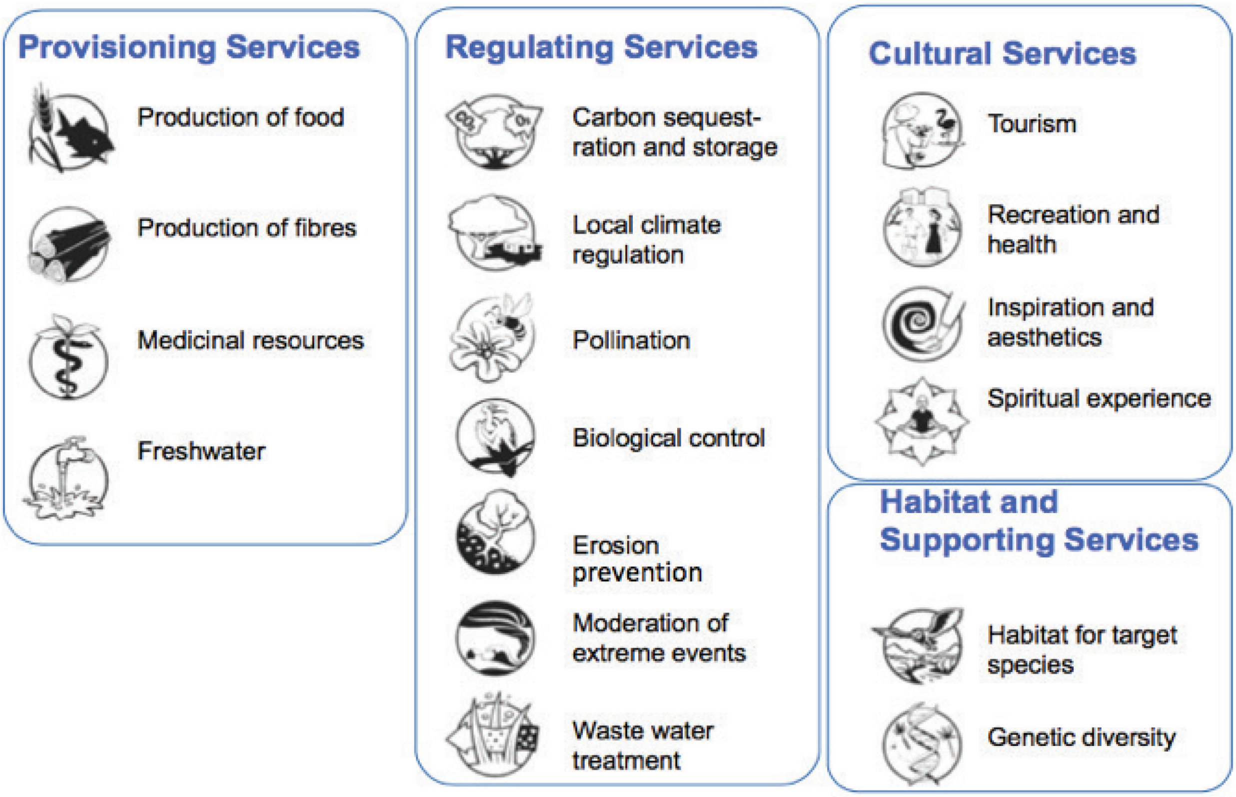
This is the area immediately adjacent to a body of water, which functions as a transition zone between the lake and its surrounding territory. It is important because it regulates inputs (nutrients and sediments), which improves lake water quality by (a) filtering the runoff from the catchment area and removing pollutants (the vegetation in the riparian zone can remove up to 90% of the nutrients passing through) and (b) aiding sedimentation (the vegetation slows the water flowing into the lake).The riparian zone also provides habitat for aquatic and terrestrial animals, including food, shade (temperature control), shelters, and areas for hunting and breeding, and it promotes bank stabilisation and thus protects the shoreline from erosion.

Littoral zone

This is the submerged section of the lake alongside the shore that generally coincides with the area where submerged macrophytes are present. This area often hosts many aquatic and non-aquatic animals. Many fish species choose this area for egg deposition and development (Rooth et al. 2007) and it is an important area for nutrient cycling. It also protects the shoreline from erosion and, by reducing wave action, promotes good water clarity.

Ecosystem services

These are the functions of the ecosystem that contribute either directly or indirectly to the wellbeing of society. They are divided into provisioning services (e.g. production of food or fibres), regulating services (e.g. erosion prevention, wastewater treatment), cultural services (e.g. tourism), and habitat and supporting services (e.g. habitats for target species) (TEEB 2012).



Drainage basin (also drainage area, catchment basin/area, watershed)

This is an area of land where all water derived from rain or melting/ice converges on a single point at a lower elevation, where the surface water then joins another body of water such as a river, lake, reservoir, estuary, wetland, sea or ocean.

Drainage basins are an important factor in an area's ecology because, as water flows over the ground and along rivers towards the outlet of the basin, it can pick up nutrients, sediment and pollutants. These can impact on ecological processes along the way and can also affect the water of the receiving source.

The modern use of artificial fertilisers containing nitrogen, phosphorus and potassium has been shown to affect the mouths of drainage basins. The minerals are carried by the drainage basin to its mouth and can accumulate there, disturbing the natural mineral balance. This can cause eutrophication where plant growth is accelerated by the additional material.

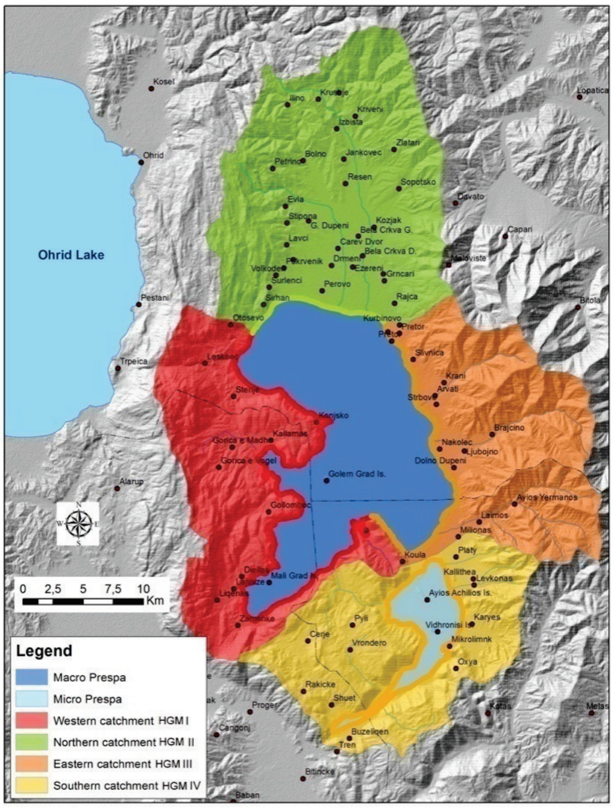
Drin River Basin

The area of land where all surface water converges on the Drin River as it works its way towards the Mediterranean Sea. The Drin originates in the drainage basin of Prespa Lake (Greece, Albania and Macedonia), the waters of which feed into Ohrid Lake (Albania and Macedonia). The latter then feeds into the Black Drin River, which traverses Albania, entering the White Drin River Basin to form the Drin River. The waters of the Drin River Basin subsequently join the waters coming from the Skadar/Shkodra Lake drainage basin (that stretches across Albanian and Montenegrin territory), which then pass downriver and finally debouch into the Adriatic Sea.

Hydrogeomorphological (HGM) area

An area with specific hydrological, geological and morphological characteristics that differentiate it from nearby areas. HGM parameters considered in this study include topography (drainage slopes that affect runoff, and the presence of reeds in the littoral zone), bedrock type (the presence of soft or hard rock, which affects water percolation), soil types and vegetation presence (which affect runoff/percolation and the concentration of nutrients from natural/anthropogenic sources).

HGM areas around Prespa Lake



Average residence time

The average time that water spends in a particular lake, from the time it enters the lake to the time it exits.

Thermic cycle

How often lake-bottom and surface waters mix within a year.

6.2 List of GIS shapefiles

Layers available prior to the SFI process (Montenegro):

- Topographic maps ratio 1:25,000 (mrsd.file)
- Topographic maps ratio 1:50,000 (hydro) (mrsd.file)
- Topographic maps ratio 1:50,000 (pedometric) (mrsd.file)
- Topographic maps ratio 1:200,000 (mrsd.file)
- Topographic maps ratio 1:300,000 (mrsd.file)
- Springs (shp.file) (vector created from hydro map 1:50,000)
- Rivers (shp.file) (vector created from hydro map 1:50,000)
- Bathymetry (dxf.file)
- Border of Skadar Lake river basin (dxf.file)
- Borders of NP Skadar Lake (shp.file)
- Flood line (maximum water level) of Skadar Lake during the floods in December 2010 and January 2011 (shp.file)

Layers created during the SFI process (.shp files – vector format with attribute database):

- Stretch line (shoreline)
- Stretch points
- Water supply sources – Bolje Sestre spring and several water pumps located along the shoreline
- Wastewater treatment – locations of WWTPs in Rijeka Crnojevica, Virpazar and Podgorica, as well as one toilet built directly on the shoreline
- Administrative and tourism facilities located 200 metres from the shoreline – border crossing (border checkpoint in Montenegro), 13 restaurants, three visitor centres and one centre for birdwatching (mostly observation)

6.3 Parameters assessed in the field and included in the SFI stretch shapefiles (line)

Each row represents a column in the GIS database and each box represents a question/parameter addressed in the field. Note that some questions require a single answer so the box has only one row (e.g. width), whereas other questions seek to collect a range of information (e.g. composition of lake shorezone) so the box has multiple rows.

Name	Parameter	Category	Significance	Comments	Area considered
Stretch_N	Stretch ID	-	-	Stretch ID as collected in the field	
Length	length			Calculated a posteriori	
SFI		1 to 5		SFI result	
Width	Width of functional lake shorezone (LS)	0 to 5	0 = 0 m 1 = 1–5 m 2 = 5–10 m 3 = 10–30 m 4 = 30–50 m 5 = >50 m	Includes both littoral and riparian zone up to 50 metres inland	LS
Tree_%	Presence of trees within LS	%	0 = none 1 = 100% of LS 0.x = inter-mediate values (e.g., 0.2 = 20% presence) Values add up to 1 (100%)		LS
Shrub_%	Presence of shrubs within LS	%			LS
Reed_%	Presence of reeds within LS	%		Water lilies, water chestnut and other vegetation with floating leaves not considered (see description of each stretch)	LS
Grass_%	Presence of (natural) grasses within LS	%		Grass beneath the vertical projection of trees not considered	LS
Bare Soil_%	Presence of bare soil within LS	%		Rocks, beaches, impermeable walls and fertilised managed gardens considered as bare soil	LS
Hygroph	Hygrophilous species	%	0 = none 1 = 100% of the LS 0 = absent Values add up to 1 (100%)		LS
No_Hygroph	Non-hygrophilous species	%		Bare soil and exotic species fall into this category	LS
Exotic_Sp	Exotic species	%	0 = none 1 = 100% of the LS 0.x = intermediate values		RIP

Heteroge	Heterogeneity of arboreal and riparian vegetation	0 to 1	See table below*	Manual, p. 45	RIP
Cont_tree	Continuity of arboreal/shrub vegetation	0 = absent 0.5 = dis-continuous 1 = con-tinuous	0.5 when the interruption >10%	Identify longitudinal interruptions (artificial or rocks/bare soil)	RIP
Cont_reeds	Continuity of wet reed zone	0 = absent 0.5 = dis-continuous 1 = con-tinuous	0.5 when interruption >10%		LIT
Cont_dryRe	Continuity of dry reed zone	0 = absent 0.5 = dis-continuous 1 = con-tinuous	0.5 when interruption >10%		RIP
Interrupti	Interruption	0 to 1	0 = none 0.1–0.9 = inter-mediate 1 = along whole stretch	Linear (e.g. beach is a continuous interruption) or scattered (e.g. fields within 50-metre area)	50
Use_0_50m	Typology of anthropogenic use of LS	0/0.5/1	0 = natural habitat 0.5 = sparse urbanisation/ meadows 1 = urbanised area	The most prevalent typology is considered	50
Use_0_200m	Surrounding territory	0 to 3	0 = natural habitat 1 = meadow/small cultivation 2 = intensive cultivation/sparse urbanisation 3 = urbanised	The most prevalent category is considered	200
Infr_Roads	Infrastructure: provincial/state roads	0 to 1	0 = none 0.1–0.9 = present only in parts of stretch 1 = present along whole stretch		200
Infr_train	Infrastructure: railroads	0 to 1			200
Infr_park	Infrastructure: parking	0 to 1			200
Infr_touri	Tourism-related infrastructure	0 to 1			200
Slope	Average slope	0 to 5	0 = flat 1 = noticeable 2 = obvious 3 = significant	(e.g. extreme or strong could be cliffs)	50

			4 = strong 5 = extreme		
Consistenc	Consistency	0/1	0 = consistent 1 = not consistent	To evaluate superficial vs hyporheic flow	50 + LIT
Concavit	Shore profile: concavity	0 to 1	0 = none 0.1–0.9 = inter-mediate 1 = along whole stretch	See examples in the manual, p. 61	SHO
Convexit	Shore profile: convexity	0 to 1			SHO
Complexit	Complexity	0 to 1	0 = none 0.1–0.9 = inter-mediate 1 = along whole stretch	Evaluates the presence of ecological niches 0 = e.g. impermeable walling	SHO or SHO LIT where applicable
Artificia	Artificiality	0 to 1	0 = none 0.1–0.9 = inter-mediate 1 = along whole stretch		SHO
Run_Off	Runoff	0 to 1	0 = diverging 0.1–0.9 = inter-mediate 1 = converging	0.5 = parallel to the shore	200
PersonalEv	Expert judgment	1 to 5	1 = high 2 = good 3 = moderate 4 = poor 5 = bad	Surveyor evaluates overall functionality of shorezone, results of which are used in the future development and control of the methodology; NB: discrepancies with calculated values may indicate errors in data collection or entry	LS
Surveyors				Surveyors that carried out survey	
DateSurvey				Date the survey was carried out	
Shore_Type		1 to 6	1 = wide belt of riparian vegetation 2 = narrow belt of riparian vegetation 3 = thin layer of shrub 4 = reeds followed by bare soil/crops 5 = bare soil/grass/high anthropogenic	Categories identified a posteriori	SHO

			impact 6 = artificial shore		
Floating		0 to 2	0 = absent 1 = present 2 = no information	Information extracted from description of stretches a posteriori	
Comments				Various info extracted from description of stretches a posteriori	
Oak		0 to 2	0 = Absent 1 = Present 2 = Information not available	Information on the presence of oak trees extracted from description of stretches a posteriori	

*Heterogeneity of arboreal and riparian vegetation

0	Native trees and shrubs are absent, or exotic are prevalent
0.1	Native trees and shrubs cover more than 2/3 of the total tree/shrub area, but there is the dominance of 1 species only, e.g. pine tree
0.2	Native trees and shrubs are prevalent, but only 1 species is dominant
0.3–0.4	Native trees and shrubs cover more than 2/3 of the total tree/shrub area, and at least 2 or 3 species are equally present
0.5	Native trees and shrubs cover more than 2/3 of the total tree/shrub area, and more than 3 species are equally present
0.6	Native **riparian** trees and shrubs cover more than 2/3 of the total tree/shrub area, but 1 species only is dominant
0.7–0.9	Native **riparian** trees and shrubs cover more than 2/3 of the total tree/shrubs area, and at least 2 or 3 species are equally present
1	Native **riparian** trees and shrubs cover more than 2/3 of the total tree/shrub area, and more than 3 species are equally present

KEY

LS = lake shorezone (both riparian and littoral)

RIP = riparian only (terrestrial)

LIT = littoral only (aquatic)

50 = the area between the shoreline to a line 50 metres inland

SHO = shoreline (i.e. the point of contact between the land and the lake)

200 = the area between the shoreline to a line 200 metres inland

SHO LIT = lakeward border of the reed belt

6.4 Sample SFI field form

For more information on this form, please refer to the following manual, available free of charge on the APPA Trento website: Siligardi, M., *Lake shorezone Functionality Index, APPA manual*, 2010.

Date	Form no
Lake	
Delimitation of stretch	
Photos no	
Surveyors	
Lake shorezone	
1. Width of lake shorezone	
0 m	0
1–5m	1
5–10m	2
10–30m	3
30–50m	4
>50m	5
2. Characterisation of lake shorezone vegetation **2.1 Cover/composition % (expressed from 0 to 1)**	
Trees %	
Shrubs%	
Reeds%	
Grasses%	
Bare soil%	
2.2 Hygrophilous and non-hygrophilous vegetation (expressed from 0 to 1)	
Hygrophilous	

Non-hygrophilous	
2.3 Presence of exotic species	
Exotics	
2.4 Heterogeneousness of arboreal-shrub vegetation	
Diversified	1
Intermediate (from 0.9 to 0.7)	
Monospecific	0.6
Autochthonous hygrophilous arboreal-shrub species >2/3	
Diversified	0.5
Intermediate (from 0.4 to 0.3)	
Monospecific	0.2
Autochthonous hygrophilous arboreal-shrub species <2/3 and autochthonous arboreal-shrub <2/3	
Autochthonous prevalence	0.1
Exotic prevalence	0
Arboreal-shrub vegetation absent	0
3. Continuity of the lake shorezone vegetation	
Arboreal and shrub zone	
None	0
Discontinuous	0.5
Continuous	1
Wet reed zone	
None	0
Discontinuous	0.5
Continuous	1
Dry reed area	
None	0

Discontinuous	0.5
Continuous	1
4. Interruption in the lake shorezone	
None	0
Intermediate (from 0.1 to 0.9)	
Present along whole stretch	1
5. Typology of anthropogenic uses within the lake shorezone	
Uncultivated meadows or unpaved streets, etc.	0
Sparse urbanisation, cultivated meadows, etc.	0.5
Urbanised area	1
SHORE AND SURROUNDING TERRITORY	
6. Main use of nearby territory	
Woods and forest	0
Meadows, forests, arable land, uncultivated farmland	1
Seasonal and/or permanent cultures, and sparse urbanisation	2
Urbanised area	3
7. Infrastructure	
Provincial/state roads	
None	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
Railroads	
None	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
Parking	
None	0

Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
Tourism-related infrastructure	
None	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
8. Emerged portion of the lakeshore zone **8.1 Average slope**	
Flat	0
Slightly noticeable slope	1
Obvious but can be overcome without problem	2
Significant but can be overcome with trails or ramps	3
Strong slope, roads or trails with bends	4
Extreme, vehicles cannot navigate it	5
8.2 Comparison between the slopes of the emerged and submerged areas	
Not consistent	0
Consistent	1
9. Shore profile **9.1 Concavity and convexity**	
Concavity	
None	0
Intermediate (from 0.1 to 0.9)	
Present along whole stretch	1
Convexity	
None	0

Intermediate (from 0.1 to 0.9)	
Present along whole stretch	1
9.2 Complexity	
None	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
10. Shoreline artificiality	
None	0
Intermediate (from 0.1 to 0.9)	
Present along the whole stretch	1
11. Apparent channelling of runoff	
No prevalent direction for the flow	0
Intermediate (from 0.1 to 0.9)	
All the runoff converges on a single point	1
12. Personal evaluation	
High	1
Good	2
Moderate	3
Poor	4
Bad	5