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Evidences of Climate Changes and Conservation Needs for Halting Further Deterioration of Small Glacial Lakes

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Abstract: Despite debates, it is generally agreed upon at the European level that small water bodies comprise lentic ecosystems that are shallow (less than 20 m) and have a surface area of a few hectares (less than 10 ha). Regarding Albania, its 87 glacial lakes constitute a substantial portion of aquatic ecosystems that sustain high levels of biodiversity, metabolic rates, and functionality. Currently, there are still more than 1300 aquatic bodies dispersed throughout the country, including rivers, lakes, ponds, coastal lagoons, marine habitats, and fluvial deltas. The overall surface area of wetlands is 970 km^2, or roughly 3% of the entire country. Most of them are part of the national protected areas system because of their unique characteristics. This paper discusses the integration of ecological sustainability into ecosystem services (i.e., cultural, regulatory, and sustaining services) and national ecological networks of protected sites. This integration is particularly important in light of recent advancements regarding European integration. This is also because of the catchment continuum, which addresses biodiversity values and gradients that in this article are considered through rotifer community and aquatic plant species. The main causes of the stressors on small ecosystems are inappropriate land use, water pollution, altered habitats, non-native species introduction, resource mismanagement in basins, inadequate planning, and a lack of sector integration.

Keywords: standing water bodies; glacial lakes; freshwater biodiversity; eutrophication; nature conservation network

1. Introduction

Significant climate-driven changes are expected during the coming decades [1,2], placing Mediterranean freshwater ecosystems at the top for vulnerability [3,4].Despite the attempts and objectives of international strategies to halt the biodiversity decline [5,6], the task is increasingly challenging [7], thus a scientific and technical management support is more than required. Being located at very specific altitudes, the glacial lake ecosystems are facing rapid changes due to the lack of snow cover and rapid increase of temperature. The plant and animal biota of alpine regions are influenced by the amount, rates, and dynamics of snow cover [8,9], and the hydrological cycle of high altitude basins is regulated by the availability of freshwater from the cryosphere in the spring and summer [10]. Thus, the rapid deglaciation of the European Alps is one of the main indicators of shifting geomorphic process speeds and global warming [11,12]. Since the end of the Little Ice Age (LIA), the area covered by glaciers has declined by more than 50% [12,13]. Several ecosystems in

Albania attest to this phenomenon, and new landscapes have emerged where there once was a water-covered area. To analyze the state, connectivity, climate change-driven impacts, and bias with conservation approaches covering mountain environments, detailed data on lake evolution, spatial distribution and lake characteristics are required. In order to contribute to the regional picture of glacial lake distribution, we consequently created an inventory of glacial lakes for the Albanian upland areas (over 1450 m above sea level). With the help of publicly accessible high-resolution picture data, lakes were manually mapped. Furthermore, we followed the current network of conservation designations where a considerable number of lakes are an integral part of the protection. The original designation was based on geological and biodiversity values of both terrestrial ecosystems. The objectives of our study are: (1) to compile a list of the high alpine lakes in the uplands of Albania; (2) to investigate lake characteristics, distribution, and highlight the biodiversity values of selected animal and vegetation components; (3) to assess the snow-cover (cm) and low-temperature days (-0°C) and hypothesize the impacts caused by both climate change and anthropogenic interventions; and (4) to discuss state of conservation and bias with protected areas designation in Albanian Alps National Park, Korab-Koritnik Nature Park, Shebenik-Jabllanica National Park, etc.

The glacial chronology and glaciations found in the mountains of Albania are related to those found in the Mediterranean and Dinaric arc regions, where the phenomena is thought to be related to certain known glaciations that occurred in the Late Pleistocene [14–17]. Furthermore, besides different interpretations, it is hypothetically assumed that the maximum of Albanian Alps (and the rest of the mountains where the glacial lakes are situated), the glaciations took place in Early or Middle Pleistocene (0.781-0.126 million years ago).

Freshwater biotic communities are important components of lake functioning. Besides altitudes and origin of glacial bodies, both vegetation and fauna groups are of high interest and amongst the least studied. One of the most significant components is zooplankton, composed of invertebrates from several taxonomic categories, the principal ones being copepods, cladocerans, and rotifers. Zooplankton serves as a vital component of the food web and plays a role in the self-purification processes of aquatic ecosystems, as it is consumed by fish and other invertebrates [18–20]. Additionally, aquatic plants are also good indicators of the ecological state and eutrophication process [21]. They are linked directly linked to the biotic integrity of aquatic ecosystems [22] and are hence incorporated in monitoring of surface water by the Water Framework Directive [23]. Presently, there are records of deterioration in the water quality of both running and standing water bodies [24].

2. Materials and Methods

Study area: A literature search for high altitude aquatic habitats and for particular glacier lakes was part of the data collection process. The dimensional limits of lentic water bodies that are shallow (less than 20 meters) and have a surface area of a few hectares (less than 10 hectares) allowed us to locate our target ecosystems and distinguish them from bigger lentic aquatic ecosystems (including large and middle size natural lakes of other-than-glacial origin and reservoirs established for different purposes as energy production, agriculture or recreation).

Geographic coverage and lakes surface data analysed: The rivers of Albania are included in the 420-Southeast Adriatic Drainage on the worldwide ecoregion map [25,26]. To the best of our knowledge, the distribution and species composition of freshwater fish species serve as the basis for this map of freshwater ecoregions, which also includes important ecological and evolutionary features [27]. Albania is home to multiple major, currently autonomous river and lake systems (Figure 1). They are listed below, north to south: The rivers Mat (B), Ishëm (C), Erzen (D), Shkumbin (E), Seman (made up of two major inflows—Devoll and Osum) (F) and Vjosë (Aoos in Greece) (G) are part of the Ohrid-Drin-Skadar system (which includes the river Buna). Several other short rivers flow from the Cika mountain to the southernmost Adriatic Sea and the northernmost Ionian Sea (H), the area surrounding Butrint Lagoon (rivers Bistrica and Pavllo) (I). The majority of the lakes and rivers listed above (A–G) are located on the Adriatic slope, while the southernmost portion (I) is located on the Ionian Sea slope. Although the Prespa Lakes do not have a surface outflow of water, there are subterranean connections with Lake Ohrid (Amataj et al., 2007). The Danube basin includes only a very minor portion of the Albanian Alps in the country's northernmost region [27]. All Albanian rivers have extremely varying seasonal discharges; in certain cases, summer discharges might be more than ten times lower than winter discharges. Since a lot of gravel and stones are deposited along the main rivers, their beds are typically very wide [27]. The topography of the region is very varied, with mountains in the east and flat plains in the west.

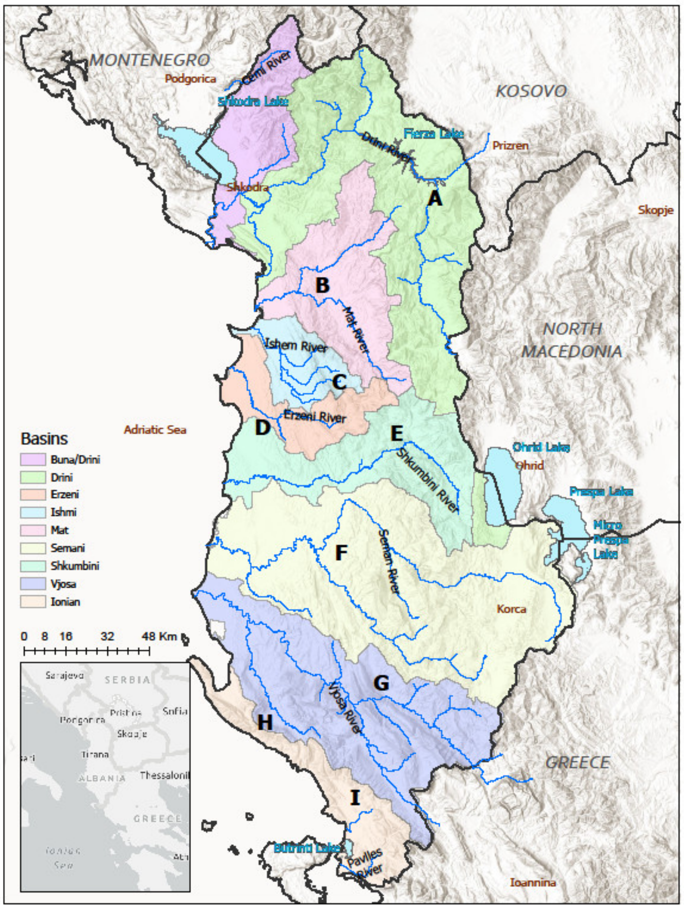

Figure 1. Albania's water basin systems:, the Ohrid-Drin-Skadar system (including River Buna) (A), Mat (B), Ishëm (C), Erzen (D), Shkumbin (E), Seman (F) and Vjosa (G), the region surrounding Butrint Lagoon (rivers Bistrica and Pavllo) (I)and the tributaries of the Ionian Sea (H).

The approach followed for calculating the surfaces of glacial lakes and lakes level annual oscillations is based on the commands used in the Google Earth Pro program. In this program, the base map is constantly updated, showing any changes in the topography over the years, but in this particular case, the most recent images were used - October 2023. To measure a polygon (in this case, the glacial lakes) in this program it is followed the sequence of commands: In the toolbar located at the top of the page, were selected "Show Ruler" and then clicked "Polygon". After that, were outlined the surface we were interested in the base map. During this process, in the small table that we had displayed on the screen, the Perimeter and the Surface appear, next to which the unit of measurement is also given, which we could change as needed. Once the data such as the area and perimeter have been obtained, we were choosing to save it as a polygon or not. To understand which lake surface we have measured or not, in this case the feature has been saved by clicking "save". Then a new window opens where we were able to mark the name of this new polygon, in this case with the name of the corresponding lake. And finally were clicked "Save" again. This whole process is repeated until all the surfaces we had planned have been measured.

Evaluation of management effectiveness and variable selection: Based on the Assessment of Management Plan Implementation, which was modified from Tool 9 of the Enhancing our Heritage toolbox [28], surveys were carried out throughout the designated protected areas of Albania. Within the limits of these protected regions are found more than 90% of glacial lakes. The purpose of this tool is to evaluate how well the protected area management plan is being implemented. The tool makes it possible to evaluate the management plan's implementation at both the overall and specific goal levels, including aquatic environments. Going over each plan action and assigning it a status category (such as "action has not commenced" to "action has been completed") was one of the adjustments made to this review. "Use of resources as lakes for recreational purposes," "glacial lakes," and "water ecosystem management" were also added.

The selected variables for monitoring and assessment of management capacities are presented in Table 1. These variables are classified into two groups and three levels, according to their status and assumed importance. So, group I, include variables representing the foundation for manager's functioning: existence of legal acts further stipulating acts to be adopted by the manager; manager's human resource capacity and group II is based variables representing the implementation of legally prescribed obligations in the field.

Table 1. Variables selected for analyze.

Group I		Group II
Level 1	Level 2	Level 3
Management Plan	Yearly revision of management plan	Number of implemented projects for 2017–2023
Trained staff	Database of performance	Glacial lakes monitoring
Service of rangers	Daily operational and guidance book	Education programs
		Biodiversity inventory database
		Hiking trails
		Visitor center and guided tours

Empirical analyses: The aggregate function S (scoring) has been introduced, allocating to each observed protected area a numerical value from 0 to 100. The assessment model was built through combination of the following variables: a1-1-if the Protected area management plan existed; 0—otherwise; a2:1 -if Professional staff consisted of at least three employees; 0—otherwise; a3-1-if the Ranger service consisted of at least three employees; 0—otherwise; b1- number of yearly management plans in 2017–2023 period, divided by five; b2-1-if the Rulebook of charges existed; 0—otherwise; b3-1-if Daily operational and guidance book existed; 0—otherwise; c1- number of projects classified into categories (values 0–4); c-2-1- f Monitoring of glacial lakes was performed; 0—otherwise; c3-1-if participation in the integration projects in the field of nature conservation was performed; 0—otherwise, etc.

Zooplankton collections and identification: For the rotifers survey 13 glacial lakes in Albania were covered and 7 field works were completed in 2013–2020. Most of the sites under study are often covered in snow and ice for eight to nine months of the year due to their high altitude; ice-free periods only happen during the warm months of June through August. Using typical plankton net with a mesh size of 55 μm, samples of zooplankton were gathered both horizontally and vertically and then fixed in 4% formaldehyde. Additionally, a plankton hand net with a mesh size of 55 μm was used to collect samples from the littoral zone. The specimens were taxonomically identified using the keys found in [29–33].

Aquatic machrophytes evaluation: During the period of 2017-2023 numerous glacial lakes site visits were conducted covering mostly the seasons of spring, summer, and autumn. 83 glacial lakes were subject of this survey. Therefore, different plant guides were used for species and habitats determination [34–37]. A five-degree scale was used to quantify the abundance of the observed and recognized macrophyte species along transects and in the deep zone of each lake: 1 represents very rare, 2 represents rare, 3 represents common, 4 represents frequent, and 5 represents abundant [38,39]. By analyzing photos captured with a drone, the MAVIC 2 Pro, the plant covering in the body of water was assessed. The results were computed by projecting the vegetation cover in the water

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column above the surface of the lake. There are five levels of macrophyte cover based on how much of each lake's surface is covered by it. There are four types of cover: none (no plants), sparse (1–25% cover), moderate (26–50%), dense (51–75% cover), and very dense (76–100% cover).

All the data were analyzed with the statistical program SPSS 29.00. Descriptive statistics, one way ANOVA, Pearson correlation (2-tailed), and relationship map were performed to examine the association between different variables. The independent variables are lakes latitude, lakes surface, water level oscillation of lakes. The dependent variables are the vegetation cover of the lakes and the total number of observed rotifer species in the Albania lakes included in the study.

3. Results

3.1. Inventory of High Alpine Lakes in the Albanian Upland Areas

Albania's elevation increases gradually from west to east. Plains comprise about 15% of the area, primarily in the West of the nation, with hills reaching up to 200 meters above sea level (Table 2). In certain places, the mountains are arranged radially, like the Albanian Alps, or they form regularly oriented chains, primarily oriented from the South-East to the North-West (Miho et al., 2013). The Western section of the mountains has sharper slopes than the Eastern section, with flat crests and steep slopes being common features. Deep valleys are regularly squeezed by narrow gorges to create canyons such as Kelcyra (Permeti), one of the largest in Albania.

Table 2. Number of water bodies and their surface area.

Type of water bodies	Surface in km^2	Number of water bodies
Natural		
Estuaries	88	9
Brackish lakes	24.2	2
Brackish marshes	8.6	2
Freshwater marshes	6.4	6
Freshwater springs	6	110
Glacier lakes	2.4	87
Lagoons	252.4	9
Lakes	335.7	228
Rivers and streams	27.1	152
Salt marshes	0.3	1
Sea bays	17.8	1
Wetland forests	4.8	1
Total Natural water bodies	773.7	617
Artificial water bodies		
Reservoirs	178.8	700
Aquaculture ponds	6.4	3
Excavations	0.3	3
Temporary wetlands	9.1	1
Total artificial water bodies	194.6	707
Total water bodies	**968.3**	**1324**

Most of the country experiences a high humidity, Mediterranean subtropical climate, which gradually shifts to a moderate continental climate in the north and east. Summers are lengthy, hot, and very dry, whereas winters are usually moderate, moist, and relatively short. There is a lot of precipitation; it increases from west to east, from roughly 1300 mm in Saranda to 2000 mm in Shkodra. When intense rainstorms occur suddenly, brooks and torrents frequently form with a high potential for erosion. Tirana receives more than 330 sunny days annually, which results in more than 2100 kWh m^{-2} $year^{-1}$[40].

Approximately 8% of Albanian territory, or more over 2300 km^2, was covered by wetlands before 1960. Since then, significant agricultural reclamation projects have drastically decreased the wetlands' overall size to less than half [40]. However, there are still more than 1300 aquatic locations spread out across the nation, including rivers, lakes, ponds, coastal lagoons, marine habitats, and fluvial deltas (Table 2). The overall surface area of wetlands is 970 km², or roughly 3% of the entire country. The majority of these aquatic environments are made up of lakes, coastal lagoons, and reservoirs. These are all characterized by a great diversity of biological species and sensitive environments that are still heavily impacted by human activity and are not well understood.

The lake inventory contains 85 lakes above 1415ma.s.l. in Albania covering a total area of 2.4 km². The lakes spread from the border to Montengro in the North to the Gramozi Lake at the South-East bordering with Greece.. Lake density, i.e., the lake area (in m²) in relation to the surface area above 1415m (in km²), varies significantly between the mountain ranges (Table 3). Highest lake density is observed in the Albanian Alps, Korabi massif and Pas Deje Lura area, while lower one can be identified in Gramozi and Jabllanica Mountains.

Table 3. Main characteristics of 87 glacial lakes.

No.	**Lake name**	**Coordinates**		**Altitude (m)**	**Geomorphology of watershed**	**Vegetation cover**	**Surface (km²)**	**Yearly water level oscillation (m)**
1	Gramozi Lake	40°21′52.17″N	20°47′25.62″E	2364	Flysch alevrolitic	None	0.48	1.5
2	Lake of Dushku	40°47′59.29″N	20°19′44.98″E	1415	Ultramafic rocks	Very dense	36.2	3.2
	Jabllanica Mt							
3	Lake of Dragani	41°16′54.71″N	20°27′2.33″E	1660	Calcareous	Very dense	7.1	3.5
4	Lake of Kusar	41°16′38.32″N	20°30′1.77″E	1862	Mix Calcareous and Granitic	None	1.15	2
5	Lake of Sal Xhyra	41°15′56.87″N	20°29′59.60″E	1850	Mix Calcareous and Granitic	None	0.77	2.1
	Shebeniku Mt							
6	Big lake of Dragostunja	41°12′43.50″N	20°27′43.20″E	2054	Ultramafic rocks	None	1.56	1.75
7	Great lake of Dragostunja	41°12′45.73″N	20°27′31.28″E	2005	Ultramafic rocks	None	1.15	1.5
8	Shebenik Lake	41°12′49.81″N	20°28′4.00″E	2006	Ultramafic rocks	None	1.52	1.4
9	Great Lake of Likopatra, Rrajcë	41°11′21.78″N	20°29′22.42″E	1905	Ultramafic rocks	None	3.54	1.2
10	Small Lake of Likopatra, Rrajcë	41°11′30.98″N	20°29′5.86″E	2007	Ultramafic rocks	None	1.54	1.2
	Valamara Mts							
11	Black Lake (Lenia)	40°45′39.98″N	20°25′50.26″E	1698	Ultramafic rocks	None	3.25	2.3
12	Black Lake of Valamara	40°46′40.10″N	20°28′0.16″E	2003	Ultramafic rocks	None	1.93	1.7
13	Lake in Valamara	40°46′20.70″N	20°28′17.99″E	1950	Ultramafic rocks	None	0.8	1.8
14	Lake of lilies (Valamara)	40°46′55.44″N	20°29′24.71″E	1865	Ultramafic rocks	Dense	2	1.75

15	Lake in Valamara 3	40°46′51.03″N	20°29′4.37″E	1910	Ultramafic rocks	None	3.9	2
16	Lake of Lenia	40°47′17.35″N	20°28′16.41″E	2110	Ultramafic rocks	None	2.9	2.1
17	Lake in Valamara 4	40°47′20.00″N	20°28′05.06″E	2121	Ultramafic rocks	None	2.37	1.4
18	The Lake of the spring foShkumbin	40°47′48.40″N	20°28′6.32″E	2147	Ultramafic rocks	None	2	1.3
19	Lake in Valamara 5	40°47′36.96″N	20°28′38.06″E	2020	Ultramafic rocks	None	0.4	1.4
20	Lake of Lukova 1	40°54′21.62″N	20°23′43.29″E	1855	Ultramafic rocks	None	6.53	1.9
21	Lake of Lukova 2	40°53′53.80″N	20°24′21.60″E	1750	Ultramafic rocks	None	4.07	1.3
	Martanesh area							
22	Lake of Sopa	41°26′5.87″N	20°17′16.73″E	1722	Ultramafic rocks	Sparse	32.2	1.35
23	Lake of Hardha	41°26′26.12″N	20°18′38.71″E	1725	Ultramafic rocks	None	7.3	1.9
24	Lake of Sopoti	41°27′6.15″N	20°18′51.51″E	1632	Ultramafic rocks	Sparse	7	2.1
25	Black Lake (Bulqiza)	41°27′15.16″N	20°18′7.29″E	1687	Ultramafic rocks	None	20	3
26	White Lake	41°27′41.28″N	20°17′43.43″E	1650	Ultramafic rocks	Sparse	7.4	3
27	Lake Kocebse	41°28′25.10″N	20°15′39.01″E	1798	Ultramafic rocks	Sparse	2.13	2.1
28	Dry Lake	41°28′15.67″N	20°15′10.82″E	1798	Ultramafic rocks	Sparse	3.8	2
29	Skënderi Lake	41°28′27.02″N	20°14′45.74″E	1725	Ultramafic rocks	Sparse	3.2	1.8
30	Lake without tracks	41°28′4.39″N	20°14′42.34″E	1860	Ultramafic rocks	None	1.2	1.6
31	Gatelli Lakes	41°28′4.39″N	20°14′42.34″E	1810	Ultramafic rocks	Sparse	2.3	1.7
32	Balgjai Lake	41°33′16.53″N	20°12′49.33″E	1775	Ultramafic rocks	None	1	1.75
33	Balgjai Lake 2	41°33′11.06″N	20°12′28.41″E	1808	Ultramafic rocks	None	4.5	1.8
34	Lake of flowers (Kacni)	41°33′37.55″N	20°13′25.69″E	1900	Ultramafic rocks	Dense	6.1	1.8
35	Lake of Ksnika	41°33′58.10″N	20°14′28.84″E	1855	Ultramafic rocks	None	1.44	1.75
36	Black Lake of Kacnia	41°34′6.51″N	20°13′55.42″E	1855	Ultramafic rocks	None	10	1.8
37	Lake of Shtrunga	41°34′23.00″N	20°14′17.30″E	1690	Ultramafic rocks	None	6	3.1
38	Lake of Barzana	41°34′23.75″N	20°13′52.16″E	1800	Ultramafic rocks	Sparse	2	1.5
39	Lake of Kacnia 1	41°34′29.70″N	20°14′5.70″E	1740	Ultramafic rocks	Dense	1.72	1.7
40	Lake of Kacnia 2	41°34′37.37″N	20°14′19.53″E	1665	Ultramafic rocks	Sparse	2	3.5
41	Lake of Bruce	41°34′18.16″N	20°15′15.14″E	1665	Ultramafic rocks	None	1.9	3

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42	Lake of Milloshi	41°34′35.29″N	20°15′20.05″E	1636	Ultramafic rocks	None	2.5	2.4
43	Lake of Kalia	41°34′43.66″N	20°15′17.02″E	1655	Ultramafic rocks	None	2	2.2
44	Lake of Batakëve 1	41°34′29.00″N	20°15′5.14″E	1686	Ultramafic rocks	Sparse	1.2	1.8
45	Lake of Batakëve 2	41°34′19.41″N	20°15′0.57″E	1715	Ultramafic rocks	Moderate	1	1.6
46	Lake of Batakëve 3	41°34′9.58″N	20°15′3.87″E	1773	Ultramafic rocks	Sparse	2.5	1.5
	Allamani Lakes							
47	Lake of Micekut	41°34′10.54″N	20°13′2.00″E	1860	Ultramafic rocks	None	4.1	1.7
48	Lake of Allamani	41°34′27.30″N	20°12′46.85″E	1784	Ultramafic rocks	None	5.34	1.6
49	Goat Lake	41°34′41.09″N	20°12′49.19″E	1780	Ultramafic rocks	Sparse	1.7	1.3
50	Lake of the Lords	41°34′45.99″N	20°13′7.14″E	1815	Ultramafic rocks	Moderate	10.23	1.4
51	Lake of flowers (Allaman)	41°34′58.98″N	20°12′49.46″E	1805	Ultramafic rocks	Dense	1.22	1.35
52	Lake of KolëMadhi	41°35′14.77″N	20°13′40.09″E	1715	Ultramafic rocks	Moderate	3	2.6
	Pas Deja-Lura							
53	The stone of Virgo	41°40′40.82″N	20°12′22.27″E	1555	Ultramafic rocks	None	3.15	3
54	Lake of Pas Deja	41°41′15.32″N	20°10′48.81″E	1892	Ultramafic rocks	None	0.44	2
55	Lake of flowers (Lura)	41°44′23.01″N	20°11′55.45″E	1588	Ultramafic rocks	None	1.44	2.3
56	Kallaba Lake	41°44′32.19″N	20°11′49.31″E	1594	Ultramafic rocks	Moderate	4.16	2.2
57	The Dryed Lake	41°45′5.52″N	20°11′55.41″E	1636	Ultramafic rocks	None	2.64	1.9
58	Black Lake, Lurë	41°45′8.89″N	20°11′35.56″E	1743	Ultramafic rocks	None	2.56	2.2
59	Hoti Lake	41°45′51.55″N	20°11′36.86″E	1683	Ultramafic rocks	None	1.84	2.5
60	Great Lake of Lura	41°47′23.20″N	20°11′35.24″E	1716	Ultramafic rocks	None	11.7	2
61	Lake of Bruçi	41°47′17.97″N	20°11′46.25″E	1724	Ultramafic rocks	Dense	0.7	2
62	Kurti Lake	41°47′17.89″N	20°12′0.08″E	1683	Ultramafic rocks	Dense	1.1	2.1
63	Lake of Rrasave	41°47′33.47″N	20°11′42.88″E	1710	Ultramafic rocks	Sparse	4	2.
64	Lake in Lura	41°47′31.59″N	20°11′31.77″E	1730	Ultramafic rocks	Sparse	0.4	2.5
65	Lake of Cows	41°47′58.60″N	20°11′20.81″E	1620	Ultramafic rocks	Dense	1.5	2.5
	Korabi Mts							
66	Lake of Ladys	41°45′22.79″N	20°30′29.15″E	1884	Granitic rocks	Dense	1.7	1.8
67	Grama Lake	41°45′34.20″N	20°29′35.71″E	1754	Granitic rocks	None	5	1.75

68	Lakes of Steps	41°47′58.12″N	20°30′4.53″E	1786	Calcareous	Moderate	0.7	1.7
69	Black Lake, Radomira	41°49′12.26″N	20°29′13.54″E	1470	Granitic rocks	Moderate	0.8	2.8
	Sylbicë-Doberdol							
70	Lake of Zanave	42°30′59.12″N	20° 5′4.61″E	2207	Granitic rocks	None	0.9	0.8
71	Lake of Black Peak	42°31′9.03″N	20° 5′0.44″E	2215	Granitic rocks	None	0.7	1.1
72	Sylbica Lake	42°31′34.13″N	20° 5′23.25″E	2090	Granitic rocks	Sparse	3	1.5
73	Yellow Lake	42°31′15.59″N	20° 5′20.66″E	2087	Granitic rocks	None	1.1	1.1
74	Lake of Dogs	42°31′21.56″N	20° 5′6.77″E	2135	Granitic rocks	None	1.1	1.2
75	Southern Lake	42°30′29.75″N	20° 5′47.21″E	2000	Granitic rocks	None	0.5	1.75
76	Lake of Sheeps	42°30′16.59″N	20° 6′4.01″E	2010	Granitic rocks	None	1	1.8
77	Lake of Dashi	42°31′47.24″N	20° 4′36.82″E	2180	Granitic rocks	None	3.5	2
78	Beri Lake	42°32′21.87″N	20° 4′25.22″E	1994	Granitic rocks	Moderate	0.7	2
	Albanian Alps							
79	Lake of Lulashi	42°28′5.23″N	19°49′0.61″E	1665	Calcareous	None	1.3	1.9
80	Lake of Shalë	42°28′11.16″N	19°48′44.75″E	1755	Calcareous	None	1.47	2.5
81	Lake of Lohjanit	42°28′4.94″N	19°48′40.08″E	1757	Calcareous	None	2.63	2.6
82	Lake of Mjelsave	42°27′55.40″N	19°48′31.38″E	1806	Calcareous	None	1.2	2.7
83	Great Lake of Jezerca	42°27′39.34″N	19°48′23.68″E	1795	Calcareous	None	4.3	2.8
84	Lake of Sheu i Bardhë	42°27′27.42″N	19°46′22.64″E	1672	Calcareous	None	0.7	2.9
85	Lake of Peshkeqes	42°26′51.13″N	19°46′14.50″E	1616	Calcareous	None	0.7	3.1
86	Ponari Lake	42°22′12.03″N	22°00′50.08″E	1363	Calcareous	Moderate	2.2	2.8
87	Lake of Kelmendi fortress	42°27′5.22″N	19°42′45.38″E	1757	Calcareous	None	1.2	1.8

Of the lakes under investigation, all have an alpine regime and a surface area over 0.5 hectares. Of them, 42 are glacial lakes with a surface area exceeding 4 ha, while only 6 are greater than 10 ha (Table 2). This table excludes 16 glacial lakes that are discovered to be dry in the summer and fall or that only have a very little amount of water on them in the winter and spring. The dried or temporary glacial lakes are found in the most northern region of the country, in Seferçe, with the dried Lake of Seferçe standing at an altitude of 1710 meters. The glacial lakes of Albania extend from the south, where there are two temporary lakes at 1850 meters above sea level in Ostrovica Mountain, to the northeast, where there is a temporary lake at 2150 meters above sea level in the Panairi area. From the geo-morphological point of view, 60 glacial lakes occur in ultramafic, twelve in granitic,twelve in calcareous geo-ecosystems and only three in mixture of geo-morphological composition.

3.2. Particularities of Glacial Lakes, Distribution and Specific Biodiversity Values of Selected Animal and Vegetation Components

A total of N=87 lakes were observed. The mean of lakes altitude is 1813.94±184.074 and the mean of water oscillation level is 2.0138±.61269. Table 4 displays general characteristics of the surveyed lakes in Albania in the frame of vegetation cover in correlation of lakes altitude, water level oscillations and geomorphology watershed of the lakes.

Table 4. Descriptive statistics for different variables performed with SPSS 29.00.

Variables	Vegetation cover	Frequency (N)	Mean*± SD
Lakes Altitude	None*1	55	1867.09±187.060
	Sparse	13	1761.85±113.593
	Moderate	9	1658.11±155.808
	Dense	8	1777.63±101.956
	Very dense	2	1537.50±173.241
	Total	**87**	**1813.94±184.074**
Water Level Oscillation of the Lakes	None	55	1.9645±.58331
	Sparse	13	1.8962±.47542
	Moderate	9	2.3111±.83133
	Dense	8	1.8750±.33594
	Very dense	2	3.3500±.21213
	Total	**87**	**2.0138±.61269**
Geomorphology Watershed	None	55	2.69±1.153
	Sparse	13	2.23±.832
	Moderate	9	2.56±1.014
	Dense	8	2.38±1.061
	Very dense	2	2.50±.707
	Total	**87**	**2.57±1.074**

*95% Confidence Interval for Mean. *1 Level of distribution of vegetation cover in observed lakes.

To understand if vegetation cover differs between lakes altitudes, water level oscillation of lakes and geomorphology watershed of lakes a one-way ANOVA and a Pearson (2-tailed) correlation coefficient was calculated. The data displayed in Table 5 show statistically no difference in the mean between vegetation cover of the lakes and the geomorphology watershed of the lakes (**$F(4,82) = .554$, $p=.696$**). We found a statistically significant difference in the mean of the vegetation cover of the lakes and water level oscillation (**$F_{(4,82)} = 3.610$ $p=.009$**).Moreover, we found a statistically significant difference (**$F_{(4,82)} = 5.013$ $p=.001$)** in the mean of vegetation cover of lakes and the altitude of lakes.

Table 5. Performing a one-way ANOVA to analyze the difference between vegetation cover and other variables (*Lake's altitude, water level oscillation and geomorphology of watershed of lakes).*

		Sum of Squares	df	Mean Square	**F**	**Sig.**
Lakes Altitude	Between Groups	572587.211	4	143146.803	**5.013**	**.001**
	Within Groups	2341369.502	82	28553.287		
	Total	2913956.713	86			
Water Level Oscillation	Between Groups	4.834	4	1.208	**3.610**	**.009**
	Within Groups	27.450	82	.335		
	Total	32.283	86			
Geomorphology Watershed	Between Groups	2.614	4	.653	**.554**	**.696**
	Within Groups	96.650	82	1.179		
	Total	99.264	86			

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There is a statistically significant correlation between vegetation cover of lakes and the water level oscillation as displayed in Table 6 (Pearson correlation 2-tailed: $R^2 = -.666$, α=99%, p<0.001).

Table 6. Pearsons correlation between vegetation cover and water level oscillations.

		Water Level Oscillation	Lakes Altitude
Water Level Oscillation	Pearson Correlation	1	-.666**
	Sig. (2-tailed)		<.001
	N	87	87
Lakes Altitude	Pearson Correlation	-.666**	1
	Sig. (2-tailed)	<.001	
	N	87	87
**Correlation is significant at the 0.01 level (2-tailed).			

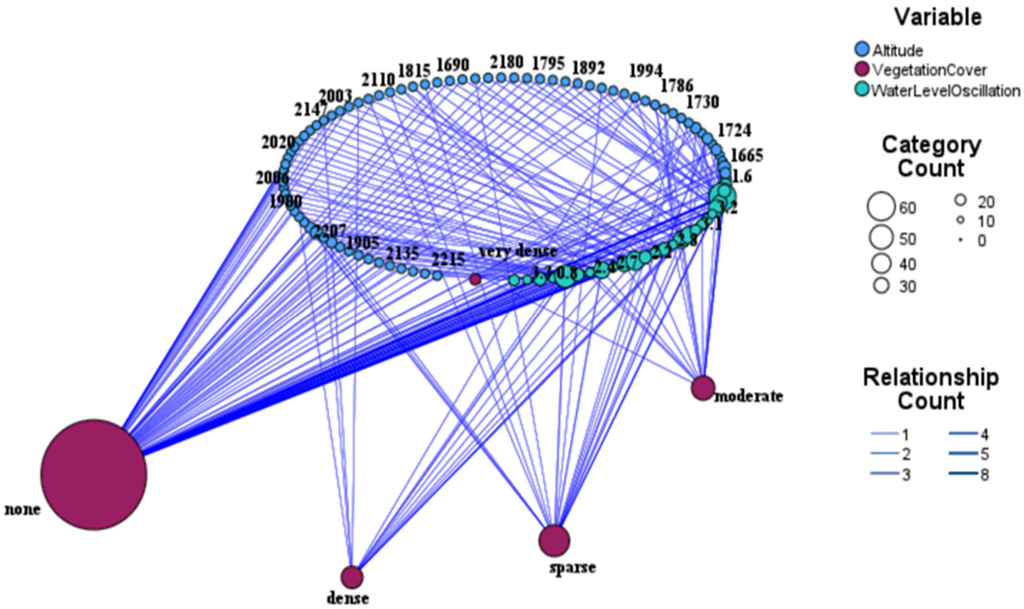

Figure 2. Relationship Map analyses.

Glacial lakes Rotifer biodiversity: In 2021, a checklist of Rotifera species found in Albanian inland waters and nearby areas was released [41]. There are 140 species of bdelloids and monogononts on the list, representing 38 genera. The genera that have been recorded as having the highest number of rotifers in Albanian inland waters are Lecane (16 species), Trichocerca (15 species), Brachionus (15 species), Keratella (7 species), Polyarthra (7 species), and Lepadella (6 species). Along with other types of ecosystems, small-standing water ecosystems, including those of glacial origin that are the focus of this work, are thought to be particularly important for biodiversity conservation, and proper management is desperately needed [42]. There are very few publications dedicated to rotifers of glacial lakes [43,44] and the particular features noted by [45] are also the case for the Albanian glacial lakes. i.e., most of these lakes are found on mountains, above the forest line (Figure 3).

With regard to rotifers a total of N=13 lakes were observed. The mean of lakes altitude is 1832.69±285.506and the mean of Rotifer species observed is 8.00±4.340. Table 7 displays general characteristics of the surveyed lakes in Albania in the frame of rotifer species number observed in lakes in correlation to lakes altitude and vegetation cover.

Table 7. Descriptive rotifers relationship statistics for different variables performed with SPSS 29.00.

Variables	Rotifer species (N)	Frequency (N)	Mean*
	3	2	2227.00±193.747

LakesAltitude	4	1	2070.00±.000
	5	2	2053.00±66.468
	7	2	1842.50±88.388
	8	1	1740.00±.000
	9	2	1655.00±77.782
	13	1	1610.00±.000
	15	1	1470.00±.000
	16	1	1380.00±.000
	Total	**13**	**1832.69±285.506**
VegetationCoverofLakes	3	2	.00±.000
	4	1	.00±.000
	5	2	.00±.000
	7	2	.50±.707
	8	1	2.00±.000
	9	2	2.50 ±.707
	13	1	4.00±.000
	15	1	3.00±.000
	16	1	4.00±.000
	Total	13	1.46±1.613

*95% Confidence Interval for Mean.

The data displayed in Table 8 show a statistically significant difference in the mean between vegetation cover of the lakes and the number of rotifer species identified in the lakes (**$F(4,8) = 15.115$, $p=.010$**). We found a statistically significant difference in the mean of the lakes altitude and the number of rotifer species identified in the lakes (**$F_{(4,8)} = 8.262$, $p=.029$**).

Table 8. Performing a one-way ANOVA to analyze the difference between vegetation cover and other variables.

		Sum of Squares	df	Mean Square	F	Sig.
LakesAltitude	Between Groups	922344.269	8	115293.034	**8.262**	**.029**
	Within Groups	55818.500	4	13954.625		
	Total	978162.769	12			
VegetationCoverofLakes	Between Groups	30.231	8	3.779	**15.115**	**.010**
	Within Groups	1.000	4	.250		
	Total	31.231	12			

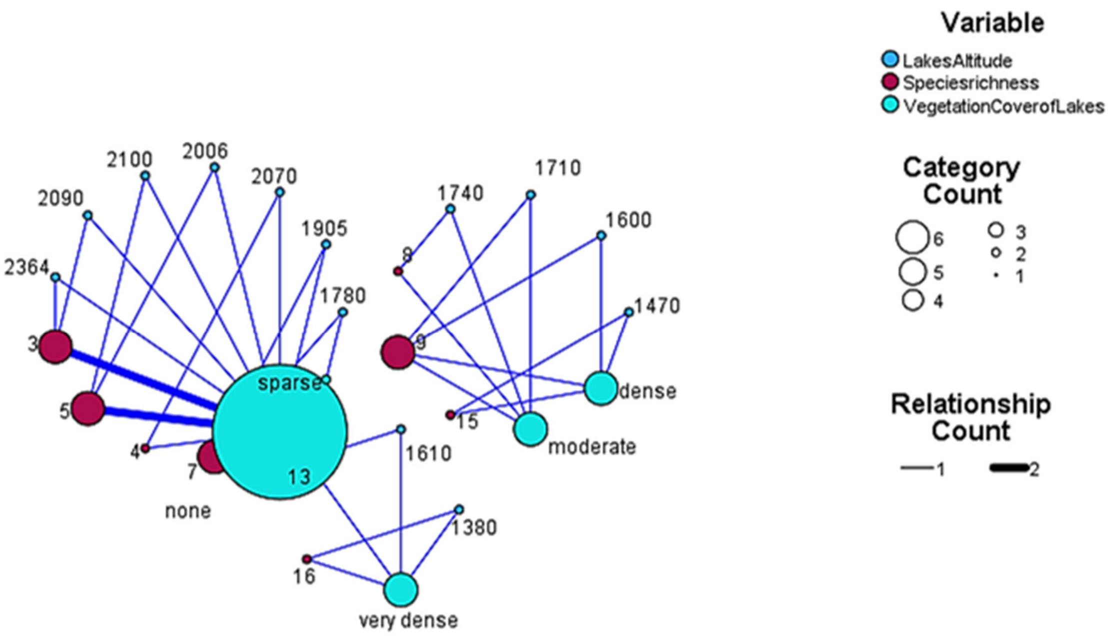

Figure 3. Relationship Map analyses of rotifers and other selected variables.

Presently the data one macrophytes of glacial lakes of Albania are very scarce. 11 macrophyte species are reported for Lake of Dushku, while the checklist of vascular plants of Albania [35] and a limited number of specimens deposited in National Herbaria in Tirana (TIR) provide the only knowledge of these ecosystems. The TIR collection includes specimens of *Nymphaea alba*, collected by K. Paparisto in Black Lake of Lura (18.08.1949) and B. Ruci in the White Lake (12.10.1999), *Eleocharis palustris* collected by B. Ruci in the White Lake and Sopoti Lake (12.10.1999), *Juncus articulatus* collected by X. Qosja, (01.08.1956) in Black Lake of Radomira and *Myriophyllum spicatum* from Lura Lakes [46].

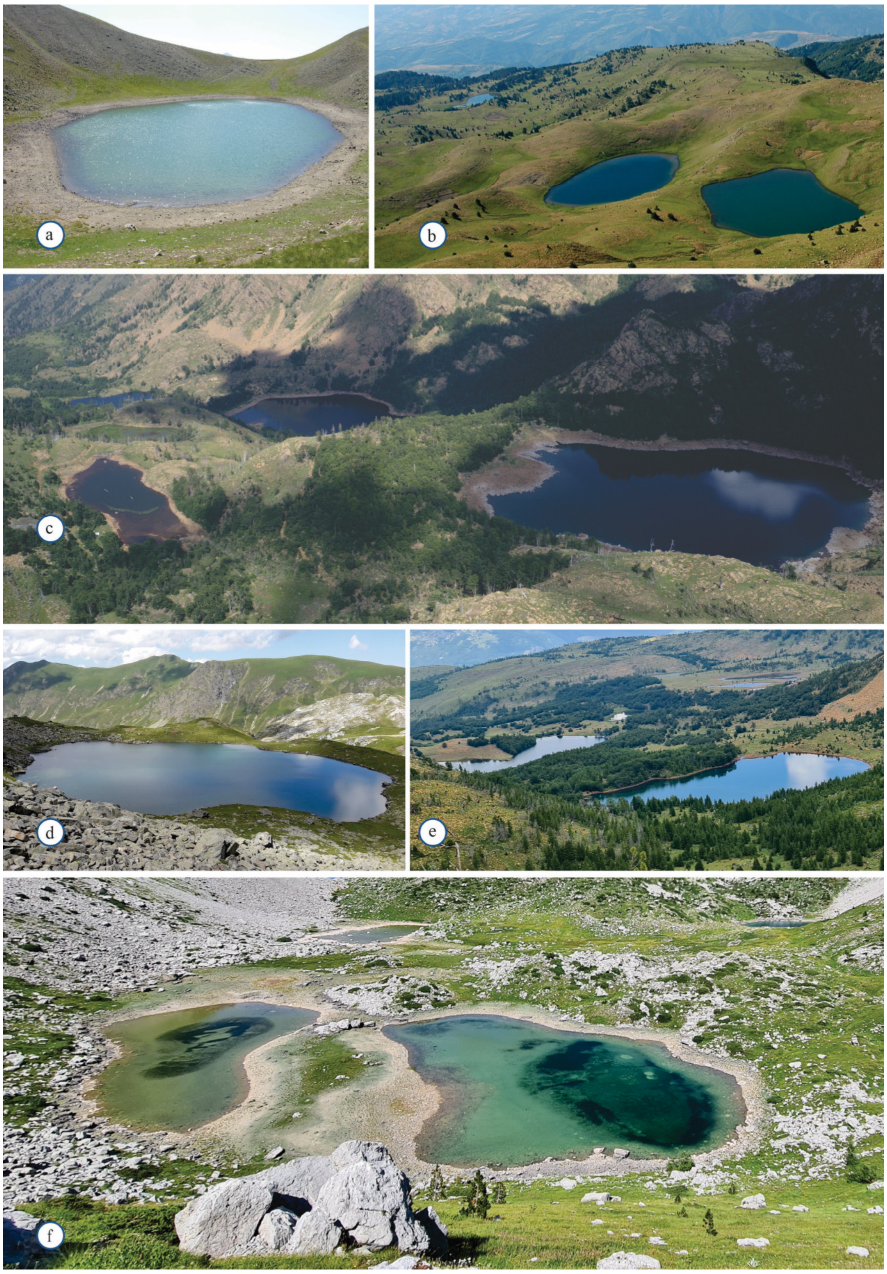

Figure 4. Selected Glacial lakes, a) Lake of Gramozi, b) Lakes on Valmara, c) Lakes of Kacnia in Balgjaj, d) Lake of Dashi in Sylbica-Doberdol and f) Lakes of Jezerca. (Author of photos: L.Shuka).

The results of study show that in 53-glacial lakes there is *no* presence of aquatic macrophytes, and they are distinguished for their high transparency and low level of nutrients [46,47]. In the other 15 lakes a cover of macrophytes was found along the peripheral areas of the lakes with shallow waters less than 20 cm, often influenced by the fluctuation of the water level during the spring-summer season, so the macrophyte coverage of these lakes is evaluated as *Sparse*. The higher coverage of macrophytes was estimated in the other 11 glacial lakes; those are evaluated as *Dense* and V*ery Dense* coverage, respectively in 8 and 3 glacial lakes (Figure 5, 5, Table 9).

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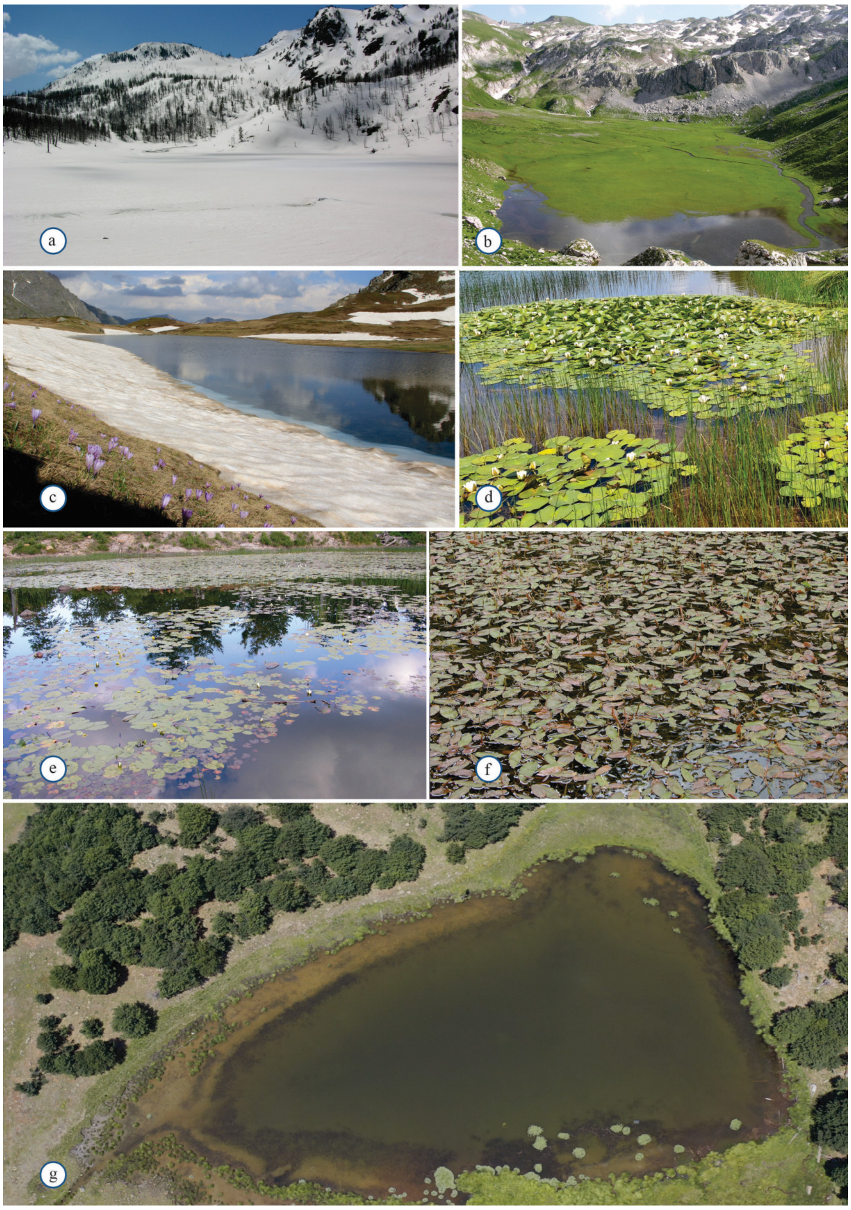

Figure 5. a) Great Lake covered by snow in Lura b) Dried Lake of Panairi in Korab, c) Yellow Lake and endemic Saffron (*Crocus bertiscensis*) during early spring, d) Floating-leaved vegetation dominated from *Nymphaea alba* in Lake of lilies (Valamara), e) Floating-leaved vegetation dominated from *Nymphaea alba* and *Nuphar lutea* in Lake of Bruçi (Lura), f) Vegetation of submersed benthic hydrophytes dominated from *Potamogetonnatans*inin Lake of Dragani (Shebenik-Jabllanica and g) *Sparse* cover vegetation in Goat Lake (Allamani) (Author of photos: L.Shuka).

Table 9. Species richness and macrophytes cover in most vegetated glacial lakes.

Name of the Lake	Altitude (m)	Geomorphology of watershed	Vegetation cover	Surface (ha)	Species richness
Lake of Dushku	1115	Ultramafic rocks	Very dense	36.2	16
Lake of Dragani	1660	Calcareous	Very dense	7.1	4
Lake of lilies (Valamara)	1865	Ultramafic rocks	Dense	2	3
Lake of flowers (Kacni)	1900	Ultramafic rocks	Dense	6.1	5
Goat Lake	1780	Ultramafic rocks	Sparse	1.7	5
Lake of Kacnia 1	1740	Ultramafic rocks	Dense	1.72	6

Lake of flowers (Allaman)	1805	Ultramafic rocks	Dense	1.22	5
Lake of flowers (Lurë)	1588	Ultramafic rocks	Very dense	1.44	7
Lake of Bruçi	1724	Ultramafic rocks	Dense	0.7	5
Kurti Lake	1683	Ultramafic rocks	Dense	1.1	5
Lake of Cows	1620	Ultramafic rocks	Dense	1.5	6
Lake of Ladies	1884	Granitic rocks	Dense	1.7	6

Regardless of the high number of the investigated lakes, the number of identified aquatic plant species is low, 27 macrophytes in 34 lakes have been recorded. The aquatic plant species belongs to 18 genera where *Potamogeton* and *Carex* are represented by three species and the genus *Eleocharis, Myriophyllum, Ranunculus* and *Typha*areis represented by two species each. The genus *Nymphaea, Nuphar, Ceratophyllum, Chara, Utricularia, Juncus, Polygonum, Alisma, Iris, Sparganium, Rorippa, Barbarea* and *Sagittaria* contribute to the floristic richness of the glacial lakes of Albania with one species each. Following Table 9, Lakes of Valamara and Dragani hosts the lower number of species, respectively 3 and 4.

The species richness of the glacial lakes in Albania is very low, ranging from 3 to 7 species in each of the observed lakes, excluding Lake Dushku, where the macrophyte richness is higher, 16 species.

The following Lakes: Kacni, Goat, Allaman, Bruçi and Kurti are characterize by low species riches (5 species), while other lakes presented in Table 3 were showing 6-7 macrophyte species.

The highest abundance was evaluated for White lily (*Nymphaea alba*) in Lake of Dushku, Lake of lilies (Valamara), Lake of flowers (Allaman), Lake of flowers (Kacni), Lake of flowers (Lurë), Lake of Bruçi, Kurti Lake and very low abundance in White Lake of Martaneshi. The most abundant species in the lakes with ultramafic bedrock is *Eleocharis acicularis* and *Eleocharis palustris*. Both water lilies (*Nymphaea alba* and *Nymphaea. lutea*) occur only in the Lake of flowers, and lakes of Bruçi, Kurti and Cows, altogether in the ultramafic geo-ecosystem of Lura. Broad-leaved pond weeds (*Potamogeton natans*) cover about 85 % of the water surface of Dragani Lake.

3.3. Rapid Changes within Snow-Coverand Low-Temperature Days (-0°C), Predicting Further Degradation due to Climate Changes and Anthropogenic Interventions

Following different scenarios, Albania will continue to experience a high degree of inter-annual rainfall variability [48]. A decrease in precipitation is expected (<10%), with the largest decreases occurring from June to September [49]. Further on it is predicted that there may also be a change in the type of precipitation, as precipitation which would normally fall as snow, is likely to fall as rain given the higher temperatures; with potential to reduce the country's snowpack as well as reduce the size of Albania's 'small glaciers' of Albanian Alps [50]. Among the other ecosystems those of glacial lakes are the first to be affected. Figure 5, shows the historical and expected number of days with Tmin< 0°C.

The field observations recorded different historical and current threats to the glacial lakes and that includes: deforestation and overuse of natural resources use of water for irrigation purposes, intervention for increasing water storage, extremely threatening use of water for energy production under small scale hydropower plants, etc.

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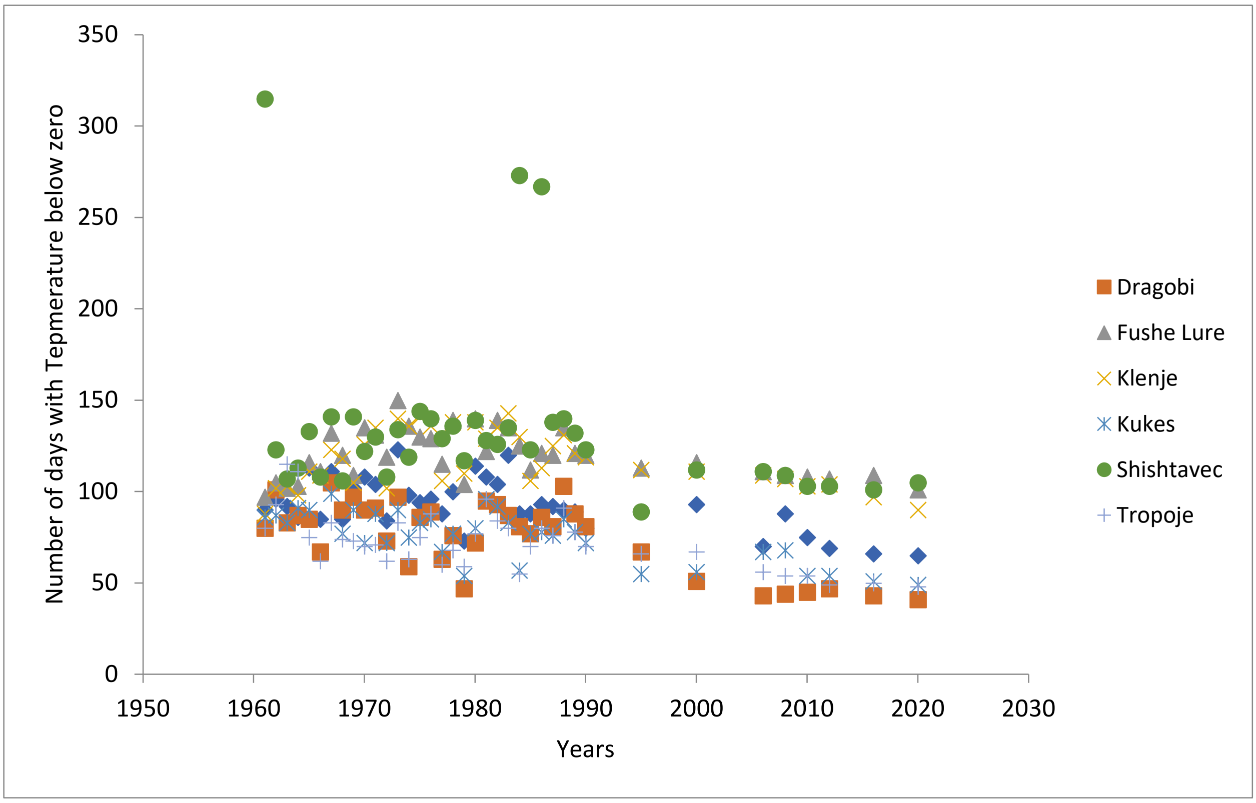

Figure 6. Number of days with negative temperature lower than 0°C (Data sources: Institute of Geosciences, Environment and Meteorology, Tirana).

3.4. The state of Conservation and Bias with Protected Areas Designation

Recent analyses [26] reveal that the Government of Albania has approved a System of Environmentally Protected Areas. Currently the area of the Network of Protected Areas of Albania reaches 504,826.3 ha, or 21% of the total area of the country. Of the total area, the Coastal and Marine Protected Areas constitute 119,224.7ha, or 23.6% of the total surface of the NPAs of the country, of which 13,261.2ha is only marine area. Moreover, 98,180.6 ha are with the status of Ramsar areas, which cover 3.42% of the total area of the country. Secured conservation connection offers prospects for species survival and life cycle performance, whereas efficient conservation management of protected areas is a precondition for their connectivity performance [51]. Moreover, large-scale ecological and evolutionary processes including gene flow, migration, and species range shifts depend on the connectivity of protected area systems.

These processes are all essential for the persistence of viable populations, especially when facing climatic and environmental changes in increasingly transformed and fragmented landscapes [52]. Improving or sustaining protected areas connectivity is, therefore, a primary concern for the effective conservation and management of biodiversity [53].

The foundation for the creation of the Albanian Ecological Network, or NPAs, is the networks of interconnected regions that have served as the basis for the establishment of corridors that span transboundary and regional contexts as well as even larger national ones. The managerial approach considered here relates to companies (in our case protected areas authorities) and non-governmental organization whose goal is to effectively preserve and advance their values and functions, and the informational resources, in order to achieve ecological sustainability of protected areas (in this case glacial lakes ecosystems) through ground based activities.

The correlation among the effectiveness management score and certain numeric properties of protected areas (surface area, percent of professional staff within the total number of employees, number of rangers per surface unit, level of conservation according to legal requirements) is examined with Spearman's rank correlation coefficient, in accordance with non-parametric nature of

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the majority of properties. Results are provided in Table 10, which contains five pairs of correlated variables. Statistical significance of the calculated Spearman's rank correlation coefficients has been confirmed with the corresponding t-test and shown with the value of t-statistics with N-2 degrees of freedom, and the corresponding p-value.

Table 10. Correlation between effectiveness score S and numeric properties of protected areas.

Variable pairs	N valid sample	Spearman coefficient R	t(N-2) Statistics	*p*-Value
S and area	14	0.2341*	1.6543	0.0154
S and % of trained staff	14	0.3323*	2.1234	0.0321
S and rangers number per ha	14	0.0110	0.7654	0.4321
S and national category	14	0.2876*	2.212	0.0245

*significance at the 0.05 level.

Following data of the analyses presented in table10, there is a statistically significant positive correlation between the measured degree of effectiveness and the following properties: the surface of the protected area where glacial lakes are located, the percentage of trained staff in the entire number of employees and the level of preservation. There is no statistically significant correlation was found between the score of effectiveness and the number of rangers per area.

Even fragmented, the analysis of threats conducted using different approaches such as the Management Effectiveness Tracking Tool, World Heritage Outlook Assessment [26]or BirdLife International's Important Bird and Biodiversity Area have identified a range of threats affecting the integrity of the considered protected areas. In the following figure (Figure 7) the rate of considerations with management plans and attention for preserving fragile aquatic ecosystems and associated biodiversity are presented. This was based on analyses of different projects implemented by protected areas authority and civil society and focused on areas were glacial lake sare located, as: EU Natura 2000 project, Balkan Lynx Recovery Program, etc.

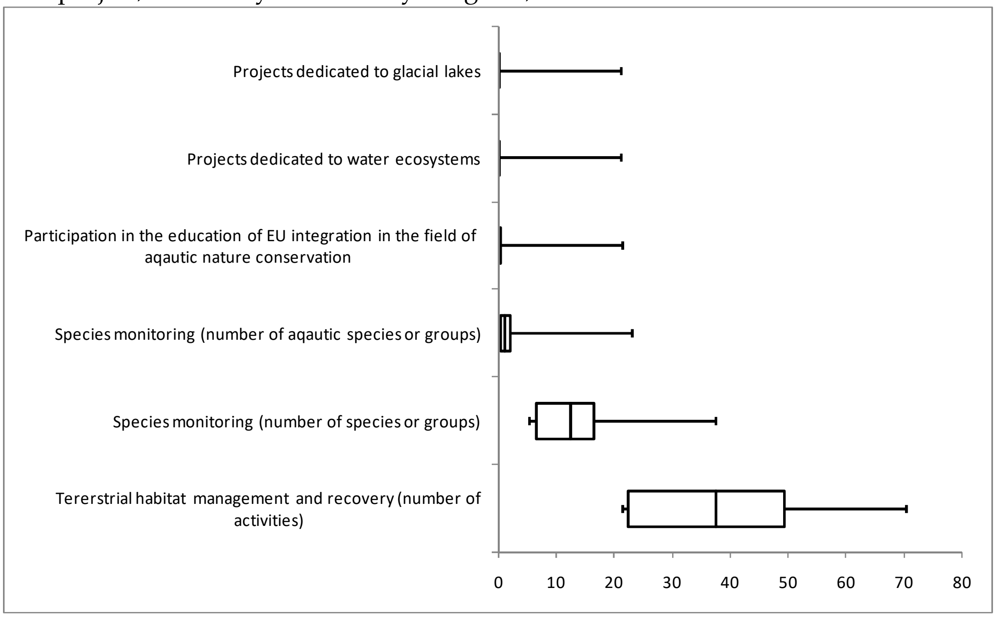

Figure 7. Box plot "Box and whiskers" showing the conservation efforts and investments for preservation of glacial lake ecosystems and associated biodiversity.

Referring specifically to important habitats for the rare, threatened and plants of community interest, there is also almost no ground conservation measures. The following plant species, *Carex davalliana* Sm., *Carex echinate, Carex flacca* Schreb., *Carex Vesicaria* L., *Eriophorum latifolium* Hoppe, *Geum coccineum* Sibth. & Sm., *Juncus effusus* L., *J. rticulates* L., *Parnassia palustris* L., *Polygonum bistorta* L., *Potentilla erecta* (L.) Raeusch, *Veratrum album*L.or threatened species of *Centaurea vlachorum* Hart,

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Silene parnassica subsp. p*indicola* (Hausskn.) Greuter, *Narthecium scardicum*Košanin, *Pinguicula balcanica* Casper, *Ranunculus degenii* Kümmerle&Jáv., *Scilla albanica* Turrill, *Soldanella dimoniei*Vierh. And *S. pindicola* Hausskn., have been most abundant around Valamara, Shebenik, Balgjaj and Lura lakes. The lake shores, water courses and the rocky cervices of the lakes in Korabi and Sylbicë-Doberdoli area [36–38] are inhabited from important endemic and subendemic species as *Barbarea balcana* Pančić, *Caltha palustris* L., *Crocus bertiscensis* Raca, Harpke, Shuka & V. Randjel., *Galanthus elwesii* Hook. F., *Heliospermum pusillum* subsp. *albanicum* (Malý) Niketić & Stevanović, *Heliospermum oliverae* Niketić & Stevanović, *Ranunculus degenii* Kümmerle & Jáv., that confirms sites conservation interest.

4. Discussion

The attempt to if the vegetation cover varies with lake elevation, lake water level fluctuations, and lake geomorphology watershed performed through analyses presented in Table 5 there is statistically no difference in the mean between the lakes' vegetation cover and their geomorphology watershed ($F(4,82) = .554$, $p = .696$). The mean plant cover of the lakes and the water level oscillation were found to differ statistically significantly ($F(4,82) = 3.610$ $p=.009$).Furthermore, we discovered a statistically significant difference between the height of lakes and their mean vegetation cover ($F(4,82) = 5.013$ $p=.001$).

According to different scenarios the Mediterranean region including Albania will continue to see a significant level of inter-annual rainfall variability under many scenarios [48]. Precipitation is predicted to decrease (by less than 10%), with the biggest reductions taking place between June and September [49]. Furthermore, given the higher temperatures, it is predicted that there may be a change in the type of precipitation as well. Precipitation that would typically fall as snow is more likely to fall as rain, which could reduce the amount of snow in the nation and the size of Albania's "small glaciers" in the Albanian Alps [50]. So, the ehe ecosystems of glacial lakes are the first to be impacted among the others.

The large number of high-alpine lake area and the number of lakes over elevation in Albania, as part of protected areas, provide an advantage for an increased attention and conservation. Despite efforts and implemented projects, management of the protected areas remains a challenging issue, connected with broad national and global public implications. The goal of current protected area management approaches is to determine which of these approaches are most appropriate and successful. In our circumstances, it is crucial to first examine if the legal requirements which the protected area managers are required to carry outare met, as this constitutes the fundamental and necessary minimum before any other analysis. The considered protected areas (and their management plans) within this analysis also paid attention to minimal conditions, i.e., standards in operating in this field of work (in our case aquatic ecosystem) which should be completed and fulfilled. This represents an initial baseline of good management, and measuring the effectiveness and creation of the best possible management model is the upgraded superstructure of previously set standards. As highlighted in Figure 6, the considerations and driven results following the Management Effectiveness Tracking Tool, show very limited attention towards preservation and increased resilience of the small water bodies.

The importance of rotifer biodiversity is linked with presence of a total of 31 rotifer taxa (Brachionidae 8 taxa, Euchlanidae 2 taxa, Mytilinidae 1 taxa, Lepadellidae 3 taxa, Lecanidae 6 taxa, Notommatidae 1 taxa, Trichocercidae 2 taxa, Synchaetidae 3 taxa, Asplanchnidae 1 taxa, Gastropodidae 1 taxa, Testudinellidae 1 taxa, Filiniidae 2 taxa). According to theanalyzed data, there is a linkage among rotifer species richness along different altitudinal distributions of lakes, where Lake of Dushku (1380 m) is distinguished by 16 taxa, while Lake of Valamare (2070 m) with four taxa. All taxa identified are new records for their localities [41,42]. In regard to the studies of high mountain lakes in Albania, 31 taxa of rotifers are reported among the zooplankton of analyzed mountain lakes, mostly at the north-eastern range, the elevation of which ranges from 1470 to 2200 m. Among them, the taxa *Brachionus quadridentatus*, *Keratella cochlearis*, *K. quadrata*, *Notholca squamula*, *Euchlanis dilatata*, *E. incisa*, *Mytilina ventralis*, *M. ventralis brevispina*, *Trichotria tetractis*, *Colurella uncinata*, *Lepadella patella*,

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L. patella similis, *Lecane flexilis*, *L. luna*, *L. lunaris*, *L. quadrientata*, *Cephalodella gibba*, *Trichocerca longiseta*, *T. rattus*, *T. similis*, *T. vernalis*, *Synchaeta pectinata*, *Asplanchna priodonta*, *A. girodi*, *Testudinella patina*, *Conochilus unicornis*, *Hexarthra fennica*, and *Filinia longiseta* were found in the present study.

Similar destruction patterns were found [44], revealing that in the high mountain lakes in Turkey, 69 taxa of rotifers were reported among the zooplankton of 16 mountain lakes in the Taurus mountain range, the elevation of which ranges from 1500 to 2660 m. Among them, the taxa of genus *Brachionus*, *Keratella*, *Notholca*, *Euchlanis*, *Mytilina ventralis*, *Trichotria*, *Colurella*, *Lepadella*, *Lecane*, *Cephalodella*, *Trichocerca*, *Synchaeta*, *Asplanchna priodonta*, *Testudinella*, *Conochilus*, *Hexarthra* and *Filinia* were found do dominate.

Rotifer species richness exhibits a monotonic decline with altitude, independent of scale effects, according to a survey carried out in the Alps region [43]. In addition, the species richness may be further elucidated by considering the following: water temperature as a proxy for energy, nitrate as a proxy for human influence—discussed in our instance under vegetation cover and habitat diversity—lake area as a proxy for habitat diversity, reactive silica and total phosphorus as proxies for productivity, and so on. Altitude therefore had no further impact on species richness, and the predictors fully explained the species richness–altitude pattern (Figure 2 and 3).

Low species richness and macrophyte coverage in the glacial lakes of Albania show a strong correlation with their small surface area, in accordance withprevious studies for the other Balkan lentic systems [46,55]. Following the results on high species richness in the Lake of Dushku compared with the lower species richness of the higher altitudinal location of the other glacial lakes, e.g., Lake of lilies in Valamara, Lake of Dragani or Lake of Flowers in Lura, Kacnia and Allamani range, they are in full accordance with the impact of climatic factors and altitudes [56], but not in accordance with other references [57,58], who connect the predominant anthropogenic pressures in lowland lakes of the Mediterranean with species loss and with decrease of species richness. Despite higher anthropogenic impact observed in Lake Dushku (maximum depth of 18 m), it is distinguished for the higher species richness and types of vegetation, unlike other glacial lakes with *dense* and *very dense* cover vegetation. The macrophyte vegetation of Dragani Lake cover 90 % and is composed only from submersed benthic hydrophytes dominated from *Potamogeton natans* that, which have not been found elsewhere in glacial lakes of Albania. The macrophyte vegetation of Lake of flowers (94 %), Kurti Lake (55%) and Lake of Bruçi (65%) in Lura geo-ecosystem is dominated from floating-leaved vegetation of *N. alba*and*N. lutea*. Yellow lily was not found in other glacial lakes of the country.

Submersed benthic hydrophytes vegetation of *Nymphaea alba* accompanied with other helophytes such as *Eleocharis acicularis* or *E. palustris* and *Carex*spp., dominate in Lake of lilies (Valamara), Lake of flowers (Allamani and Kacni area) and Lake of Kacnia 1. All the above lakes are characterized by a depth of less than 2 m and high biomass accumulation of helophytes species, contributing to primary productivity, sediment accumulation and stabilization, storage and cycling of nutrients according to [22], which accelerate their deterioration. The relict, endemic and subendemic species such as *Barbarea balcana, Caltha vlachorum*, *Crocus bertiscensis, Heliospermum pusillum* subsp. *albanicum* and *Heliospermum. oliverae*, *S. parnassica* subsp. subsp. *pindicola*, *Narthecium scardicum*, *Pinguicula balcanica*, *Ranunculus degenii*, *Scilla albanica*, *Soldanella dimoniei* and *Soldanella pindicola*, recorded in the shores and the belt around glacial lakes in Albania [36,37,54] might be considered as good indicators for the water quality and habitat integrity.

The historical and current threats to the glacial lakes and their basins, such as deforestation and overuse of natural resources, use of water for irrigation purposes, intervention for increasing water storage, and the extremely threatening use of water for energy production under small scale hydropower plants, seem to accelerate the deterioration of integrity.

The relationship between the management effectiveness scores and a few external factors—such as surface area, the proportion of staff with training, the number of rangers per surface unit, and the national protected area classification—has been studied in relation to the management effectiveness along the protected areas that include glacial lakes. The results of the analysis show that there is a substantial relationship between the management effectiveness score and the classification of national protected areas, surface area, and the proportion of trained personnel among all employees.

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It is evident that more work and ground-based methods are required in light of the lack of a statistically significant association between the effectiveness of the protected area and the number of rangers stationed there. More analysis is required to take this and related factors into account. In terms of other components, the outcomes are anticipated because professional staff is primarily responsible for managing protected areas; that is, higher conservation levels are predicted to result in stricter conservation implementation measures within specific protected areas.

5. Conclusions

This paper has set four basic objectives: - to create an inventory of high alpine lakes in the Albanian upland areas; - to investigate lake characteristics, distribution and highlight the biodiversity values of selected animal and vegetation components; - to assess the snow-cover and low-temperature days (-0°C) and hypothesize the impacts caused by both climate changes and anthropogenic interventions; and -to discuss state of conservation and bias with protected areas designation in Albanian Alps National Park, Korrab-Koritnik Nature Park, ShebenikJabllanica National Park, etc.

The authorsconclude that current management plans of the considered protected do not meet minimum requirements for adequate management in terms of the legally prescribed management criteria. Following the analysis of additional issues, they conclude that aquatic ecosystems lie under category of most vulnerable ecosystems.

The results indicate that the effectiveness management of the protected areas needs to be employed within standard practices of management of protected areas, including all types of ecosystems. Further measures building resilience of aquatic ecosystems are vital for preserving entire biodiversity values.

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