UNIUNEA EUROPEANĂ

GUVERNUL ROMÂNIEI
MINISTERUL MUNCII, FAMILIEI, PROTECŢIEI SOCIALE ŞI PERSOANELOR VÂRSTNICE
AMPOSDRU

Fondul Social European
POSDRU 2007-2013

Instrumente Structurale
2007-2013

MINISTERUL EDUCAŢIEI NAŢIONALE
OIPOSDRU

UNIVERSITATEA TEHNICA "GHEORGHE ASACHI" DIN IASI

BABEŞ-BOLYAI UNIVERSITY

Faculty of Environmental Science and Engineering

HUMAN IMPACT AND RISK ASSESSMENT IN THE PERIMETERS OF SOME GLACIAL LAKES FROM ROMANIAN CARPATHIANS

- PhD thesis -

-Abstract-

Coordinator:

Prof. univ. dr. ing. ALEXANDRU OZUNU

PhD Student:

ANDREEA IOANA POP

CLUJ-NAPOCA - 2013

CONTENTS

The abstract contains part of the thesis results, conclusions and selective bibliography. Notations contents, chapters, sub-chapters, figures, tables and equations are identical to those of the thesis.

Keywords: glacier lakes, Romanian Carpathians, impact and risk assessment, human impact

I. INTRODUCTION. Concept and Objective

1.1.General introduction

Mountainous regions represent the most distant and least less inviolate environments on the entire planet. The mountains represent an essential source of fresh water at a global level. Their global role as a source of fresh water could be altered considerably due to climate changes and continuous human impact.

The mountainous area, with an altitude over 1000 meters, on the entire European continent sums up 27% of the total earth surface (Ives, et al, 1997). At a global level it is estimated that approximately 40% of earth's population lives in the hydrographic basins of rivers that originate from the mountainous regions (Beniston M, 2003).

The alpine level plays a critical part in the water cycle and its main purpose is to entrap the moisture from the air mass and to store precipitations in the form of snow until they melt away in the spring. Due to this process, mountains can retain large quantities of water through the winter period and deliver them all through the summer and autumn, therefore representing the main fresh water supplies of the world.

Mountainous lakes represent, in many cases, the main source of water that forms rivers, due to the fact that around them, many high altitude springs develop in direct connection to the great water basins entrapped inside the rock structure of the mountainous area.

The hydrologic importance of the mountainous regions is in a constant contrast with their vulnerability. In many cases, the intense use of mountainous terrains, near a source of water, can induce a direct and increased stress upon the environment and can lead to a faster deterioration of the ecosystems and of the alpine landscape (Wouter B. et. al., 2006).

The mountains carry out important ecological and economical tasks for the lower areas around them, which include sustaining the minimal ecologic flow like: the production of water for agriculture, the production of food and the production of hydropower.

At a global level, many studies regarding the importance of mountainous regions and their fresh water resources have been developed, all of the unanimously proving that these resources should be protected and concluding that they are the only fresh water source on the continent that influences our lives continuously.

A more thorough approach in the study of the mountainous areas water resources and especially of the mountainous lakes would contribute to the better understanding of the mountainous ecosystems problems on a national and also international scale, the improvement of the national and international databases and the review of the study models developed to this day specifically for the mountainous lakes at an international level.

In my opinion, the necessity of such a study in Romania represents a priority and there is also a strong need for the population's better awareness of the importance of mountainous regions and glacial lakes as the main resources of fresh water.

This paper will present a complex study of 6 glacial lakes and associated areas in the Romanian Carpathian Mountains, made by evaluating the anthropic impact and assessing the risks that can lead to the degradation of these areas.

1.2.Concept and Objectives

The main concept behind this study is the improvement of the national and international database in the field of glacial lakes, especially due to the lack of research on the anthropic impact and risks assessment on these areas and the associated ones, as well as the proposal of new techniques and innovative assessment methodologies of these areas, through the identification of parameters relevant to the evaluation and analysis matrix.

To this day, very few studies regarding the glacial lakes in Romania have been made. The most recent of these studies analyze the geological and geomorphic elements (Urdea P.,Vespremeanu- Stroie A., 2008, 2010), the physicochemical properties (M.Mîndrescu 2004, 2010) and the algal flora (Lehaci I., 2012). The necessity of the evaluation is also of great importance due to the need to integrate the data in the European databases (international publications) (Pop.A.I. et al, 2011, 2012, 2013; Mihăiescu R. et al, 2012).

The evaluation studies of the anthropic impact and risk in these areas are practically inexistent. There are numerous international publications on the matter and a wide and comprehensive database, but in our country they are completely missing.

The main objectives of this paper can be summed up as follows:

The chosen study has an acute applied character, proposing a detailed and complex investigation of the glacial lakes and their associated areas through thorough research which includes:

1. **The detailed analysis of the physicochemical properties of the studied lakes.**

The term detailed analysis refers to the drawing of water samples in order to identify and assess the physicochemical properties through parameters such as: pH, conductivity, oxygen content, salinity, heavy metals, organic pollutants, nitrates, sulfates, phosphates.

2. **Study and characterization of algal flora**

The species of identified algae can lead to a better understanding of the obtained results due to the fact that many of these species are valuable naturally occuring biological indicators. The literature on the subject comprises of studies regarding only 3 of the 6 studied lakes**. The remaining 3 lakes are being assessed for the first time**.

3. **Quantifying the accessibility level in the studied areas, as well as identifying the environmental impact associated to tourism flow and tourist activities.**

The accessibility degree is assessed through modern accessibility quantification techniques and methods for different interest points. Accessibility is in a strong relation to environmental impacts associated to tourism. Glacial lakes are important tourist attractions for the mountainous areas. The number of tourists visiting can influence environmental pressure directly.

4. **Evaluating the human impact on mountainous lakes with the help of evaluation matrixes, methods and techniques.**

In regard to the proposed studies, the evaluation of the anthropic impact shows the final results as well as the development of an environmental database and also the spread of the results at a larger scale in order to increase public awareness for the protection of these areas.

5. **Risk assessment and identifying the potential hazard elements that can lead to the degradation of these areas.**

The risk assessment in these areas will be done with the help the qualitative evaluation techniques, methods and matrixes. These methods will be adapted to the study so as to increase its relevance.

6. **Modeling the data with the help of geographical systems programs.**

Programs such as ArcGis, Arcview si Global Mapper will be used to highlight the obtained results through graphical representations and maps.

7. **Proposing a new human impact evaluation methodology for the mountainous areas as well as a new qualitative risk evaluation methodology, containing new elements, modified and adapted for these kinds of studies.**

Premises for pertinent decision making will be created, in regards to the effects of pollution and negative anthropic influence on the quality of the glacial lake water and the surrounding area, by creating a new anthropic impact evaluation matrix

Therefore, the application of new rules for the conservation and consolidation of biological and ecological diversity of lake and surrounding areas will be scientifically substantiated.

1.3. Thesis structure

Chapter I represents the introduction of the thesis, underlining the necessity of advanced studies in the field of glacial lakes and the importance of the mountainous areas. The major concept and objectives behind this thesis are also presented in this chapter.

Chapter II presents, in a detailed manner, the importance of mountainous areas at an international and also national level. This chapter also describes the benefits of the population from the mountainous areas and the numerous resources by which we can benefit.

Chapter III contains the detailed bibliographic study of the discussed areas.
The bibliographic study contains numerous data obtained from various previous studies as well as personal conclusions and data obtained through vast and often field monitoring trips which are essential to the present study. The main study areas of this thesis are represented by 6 glacial lakes. The lakes are as follows: Iezerul Pietrosului Lake and Buhăiescu Lake in the Rodnei Mountains National Park, Bucura Lake and Galeş Lake in the Retezat Mountains National Park and Bâlea Lake and Călțun Lake in the Făgăraş Mountains. All of these lakes are situates in the Carphatian Mountains, Romania.

Chapter IV presents the results of research on the state of water quality in the studied lakes, as follows:

-presents the results obtained through the analysis of the water samples drawn from the previously mentioned sites. The monitoring and sample drawing took place in the summer period of 2011 and 2012/ The obtained results have been interpreted according to the Ordinul161 from 2006 regarding the state of lake water quality and the 5 ecologic states of the mountainous lakes. To this date there had never been studies regarding these kinds of lakes, with the exception of Bâlea Lake, therefore this study comes as a substantial betterment of the present, almost inexistent, database.

- describes existing the algal flora composition from 5 of the 6 studied lakes. The algae are important biological indicators, especially in the identification of early water pollution. The data obtained has also been interpreted according to the Ordinul161 from 2006 regarding the 5 ecologic states of mountainous lakes. This chapter comes as an improvement of the current database, providing data for 2 new, previously unstudied, lakes (Buhăiescu Lake and Călțun Lake).

Chapter VI focuses on identifying environmental pressures and human impact assessment by:

- details through innovative methods, adapted completely to this study, the quantification of accessibility in the studied areas as well as the identification of environmental impact due to touristic activities. The used methodology has been adapted to the studied areas due to the fact that to this day this type of study has never been published, and the elements taken into consideration are the ones identified during the field monitoring trips.

- concentrates on the evaluation of the anthropic impact with the help of the evaluation techniques, methods and matrixes. The synthetic evaluation of the anthropic impact on environmental components was done by using a rapid evaluation matrix (RIAM - Rapid Impact Assessment Matrix), a matrix elaborated by Pastakia and Jensen in the year 1998. In this matrix 59 components, identified from the studied areas, have been selected and analyzed. These were divided into four large evaluation classes like: physical and chemical components, biological and ecological components, sociological, cultural and terrain usage components, economical and operational components.

Chapter VI describes the risks identified through qualitative risk identification methods and presents in detail the risk level for each lake and the hazards that might appear. This chapter also presents the final results of this study in a systematic matter and shows the numerous negative consequences that appear due to the intense anthropic impact in these areas.

Chapter VII presents the final conclusions of the thesis and the personal contributions to it (articles, conferences, workshops, summer schools etc.).

II. THE IMPORTANCE OF THE MOUNTAINOUS AREAS

2.1. General description of the mountainous areas

More than half of the human kind depends on fresh water, captured, deposited and purified in the mountainous regions. Ecologically speaking mountainous regions are hotspots for biodiversity, while socially speaking mountains are of enormous world importance as key destinations for touristic and recreational activities (A. Grêt-Regamey, et all, 2010).

The arctic and alpine regions of Europe are the least anthropic environments in Europe. They are constantly under the threat of acid deposits, toxic air pollutants and climate change.

In Romania the mountainous region represents the area with the most important fresh water source, summing up 80% of Romania's total water reserve. This is mostly due to the numerous streams and water deposits. Glacial lakes are fueled by existing streams, even at altitudes between 1800 and 2400 meters.

Mountain lakes that appear on the course of these regions are extremely delicate, while the emergence of new threats is inevitable. These threats can come from various sources.

Many lakes don't have the capacity to neutralize acidity due to their shallow bed, represented by a thin layer of sediments, which can be easily transported and relocated by the water. Also, the nitrate level is usually high due to the fact that the basin of these lakes have little soil and vegetation and lack the capacity to completely assimilate nitrogen deposits.

Toxic metals and organic traces accumulate in the trofic chain easily and certain pollutant substances (mercury, volatile organic pollutants etc.) can accumulate especially in the colder regions. Mountain lakes are especially prone to such accumulation due to their high altitude positioning (Preston F., 2009).

Global warming in Europe is said to be more noticeable in the arctic and alpine regions. This is where it can be observed and monitored easily. The Carpathian Mountains have altitudes of over 2000 meters, meaning that the climate changes which can occur here might also be of significance to the rest of Europe.

Due to their high vulnerability mountain lakes are not only sensible to environmental changes but also to changes of any kind, making them excellent environmental sensors. Their high quality recording system, the sediment substrate, can be used to estimate the speed, direction and biological impact of the changes in air quality and climate.

2.4.The mountain ecosystem services

This concept is at the present a connecting bridge between the mountain and what it can offer for mankind's wellbeing.

In more popular terms, the ecosystem services represent the benefits that people can obtain by exploiting the natural ecosystems.

The term ecosystem services was first mentioned by Ehrlich and Ehrlich(1981). The development of the concept combined the stored to date and perspective knowledge which results from the limited nature of the natural resources and studied ecosystems.

The concept was first defined by Constanta et al. (1997), Daily (1997) and Walter et al. (2005). Constanza et al. (1997)defined the ecosystem services as the representation of the goods and services derived from the ecosystem's function, while Daily(1997) considered that the ecosystem services exist through the conditions and processes of the natural ecosystem due to human existence.

Mountainous ecosystems offer a large array of goods and services to human kind, for people living in the mountains as well as around its area.

For example, more than half of mankind depends on fresh water, captured, deposited and purified in the mountainous regions. From an ecological point of view, mountainous regions are a biodiversity hotspot, while from a social point of view they are of paramount importance as key destinations for tourism and recreational activities (A.

Grêt-Regamey et al., 2010). The number of documents which mention the term of ecosystem services in the mountainous areas has exponentially risen due to Daily's first book (1997).

Even so, the known literature has shown that less than two thirds of the documents referencing the concept of agreement with the ecosystem services in mountainous areas, refer to the idea of benefits to mankind, and out of these only one quarter refer to ecosystem services as a paying benefit. Taking into account the definition mentioned above, less than 15% of the studies dealing with the concept of ecosystem services use the term concretely, through explanations and implementation. More than 85% of the to date contributions use the concept as a new expression and don't approach the term substantially and from a practical point of view (A. Grêt-Regamey, et all, 2010).

III. STUDIED AREAS

3.1.General description of the mountain lakes from Romania

In Romania, due to approximately even distribution of the major relief forms and the influence of the other components of the geographical landscape, numerous lakes can be found which differ from each other in terms of morphology, morphometric and especially on their genesis (Appendix 3.1).

According to the genesis of lacustrine cuve and their distribution in different mountainous regions we can classify them as follows: volcanic lakes, glacial and periglacial lakes, karstic lakes and antrophic lakes.

Glacial and periglacial lakes, are the category best represented in the alpine level, sculpted and modeled by the action of the quaternary glaciers. The traces left by these glaciers in the Oriental Carpathians, especially in the Rodnei Mountains, and in the Meridional Carpathians are well kept at altitudes beyond 1800 meters (P.Gâştescu, 1971).

3.2.The characterization of the studied areas

3.2.1. Făgăraş Mountains: Bâlea Lake and Călțun Lake

Făgăraş Mountains, also named by Emmanuel de Martonne "The Transilvanian Alps" (E. De Martonne, 1906), appear as a grand stone wall. Oriented on an east to west direction, their length reaches 70 Km and their width 40 Km. To the west they are limited by the Otului Gorge and to the east by Bârsa Grosetului and Dâmbovița. To the north they are bounded by the Făgăraşului depression, also know as Oltului Country (which it dominates through a great and abrupt tectonic), while to the south by a depression chain made by Câmpulung, Brădetu, Arefu and Jiblea depressions**.**

The total surface of the massif is of over 3000 km^2. Due to the highly fragmented relief, made of crystalline schists, 8 peaks of over 2500 meters emerge all along its length (Pişota I., 1971) and approximately 25 glacial lake, 20 of which at altitude of 2000 meters (Giurigu I., Silvăşan G., 2005). The massif presents itself in the shape of a main summit with peaks breaking from its northern and southern margins.

Bâlea and Călțun glacial lakes

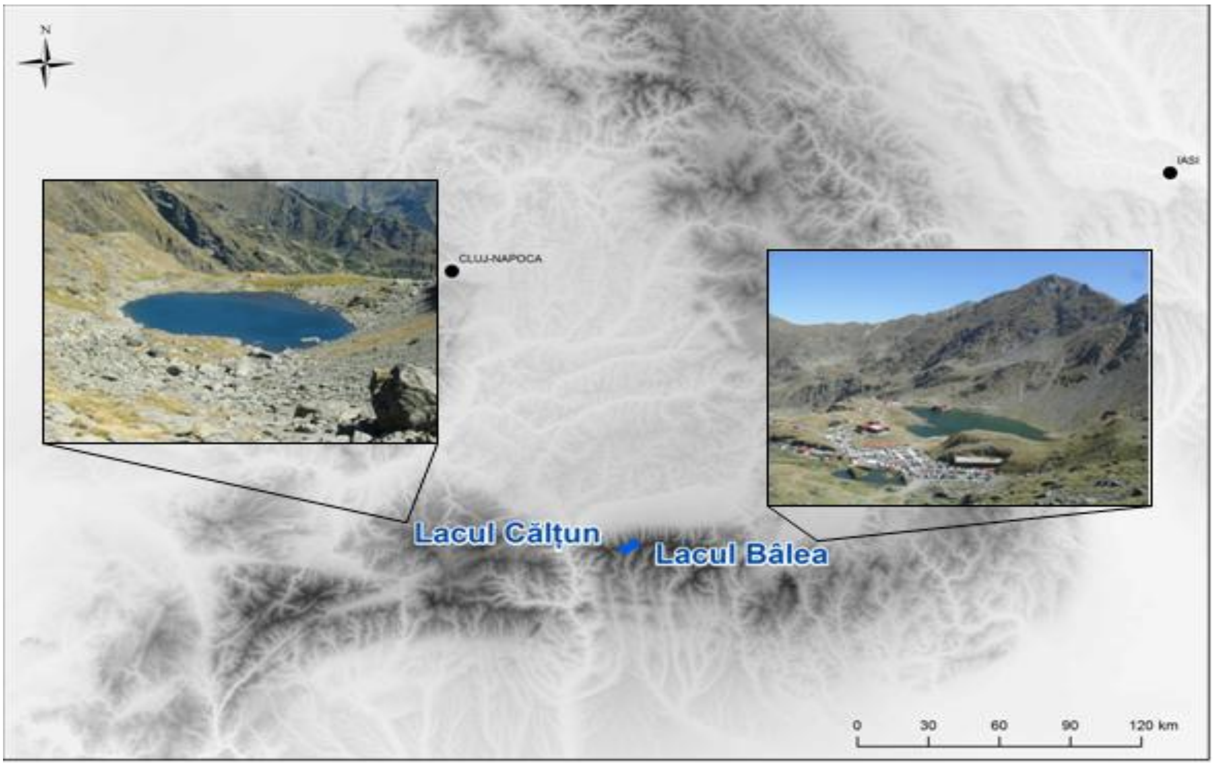
Bâlea Lake (fig.3.1) is one of the best known glacial lake in the Făgăraş Mountains, mainly due to its high accessibility. It is situated near the national road DN 7C, Fransfăgărăşan, which connects Sibiu county to Argeş county. The lake is under a very high antrophic impact due to the very hig number of tourist in the summer, but also due to the numerous facilities built by its sides (Pop, A.I., et al, 2012).

The lake is located at an altitude of 2034 meters, its dimensions being: a length of 360 m, a total surface of 46508 m^2 and a maximum depth of 11.35 meters (I. Pişota, 1971). In the year 1932 Bâlea Lake and a surface of approximately 180 ha surrounding it have been declared as scientific reservation.

Călțun Lake(fig.3.1) is one of the most beautiful lakes in the Făgăraş massif, being situated under the steep wall of the Negoiu Peak, in the Călțunului depression. The lake doesn't present a high risk of antrophic impact due to it's difficult to reach location.

The lake is situated at an altitude of 2135 de meters, it has a depth of maximum 12,1 meters and a total surface of 7.751 m^2 (A. Vespremeanu-Stroie etal, 2008).

Fig 3.1.The position of glacial lakes Bâlea and Călțun in Făgăraş Mountains



3.2.2 Retezat Mountains National Park: Bucura Lake and Galeşu Lake

Retezat Mountains, are part of the Meridional Carpathian Mountains, Retezat-Godeanu group. They are situated between two major depressions, Petroşani and Haţeg and between two major rivers, Râul Mare, bounding them to the north and east and Jiul de Vest, bounding them to the south. They are surrounded by Ţarcu Mountains to the west, Godeanu Mountains, to the south-west and the Vâlcan Mountains, to the south. The most important part of the massif is mainly made of crystalline rocks and is called Retezatul Mare, while the southern park, is mainly rich in limestone masses and vast formations and is named Retezatul Mic. The two unite somewhere close to Bucura Lake (P.Urdea, 2000).

Retezat Nationa Park was the first national park founded in Romania, in the year 1935, and today part of the park has been proclaimed as A Biosphere Reservation. Retezat Mountains have over 80 lakes and tarns, of which approximately 25 are situated at altitudes above 2000 meters, the mountains being sometimes called "the blue eyed land", due to their high density in all of the glacial lakes. (Admin, P.N. Munții Rodnei, 2010).

Bucura Lake (fig.3.2) is the glacial lake with the biggest surface in our country. The lake is situated at an altitude of 2041 meters, in Bucurei depression, under the Peleaga Peak. The lake dimensions are as follows: the surface measures up to 8.9 hectares, the length is of 550 meters, maximum depth is of 15.5 meters and the estimated volume is of 625.000 m^3 (I. Pişota, 1971). Bucura Lake present a high degree of anthropic impact, being situated between the intersection of many major touristic trails.

Galeşul Lake(fig.3.2), has a surface of 3,68 hectares, a maximum depth of 20,5 meters (I.Pişota, 1971) and can be easily proclaimed as one of the most beautiful lakes of the massif. It is situated on the Galeşul Valley, under Vârful Mare, at an altitude of 2100 de meters.

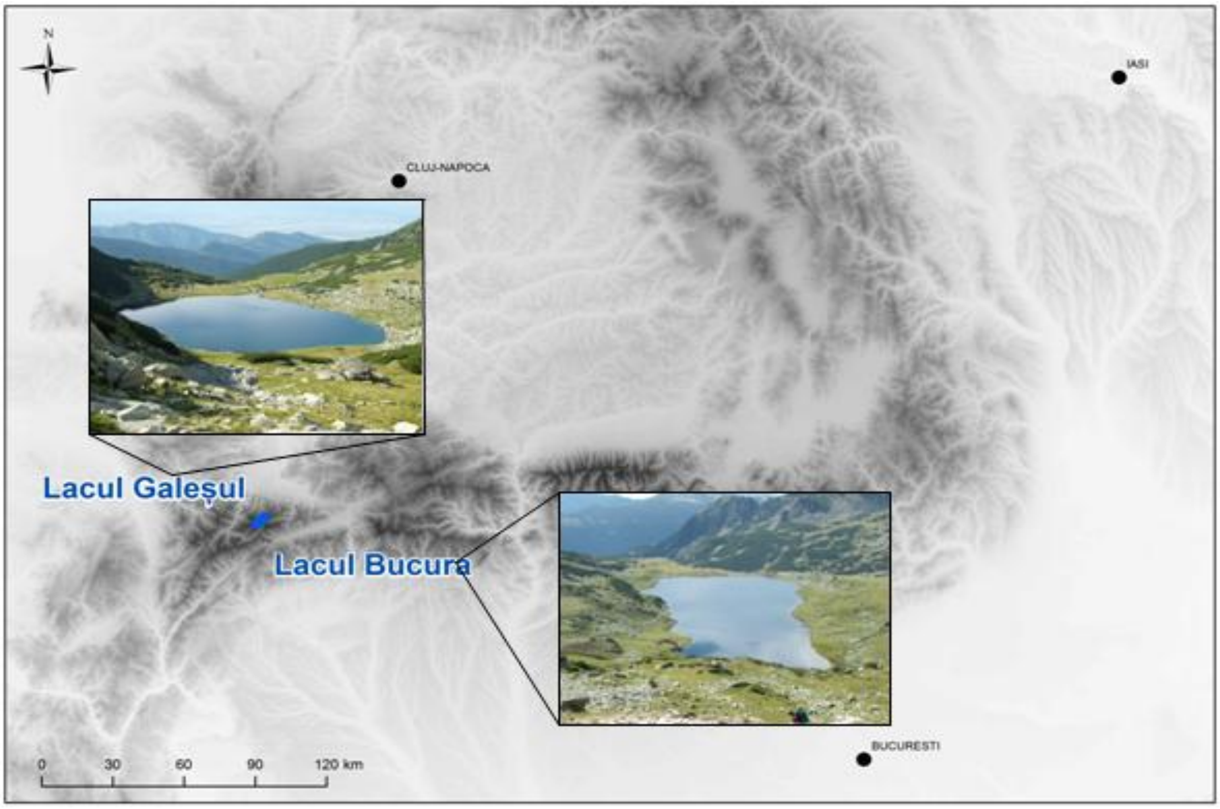


Fig. 3.2.The position of glacial lakes Bucura and Galeşul in the Retezat Mountains

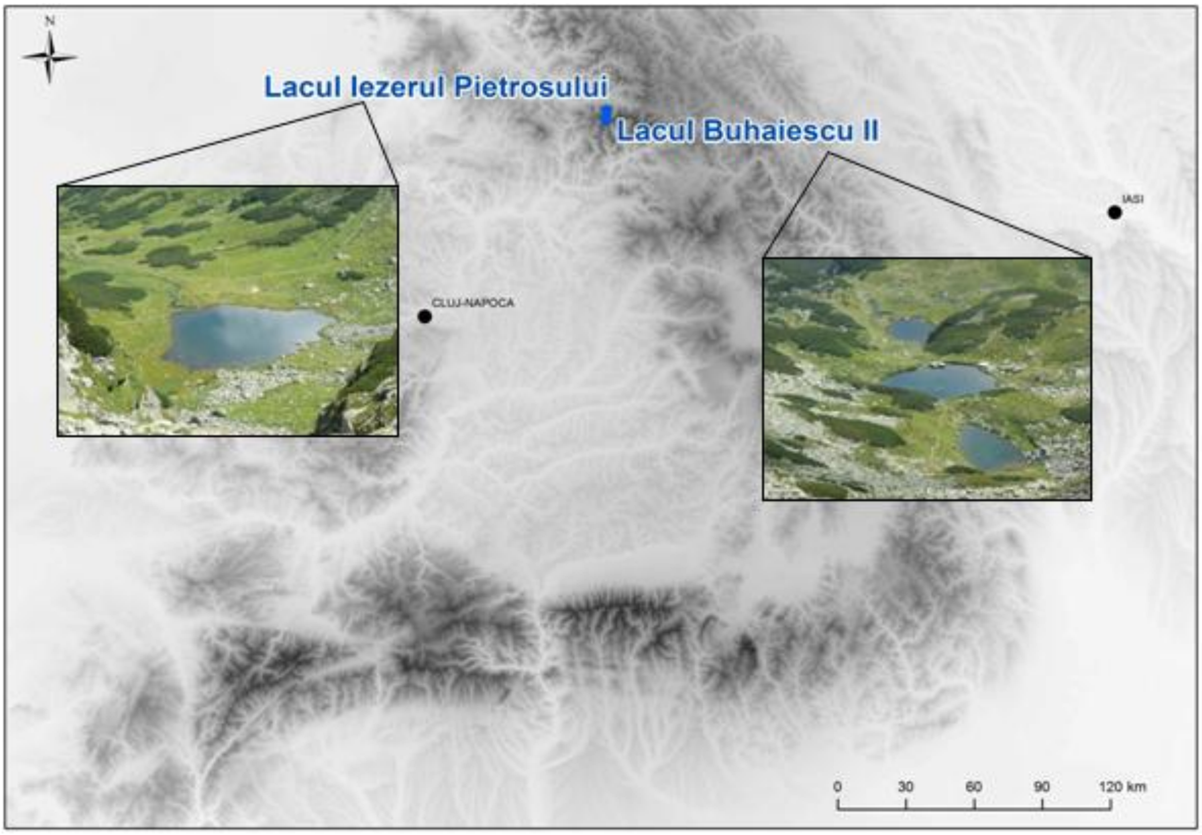
3.2.2. Rodnei Mountains National Park: Iezerul Pietrosului Lake and Buhăiescu Lake

Rodnei Mountains, situated in the Northern part of the country, has the highest altitudes in the Oriental Carphatian Mountains. On the park's territory there are approximately 23 glacial and sub glacial lakes, few of them being situated at altitudes of over 2000 meters.

Iezerul Pietrosului Lake(fig.3.3), is situated at an altitude of 1825 and is one of the most important lakes of this massif. It has a surface of 3450 m^2, a maximum depth of 2.5 meters and a length of 84 meters. This lake presents a high degree o anthropic impact due to the sylvan road which connects Borşa Region to Weather Station.

Buhăescu 2 Lake(fig.3.3), situated at an altitude of approximately 1900 meters, is part of "Tăuri Buhăescu chain", being located between Buhăescu 1 tarn and Buhăescu 3 tarn. The chain is located in the a Buhăescu depression, under Buhăescu peak and Vârful Pietrosul Rodnei. It has a surface of approximately 1500 m^2, the maximum depth being of 5.5 meters (Admin, P.N. Munții Rodnei, 2010).

Fig. 3.3.The position of glacial lakes Iezer and Buhăescu II in the Rodnei Mountains



IV. STATE WATER QUALITY IN STUDIED LAKES

4.1. Physico-chemical properties of the studied lakes

4.1.1 Introdaction

Mountain lakes water quality is determined by various factors, some governed by the local conditions of the watershed, others by remote influences due to atmospheric transport of various substances generated by natural and anthropic causes.

Recent researches demonstrated that mountain lakes can act as sensitive indicators of environmental change and human impacts such as atmospheric pollution with examples across Europe (Arnaud et al., 2003; Boyle et al., 2004; Curtis et al., 2005; Kopáček et al., 2006; Šporka et al., 2002).

Taking into account the importance of mountain areas in constituting the fresh water resources, at the international level, the need to develop management systems for water/river basins specifically designed for mountain areas was recognized. The EU Water Framework Directive establishes "….*the basic principles of sustainable water policy in the European Union […] in order to coordinate Member States' efforts to improve the protection of Community waters in term of quantity and quality, to promote sustainable water use, to contribute to the* *control of trans-boundary water problems, to protect aquatic ecosystems and wetlands*"(Mihăiescu & Mihăiescu, 2009).

The main factor of degradation of the biosphere is the natural or artificial environment pollution.

In primitive society, the cycles of matter and energy were not disturbed, so self-purification capacity of water, air and soil work perfectly.

4.2.1. Morphometric characteristics of the studied lakes

The sampled lakes were selected in three main areas of the Romanian Carpathians: the Rodna Mountains - 2 sites, Iezerul Pietrosului and Buhăiescu in north-eastern Romania, the Făgăraş Mountains - 2 sites, Bâlea and Călțun and Retezat Mountains - 2 sites, Bucura and Galeşu in the Southern Carpathians (central, southern Romania)(Fig.4.1)

The main morphometric characteristics of the studied lakes are presented in Table 4.1.

Table.4.1. Main morphometric characteristics of the studied lakes

Locația / Lacul	Altitudine, m	Locație	Bazinul lacului, m^2	Suprafața, ha	Capacitatea captare	deAdâncimea Max, m
Rodnei Mountains						
Iezerul Pietrosul	1,825	47° 35' 54" N 24° 38' 52" E	54.4	0.41	132.7	**2.3***
Buhăiescu II	1,890	47° 35' 14" N 24° 38' 48" E	62.9	0.2	314.5	**5.2***
Făgăraş Mountains						
Bâlea	2,034	45° 36' 13" N 24° 37' 07" E	45.5	4.78	9.5	**11.35*** **16.9****
Călțun	2,135	45° 34' 55" N 24° 34' 26" E	18.6	0.8	23.3	**11,8***
Retezat Mountains						
Galeş	2,040	45° 38' 70" N 22°.91' 11" E	167.206	4.04	41.4	**20.1*** **20.5****
Bucura	**2,041**	**45° 36' 24" N 22° 87' 65" E**	**202.08**	**8.92**	**22.7**	**15.7*** **17,5****

*Pişota, I., 1971
**Vespremeanu et al., 2008

4.1.2. Metodology

4.1.2.1.Sampling

The lakes were sampled in 2011 and 2012. In all the surveys, the lakes were sampled in summer–early autumn period, in the ice-free conditions, and a mean value of the two study years was calculated in order to reduce the interannual variability related to meteorological and hydrological features.

The water samples were collected from the inlet, outlet and center part of the lake at about 50 cm below the water surface. Samples were stored in clean plastic bottles.

Fig.4.2. Sampling in Galeşul Lake

Fig.4.3. Sampling in Buhăiescu II Lake

Standard laboratory procedures and appropriate conservation criteria (cooler storage boxes, acidification, filtration through a 0.45 µm membrane filter Millipore, to remove particulate material etc.) were followed for analyses of water samples. Water samples were analyzed for a pre-defined set of physical and chemical indicators to permit monitoring of how climate-driven environmental change will affect water quality and their ecosystem functioning and to create a reference database that can be used for comparative assessment and trend delineation.

Water temperature, dissolved oxygen, electrical conductivity (at 25°C) and pH were measured in-situ (Fig.4.2, Fig.4.3.) using a thermometer and electrodes (WTW instruments), respectively.

4.2.1.2. Laboratory equipment

The concentrations of major anions and cations were measured using ion chromatography ((DIONEX ICS-1500 IC system).

The total concentrations of metals were determined using an Inductively Coupled Plasma Mass Spectrometer (SCIEX Perkin-Elmer Elan DRC II). Analyses were made in triplicate and the mean values are reported. The samples with ion concentrations exceeding the calibration range were diluted accordingly and re-analyzed. All reagents were of analytical-reagent grade and all solutions were prepared using ultrapure water with a specific resistance of 18.2 MΩ/cm.

Major concentrations of anions and cations were measured by ion chromatography (Shimadzu system) equipped with a conductivity detector, 7U Allsep anion column (150 x 4.6

mm) and 7U Universal Cation Column (100 x 4.6 mm) and also and ion chromatography (ICS-1500 system DIONEX IC).

Concentrations of TOC (total organic carbon) and TN (total nitrate) were measured with a total organic carbon analyzer (Shimadzu TOC-VCHH/CPN) equipped with a module for total nitrogen (TNM-1). TOC and TN concentrations were detected simultaneously by combustion and catalytic oxidation of sample injected.

The results were interpreted using Statistical Program ver. 7.0.

The obtained data were classified according to Order 161/2006 into five quality classes, and the lake's classification was established by using the percentile system V (90%) (Tabelul 4.3) (Pop.A.I. et al., 2013).

4.1.4. Results

4.1.4.1. Classified parameters according to Order 161/2006 for each

Classification of water quality in lakes, to determine the ecological status was done under Order 161/2006. Establishing the state of water quality was made only on the basis of quality indicators law.

According to Order 161/2006, there were five different quality classes, as follows:

- Class I quality reflects natural conditions the maximum allowable reference or background concentrations;
- Grade II quality within that class corresponding target values (benchmarks) and reflects the quality condition for the protection of aquatic ecosystems;
- Class III-IV-V quality limit values corresponding to these classes which are 2-5 times higher than those of the benchmarks and reflects the weight of anthropogenic influence.

The values obtained by the methods of investigation and data processing were compared with permissible limit values set out in the Order 161/2006 (Tab 4.3).

Table.4.3. Mean chemical characteristics of the studied glacial lakes (Pop.A.I. et al., 2013).

Lake	Parameter	Mean ± $SE_{\bar{x}}$	Confidence - 95%	Confidence 95%	Median	Minimum	Maximum	V (90%)	Quality Class
Iezerul Pietrosului	pH (25°C), pH unit	7.9 ± 0.08	7.7	8.1	7.9	7.7	8.2	8.1	OK
	EC (25°C), µS cm^{-1}	28.7 ± 1.11	25.8	31.5	28.7	24.8	32.5	31.5	-
	DO, mg O L^{-1}	11.4 ± 0.52	10.1	12.7	11.4	9.6	13.2	12.8	I
	Na^{+}, µeq L^{-1}	21 ± 1.52	17	24	19	16	28	26	I
	K^{+}, µeq L^{-1}	4 ± 0.40	3	5	5	3	6	5	-
	Ca^{2+}, µeq L^{-1}	227 ± 15.27	192	262	205	200	341	262	I
	Mg^{2+}, µeq L^{-1}	22 ± 2.32	17	28	25	14	31	31	I

	Cl^-, μeq L^{-1}	6 ± 0.17	5	6	6	5	6	6	I
	NO_3^-, μeq L^{-1}	32 ± 3.09	25	39	37	17	40	40	II
	SO_4^{2-}, μeq L^{-1}	141 ± 0.65	139	142	141	139	145	143	I
	Mn, μg L^{-1}	0.59 ± 0.11	0.31	0.86	0.52	0.30	0.90	0.90	I
	Zn, μg L^{-1}	4.04 ± 1.01	1.46	6.63	3.26	1.33	8.40	6.80	I
	Ni, μg L^{-1}	0.84 ± 0.2	0.32	1.36	0.73	0.36	1.40	1.40	I
	Cu, μg L^{-1}	3.31 ± 0.6	1.77	4.86	3.02	1.75	6.00	4.85	I
	Cd, μg L^{-1}	0.21 ± 0.05	0.08	0.34	0.22	0.00	0.38	0.33	I
	Pb, μg L^{-1}	5.54 ± 1.37	2.02	9.06	5.73	0.00	9.20	8.75	II
Buhăiescu	pH (25°C), pH unit	7.9 ± 0.18	7.5	8.4	7.9	7.4	8.4	8.3	OK
	EC (25°C), μS cm^{-1}	17.3 ± 0.8	15.2	19.3	16.6	15.2	20.4	19.7	-
	DO, mg O L^{-1}	8.6 ± 0.28	7.8	9.3	8.8	7.2	9.1	9.0	I
	Na^+, μeq L^{-1}	18 ± 0.92	15	20	18	14	20	20	I
	K^+, μeq L^{-1}	4 ± 0.31	3	4	4	3	4	4	I
	Ca^{2+}, μeq L^{-1}	142 ± 2.34	136	148	142	136	151	148	I
	Mg^{2+}, μeq L^{-1}	15 ± 0.86	13	17	15	13	18	18	I
	Cl^-, μeq L^{-1}	6 ± 0.12	5	6	6	5	6	6	I
	NO_3^-, μeq L^{-1}	37 ± 8.45	15	58	38	0	61	56	III
	SO_4^{2-}, μeq L^{-1}	116 ± 3.56	107	125	117	106	130	125	I
	Mn, μg L^{-1}	0.69 ± 0.19	0.19	1.18	0.47	0.30	1.50	1.25	I
	Zn, μg L^{-1}	3.03 ± 1.1	0.20	5.86	2.57	0.32	7.30	5.95	I
	Ni, μg L^{-1}	0.42 ± 0.02	0.36	0.47	0.41	0.36	0.50	0.48	I
	Cu, μg L^{-1}	2.66 ± 0.22	2.11	3.22	2.80	1.75	3.20	3.12	I
	Cd, μg L^{-1}	0.25 ± 0.06	0.09	0.40	0.28	0.00	0.39	0.38	I
	Pb, μg L^{-1}	3.56 ± 0.74	1.64	5.47	4.29	0.00	4.90	4.73	I
Galeșu	pH (25°C), pH unit	7.51 ± 0.46	6.3	8.7	7.6	6.3	8.7	8.7	OK
	EC (25°C), μS cm^{-1}	14.2 ± 0.81	12.1	16.3	14.1	12.2	16.8	16.3	-
	DO, mg O L^{-1}	12.1 ± 0.31	11.3	12.9	12.0	11.1	13.2	13.0	I
	Na^+, μeq L^{-1}	33 ± 2.44	27	39	33	26	41	40	I
	K^+, μeq L^{-1}	4 ± 0.13	4	5	4	4	5	5	I
	Ca^{2+}, μeq L^{-1}	74 ± 1.72	69	78	73	69	80	79	I
	Mg^{2+}, μeq L^{-1}	15 ± 1.3	12	19	16	9	18	18	I
	Cl^-, μeq L^{-1}	6 ± 0.37	5	7	6	6	8	7	I
	NO_3^-, μeq L^{-1}	33 ± 4.19	22	43	32	22	46	44	II
	SO_4^{2-}, μeq L^{-1}	64 ± 0.79	62	66	65	61	66	66	I
	Mn, μg L^{-1}	0.77 ± 0.22	0.20	1.33	0.73	0.00	1.50	1.35	I
	Zn, μg L^{-1}	2.54 ± 0.66	0.85	4.22	1.97	1.20	5.40	4.40	I
	Ni, μg L^{-1}	0.34 ± 0.12	0.02	0.66	0.18	0.13	0.90	0.70	I
	Cu, μg L^{-1}	1.45 ± 0.41	0.41	2.49	1.56	0.31	2.50	2.40	I
	Cd, μg L^{-1}	0.4 ± 0.05	0.28	0.52	0.45	0.21	0.5	0.5	I
	Pb, μg L^{-1}	1.32 ± 0.47	0.11	2.52	1.16	0.00	2.74	2.57	I

Table 2 (continued)

Bucura	pH (25°C), pH unit	7.2 ± 0.21	6.7	7.8	7.4	6.3	7.7	7.7	OK
	EC (25°C), μS cm^{-1}	14.4 ± 0.23	13.8	15.0	14.5	13.7	15.2	15.0	-
	DO, mg O L^{-1}	10.3 ± 0.42	9.2	11.4	10.1	9.1	12.1	11.5	I
	Na^+, μeq L^{-1}	58 ± 2.98	50	65	58	49	71	65	I
	K^+, μeq L^{-1}	4 ± 1.5	4	5	4	4	5	5	I
	Ca^{2+}, μeq L^{-1}	69 ± 2.35	63	75	70	60	76	75	I
	Mg^{2+}, μeq L^{-1}	15 ± 0.86	13	17	15	13	18	18	I
	Cl^-, μeq L^{-1}	6 ± 0.44	5	7	6	5	8	7	I
	NO_3^-, μeq L^{-1}	12 ± 4.17	2	23	16	0	23	22	II

	SO_4^{2-}, µeq L^{-1}	73 ± 2.89	65	80	73	63	81	81	I
	Mn, µg L^{-1}	1.46 ± 0.24	0.83	2.08	1.35	0.90	2.30	2.10	I
	Zn, µg L^{-1}	2.98 ± 0.72	1.15	4.82	2.51	1.48	6.00	4.90	I
	Ni, µg L^{-1}	1.12 ± 0.38	0.15	2.10	0.96	0.14	2.70	2.10	I
	Cu, µg L^{-1}	1.91 ± 0.21	1.36	2.45	1.84	1.37	2.80	2.45	I
	Cd, µg L^{-1}	0.35 ± 0.05	0.22	0.48	0.31	0.20	0.50	0.50	I
	Pb, µg L^{-1}	2.83 ± 0.58	1.35	4.32	3.15	0.90	4.20	4.15	I
Bâlea	pH (25°C), pH unit	7.7 ± 0.23	7.1	8.3	7.7	7.0	8.4	8.3	OK
	EC (25°C), µS cm^{-1}	101.5 ± 2.63	94.7	108.2	102.9	91.1	107	106.9	-
	DO, mg O L^{-1}	9.9 ± 0.27	9.2	10.5	10	8.9	10.8	10.5	I
	Na^+, µeq L^{-1}	18 ± 1.29	15	21	18	14	23	22	I
	K^+, µeq L^{-1}	8 ± 0.71	6	10	8	6	10	10	I
	Ca^{2+}, µeq L^{-1}	798 ± 27.50	727	868	791	708	878	154	I
	Mg^{2+}, µeq L^{-1}	148 ± 2.36	142	154	148	141	156	873	I
	Cl^-, µeq L^{-1}	62 ± 0.86	60	64	62	59	65	6	I
	NO_3^-, µeq L^{-1}	53 ± 14.88	14	91	60	0.0	88	88	III
	SO_4^{2-}, µeq L^{-1}	115 ± 2.03	109	120	116	106	120	119	I
	Mn, µg L^{-1}	5.02 ± 0.20	4.52	5.53	4.92	4.43	5.67	5.58	I
	Zn, µg L^{-1}	1.41 ± 0.12	1.11	1.72	1.40	1.09	1.90	1.70	I
	Ni, µg L^{-1}	0.28 ± 0.09	0.04	0.52	0.32	0.01	0.52	0.51	I
	Cu, µg L^{-1}	5.29 ± 0.88	3.04	7.55	5.33	2.80	7.79	7.60	I
	Cd, µg L^{-1}	0.31 ± 0.07	0.12	0.49	0.26	0.18	0.66	0.48	I
	Pb, µg L^{-1}	4.18 ± 1.13	1.28	7.08	4.13	0.0	8.70	6.51	II
Căltun	pH (25°C), pH unit	7.3 ± 0.18	6.8	7.7	7.4	6.4	7.7	7.6	OK
	EC (25°C), µS cm^{-1}	27.0 ± 0.42	25.9	28.1	26.8	25.8	28.4	28.2	-
	DO, mg O L^{-1}	9.8 ± 0.39	8.8	10.8	10.0	8.7	10.9	10.8	I
	Na^+, µeq L^{-1}	33 ± 1.7	29	38	35	25	36	36	I
	K^+, µeq L^{-1}	4 ± 0.41	3	5	4	3	6	5	I
	Ca^{2+}, µeq L^{-1}	117 ± 2.17	112	123	118	111	126	123	I
	Mg^{2+}, µeq L^{-1}	20 ± 2.05	14	25	18	15	28	26	I
	Cl^-, µeq L^{-1}	6 ± 0.18	6	7	6	6	7	7	I
	NO_3^-, µeq L^{-1}	4 ± 1.23	1	7	4	0	8	7	I
	SO_4^{2-}, µeq L^{-1}	169 ± 3.63	160	178	167	161	186	178	I
	Mn, µg L^{-1}	3.14 ± 0.51	1.83	4.45	3.15	1.68	4.58	4.54	I
	Zn, µg L^{-1}	1.61 ± 0.02	1.55	1.67	1.61	1.50	1.66	1.65	I
	Ni, µg L^{-1}	0.98 ± 0.1	0.73	1.24	1.05	0.50	1.14	1.14	I
	Cu, µg L^{-1}	3.01 ± 0.38	2.03	4.00	3.25	1.90	3.89	3.89	I
	Cd, µg L^{-1}	0.21 ± 0.01	0.18	0.24	0.22	0.17	0.24	0.24	I
	Pb, µg L^{-1}	1.29 ± 0.31	0.51	2.08	0.86	0.85	2.67	2.16	I

Mean values of 2011–2012
SE$\bar{x}$ - Standard Error of Mean
EC- Electrical Conductivity
DO – Dissolved Oxygen
Quality Class according to Order 161/2006
V (90%) - Percentile system

Levels of pH in the studied lakes are summarized in Table 2. All glacial lakes presented pH levels (7.2 – 7.9) that were generally within the acceptable range for lake ecosystems (6.5 – 8.5) and are typical for lakes that are not impacted by acidic depositions. The lower pH values were recorded in the 2011 (Călțun, Bucura, Galeşu lakes) in the early summer period, during the melting of the consistent snow accumulated in winter. The slight decrease of the pH values can be attributed to the concentration of the acidic substances accumulated in the snow layer and washing of the slopes subjected to increase in carbon dioxide caused by bacterial decomposition.

The low electrical conductivity (EC) values (14.2 – 101.5 μS cm^{-1}) are characteristic of good quality spring water, the levels are typical of natural levels and remained fairly consistent over time.

The dissolved oxygen (DO) values indicate that the water column is well mixed. The DO values ranged from 8.6 – 12.1 mg O L^{-1}. The lower DO concentrations were during the summer, when the water temperatures were highest. The DO concentration was dependent on the change of temperature.

Nitrates concentrations showed variations probably due to the presence of local input from touristic activities and sheep grazing during the summer period. Ionic composition is correlated with the bedrock characteristics.

Heavy metal concentrations were low despite of potential pollution sources originated from the road traffic. The results can be correlated with the season (temperature of water, raining regime, biological uptake) and with water pH, which may determine the solubilisation of metallic ions. In the spring, the biologic activity can influence directly (by metal uptake) or indirectly (by pH rising) the metal concentrations in water. Chromium, arsenic, and cobalt (not shown in Table 2) were below the detection limits of the method (0.05, 0.2 and 0.1 μg L−1, respectively). Other metals which can be attributed mainly of anthropogenic origin show low concentration in the analyzed water lakes: zinc (1.41-4.04 μg L^{-1}), manganese (0.59-5.02 μg L^{-1}), nickel (0.28-1.12 μg L^{-1}), copper (1.45-5.29 μg L^{-1}), cadmium (0.21-0.4 μg L^{-1}), which are below the maximum allowed concentration for first quality class according to Order 161/2006. In contrast, measured lead concentration varied between 1.29-5.54 μg L^{-1}. The majority of the lakes can be classified as first quality class excepting Bâlea Lake and Pietrosul Lake with values according the second class. The slight increase in lead concentration can be attributed to atmospheric transport and deposition and in Bâlea Lake case due to road traffic or local unknown sources.

4.1.5. Conclusions

The differences in water chemistry between the studied glacial lakes can be attributed to several factors such as geology, climate and relief (different input from the weathering, different size of the watersheds, different retention times) and sometimes human influence.

Despite the fact that thousands of tourist are present yearly in the mountain lake catchments the water quality is still maintaining in good quality as shown by the obtained results. At present, the studied lakes seem to be well preserved by acidification risk, but further studies are required to identify the ecological impact of other human disturbance and to determine the sources and impacts of heavy metals, on the quality of the water.

The presence of unique and valorous mountain ecosystems, highly valued by general public, should justify even greater protection and conservation efforts, in the conditions of constantly increasing tourist traffic.

Mountain areas represent a field were, perhaps, more than in other places, measures that are needed to be taken in order to preserve and protect ecosystems, as required by EU Directives, need to be constantly adapted to a possible future climate change.

4.2. Study of algal flora in monitored lakes

4.2.1. Sampling

Algal samples were collected in the summer and autumn of 2011, as follows: in August we took samples from Buhăiescu II Lake, Iezer Lake, Bucura Lake respectively in September from Călțun Lake and Balea Lake.

For plankton sampling we used a polyethylene container of known volume to filter the plankton net mesh size of 40 mm diameter, equal amounts of water for each sample.

The ground samples were stored in one container of 20 ml each and then permanently fixed by adding a few ml of formaldehyde concentration of 38-40%, the final concentration of the sample was 4%.

4.2.2. Laboratory processing

In determining algal species, we used wet preparations, except that I realized diatoms permanent preparations.

Examination of samples was performed using a Nikon Eclipse E400 microscope using a 40x objective, wet preparations and the immersion (100x) fixed preparations.

Identification and characterization of taxa ecological preferences of the species was done using the following determination and scientific publications: Coesel (1991, 1997), Huber-Pestalozzi (1950.1955), John (2005), Komarek and Agnanostidis (1998), Komarek and Fott (1983), Krammer (2000, 2002, 2003), Lee (2008), Lenzenveger (1994), Olaczek (1988), Prescott (1962), Werner (1977), Wurm (1984), Wurm and Oslo (1993), Wurm and Esterl (1993) and others.

Systematic classification of taxa and their phylogenetic sorting was performed using the model provided by Guiry MD and Guiry GM (2012) by Algae Base database.

4.2.3. General characterization of the algal flora

After examining microscopic preparations we identified 192 taxa. In terms of species are systematically classified into six phyla. Most species belonging to the phylum Ochrophyta (123), while clade Euglenophyta (3) and Pyrrophyta (3) are best represented, with the lowest number of species. Phylum Charophyta is represented by a total of 32 species, Phylum Chlorophyta 14, Cyanophyta species and Phylum by a total of 17 species.

In Fig. 5.1 it can be seen that the various species of diatoms are (class Bacillariophyceae), that is 121 in number. Zygnematophyceae class consists of 32 species and class Cyanophyceae is the 17 species. Classes Dinophyceae Euglenophyceae and represented each of 3 taxa. Green algae were classified into two classes (Chlorophyceae and Trebouxiophyceae) totaling 14 species.

The highest number of taxa was determined Balea Lake (80), followed by Lake Iezer (73), Lake Hail (71), Buhăescu (60) and the lowest number of species is Lake Călțun (21).

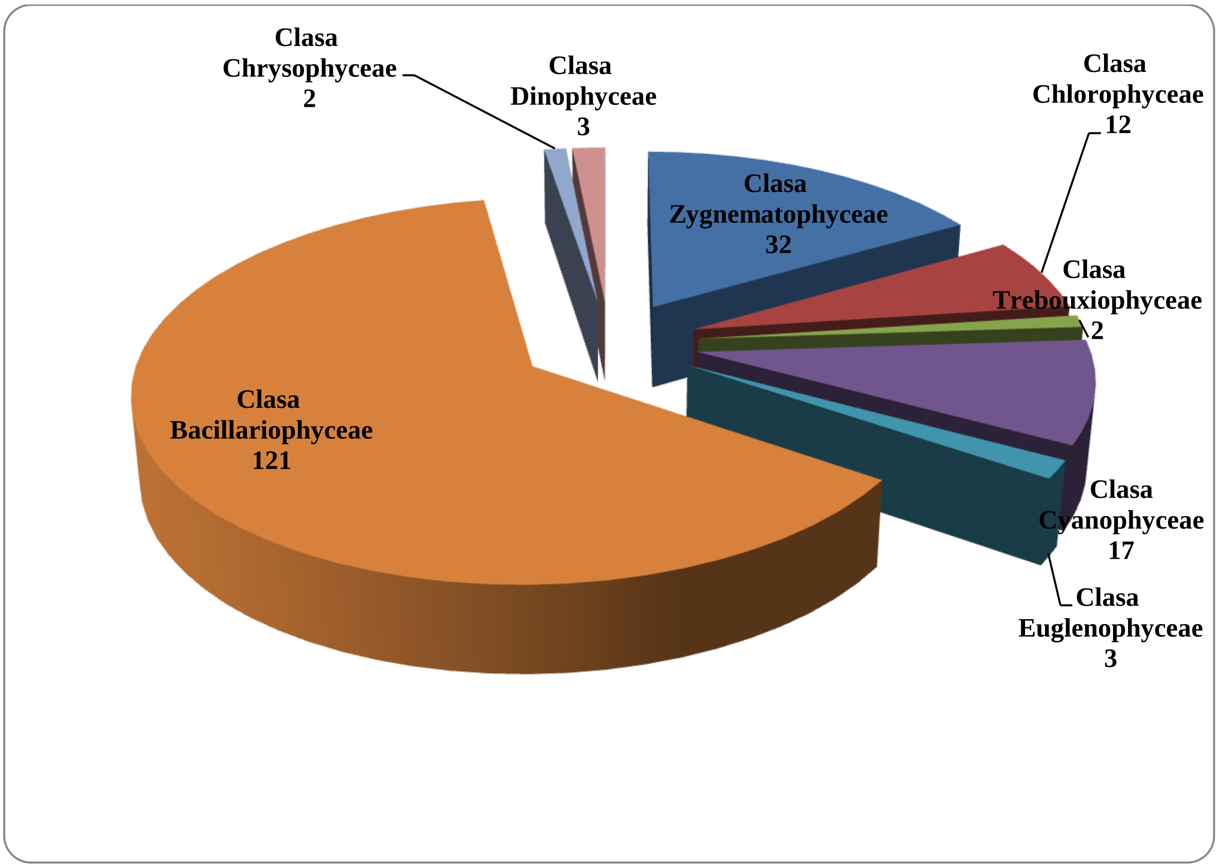


Fig.4.14. Class distribution of the identified species

4.2.5.3. The algal floristic similarity

To analyze the degree of floristic similarity we used Jaccard index. We took into account the presence or absence of taxa in each sample from each sampling point.

Similarity index value is low and ranges between 0.08 and 0.4, indicating a low floristic similarity (Fig.4.25). From the dendrogram there is a separation of algal communities from Lake Călțun of other communities from other lakes, floristic similarity is 0.08.

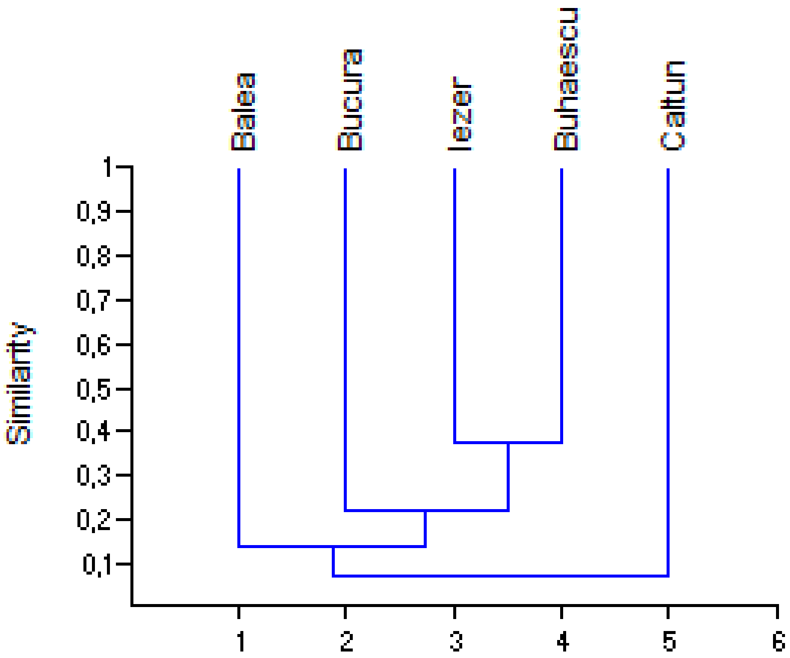


Fig.4.25. Floristic similarity and planktonic algal communities (Lehaci. I.,2012.)

4.2.6. Conclusions

- Each lake retains the same structure classes, differ only in the number of species Balea Lake (80), followed by Lake Iezer (73), Lake Hail (71), Buhăescu (60) and the lowest number of species is Lake Călțun (21) (Lehaci I., 2012).
- In Buhăescu II and Călțun Lake were conducted for the first time algological research Având în vedere preferințele ecologice ale speciilor de alge, s-au înregistrat un număr relativ mare de specii cosmopolite: *Merismopedia glauca*, *Chroococcus limneticus*, *Phormidium inundatum* etc.
- From the 30 rare species determined in this mountain lakes, 14 of them are mentioned for the first time in Romania algoflora (Lehaci I. et al, 2012). In particular biogeographical importance are the arctic-alpine as: Cosmarium crenatum, Achnanthes ventralis, Pinnularia rupestris, Aulacoseira alpigena, Eunotia serra var. tiara, Neidium alpinum.
- Regarding the assessment of ecological status of mountain lakes studied, we can say that the prevailing the characteristic of oligotrophic species waters and mesotrophic waters
- Bâlea Lake has a fairly large number of species characteristic of mesotrophic waters.

• As a result of these data (Tab 4.6), water quality and ecology in mountain lakes, in terms of existing algal communities, belongs to Class II meaning good, or in Bâlea Lake, moderate to good.

V. HUMAN IMPACT ASSESSMENT IN STUDIED AREAS

5.1. Impact assessment

Environmental impact is defined as "a direct or indirect effect of human activities cause a change of the direction of development of the quality status of ecosystems, change that can affect human health, environmental integrity, cultural heritage or socio-economic conditions' (Rojanschi V., Bran F., 2000). The environmental impact assessment is mainly instrumental in assessing the impacts caused by human activities (Cartis C., 2000).

The first methodology for environmental impact assessment was first proposed in the United States in 1970 in the National Environmental Policy Act. Canada and France followed in 1973 and respectively in 1975. In the EU policy was implemented as a method of assessment on pollution prevention in Directive 85/337 as amended set of terms and conditions for the implementation of Directive 99/11.

For a more objective assessment of the environmental impact there are many methods, techniques and matrices that specialists using them and each trying to adapt the study to have a more relevant.

Anthropogenic impact assessment using matrices and methods can help early identification of existing impacts and help the environment and improving public awareness on the importance of these areas and their protection. This may establish measures to minimize the negative effects before they become irreversible.

5.2. Quantifying the accessibility and environmental impacts associated with tourism activity

According to preliminary studies, it appears that in mountainous studied areas, located in protected areas, the main environmental pressures attributable to tourism activities and their associated environmental impacts.

Tourist flow is closely related to the accessibility in this regions, such as the accessibility is higher, the number of tourists will grow.

5.2.1. The importance of quantifying accessibility

Accessibility is a key element to an area of study because it is the direct expression of mobility by various forms of manifestation. Accessibility highlights an area networks, flows, time and type of transport, which are essential for the development of economic investment, tourism and environmental protection.

Mountainous areas generally have low accessibility due to conformation relief and low level of development of transport infrastructure. To assess accessibility in these areas should apply custom matrices consider these destinations to the main site network flow transmitters, direct access modalities and time estimate.

5.2.1.1.Methodology

The methodology used is based on multiple previous research accessibility and use modern techniques to calculate the distance between points analyzed satellite access points to the transmission. For a better distinguish them, were measured and recorded with numerical indices. For the calculation of the accessibility in mountain areas was based on next analysis:

A. The location to the main transport network flow transmitters;

B. Type and number of direct accesses to the destination;

C. Access time to a destination network

According to the methodology used accesebilitatea in mountainous areas can have values between 0 and 100 points (Table 5.1) and can be divided into levels of accessibility.

Tab.5.1. Accessibility levels

Points	Accessibility levels
0-10	Very low
11-25	Low
26-50	Medium
51-75	High
76-100	Very high

The following table will present the final results obtained by quantifying the level of accessibility.

Tab.5.2. Quantify accessibility matrix for Lakes Bâlea, Călțun, Bucura, Galeşul, Iezer and Buhăiescu II

ELEMENTS ASSESSED	ACCES	Ponits.	BÂLEA Lake	CĂLȚUN Lake	BUCURA Lake	GALEȘ Lake	IEZER Lake	BUHĂIESCU Lake
A. *The location to the main transport network flow transmitters*								
A1. NETWORK COUNTY ROAD	DIRECT	3 PCT	0	0	0	0	0	0
	0-5 km	2 PCT	0	0	0	0	0	0
	5,1-10 km	1 PCT	0	0	0	0	0	0
A2. NETWORK NATIONAL ROAD	DIRECT	3 PCT	3	0	0	0	0	0
	0-5 km	2 PCT	0	0	0	0	2	0
	10,1-20 km	1 PCT	0	1	0	0	0	1
A3. NETWORK EUROPEAN ROAD	DIRECT	3 PCT	0	0	0	0	0	0
	0-20 km	2 PCT	0	0	0	0	0	0
	20,1-50 km	1 PCT	1	1	1	1	0	0
A4. NETWORK HIGHWAYS ROAD	DIRECT	3 PCT	0	0	0	0	0	0
	0-50 km	2 PCT	0	0	0	0	0	0
	50,1-100 km	1 PCT	1	1	1	1	0	0
A5. RAILWAY NETWORK	DIRECT	3 PCT	0	0	0	0	0	0
	0-20 km	2 PCT	0	0	0	0	0	0
	20,1-50 km	1 PCT	1	1	1	1	1	1
A6. AVIATION NETWORK	DIRECT	3 PCT	0	0	0	0	0	0
	0-50 km	2 PCT	0	0	0	0	0	0
	50,1-100 km	1 PCT	1	1	0	0	0	0
B. *Type and number of direct accesses to the destination*								
B1. CABLE ACCESS		1-4 PCT	1	0	0	0	0	0
B2. NETWORK RAIL ACCES		1-4 PCT	0	0	0	0	0	0
B3. HIGHWAY ACCESS		1-4 PCT	0	0	0	0	0	0
B4. EUROPEAN ROAD ACCESS		1-4 PCT	0	0	0	0	0	0
B5. NATIONAL ROAD ACCESS		1-4 PCT	1	0	0	0	0	0
B6. COUNTY ROAD ACCESS		1-4 PCT	0	0	0	0	0	0
B7. LOCAL AND FOREST ROAD ACCESS		1-4 PCT	0	0	0	0	4	0
B8. TOURISTICAL TRAILS ACCESS		1-4 PCT	4	4	4	2	2	2
C. *Access time to a destination network*								
C1. UNDER < 1HOUR		50 PCT	50	0	0	0	0	0
C2. BETWEEN 1 - 2 HOUR		40 PCT	0	0	40	0	0	0
C3. BETWEEN 2 - 3 HOURS		30 PCT	0	30	0	0	0	0
C4. BETWEEN 3 - 4		20	0	0	0	0	20	0

HOURS	PCT						
C5. BETWEEN 4 - 5 HOUR	10 PCT	0	0	0	10	0	0
C5. BETWEEN 5 - 6 HOUR	5 PCT	0	0	0	0	0	1
PUNCTAJ TOTAL		63	39	47	15	29	5

5.2.2. Quantifying the environmental impacts associated with tourism activity

After quantifying the accessibility in areas of study is important to identify the number of potential tourists, representing the main factor of degradation of these areas.

Tourism is the first threat that leads to the degradation of these areas (Pop.AI, 2011). It is given in particular violation of the rules of national parks management plan, prohibiting many things, but no one is held accountable. Fine stipulated in the management plan are only theoretical.

The next major factor that leads to the degradation of these areas are numerous cottages that appear around Bâlea Lake and Iezerul Pietrosul (Fig. 5.3 and 5.4).

Fig.5.3. Buildings around Bâlea Lake

Fig.5.4. Buildings around Iezer Lake

5.2.2.1. Mounatin tourism

In our country mountain tourism is practiced especially in summer, from May to September, due to very difficult accessibility and the need for special equipment in winter time.

Among the studied areas in this study, gaining access most easily in winter can be up to Bâlea Lake because there is a cable car that works especially for tourists who want to visit the ice hotel in the winter and skiing in Bâlea Valley.

5.2.2.2.Quantifying the number of tourists annually in studied perimeters

Data for this study were acquired from the hotels and cottage administration and from self-monitoring of tourists in two seasons of study in field work.

So far governments and national parks administration do not have an approximate figure of the number of tourists in the studied areas, tourists are not monitored by the park entrance tickets or other forms.

5.2.2.3.Tourists monitoring near Iezerul Pietrosul and Buhăiescu II lakes

The obtain data for tourists monitoring (tab.6.3 and Tab 6.4) in this region are from weather stations administrator that is near Iezerul Pietrosul Lake and from Mountain Rescue Service cottage close to weather staion.

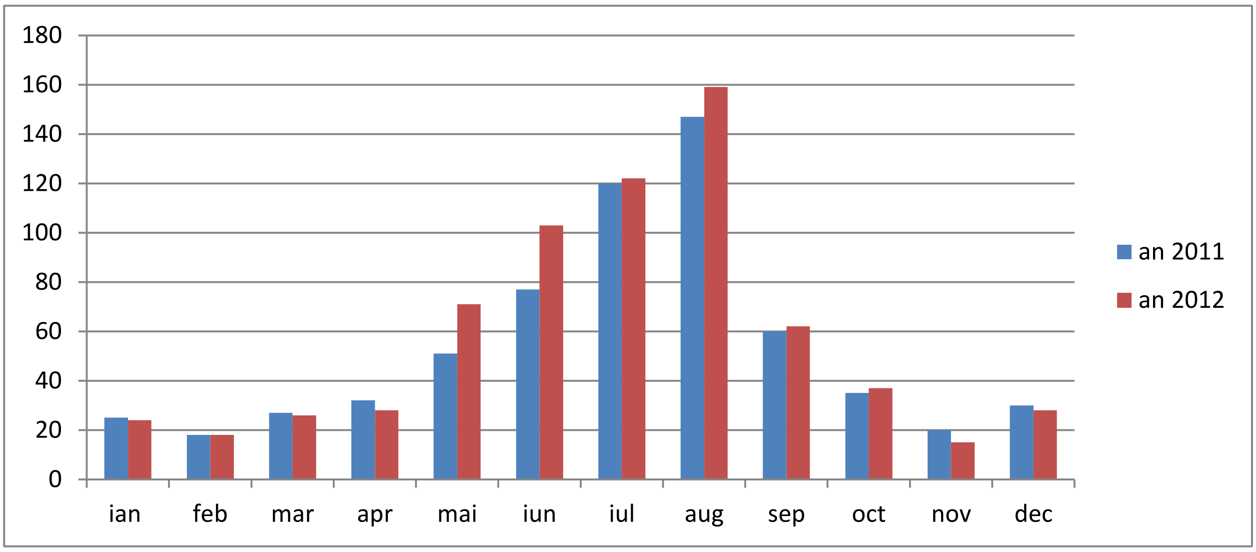
Tab.5.3.The number of tourists accommodated in 2011 near Lake Iezer

No. Tourist / Month Location	**JAN 2011**	**FEB 2011**	**MAR 2011**	**APR 2011**	**MAY 2011**	**JUN 2011**	**JUL 2011**	**AUG 2011**	**SEP 2011**	**OCT 2011**	**NOV 2011**	**DEC 2011**
Weather Station	15	14	19	24	44	60	75	90	40	25	10	20
Mountain Rescue service	10	4	8	8	27	37	45	57	20	10	10	10
TOTAL	25	18	27	32	51	77	120	147	60	35	20	30
TOTAL 642												

Tab.5.4.The number of tourists accommodated in 2012 near Lake Iezer

No. Tourist / Month Location	**JAN 2012**	**FEB 2012**	**MAR 2012**	**APR 2012**	**MAY 2012**	**JUN 2012**	**JUL 2012**	**AUG 2012**	**SEP 2012**	**OCT 2012**	**NOV 2012**	**DEC 2012**
Weather Station	16	14	18	20	47	65	75	102	42	27	10	18
Mountain Rescue service	8	4	8	8	24	38	47	55	20	10	5	10
TOTAL	24	18	26	28	71	103	122	159	62	37	15	28
TOTAL 693												

Tab.5.8. Tourist number variation in 2011 and 2012 in Rodna Mountains



In the chart above (Tab 5.8.) we can see the official number of tourists who slept at least one night near these lakes. Official number daily, those who pass these trails is one much bigger. An example is self-monitoring of the number of tourists from 11-15 August 2011 and 22 to 26 July 2012 (Tab 5.5.).

Tab.5.5. The number of tourists identified in self-monitoring, in Rodna Mounatins

PERIOD	**2011**					**2012**				
	15 AUG	**16 AUG**	**17 AUG**	**18 AUG**	**19 AUG**	**22 JUL**	**23 JUL**	**24 JUL**	**25 JUL**	**26 JUL**
Tourist No.	46	65	87	102	32	28	31	55	42	56
	TOTAL **332**					TOTAL **212**				

In conclusions the environmental impact is much higher when talking to hundreds of people who pass daily through these areas (Figure 5.9 and Figure 5.10).

Fig.5.9.Waste near Iezer Lake

Fig.5.10.Human impacts on Iezer Lake

5.2.2.4. Tourists monitoring near Balea Lake and Călțun

Monitoring of this area differs from the rest because of the national road that pass near the lake, increasing the accessibility of the area (Tab 5.6 and Tab.5.7).

Because of the road in the summer the number of tourists increases considerably and human impacts are very visible. Many itinerant traders and uncontrolled waste disposal leads to a landscape degradation, chalets and hotels built near the lake leads to a visible bank erosion and water pollution.

Tab.5.6. Number of tourists accommodated in 2011, near Balea Lake

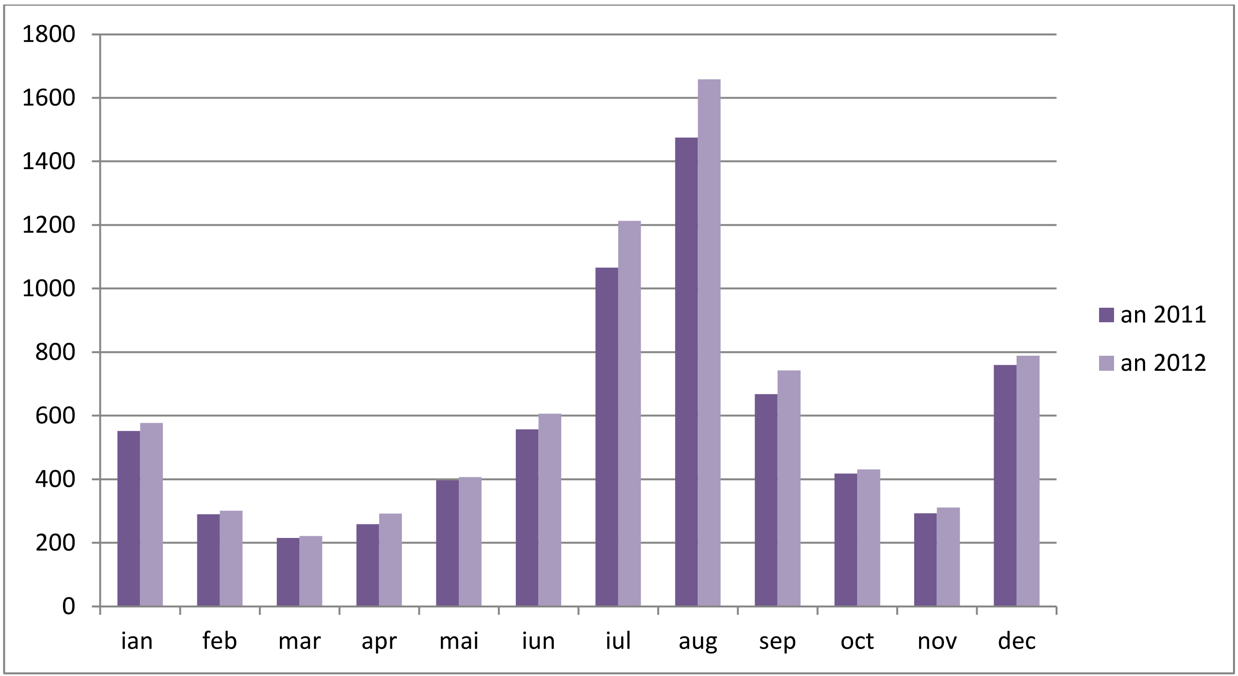
Tourist No. / Month Location	JAN 2011	FEB 2011	MAR 2011	APR 2011	MAY 2011	JUN 2011	JUL 2011	AUG 2011	SEP 2011	OCT 2011	NOV 2011	DEC 2011
Bâlea Hotel	260	165	120	143	175	252	420	575	202	167	145	310
Paltinul Cottage	242	102	78	86	132	160	405	620	320	175	123	270
Mountain Rescue Cottage	50	23	17	30	90	110	187	210	100	76	25	180
Camping	0	0	0	0	0	35	54	70	46	0	0	0
TOTAL	552	290	215	259	397	557	1066	1475	668	418	293	760
TOTAL 6.950												

Tab.5.7. Number of tourists accommodated in 2012, near Balea Lake

Tourist No. / Month Location	JAN 2012	FEB 2012	MAR 2012	APR 2012	MAY 2012	JUN 2012	JUL 2012	AUG 2012	SEP 2012	OCT 2012	NOV 2012	DEC 2012
Bâlea Hotel	265	154	108	173	180	257	425	589	207	173	148	320
Paltinul Cottage	257	122	94	88	135	167	414	625	327	180	136	276
Mountain Rescue Cottage	55	25	19	31	92	112	189	214	111	78	27	193
Camping	0	0	0	0	0	70	185	230	97	0	0	0
TOTAL	577	301	221	292	407	606	1213	1658	742	431	311	789
TOTAL 7.548												

The number of tourists identified in this area of study is superior to the rest areas because of a very high accessibility (Fig.5.11).

Fig.5.11. Tourist number variation in 2011 and 2012 in Făgăraş Mountain



5.2.2.5.Tourists monitoring near Bucura and Galeşul Lakes

The monitoring data of tourists in this area, were also obtained with owners cottage help, situated on major routes to these lakes.

After obtaining statistics from each cottage, the data were divided into the following two tables: Table 5.10 the number of tourists accommodated in 2011, and Table 5.11 presents the number of tourists accommodated in 2012, in Retezat National Park.

Tab.5.10 Number of tourists accommodated in 2011, in Retezat Mountains

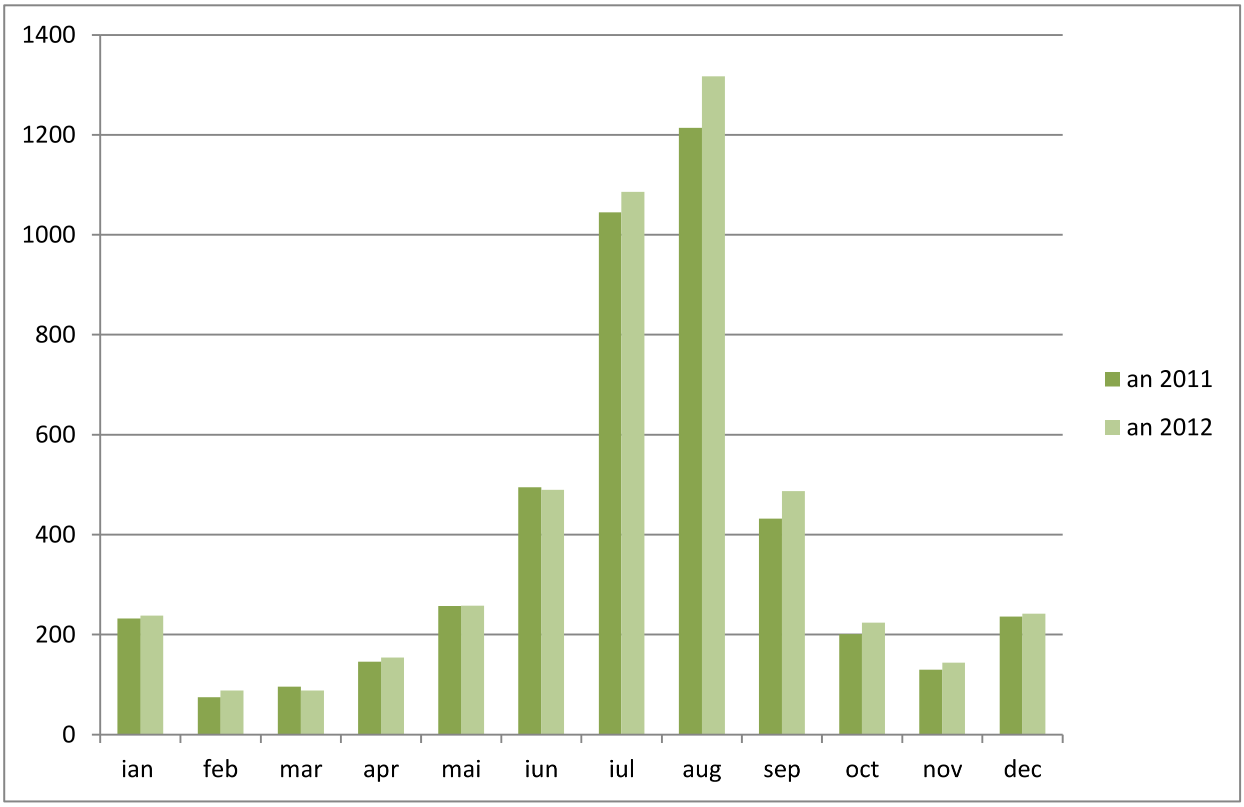
Tourist No. / Month Location	JAN 2011	FEB 2011	MAR 2011	APR 2011	MAI 2011	JUN 2011	JUL 2011	AUG 2011	SEP 2011	OCT 2011	NOV 2011	DEC 2011
Pietrele Cottage	135	35	42	67	110	175	357	402	156	87	71	106
Pietrele Camping	0	0	0	0	20	35	140	210	80	10	0	0
Gențiana Cottage	62	18	21	43	58	100	243	255	87	53	35	85
Bucura Camping	0	0	8	16	26	80	135	164	35	20	0	0
Buta Cottage	35	22	25	20	43	75	170	183	74	31	24	45
TOTAL	232	75	96	146	257	495	1045	1214	432	201	130	236
TOTAL 4.529												

Tab.5.11. Number of tourists accommodated in 2012, in Retezat Mountains

Tourist No. / Month Location	JAN 2012	FEB 2012	MAR 2012	APR 2012	MAI 2012	JUN 2012	JUL 2012	AUG 2012	SEP 2012	OCT 2012	NOV 2012	DEC 2012
Pietrele Cottage	141	42	37	71	78	181	362	470	175	93	82	112
Pietrele Camping	0	0	0	0	22	36	147	220	92	15	0	0
Gențiana Cottage	62	19	23	42	64	105	253	257	92	41	38	85
Bucura Camping	0	0	0	23	43	86	142	175	43	23	0	0
Buta Cottage	35	27	28	18	51	82	182	195	85	52	24	45
TOTAL	238	88	88	154	258	490	1086	1317	487	224	144	242
TOTAL	**4.816**											

As we can seen from the following graph (Figure 5.14), the number of tourists is constantly increasing.

Fig.5.14. Tourist number variation in 2011 and 2012 in Retezat Mountains



5.2.3. Conclusions

As it can be seen in the graphs above, Fig.5.8, Fig 5.11 and Fig 5.14, the number of tourists is constantly increasing, which should be a warning for parks administrations to manage the situation and trying to protect biodiversity and alpine landscapes.

In the following figures (Fig. 5.15, 5.16, 5.17, 5.18, 5.19, 5.20) will be able to identify the detailed maps, processed using ArcGIS, accesses the perimeter of each lake, the buildings around the lake, tourists flow direction and the level of accessibility for each lake from its quantification in Table 5.2.

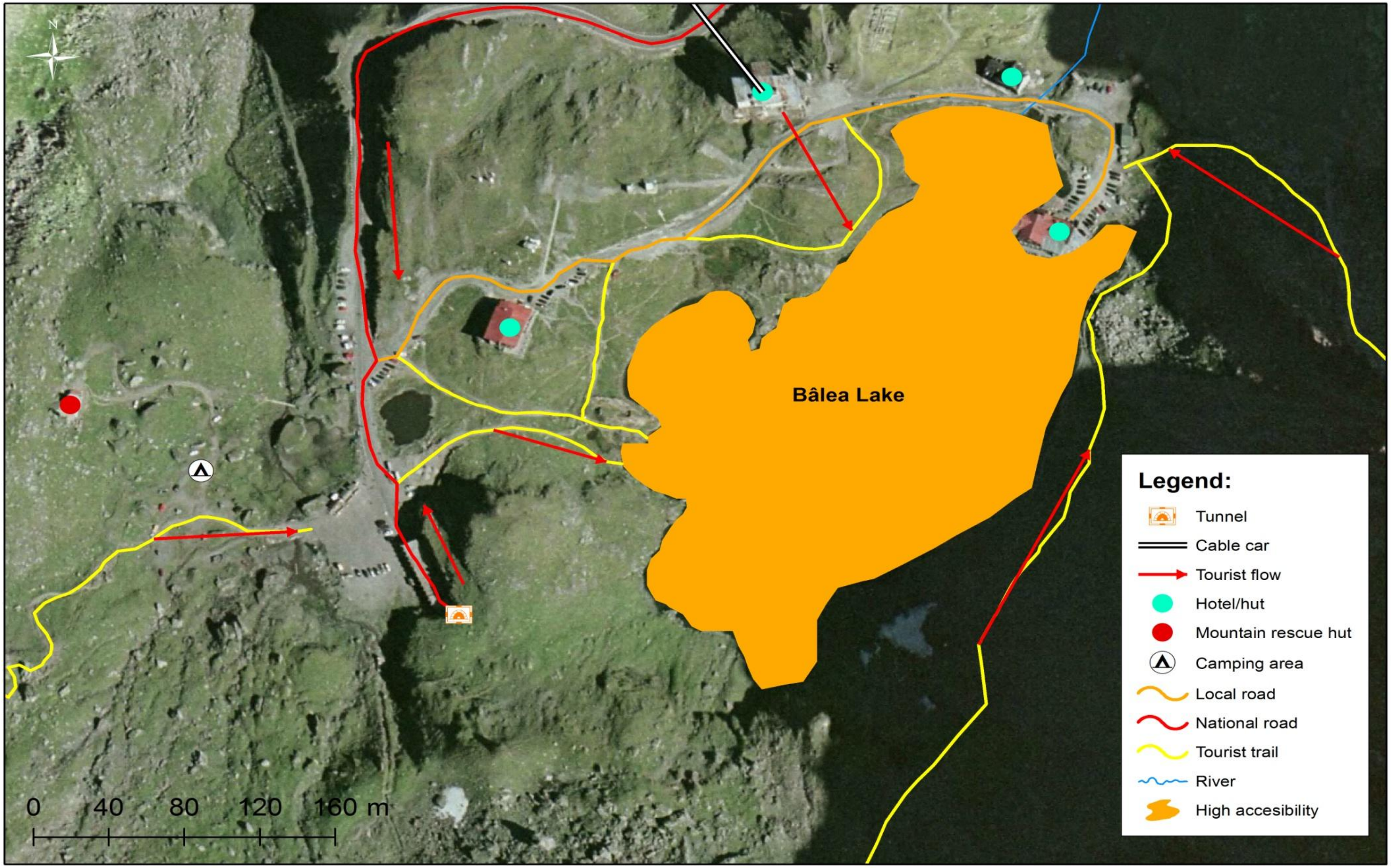


Fig. 5.15. Accessibility and tourist flow near Bâlea Lake area

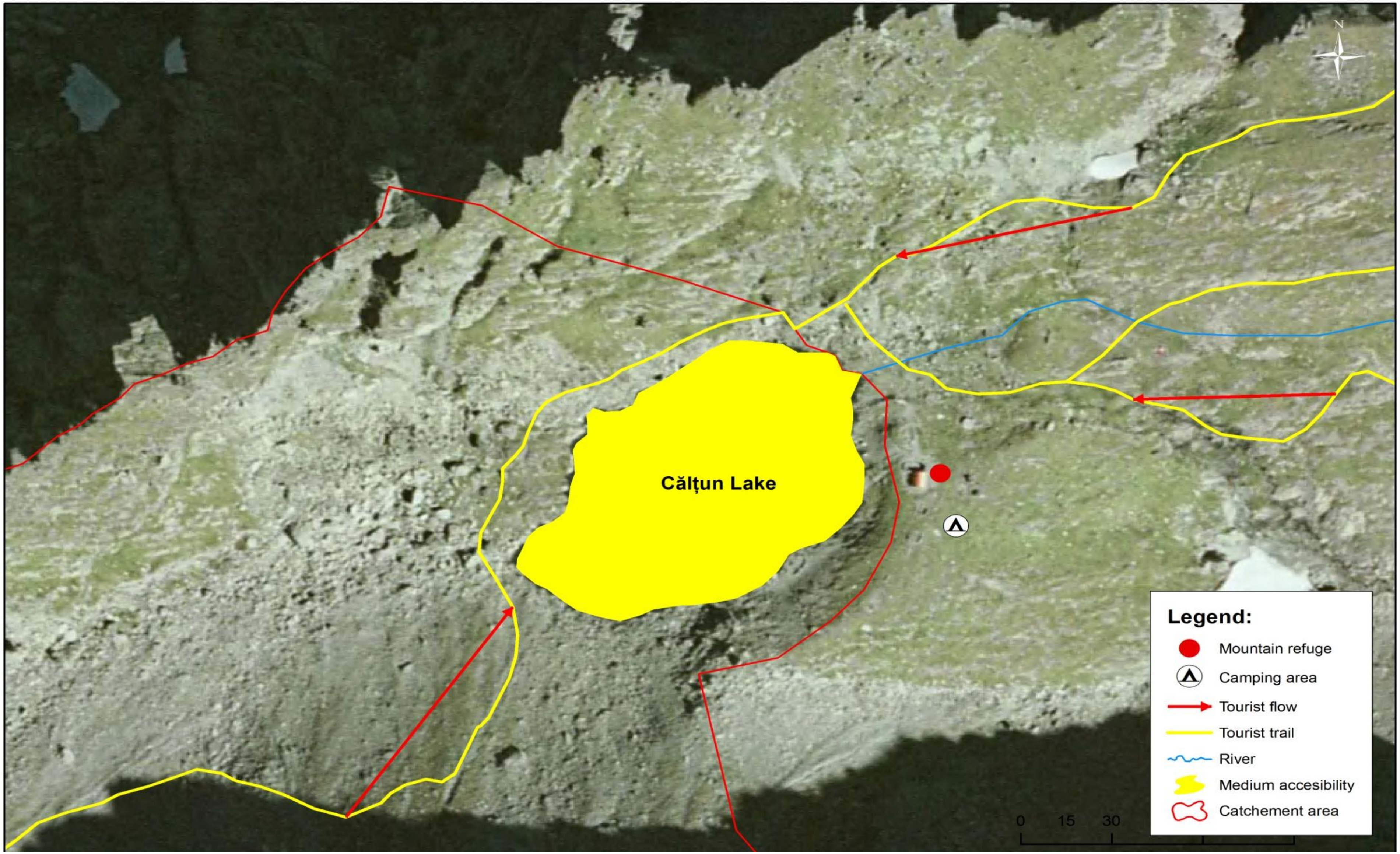


Fig. Accessibility and tourist flow near Călțun Lake area

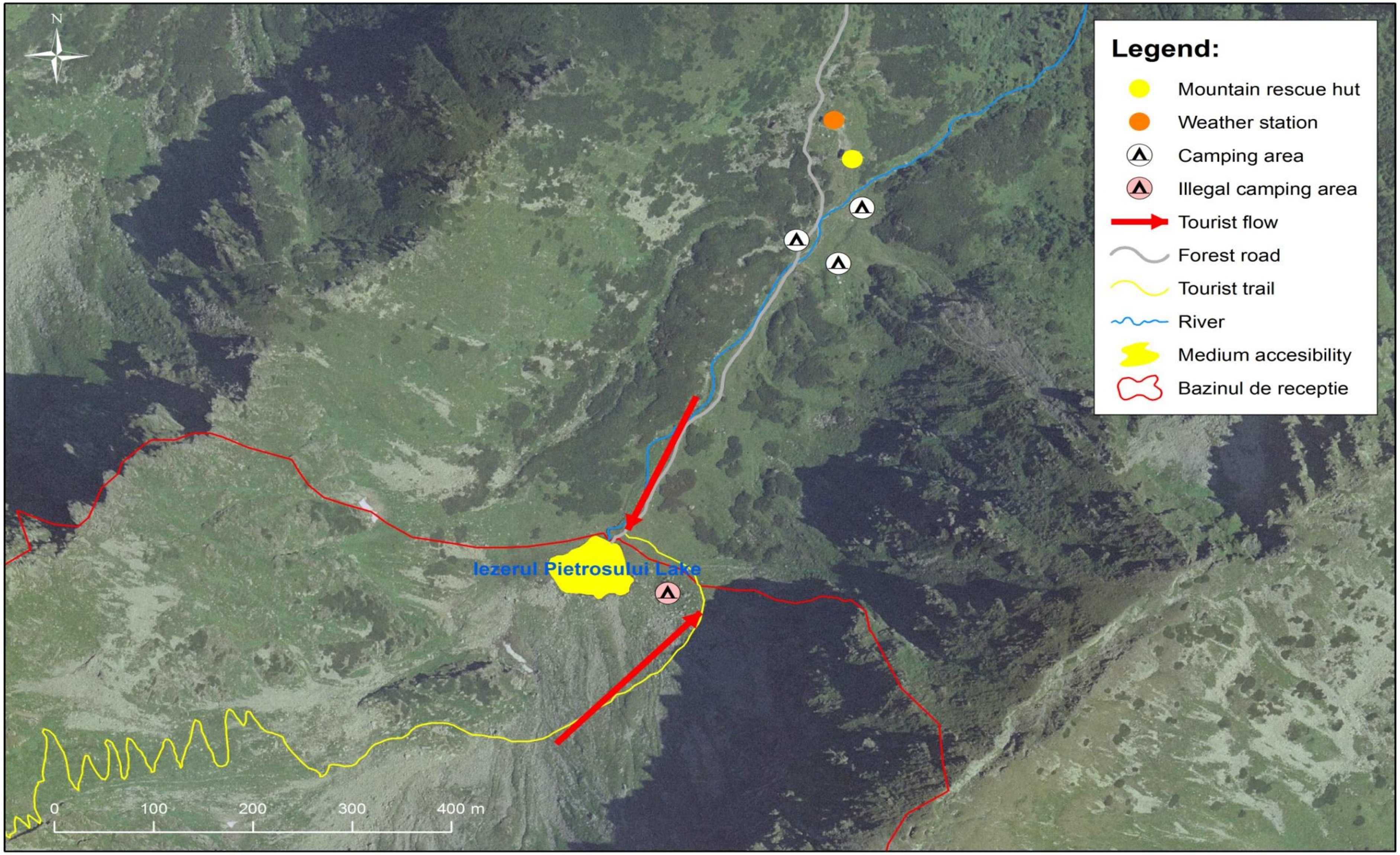


Fig. 5.17. Accessibility and tourist flow near Iezer Lake area

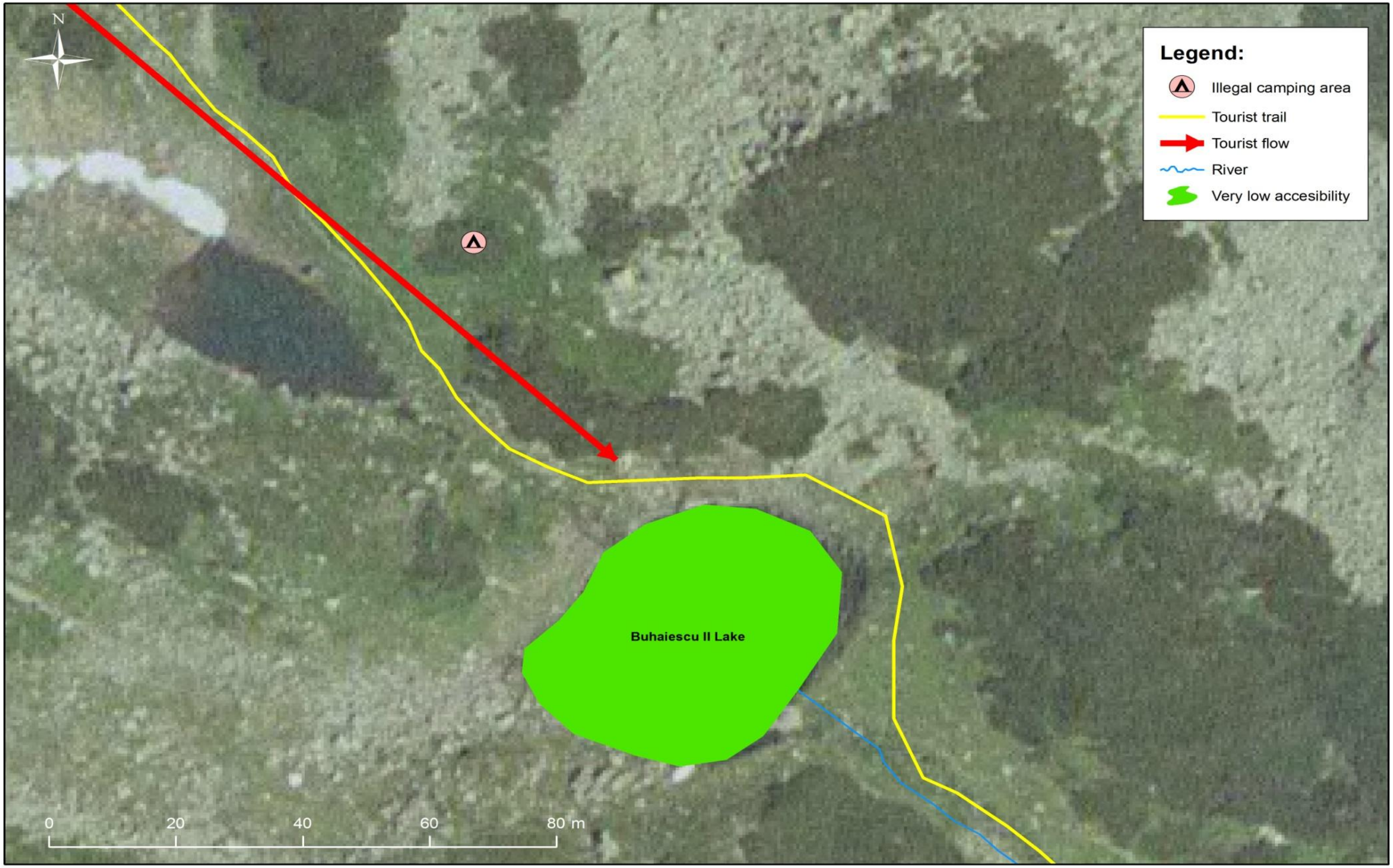


Fig. 5.18. Accessibility and tourist flow near Buhăiescu II Lake area

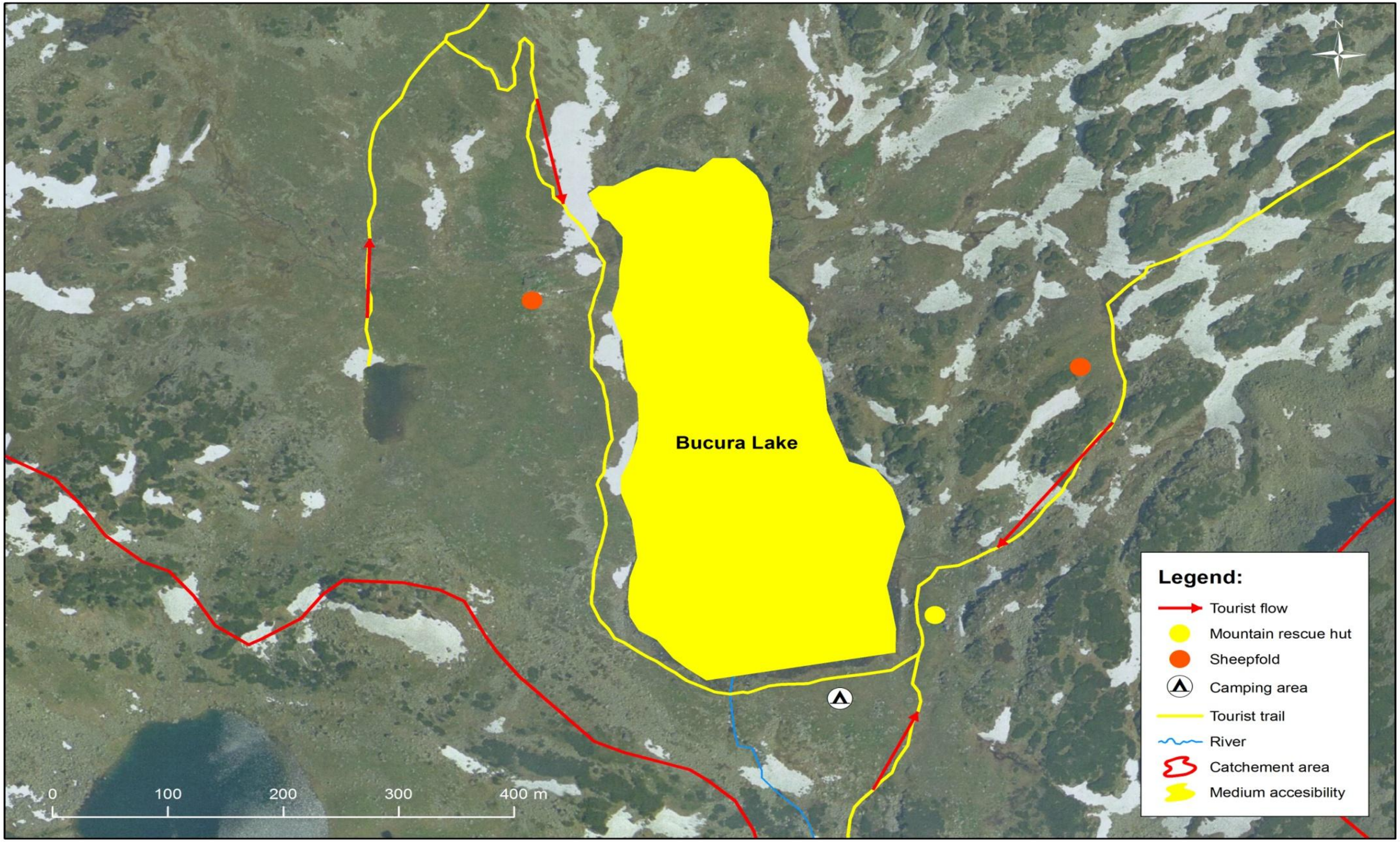


Fig. 5.19. Accessibility and tourist flow near Bucura Lake area

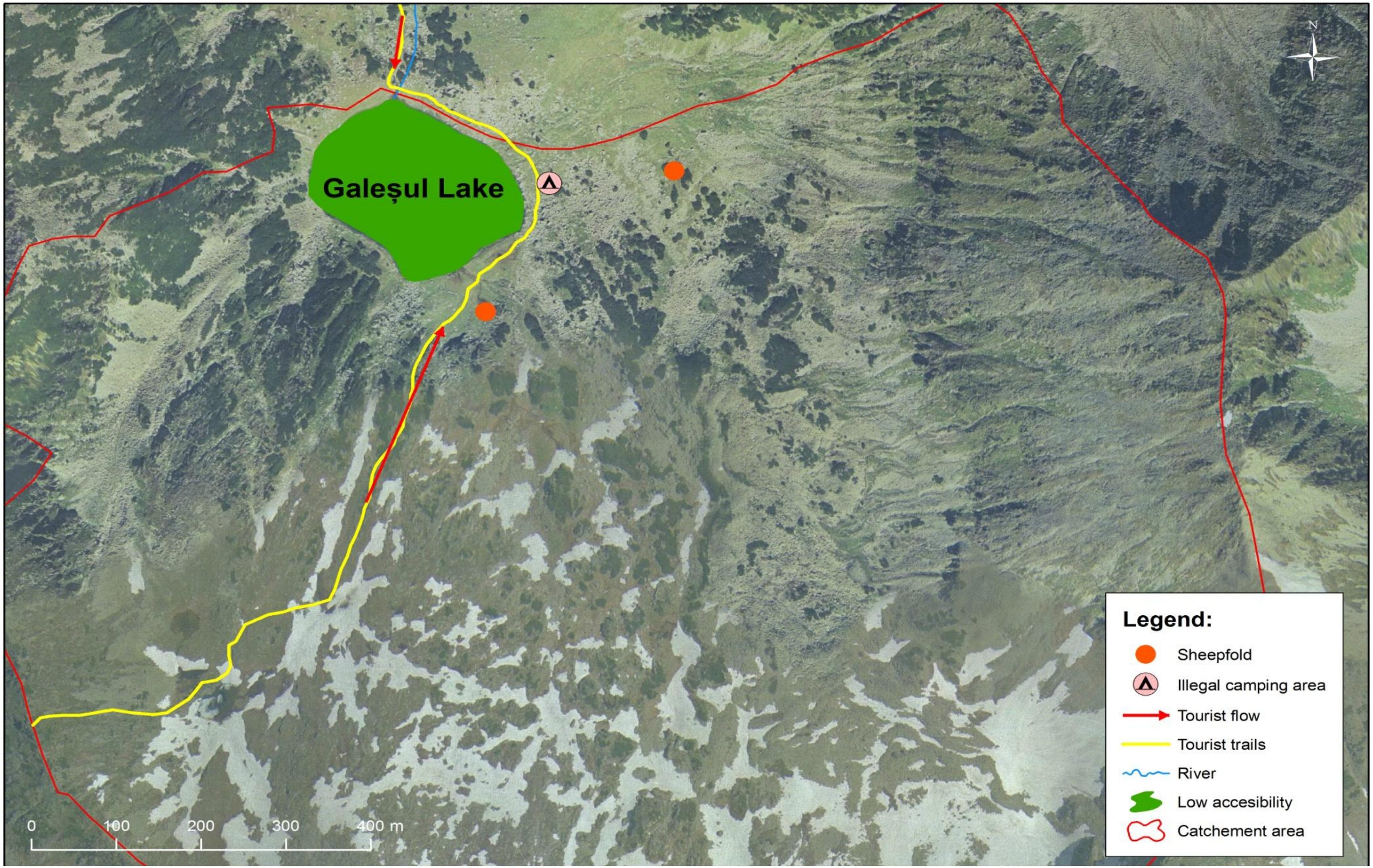


Fig. 5.20. Accessibility and tourist flow near Galeşul Lake area

5.3. Environmental Impact Assessment Matrix in studied areas

5.3.1. Metodology

There are many tools and techniques that have been developed for use in impact assessment processes, including scoping,checklists, matrices and qualitative and quantitative models (Canter, 1996; Morris and Therivel, 2004). While impact assessment processes have become more technically complicated, it is recognized that approaches including simpler applications of available tools and techniques are also appropriate (Markku Kuitunen, et al., 2008).

The Rapid Impact Assessment Matrix (RIAM) is a tool for organizing, analysing and presenting the results of a holistic environmental impact assessment (Pastakia and Jensen, 1998). RIAM was originally developed to compare the impact of alternative procedures in a single project.

The basic principle of RIAM is that characteristics of impact form the basis for scoring (Pastakia, 1998;Pastakia and Jensen, 1998).

RIAM (Rapid Impact Assessment Matrix) is a matrix method developed specifically to transform subjective decisions in a transparent manner in the assessment of human impact (Ijäs A, 2010).

The matrix was applied to all 3 areas of study / for all 6 lakes of this research as: Făgăraş Mountains - Bâlea Lake and Lake Călțun, Retezat Mountains – Bucura Lake and Galeşul Lake, Rodna Mountains - Iezerul Pietrosul Lake and Buhăiescu II Lake.

Environmental components were stated for each location separately and were classified into four categories:

a. Physical and chemical components, referring at aspects like physical and chemical processes and phenomena (were selected and analyzed 15 components);

b. Biological and Ecological components referring at biotic environment (were selected and analyzed 15 components);

c. Social and Cultural components, include human aspects in the environment (were selected and analyzed 14 components);

d. Economic and operational components, identifying qualitative economic and social effects (temporary and permanent) on the environment (were selected and analyzed 15 components).

The evaluation criteria are of two types: (A) criteria that can change individual environmental score obtained, (B) the criteria that individual can not change environmental assessment score (Table 5.12).

Tabel 5.12 Description of evaluation criteria

Evaluation criteria	Scors	Description
A1 is the importance of impact;	4 3 2 1 0	Important to national/international interests. Important regionally. Important to areas immediately outside the local context. Important only in the local context No geographical or other recognized importance.
A2. Magnitude of change and effect.	+3 +2 +1 0 -1 -2 -3	Major positive benefit Significant improvement in status quo Improvement in status quo No change in status quo Negative change to status quo Significant negative disadvantage or change Major disadvantage or change
B1. Permanence of the impact-causing activity	3 2 1	Permanent: The project or activity causing impact is meant to be a permanent one. Some examples from our data: Nature trails, snowmobile routes, roads, building,etc Temporary:The project or activity causing impact is temporal. Some examples from our data: rehabilitationof watersheds, villages, residential areas or environmental restoration, completion of construction, No change/not applicable
B2. Reversibility of impact.	3 2 1	Irreversible impact: The impact is irreversible, if the original state is not restored after the activity is finished. Such activity has changed the environment permanently or for a long period of time. Some examples from our data: Roads, buildings Reversible impact: The impact is reversible, if the originalstate will be restored after the activity is finished. Someexamples from our data: Nature trails, camping, restoration activity, repair building. Not applicable: Targeting the impact is impossible, e.g. the impact of educational activity is difficult to determine as reversible or irreversible.
B3. Accumulation of impact.	3 2 1	Impact is cumulative or synergistic. The project or activity probable has combined impact with other projects or activities in the same area. Examples from our data: noise pollution, air pollution and wastewater emissions, e.g. to the watershed of soil. In the context of social issues, impact in general is often cumulative. Impact is non-cumulative No change/not applicable

The scoring followed RIAM's original five criteria (Fig.5.12.), as presented by Pastakia and Jensen (1998). However,with the aim of repetitive assessment, we specified the evaluation order for each criterion to match our test. According to these orders, the assessment and usage of that method is also a hopeful possibility in future studies. The basic formula for the RIAM is (Pastakia and Jensen, 1998):

$$(A1) \times (A2) = (At) \qquad (1)$$

$$(B1) + (B2) + (B3) = (Bt) \qquad (2)$$

$$(At) \times (Bt) = (SE) \qquad (3)$$

Environmental components, 59 components, are detailed in the assessment matrix in Table 5.14. Most components were selected from the matrix Leopold (1971) environmental matrix and adapted to the evaluation methodology and analyzed territorial context.

The environmental scores (ES) were classified as follows (Pastakia, 1998; Pastakia and Jensen, 1998) (Tab.5.13).

Tabel.5.13. Description of range bands

Environmental Score	Range Bands	Description of range bands
+72 to +108	+E	Major positive change/impact
+36 to +71	+D	Significant positive change/impact
+19 to +35	+C	Moderately positive change/impact
+10 to +18	+B	Positive change/impact
+1 to +9	+A	Slightly positive change/impact
0	N	No change/status quo/not applicable
−1 to −9	−A	Slightly negative change/impact
−10 to −18	−B	Negative change/impact
−19 to −35	−C	Moderately negative change/impact
−36 to −71	−D	Significant negative change/impact
−72 to −108	−E	Major negative change/impact

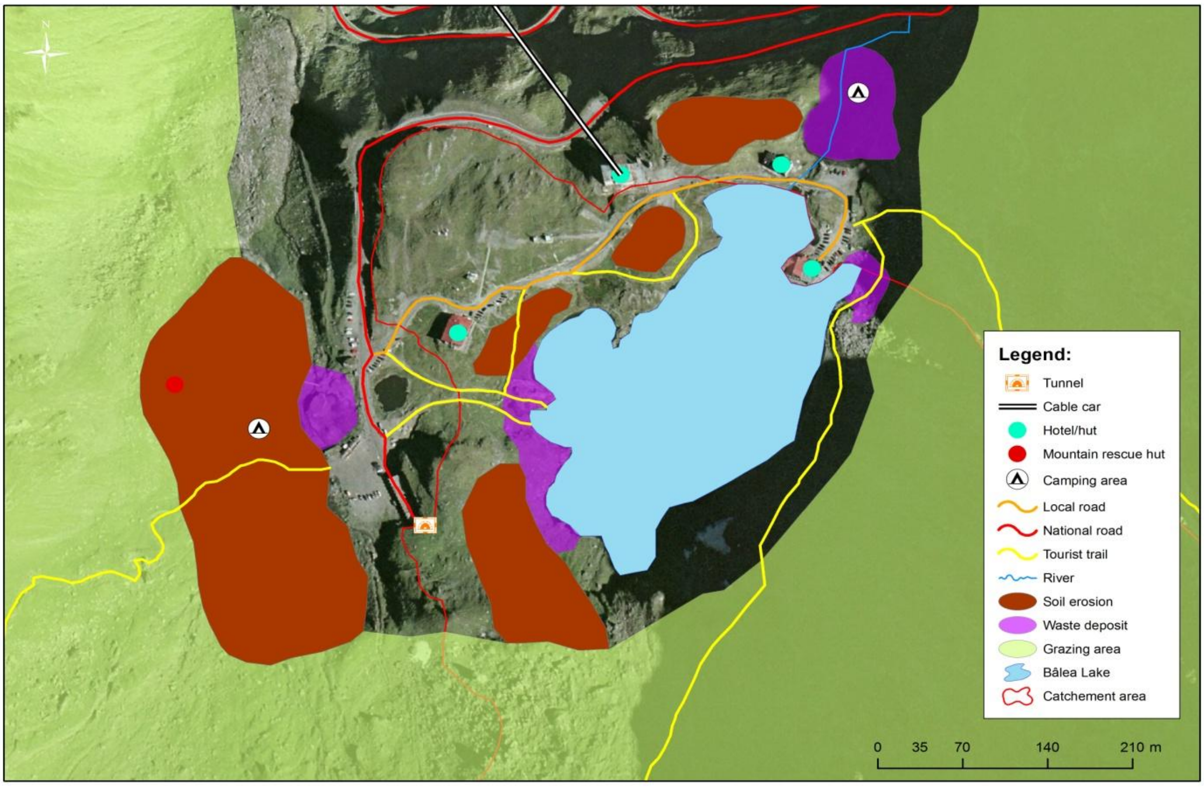
Matrix developed by Pastakia and Jensen (1998) is a territorial analysis and evaluation that allows a consistent presentation of anthropogenic impact assessment on environmental components. The method has several advantages among which: the opportunity to make comparisons (based on common judgment) between different types of impact, transparency and continuous process of analysis and evaluation method flexibility combined with graphical representation of the results obtained, it is easy to achieve (economic) and applied (fast) environmental supports planning and territorial development.

Deficiencies matrix are: judgment involves subjectivity of the evaluator or evaluation team, evaluation is qualitative although quantitative results notes, transparency and objectivity of the evaluation can be influenced by contextual factors or permanent. As such, the methodology used in this study requires an inter-disciplinary assessment by a team of evaluators (subjective approach falls in this case).

For a detailed highlight on existing anthropogenic impacts around the lakes, we have created detailed maps of environmental pressure (Fig.5.21.) which exist and which have been identified in studied perimeters.

Also detailed maps for each lake can be found at the annex, at the end of the thesis. Annex 5.1, 5.2, 5.3, 5.4, 5.5, 5.6).

Fig 5.21. Environmental pressures identified in Balea Lake area.



As we can see in Tab.5.20 assessment scores for all six locations are: Bâlea Lake (-39), Călțun Lake (-4), Iezer Lake (-18), Galeşul Lake (-26), Bucura Lake (-24) and Buhăiescu II Lake (+ 18).

Tabel 5.20. Scoruri de evaluare finală

Lake	Assessment Score	Evaluation class
Bâlea	-39	-B
Călțun	-4	- A
Iezer	-18	- A
Buhăiescu	18	+A
Bucura	-24	- A
Galeşul	- 26	- A

The applied matrix on impact assessment on Romanian Carpathians glacial lakes, taking into account the human factor, the availability and distribution of lakes in different mountain ranges, resulted in a score of negative evaluation, in most areas, except around Lake Buhăiescu, which allows classification the general category of impact - A slightly negative impacts lakes Călțun, Bucura, Galeşul şi Iezerul Pietrosului, the general category of impact + A corresponding to positive impacts, Buhăiescu Lake and only the Bâlea Lake corresponding impact category - B negative impacts.

Environmental Impact Assessment highlights are the following aspects:

- The negative impact that occurs in Balea Lake, which is due to heavy traffic and tourism during the summer (June-October), numerous cottage and hotels that are built into the perimeter of the lake, although it is a nature reserve, lack of sanitation into the lake and a very poor waste management.
- Slightly negative impact Călțun, Bucura, Galeşu and Iezerul Pietrosul Lakes, is due to intense overgrazing and the numerous sheepfold in the summer. Areas close to many lakes being important points for sheep flocks, because of water. Also, the lake is a good place for camping, for tourists. Sheep flocks, lead to a very visible erosion slopes near the lake. Because of an irresponsible tourism and tourists, these areas are "high altitude landfill" (Pop AI, et al, 2011).
- Slightly positive impact around Lake Buhăiescu is because it is not on a main ridge route, being in a more remote area. Being a narrow valley filled with juniper, juniper and quite large rocks, sheep flocks avoid this area. Around the lake, the area is not so good for camping, leading to the preservation of the area as natural and intact. All this, leading to keeping the lake perimeter as natural as possible and intact.

6. RISK ASSESSMENT IN THE STUDIED AREAS

6.1. Concept of Risk Assessment

Risk assessment is the determination of quantitative or qualitative value of risk related to a concrete situation and a recognized threat (also called hazard).

A man living permanently in an environment that is exposed to a wide range of factors more or less hazardous, generated by numerous events that can occur.

The concept of hazard can be defined as "a potential accident situation" (Ozunu, 2000), "threatening event, representing the possibility of a potentially damaging phenomenon to happen" (Bălteanu, 2001).

Natural risk is a function of the likelihood of damage and likely consequences as a result of an event, it being understood that as the size of a natural "threat" (Buwal, 1991). So, natural risk represent a possible danger caused by extreme manifestations of natural phenomena.

Risk management process consists of three phases: risk identification, risk analysis and risk response.

A widely accepted definition defines risk as the product of the probability that an event will happen and the negative consequences it can have, is expressed as follows:

$$R = F \times C$$

where: R-risk (loss / unit time), F-frequency (number of events / unit time), C-consequences (loss / event).

Another definition is given by the Ozunu and Anghel in 2007:

$$R = F \times C \times V \text{ (ec. 2.4)}$$

where: R - risk, F-rate, C - the consequences and V-vulnerability (-).

6.2. Qualitative risk analysis

A qualitative analysis involves the use of qualitative criteria, using different categories to identify the parameters, using different qualitative scales for each category. Also, qualitative decisions are based on experience evaluator in order to assign items to categories. This approach is subjective, but allows a higher degree of generalization, the less restrictive (Ajtai N., 2012).

Quality classes used in the majority of methodologies for quantifying the risk is represented by the frequency and consequences (Ajtai N., 2012., Török et al. Burton et al., 1978). Majority of existing methodologies, provide qualitative risk quantification technology (Ozunu, 2007 Ajtai et al., 2012 Torok, et al., 2011, 2012, etc.), which differ by the case presented.

Therefore it's developed a new methodology adapted with new reference material for this assessment. The indicator frequency been replaced by the accessibility indicator.

For an accurate evaluation, of the phenomena on these areas of study, we propose two classes for quantifying qualitative assessment: quantifying the accessibility (Table 6.1) and classes on quantifying the consequences (Table 6.2.)

$$\text{Risk (R)} = \text{Accessibility (A)} \times \text{Consequences(C)}$$

Tab.6.1 Accessibility quantification

Evaluation score	Points	Category Description
<10	1	Very low
11-25	2	Low
26-50	3	Medium
51-75	4	High
76- 100	5	Very high

Tab.6.2. Consequences quantification

Points	Category Description
1	Insignificant
2	Minor
3	Medium
4	Significant
5	Major

The existing risk quantification results, is classified in Tab 6.3, Tab 6.4.

Tab.6.3. Classification and description of categories of risk based on assessment scores

Evaluation score	Risk category	Risk Category Description
1 – 5	A	Very low
6 - 10	B	Low
11 - 15	C	Moderate
16 - 20	D	High
>20	E	Extrem

Tab.6.4. Quantification of final Risk

Evaluation score	Risk final	Risk Category Description
< 30	A	Very low
31 - 60	B	Low
61 - 90	C	Moderate
91 - 120	D	High
>120	E	Extrem

In the following table (Tab 6.11) will be quantified the final risk for all identified hazards in the perimeter of each lake and in all surrounding area.

Tab.6.11. Hazards / Checklist

Lac / Hazard	BÂLEA	CĂLŢUN	IEZERUL PIETROSULUI	BUHĂIESCU	BUCURA	GALEŞUL
Eutrophication	D	B	B	A	C	A
Heavy metals pollution	C	A	B	A	B	A
Nitrate pollution	C	B	B	A	C	B
Soil erosion	D	C	C	A	C	C
Biodiversity degradation	D	A	C	A	C	B
Landscape degradation	D	A	C	A	C	B
FINAL RISK	104, D	30, B	72, C	13, A	72, C	41, B

6.3. Conclusion

As we can see in Table 6.11, probability that hazards to manifest and achieve a high level of risk, are particularly around Bâlea Lake, and around the lakes Bucura, Iezerul Pietrosul and Călțun. In Buhâiescu Lake, the risk of hazards to manifest is low, but exists also.

To minimize the risk in the perimeter of each lake, would be necessary awareness, mainly to locals, which means to understand what sustainable development means and make them understand that intensive grazing leads to soil erosion, loss of biodiversity, water pollution by nitrates and nitrites, even alpine landscape degradation.

VII. FINAL CONCLUSIONS AND PERSONAL COTRIBUTIONS

7.1. Final conclusions

➡ This paper describes in detail the study of six glacial lakes in the Carpathian Mountains, Romania. These lakes are: Iezerul Pietrosul Lake and Buhăiescu II Lake in Rodna Mountains, Bucura Lake and Galeşul Lake in Retezat Mountains and Bâlea Lake and Călțun Lake in Fagaraş Mountains.

➡ Because of their sensitivity to small changes in environmental factors, mountain lakes can be laboratories of study for evidence of early human impact phenomena (Pop AI, et al, 2011).

➡ The study of these lakes could lead to the identification of risks induced by climate change and anthropogenic pressures in different forms and can help to generate improved conservative strategy. The sensitivity of mountain lakes can be an early indicator for the start of the dangerous phenomena performance, and thus contribute to the implementation of early remedial action.

➡ More than half of humanity depends on fresh water that is captured, stored and purified in mountainous regions. From an ecological point of view, mountain regions are hotspots for biodiversity, as well as socially mountains are of global importance as key destinations for tourism and leisure activities (Greta-Regamey A., et all, 2010).

➡ The difference in water chemistry between all this studied glacial lakes can be attributed to several factors such as: geology, lake area, lake depth, influence of weather and terrain (impaired lakes of different weather, different sizes of river basins, different retention times) and human influence, more visible or more moderate.

➡ The water quality of the lakes studied are within normal limits, except for a parameter Pb in lakes Călțun and Bâlea, and parameters as nitrates in lakes Bâlea, Bucura, Galeşul, Iezerul Pietrosul and Buhăiescu II.

➡ Behind the algological studied we identified 192 taxa belonging to 8 classes. Most taxa can be found in the class Bacillariophyceae or diatoms in the number of 121. Zygnematophyceae class consists of 32 species and class Cyanophyceae is the 17 species. Classes Dinophyceae Euglenophyceae and represented each of 3 taxa. Green algae were classified into two classes (Chlorophyceae and Trebouxiophyceae) totaling 14 species. The Class Chrysophyceae is poorly represented by only two species.

➡ From all the studied lakes, in Călțun Lake and Buhăescu II Lake algological research conducted was for the first time, in other lakes there are previous studies older or more recent.

➡ Of the 30 rare species determined, 14 of them are mentioned for the first time in Romania algoflora. In particular biogeographical importance are the arctic-alpine as: Cosmarium crenatum, Achnanthes ventralis, Pinnularia rupestris, Aulacoseira alpigena, Eunotia serra var. tiara, Neidium alpinum.

➡ Regarding the assessment of the ecological status of mountain studied lakes, we can say that the predominant species are characteristic to oligotrophic waters and less characteristic species for mesotrophic waters.

➡ Following these data as Tab 5.2, water quality and ecology in mountain lakes, in terms of existing algal communities, belongs to category II that means good, or in Bâlea Lake, moderate to good.

➡ According to the results of quantification accessibility matrix (Tab 5.2), we see that accessibility varies from one lake to another, and can identify Bâlea Lake having the highest accessibility with 63 points and Buhăiescu II Lake lowest with 5 points.

➡ Accessibility level directly affect the annually tourists flow in these perimeters, and degradation of these areas. Alpine tourism in Romania it is practiced especially in the summer season.

➡ In 2011 and 2012, the largest flow of tourists has been monitoring near Bâlea Lake (6.950 and 7.458 accommodated at the nearby lodges, but their actual number is over 3000 people daily, according to Tab 5.9 and Tab.5.10), followed by lakes in the Retezat Mountains and then the Rodna Mountains.

➡ As we can be seen in graphs Fig.5.5, Figure 5.9 and Figure 5.12 in Chapter V, the number of tourists is constantly increasing, which should be a warning for national parks administrations and they must trying to manage the situation to protect biodiversity and alpine landscapes.

➡ Various types of impacts, both natural and human, occur on these sensitive ecosystems. Generated impacts may be originated from local, regional and global pressures. It is requires environmental remediation due to local impacts.

➡ The applied matrix on impact assessment on Romanian Carpathians glacial lakes, taking into account the human factor, the availability and distribution of lakes in different mountain ranges, resulted in a score of negative evaluation, in most areas, except around Lake Buhăiescu, which allows classification the general category of impact - A slightly negative impacts lakes Călțun, Bucura, Galeşul şi Iezerul Pietrosului, the general category of impact + A corresponding to positive impacts, Buhăiescu Lake and only the Bâlea Lake corresponding impact category - B negative impacts.

➡ To keep a balance between the natural environment and human resources it is necessary to develop a strategic plan, so that always can be a stable relationship between natural habitat and human population.

➡ Natural hazards and threats that may apper in mountainous areas are affected by human activity on nature negative character.

➡ Risk assessment in the present study was performed using qualitative methods and evaluation techniques. The accessibility plays an important role in quantifying the risk as follows: **R = A x C**, where R is risk, is accessibility and C are consequences.

➡ Final checklist (Fig.6.11) that quantify the final risk category for each studied parameters present that Bâlea Lake present the highest risk with 104 points, representing Class D – Higher risk, followed by Bucura Lake and Iezerul Pietrosul Lake with 72 points, Class C - moderate risk and with 30 and 41 points in Class B - low risk – are situated respectively Călțun Lake and Galeşul Lake, and the lowest score with 13 points, corresponding class A - very low risk - Buhăiescu II Lake.

➡ The main risks identified in the studied areas are: eutrophication, pollution by heavy metals, nitrates, nitrites, nitrates because of overgrazing, soil erosion, biodiversity extincion, and alpine landscape degradation.

➡ Importance of increasing public awareness for tourists on environmental protection and conservation need to provide a national priority.

➡ The mountain lakes are important elements of natural capital, which must be protected, preserved, because of the many ecosystems that live, in accordance with EU directives.

➡ The presence of mountain ecosystems unique, valuable and highly appreciated by the public, should justify even greater protection and great efforts of conservation, given that tourism is continuously growing.

7.2. Personal contributions

Studies from this thesis improve the current database with:

- **New data on physico-chemical properties in all 6 lakes**. In the literature there are no new data on 5 lakes except Lake Balea. Such studies have been made only in the years 1960 - 1972 by P. Gâstescu, V. Trufaş and I. Pişota.
- **Algological study in Călțun and BuhăescuII Lakes was investigated for the first time**, but also improve algological studies of other lakes.
- **Quantifying the accessibility** by adapting existing methods with new, relevant to this study.
- **Identify and quantify the approximate number of tourists** in the most disposed areas to pressure on environmental degradation.
- **Human impact assessment** in the studied area by the relevant methods and techniques adapted to this areas.
- **Risk identification** using qualitative methods and evaluation techniques.
- **Proposing new methodologies for human impact assessment and risk quantification** for such areas.

Personal contributions in this paper are included in the: 2 ISI article published, 6 article published BDI, 3 article published C, 2 article submitted for publication, and participation in international conferences and workshops: 6 conferences, 2 workshops and 1 summer school.

- **2 article publish ISI**

- <u>Andreea Ioana POP</u>, Radu MIHĂIESCU, Tania MIHĂIESCU, Marius George OPREA, Claudiu TĂNĂSELIA, Alexandru OZUNU, 2013. **Physico-chemical properties of some glacial lakes in the Romanian Carpathians**. Carpathian Journal of Earth and Environmental Science, Vol. 8, No. 4, p. 5 – 11. ISSN Printed: 1842 – 4090, ISSN Online: 1844 - 489X. ISI- **IF 1,495.**

- Radu Mihaiescu, **<u>Andreea Ioana Pop</u>**, Tania Mihaiescu, Edward Muntean, Simion Beldean, Livia Alhafez, Alexandru Ozunu, 2012. **Physico-Chemical characteristics of the karst Lake Ighiu (Romania).**Environmental Engineering and Management Journal March 2012, Vol.11, No. 3, 623-626, ISSN: 1582-9596. ISI– **IF 1,43**

- **6 article publish BDI**

-<u>Andreea Ioana Pop</u>, Radu Mihăiescu, Tania Mihăiescu,Edward Muntean,Claudiu Tănăsălie, Cristian Maloş, Marius-George Oprea, Alexandru Ozunu, 2012**. Study on Bâlea and Călțun Glacial Lakes, from Făgăraş Mountains.** Bioflux, ProEnvironment, Nr. 5 (2012) 260 – 265, ISSN: 2066-1363.

-<u> Andreea Ioana Pop</u>, Radu Mihăiescu, Alexandru Ozunu, Tania Mihăiescu, Marius-George Oprea, Ioana-Violeta Ardelean, Ionuț Lehaci, 2011. **The impact of tourism in mountain lakes ecosystems. Case study: Lake Avrig, Fagaras Mountains.** Bioflux, ProEnvironment, Nr. 4, pag. 319 – 323, ISSN: 2066-1363.

- O. L. Muntean, R. Mihăiescu, F. Stoica, C. Maloş, N. Baciu, V. Arghiuş,T. Mihăiescu, Gh. Roşian, **<u>Andreea Ioana Pop</u>**, 2010.Constraints in Management of Protected Areas **Case Study: Buila - Vânturarița National Park**. Bioflux, ProEnvironment 3 (2010) 367 – 374, ISSN: 2066-1363.

- O. L. Munteanu, R. Mihăiescu, F. Stoica, C. Maloş, N. Baciu, V. Arghiuş,T. Mihăiescu, Gh. Roşian, **<u>Andreea I. Pop</u>**,2010. **Constrângeri în Managementul Ariilor Protejate.** Bioflux, ProEnvironment 3 (2010) 549 – 557, ISSN: 2066-1363.

- **<u>Andreea Ioana Pop</u>,** Ioana-Violeta Ardelean, 2011. **Natural Conditions of a few remote mountain lakes from the Romanian Carpathians. Case Study:Bucura Glacial Complex from Retezat Mountains and Bâlea-Capra Glacial Complex from Făgăraş Mountains.** Regional Environmental Problems, vol nr.4, pag 224-227, Odessa, Ucraina. ISSN: ББК 28.081, УДК 504, P 31,.

- **<u>Andreea Ioana Pop</u>**, 2010. **Monitoring plan for Râpa Roşie Natural Reservation**. Regional Environmental Problems, vol nr.3, pag 269-274, Odessa, Ucraina. ISSN: ББК 28.081, УДК 504, P40.

- **3 article publish C category**

- **<u>Andreea Ioana Pop</u>**, 2013. **Proprietățile fizico-chimice a 6 lacuri glaciare studiate, din Carpații Româneşti.** Volum lucrări „*Tendințe şi cerințe de interdisciplinaritate în cercetare. Prezentarea rezultatelor obținute de doctoranzi.* Editura Politehnium Iaşi ISBN 978-973-621-408-0.

- Dan Pavel Turtureanu, **<u>Andreea Ioana Pop</u>**, Radu Mihăiescu, 2009. *Forest Communities with European Larch (Larix decidua mill.) at Vidolm, Alba County (Comunitățile forestiere cu larice (Larix decidua mill.)de la Vidolm -județul Alba)*. Environment & Progress – 13/2009, pag. 269-274. ISSN 1584–6733, Cod CNCSIS 697/2006

-**<u>Andreea Ioana Pop</u>**, Dan Pavel Turtureanu, Doradia Folfă, 2009. **Management plan consideration for Râpa Roşie Natural Reservation**. Environment & Progress – 13/2009, pag. 246-253. ISSN 1584–6733, Cod CNCSIS 697/2006

- 2 articles submitted for publication:

- **<u>Andreea Ioana Pop</u>,** Radu Mihăiescu, Liviu Muntean, Tania Mihăiescu, Marius-George Oprea, Alexandru Ozunu, Cristi Maloş, Dezsi Ştefan. **Impact and risks assessment, influence by tourists flow in Romanian glacial lakes perimeter**.

- **<u>Andreea Ioana Pop</u>**, Momenu Laura, Lehaci Ionuț, Radu Mihăiescu, Tania Mihăiescu, Marius-George Oprea. **Study on algal flora from some glacial lakes, in Romanian Carpathians.**

- **6 conference participation:**

-*The 9th edition of the International Conference "Environmental Legislation, Safety Engineering and Disaster Management" - ELSEDIMA,* Universitatea Babeş-Bolyai, Facultatea de Ştiința şi Ingineria Mediului, Cluj Napoca, 25-27.10.2012, România.

-*"Sesiunea de Comunicări Ştiințifice cu participare internațională, Bune Practici în Evaluarea şi Monitorizarea Resurselor de Apă"*, Ediția a III-a, Universitatea de Ştiinte Agricole şi Medicină Veterinară, Cluj-Napoca, 23.03.2012, România.

-*"6th International Conference, Environmental Engineering and Management",* Ediția VI-a, Universitatea din Veszprem, Balatonalmadi, 01-04.09.2011, Ungaria.

- *IV International Scientific Conference* „*Regional environmental problems as well as methodological and applied ways for finding solutions to them*”. Universitatea de Mediu din Odessa, 24-25 martie 2011, Odessa,Ucraina.

-*“Sesiunea de Comunicări Ştiinţifice cu participare internaţională, Bune Practici în Evaluarea şi Monitorizarea Resurselor de Apă”*, Ediţia a III-a, Universitatea de Ştiinte Agricole şi Medicină Veterinară, Cluj-Napoca, 17.03.2011, România.

- *III International Scientific Conference* “*Environmental problems and the ways for finding solutions*”. Universitatea de Mediu din Odessa, March 24-26, 2010, Odessa, Ucraina.

- **2 workshops participation**

-Impact of climate change on water resources. Organizator: Universitatea din Bucureşti, Mangalia, România, 29 mai – 2 iunei 2011.

-Water use and demand. Organizator: Universitatea Sf. Andrei din Tibilisi, Tibilisi, Georgia, 23 – 26 aprilie 2012

- **1 summer school**

-Environmental problems of general public interest: *Water management, Impact of climate change on water resources, coastal erosion and Socio-economical implications and transboundary issues in the management of the Danube delta*. Organizator: Universitatea din Odessa, Ucraina, 10-18 septembrie 2012.

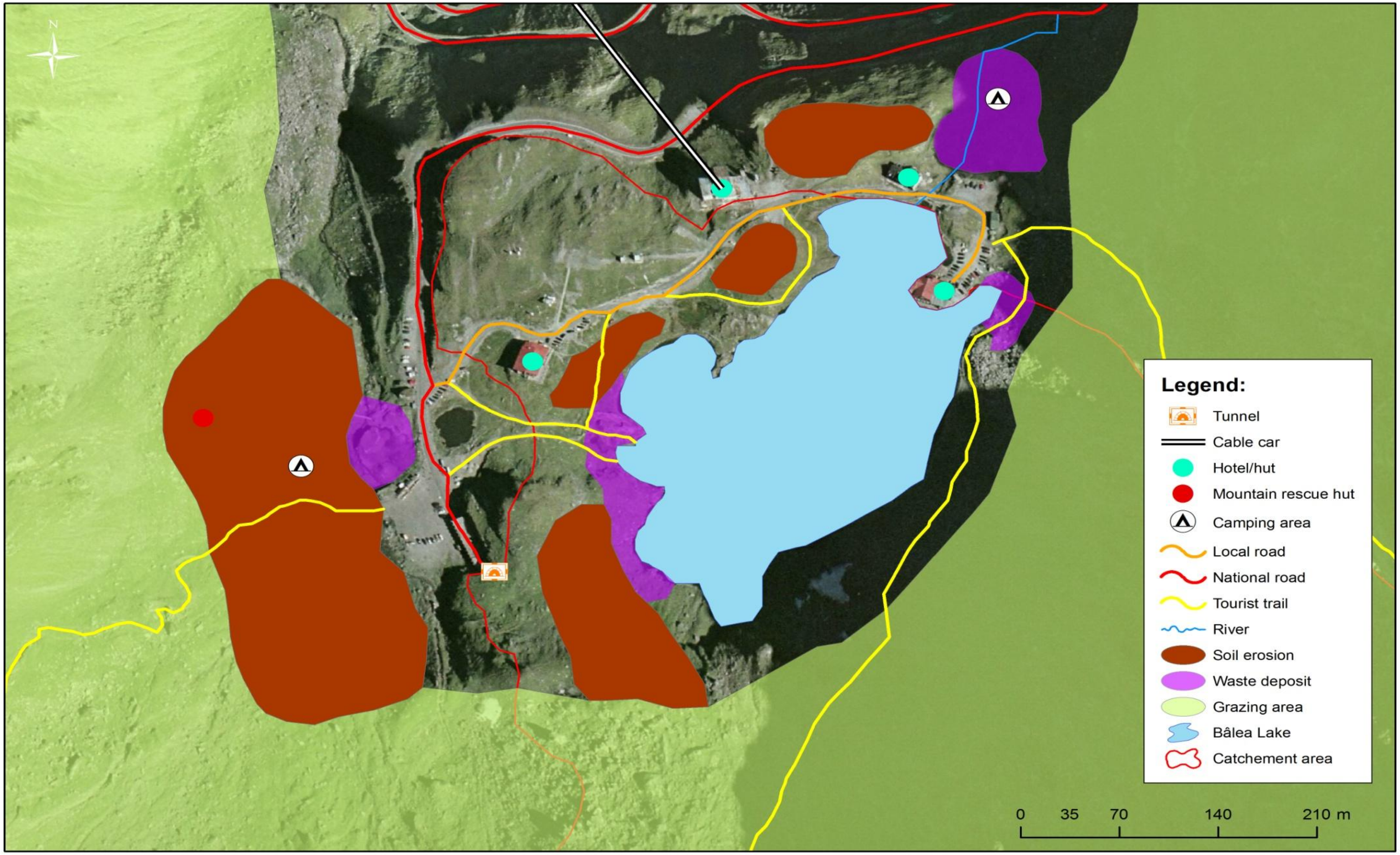
Selectiv Bibliography

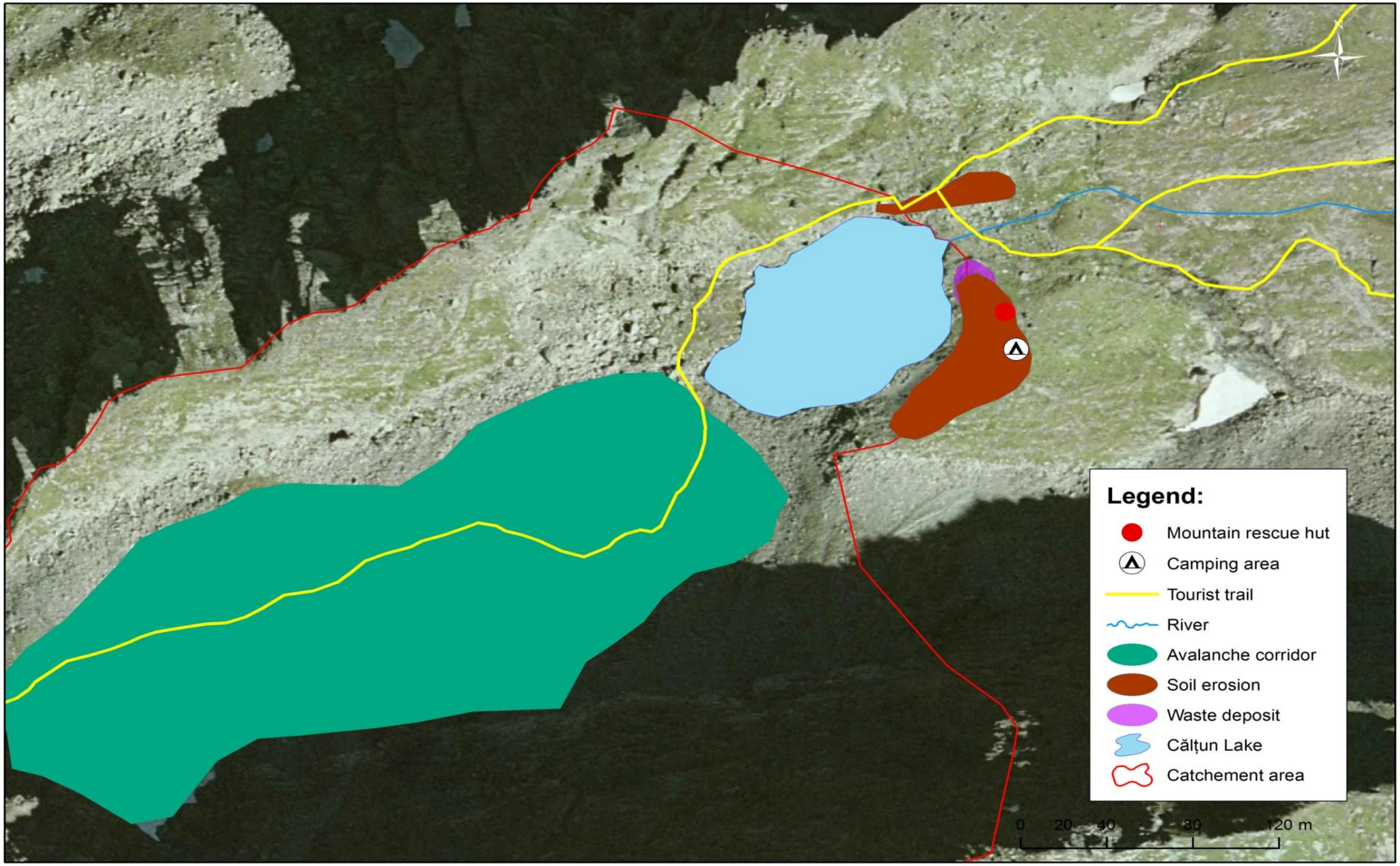
1. Ajtai Nicolae, 2012. *Tehnici Optoelectronice de monitorizare a atmosferei utilizate în evaluarea hazardurilor naturale şi riscurilor tehnologice*. – Teză de doctorat.
2. Bălteanu, D., Alexe, R., (2001), *Hazarde naturale şi antropogene*, Editura CORINT, Bucureşti.
3. Constanza R., et al, 1997. *The value of the world’s ecosystem services and natural capital*. Nature, Vol 387.
4. Daily, Gretchen C. (ed.). 1997. *Nature´s Services. Societal Dependence on Natural Ecosystems*. Washington, D.C., Covelo, California: Island Press.
5. E. de Martonne, 1906. *Recherches sur l'Évolution morphologique des Alpes de Transylvanie (Karpates méridionales)* Paris, Delagrave.

6. Gâştescu P., 1960. *Caracteristicele hidrochimice ale lacurilor din R.P.R.* Meteorologia, hidrologia şi gospodărirea apelor, V, 1, 22-25.
7. Gâştescu P., 1971. *Lacurile din România*. Limnologie Regională. Editura Academică Bucureşti, p 330-343
8. Ijäs A. et al, 2010. *Developing the RIAM method (rapid impact assessment matrix) in the context of impact significance assessment*. Environmental Impact Assessment Review 30 (2010) 82–89.
9. Kováč M., Plašianka D., 2002, *Geological structure of the Alpine-Carpathian-Pannonian junction and neighbouring slopes of the Bohemian Massif*. Comenius University, Bratislava, 88.
10. Lehaci I., 2012. Lucrare de dizertaţie, *Date privind compoziţia calitativă a comunităţilor algale din câteva lacuri glaciare situate în Munţii Carpaţi.*
11. Martin F. Price, 2007. *Mountains: globally important ecosystems.* Environmental Change Unit, University of Oxford, UK
12. Momeu, L., 2008*, Evaluarea calităţii apelor de suprafaţă – râuri şi lacuri naturale şi de acumulare pe baza analizei fitoplanctonului şi a fitobentosului (Suport de curs)*, Cluj-Napoca.
13. Mihaiescu R., Pop A.I., et al, 2012. *Physico-Chemical characteristics of the karst Lake Ighiu (Romania).*Environmental Engineering and Management Journal March 2012, Vol.11, No. 3, 623-626, ISSN: 1582-9596.
14. Muntean, O.L., 2004. *Impactul antropic asupra mediului înconjurător în Culoarul Târnavei Mari (sectorul Vânători-Micăsasa). Studiu de evaluare şi planificare a mediului înconjurător*, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca (209 pg) (ISBN-973-686-614-9).
15. Muntean. O.L., 2005. *Evaluarea impactului antropic asupra mediului*, Ed. Casa cărţii de Ştiinţă, Cluj-Napoca (129 pg) (ISBN-973-686-733-1)
16. Muntean O.L, Pop A.I., et al,, 2010.*Constraints in Management of Protected Areas Case Study: Buila - Vânturariţa National Park*. Bioflux, ProEnvironment 3 (2010) 367 – 374, ISSN: 2066-1363.
17. Ozunu, A., (2000), *Elemente de hazard şi risc în industrii poluante*, Editura Accent, Cluj-Napoca.
18. Ozunu, A., Anghel, C., (2007), *Evaluarea riscului tehnologic şi securitatea mediului*, Editura Accent, Cluj-Napoca.
19. Pastakia C. M. R., Jensen, A., *(1998), The Rapid Impact Assessment Matrix (RIAM) for EIA, Environmental Impact Assessment, 18.*

20. Pişota I, 1956. *Câteva observații hidrologice asupra Lacului Bâlea şi bazinului Bâlea-Cârțisoara*
21. Pişota I, 1957. *Lacul Călțun (Observații limnologice*), Probleme de Geografie V.
22. Pişota I., 1971. Lacurile glaciare din Carpații Meridionali. Studiu hidrologic, Ed. Academiei RSR., Bucureşti .
23. Pişota, I., 1964, Lacurile glaciare din Munții Retezat, Natura, XXVI, 6, 21-30.
24. Pişota I., Trufaş V., 1961. Sursele de alimentare cu apă a lacurilor din relieful glaciar al Carpaților Meridionali, Analele Universității Bucure ti, seria Geografie, 27.
25. Pop A. I., Ardelean I.V., 2011. *Natural Conditions Of A Few Remote Mountain Lakes From The Romanian Carpathians.* Regional Environmental Problems, vol 4, nr.1, Odessa.
26. Pop A I., et al., 2011. *Human impact on remote mountain lakes from Romanian Carphatians. Case Study: Avrig Lake, Făgăraş.* ProEnvironment –ProMediu, vol.4, Cluj-Napoca.
27. Pop A.I., et al, 2012. *Study on Bâlea and Călțun Glaciar Lakes, from Făgăraş Mountains***.** Bioflux, ProEnvironment, Nr. 5 (2012) 260 – 265, ISSN: 2066-1363.
28. Pop A.I., el al, 2013. *Physico-chemical properties of some glacial lakes in the Romanian Carpathians.* Carpathian Journal of Earth and Environmental Science, Baia Mare, România. ISSN Printed: 1842 – 4090, ISSN Online: 1844 - 489X.
29. Preston, L., ed. 1997. *Investing in mountains: innovative mechanisms and promising examples for financing conservation and Sustainable development.* Franklin, USA, The Mountain Institute/FAO
30. Roşu A., 1980. *Geografia fizică a României*, Ed. Did. şi Pedag., Bucureşti.
31. Sârcu I., 1964, Cîteva precizări în legătură cu glaciația cuaternară din Carpații Orientali Româneşti, Natura, Seria Geologie-Geografie, 3, 24-31.
32. Török Z., (2010), *Analize calitative şi cantitative în managementul riscului în sectorul industrial chimic*, Teză de doctorat, Universitatea Babeş-Bolyai, Cluj-Napoca.
33. Urdea P., 2000. *Munții Retezat. Studiu geomorfologic*. Ed. Academiei Române, Bucureşti, 272.
34. Urdea P., 2008. *Raport Ştiințific al Proiectului CEEX 738/2006, ,,Impactul schimbărilor climatice asupra dinamicii holocene şi actuale a mediului alpin din Carpații Romaneşti.* Implicații în gestiunea riscului şi amenajarea peisajului (MEDALP)”.
35. Vespremeanu-Stroe A., Urdea P et al, 2008. *Date noi privind morfologia lacurilor glaciare*, Revista de geomorfologie, 10, 73-87.

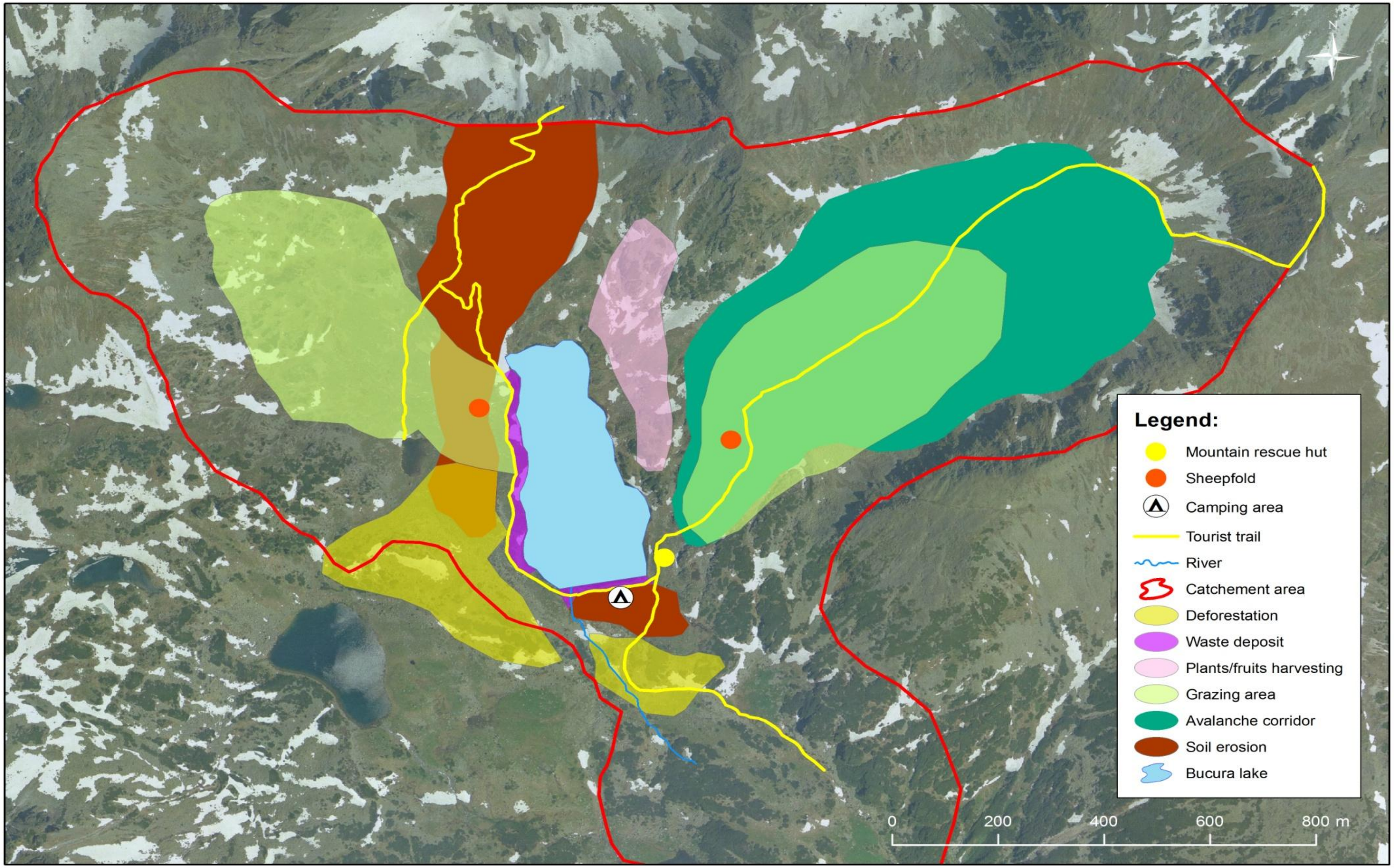
Annex 5.1. Identified environmental pressure in the Bâlea Lake perimeter

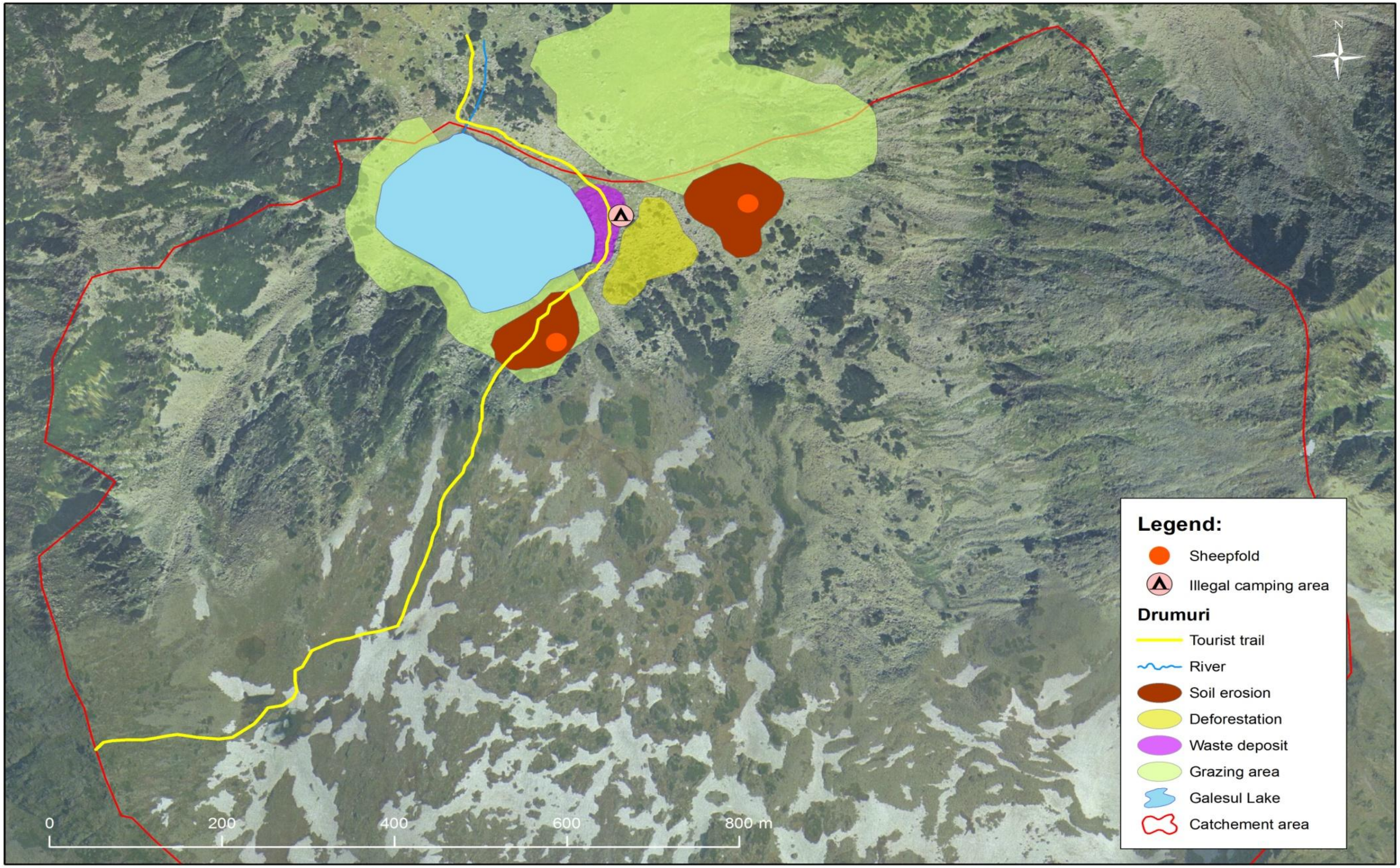




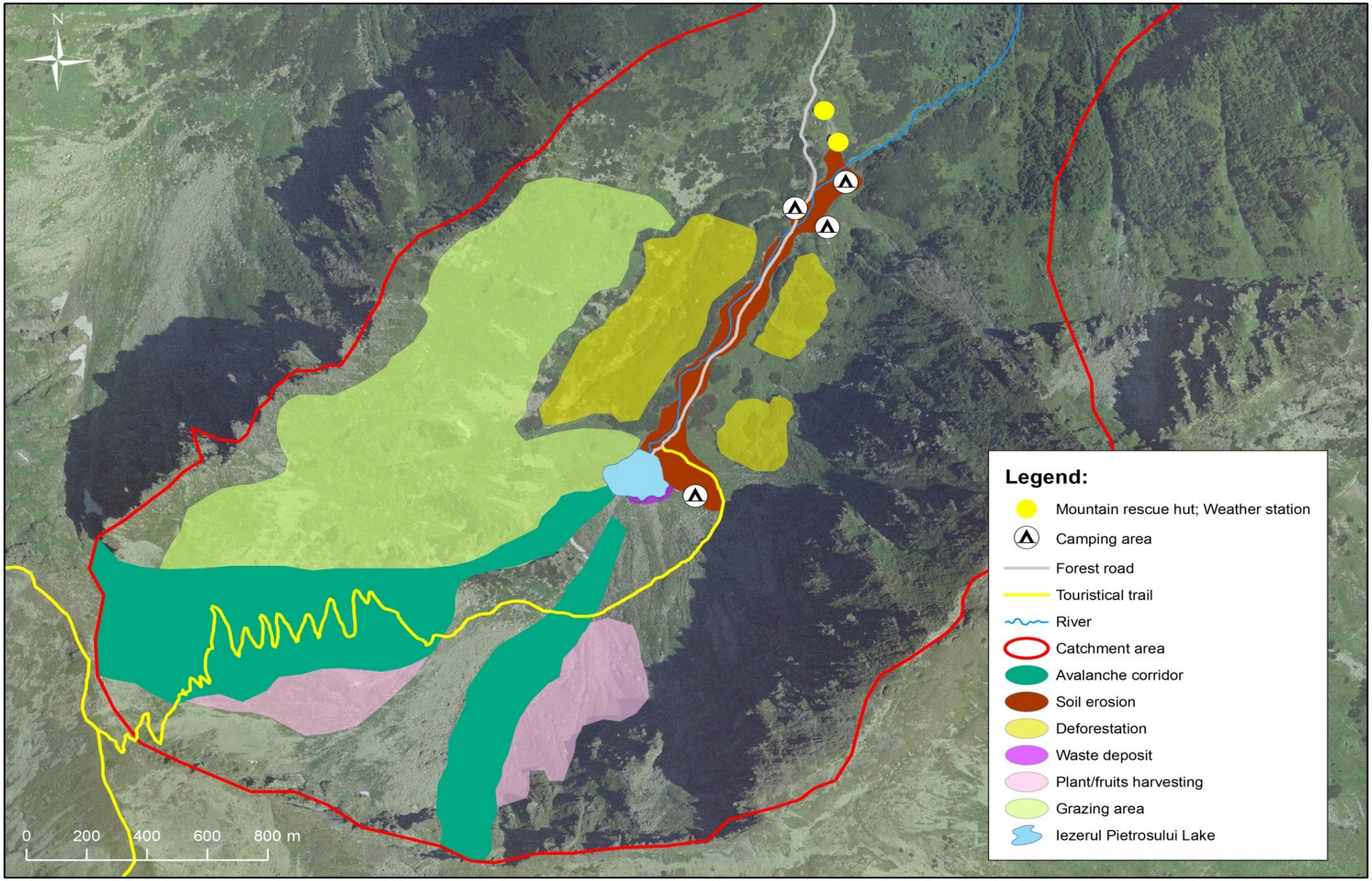
Annex 5.2. Identified environmental pressure in the Călțun Lake perimeter

Annex 5.3. Identified environmental pressure in the Bucura Lake perimeter

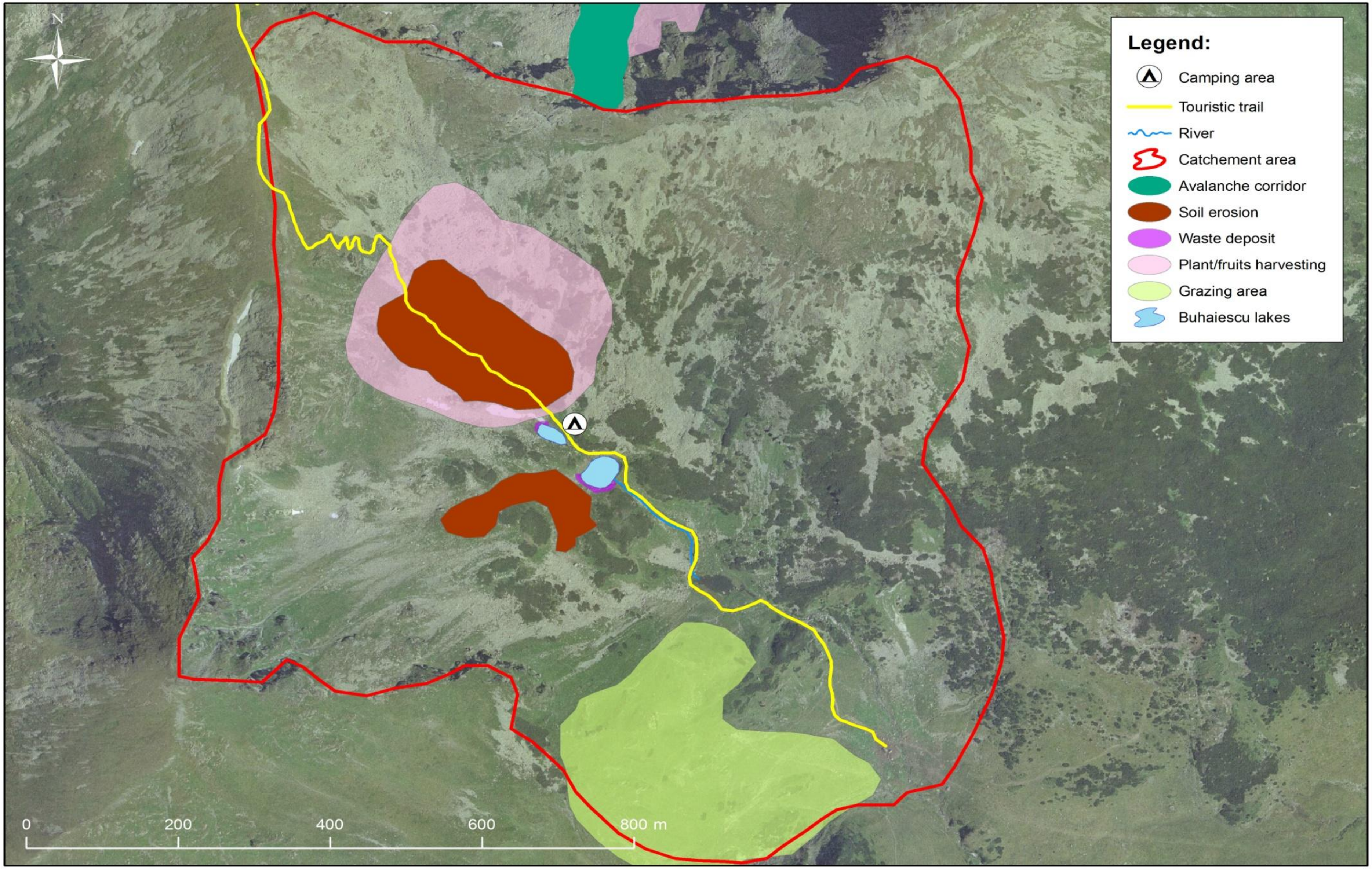




Annex 5.4. Identified environmental pressure in the Galeşul Lake perimeter



Annex 5.5. Identified environmental pressure in the Iezer Lake perimeter



Annex 5.6. Identified environmental pressure in the Buhăiescu II Lake perimeter