

## TOURISM AND NATURAL HAZARDS IN BÂLEA GLACIAL AREA VALLEY, FĂGĂRAȘ MASSIF, ROMANIAN CARPATHIANS

Mathieu GRATTON<sup>1</sup>, Stéphanie MORIN<sup>1</sup>, Daniel GERMAIN<sup>1\*</sup>, Mircea VOICULESCU<sup>2</sup> & Ana IANĂȘ<sup>2</sup>

<sup>1</sup>Université du Québec à Montréal (UQAM), Department of Geography, CP 8888, succursale Centre-ville, Montréal (Québec) Canada H3C 3P8

\*Corresponding author Daniel Germain [germain.daniel@uqam.ca](mailto:germain.daniel@uqam.ca)

<sup>2</sup>University of West Timișoara, Department of Geography, B<sup>dul</sup> Vasile Pârvan, 4, 300223-Timișoara, Romania

**Abstract:** This paper assesses the interrelationship between tourism and natural hazards, on geological and geomorphological hazards in Bâlea glacial area (glacial cirque and valley), located in the Făgăraș massif - Southern Carpathians (Romanian Carpathians). With the adhesion of Romania to the European Union (EU) in 2007, tourism development of the Romanian Carpathian will continue to accelerate, and Bâlea glacial area will be at the forefront. However, only few studies have been made to date concerning the impacts of tourism on the natural environment in the glacial cirque and valley. As such, the question of how the occurrence of natural hazards influences tourism activities, and vice versa, remains largely unanswered. In this respect, the description and mapping of the main hazards have been carried out, as has a description of the tourism development context since the 1880s. According to our findings, natural hazards restrict the potential for mass tourism, because an increase in tourism infrastructures would exceed the environmental carrying capacity and hazards would be expected to occur more often. Tourism activities are also limited by the lack of security measures with regards to the hazards, which further prevents optimal tourism development. Better location of the infrastructures, accounting for natural hazard “hot spots” is a necessary precaution for tourism development. In order to achieve this, the involvement of all actors and their multilateral cooperation should be the first steps toward the sustainable development of tourism in Romania.

**Keywords:** natural hazards, tourism, risk management, Bâlea glacial area, Făgăraș massif, Southern Carpathians, Romanian Carpathians

### 1. INTRODUCTION

In mountain areas occur a high number of natural hazards in the 20th century (Hewitt, 1997b). The concerns about natural hazards and their impact on mountain areas (Chardon, 1990; Gardner et al., 1992; Gardner & Saczuk, 2004; Mass & Ondrášik, 2004) and on tourism activities especially are of great interest (Nöthiger & Elsasser, 2004; De Scally, 1994). Thus, people and human communities of the mountains living with the different hazards such as earthquakes, snow avalanches, debris flow, landslides, rockfalls, erosion especially, but also with floods, fires, cold temperatures, storms or wild animals (Hewitt, 1992, 1997a).

In Romania the research on mountain hazards are singular and refer to environmental hazards

(Velcea, 1997), to geomorphological risk (Urdea, 2000; Voiculescu, 2002b), to snow avalanche impact on tourism activity and on Transfăgărașan highway and their management or to mountain environment (Voiculescu, 2009; Voiculescu & Popescu, 2011; Voiculescu & Ardelean, 2012). In Romania, ex-communist country, “*tourism will have an increasing role to play ... using the country’s considerable advantages - including its prime central European location and rich cultural and natural diversity - as a base*” (WTTC, 2006). However, after the fall of the communist regime in 1989, economic and political restructuring proved difficult and unstable until 1997, which has had an adverse effect on tourism activity (Light & Dumbrăveanu, 1999). Nevertheless, since the adhesion of Romania to the NATO in 2004 and to

the European Union in 2007, tourism has presented an important economic lever.

Tourism plays an important role in the Făgăraș massif and in the Bâlea glacial area, especially. The principal attraction is the high summits and slopes where skiing and hiking attract the majority of tourists. However, several active geomorphic processes persist in this glacial valley, such as snow avalanches, which represent a major threat to human life and infrastructure (Voiculescu, 2009; Voiculescu & Popescu, 2011). Therefore, both the impact of natural hazard on tourism activity as well natural hazard management represent very important challenges for this mountain area.

It is therefore of interest to understand how natural hazards, geologic (earthquakes) and mass movement hazards (snow avalanches, rockfalls, landslides, skin slide and superficial erosion) influence tourism activity in Bâlea glacial area. In order to do so, four objectives have been established: (i) to explore and evaluate the development touristic infrastructure and natural hazards; (ii) to describe the geodynamics of the Făgăraș massif; (iii) to highlight points of intersection of natural hazards and tourism; and (iv) to evaluate the natural hazard risk management.

## 2. STUDY AREA

The Făgăraș massif is located at the intersection of the 45°30' N parallel and the 24°30'

E meridian in the eastern part of the Southern Carpathians. The highest elevation of the Făgăraș massif is 2544 m asl and their total length is 80 km. The Bâlea glacial area is located in the central part of northern slope of the Făgăraș massif (Fig. 1).

Bâlea glacial area is characterised by metamorphic rocks such as micaschists, gneiss, amphibolites and pure marbles, but it is also possible to find basic veins throughout the entire massif (Voiculescu et al., 2011). From a geomorphological point of view, Bâlea glacial area still has a few vestiges of the last glaciation, such as a glacial cirque and a glacial lake, glacial valley and two topographical thresholds (verrous) (Germain & Voiculescu, 2007; Voiculescu et al., 2011). The U-shaped valley is dominated by sharp ridges (Voiculescu, 2002a). In the area, three bioclimatic zones are present: mountain (between 800 m and 1500-1600 m), subalpine (between 1500-1600 m and 2100-2200 m) and alpine zones (between 2100-2200 m and highest ridges). Bâlea glacial area is the main attraction of the Southern Carpathians largely because of relative ease of access via the Transfăgărașan highway. This highway (built between 1970-1974) and the cable car (between Bâlea Cascadă and Bâlea Lake) is essential to travel between the Transylvanian (north) and the Walachian (south) regions.

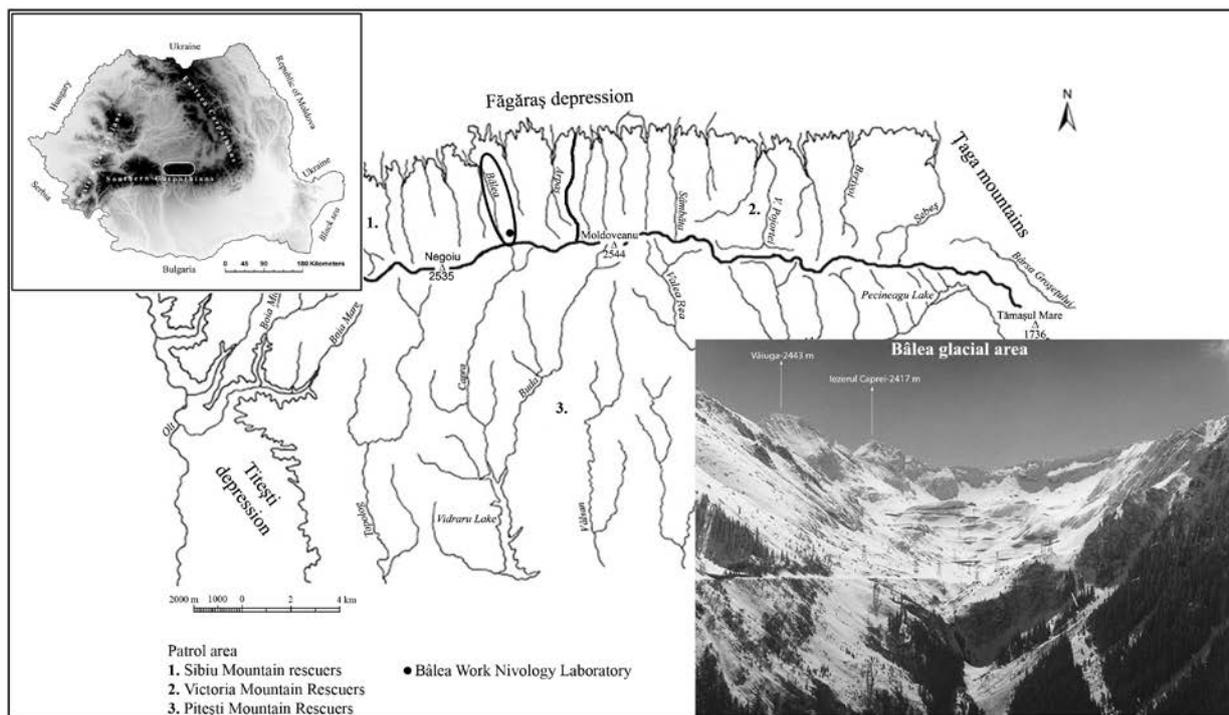


Figure 1. The location of Făgăraș massif and of Bâlea glacial area (Voiculescu et al., 2011)

### 3. METHODOLOGY

The description of the geodynamic context and the hazard assessment were undertaken for Bâlea glacial area. For the seismicity context, an historical research in the Făgăraș Mountains was carried out. Ab30 m-resolution digital elevation model (DEM) derived from SPOT satellite images were used to delineate the spatial extent of the Bâlea glacial area. According to Ciolli et al., (1998); Walsh et al., (1994), we have extracted from the DEM the elevation map and slope inclination map. We have also used GPS points collected in the field in order to realize an accurate assessment of the location some natural hazards (e.g. rockfalls, skin slides or superficial erosion). The mass movement hazards (snow avalanches, rockfalls, skin slides and superficial erosion), were georeferenced and described along the Transfăgărașan highway and along the touristic trail. Meteorological data has been analyzed from the three weather stations: Bâlea Lake (2070 m asl, 45°36' N; 24°37' E), Cozia (1577 m asl, 45°18' N; 24°20' E) and Cumpăna (830 m asl, 45°26' N; 24°37' E), between 1979 and 2011, 1981 and 1996 and 1983 and 1996 respectively. In order to obtain information on avalanche fatalities and injuries we have consulted several sources: until the founding in 1968 of the Sibiu Mountain Rescue Public Services (Sibiu MRPS), we use personal archives and websites. After foundation, we use both Sibiu MRPS and Programme of Nivometeorology within the National Administration of Meteorology (PN-NAM) database statistics (founded in 2003-2004 in partnership with Météo France, Centre d'Études de la Neige-Grenoble) and also the Sibiu Regional Weather Forecasting Service statistics (Sibiu RWFS). The general state of infrastructures was described using the following indicators: (i) year of construction; (ii) renovation; (iii) presence of damage; and (iv) functionality. It was then classified on a scale of one to five, where one is excellent and five is disused. In order to understand how the territorial branding of Bâlea glacial area development was put forward by the government and the regions, we sampled promotional items in several tourism centers in Timișoara, Sibiu and Bâlea glacial area. We also investigated governmental and tourism websites. This information allowed us to examine the external and internal extent of tourism promotion of the Bâlea glacial area. Several interviews were carried out with researchers of the West University of Timișoara, the employers of the weather centers in Sibiu and in the Bâlea glacial area, the members of the Sibiu MRPS, hotel managers and the tourism center employers at Sibiu. These were undertaken to enhance understanding of the complex dynamics of the

territory, including tourism and its promotion, historical disasters.

### 4. RESULTS

To understand a natural hazards and its consequences must be known two dimensions, human and natural or bio-geophysical (Wisner et al., 2004; Steinberg, 2000; Velcea, 1997). On the other hand, the risk management is based on risk analysis, risk assessment and risk management (Bell & Glade, 2004).

#### 4.1. Geologic hazards

The Carpathian Range appeared in the Mesozoic Era upon subduction of the Eurasian and African tectonic plates. This event leads to the birth of the active seismic zone of Vrancea near the Southern Carpathian Mountains (Ardeleanu et al., 2005). Between 1091 and 1979, this zone produced 95% of the seisms in Romania that are deeper than 60 km (Bala et al., 2003). Moreover, Bala et al. (2003) found that high intensity earthquakes were recorded in 1977 (7.5 Mw), 1986 (7.2 Mw) and 1990 (6.9 Mw). However, in the Făgăraș mountains, "the majority of seismic events had magnitudes between 3 and 4, with only a few over 5" (Bala et al., 2003, pp. 131). The centenary earthquakes should not be underestimated. In fact, "most of the earthquakes are of low energy, but once per century a large destructive event with epicentral intensity larger than height is expected in Făgăraș" (Moldovan et al., 2006). It thus seems that this region is prone to seismic hazards which should not be neglected.

#### 4.2. Mass movement hazards

This study found that many geomorphic processes co-occur within Bâlea glacial area: snow avalanches, rockfalls, skin slide and superficial erosion. Bâlea glacial has 8.85 km<sup>2</sup> (the alpine and subalpine zones covers 6.57 km<sup>2</sup> and the forest the rest of the 2.28 km<sup>2</sup>). Terrain factors and the climatic variables plays a major role in triggering and dynamics of snow avalanches (McClung, 2001; McClung & Shaerer, 2006; Schaerer, 1977). On the other hand these parameters can be used to evaluate the magnitude and frequency of the snow avalanches (Butler et al., 1992; McClung & Schaerer, 2006). The risk of snow avalanche accidents during winter season was analysed and related to terrain factors such as elevation level and slope inclination, whose values are presented in table 1. Elevation levels can affect snow avalanche risk (Grímsdóttir & McClung,

2006). Elevation ranges from 600-700 m in glacial valley to 2507 m (Vânătoarea lui Buteanu). The largest elevation levels are between 1600-1800 m with 2.01 km<sup>2</sup> and between 1800-2000 m with 1.71 km<sup>2</sup> (Fig. 2a). The high elevation is given for the starting zone of the snow avalanches. Optimal slopes for snow avalanches are between 25° and 50° (McClung & Schaerer, 2006). We calculated also the slope inclination of snow avalanches and of other mass movement hazards. The most favorable snow avalanche slopes covers (Fig. 2b) 4.54 km<sup>2</sup> while the slopes >35° covers 3.84 km<sup>2</sup>, which highlights the suitability relief for avalanches (Voiculescu et al., 2011). The most favorable slopes to other mass movements are between 20° and 35° with 3.40 km<sup>2</sup> and between 35° and 50° with 3.67 km<sup>2</sup> respectively (Fig. 2c).

The climate of Făgăraș massif is temperate continental. Bâlea glacial area is under cold air masses influences from the Baltic Sea and the Arctic Ocean. The mean annual air temperature is 0.2°C and the mean annual precipitation is between 1,200-1,300 mm (at 2050 m). 90-100 days with snowfalls and 8-9 month/year with a snow layer are characteristics. Snow is an important climatic variable in high mountain regions and is caused by temperature and precipitations (Beniston et al., 2003; Bednorz, 2013; Lopez-Moreno & Goyette, 2011). On the other hand the snow is an important

touristical resource for the Romanian Carpathians (Micu, 2009) and can generate natural hazards (i.e. snow avalanches) (Beniston et al., 2003; Elsasser & Messerli, 2001). Snow depth is cause by climatic influences, snowfall frequency, and the elevation of the 0°C isotherm, slope aspect and topographic features. Therefore, snow cover (defined as days with snow depth ≥ 1 cm) consistent with great spatial variability. At the highest elevations of alpine zone, snow depth constantly grows from October until April or even May when it climaxes; after which it decreases until July. The best Pearson correlation was given by snow depth and elevation, as well (R<sup>2</sup>=0.992) and by elevation and number of days with snowfalls: R<sup>2</sup>=0.831 (Fig. 3a and Fig. 3b). The value of 30 cm of fresh snow is the threshold beyond which avalanches are dangerous (Schweizer et al., 2003; Schweizer, 2008). The new snow depth is not sufficient to explain snow avalanche activity and other factors (wind, radiation, temperature, snow stratigraphy) should be considered (Schweizer et al., 2003). In fact, snowfalls, strong winds, high temperatures or interactions of warm and cold phases, are responsible for poor snowpack stability. On the other hand, the number of days with snow cover and number of days with snowfalls (Fig. 3c) are well correlated (R<sup>2</sup>=0.896), long winters are associated with a large snow depth, which implies a large avalanche activity.

Table 1. Hypsometry values in the Bâlea glacial area

Hypsometry (m)	<1000	1000-1200	1200-1400	1400-1600	1600-1800	1800-2000	2000-2200	2200-2400	>2400
Surface (km <sup>2</sup> )	0.04	0.48	1.09	1.21	2.01	1.71	1.54	0.75	0.02

Slope inclination values in the Bâlea glacial area

Slope inclination	Snow avalanche				Other mass movement hazards (skin slide, superficial erosion, rockfall)				
	<10°	10°-25°	25°-35°	>35°	<10°	10-20°	20-35°	35-50°	>50°
Surface (km <sup>2</sup> )	0.47	2.01	2.53	3.84	0.47	1.18	3.40	3.67	0.13

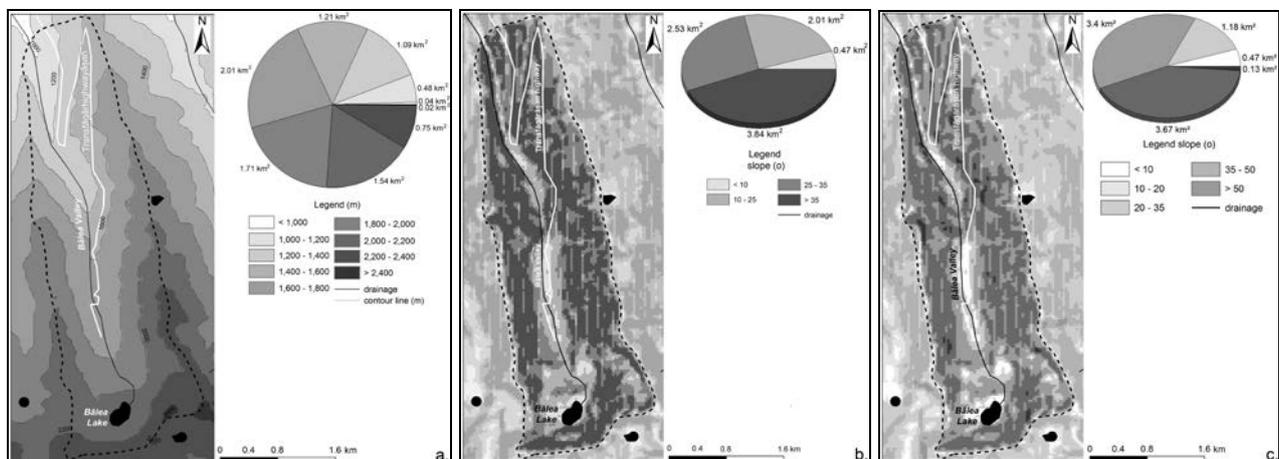


Figure 2. Elevation map (a.), slope inclination: of snow avalanches (b.) and of other natural geomorphic hazards (c.)

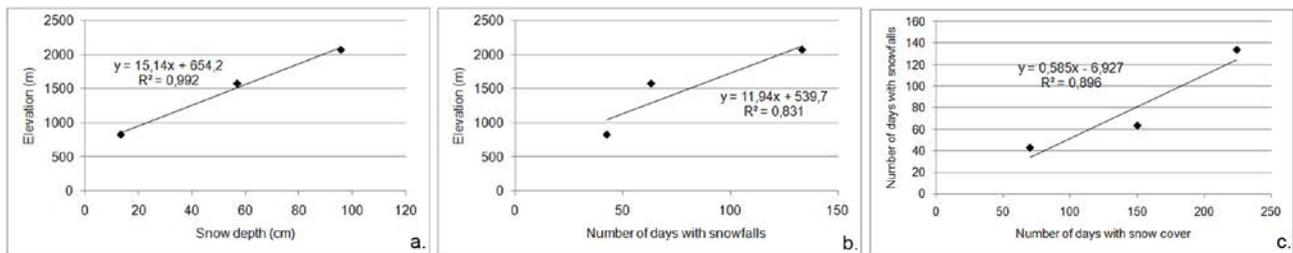


Figure 3. Correlation between elevation and snow depth (a.), elevation and between number of days with snowfalls (b.) and between number of days with snowfalls and number of days with snow cover (c.)

Table 2. Patterns of mass movement (according to Varnes, 1978 and our observations )

Mass movements	Type	Material	Water content	Rate
rockfall	fall	rock (fractured rock)	dry	extremely rapid
skin slide	slide	fine/coarse mixture, debris, sometimes with ice and snow	wet or very wet	from moderate to rapid
superficial erosion	slide	soil or debris mixture	wet or very wet	from moderate to rapid
avalanche	slide /flow	snow/ice or debris, vegetal material and earth mixture		

The geological structure (predominant flysch), seismic activity, climatic conditions, the action of surface water, vegetation composition and human impact by pastoral activities, the building of Transfăgărășan highway and traffic vibrations are causes of mass movements. According to Šilhán (2012) the main climatic factors that trigger mass movement are short-term extreme total precipitations (108.7 mm in May and 104.5 mm in June, respectively) and fast melting of snow in spring (between April or May and June in our case) due to maximum snow depth in April (130.1 cm) and May (93.5 cm) (Voiculescu et al., 2011) and to positive temperatures in May (3.8°C) and 6.7°C in June respectively.

In table 2, we have summarized the most important patterns of mass movement observed, described and inventoried in the field, including type, material, water content and rate. Snow avalanches are one of the most important natural hazards in Făgăraș massif and also in Bâlea glacial area (Fig. 4) that cause damages on economic activity and loss of human life. More than 50 snow avalanche paths were recorded in the our area, of which the majority followed the deep faults of hillslopes, 18 in the forest zone and 29 in the subalpine and alpine levels. Of these, 29 snow avalanche tracks are most active, located on the eastern and western slopes of Bâlea glacial valley and glacial cirque (Voiculescu et al., 2011). In this context, in the glacial cirque, avalanches did not follow any preferential direction, and debris deposits were left everywhere. As a result of high-magnitude events, such as one in 1977 which caused the deaths of 23 people, or one in 1997 which destroyed the Paltinu Hotel (Scheaua & Duc, 2007), the whole

area should be considered at high avalanche risk. The frequency of this hazard appears to be high, because the slopes of the glacial cirque are almost completely free of vegetation. The presence of *Alnus viridis* also suggests the high frequency of avalanches in the area. This type of shrub is characteristic of snow avalanche paths. Its flexible branches and deep roots help it to survive the extreme conditions caused by snow avalanches (Wiedmer & Senn-Irlet, 2006). Dendrochronological analysis should be undertaken at lower elevations, however, so as to better understand the frequency-magnitude relationships of the snow avalanches. With regards to the rockfalls, 53 points (38 in the forest zone and 15 in the subalpine and alpine zones) were georeferenced along the Transfăgărășan highway (Fig. 5).

The schist lithology, combined with the numerous diachlases present, favors weathering and generated important production of debris (Urdea, 1998). The spatial distribution of scree slopes in the valley displayed a progressive increase in density with increase in elevation. Deposits in the mountain zone were colonized by vegetation, whereas those in the alpine and subalpine levels were unstable and without vegetation. Other geomorphic processes were noted along the Transfăgărășan highway (see Fig. 3), such as superficial erosion (14 in the forest zone and 3 in the subalpine and alpine zones) and two skin slides in the forest zone. These observations accord with previous work (Török-Oance et al., 2006). This section provides the historical background of tourism development in Bâlea glacial area from 1880 to 2010, as well as future prospects. Table 3 provides additional detail of the stages which are summarized in the following

text. Tourism development began slowly, supported by governmental policy until the end of the communism totalitarian regime, at which time it ceased (Bălăceanu & Cristea, 1984; Baticu & Țițeica, 1984; Berbecaru & Botez, 1977; Borda, 1979; Florea, 1998; Popescu, 2010b). However, this resulted in the construction of the Transfăgărășan highway to serve the practical needs of communism periode, which in turn played a major role in the further development of tourism in the valley.

### 4.3. Tourism development

This highway also became a symbol of unification of the north and the south of Romania (Voiculescu, 2009). Prior to 2007, international tourism in Romania represented about 8000 visitors and 1464 M€/year (Fonai & Silaghi, 2009). Only

5% of the Gross domestic product (GDP) came from tourism, which represents 485000 jobs. Moreover, the absence of sustainable government policy to guide tourism evolution was an obstacle to its development. In 2007, Romania was added as a member of the European Union (EU), which helped its economic and tourism growth. The EU invested in the Romanian economy on three levels: 150 M€ for marketing activities of tourism-related businesses, 570 M€ for regional sustainable development and 2.2 B€ to improve the quality of life of rural populations (Fonai & Silaghi, 2009). It was then possible to restore old tourism infrastructure and to add to these in order to meet growing demand. These investments generated an increase of 27% in foreign tourism to Romania in 2008 (Fonai & Silaghi, 2009).



Figure 4. Spontaneous avalanche started in May 20, 2011 in Bâlea glacial cirque (by Voiculescu, 2011)

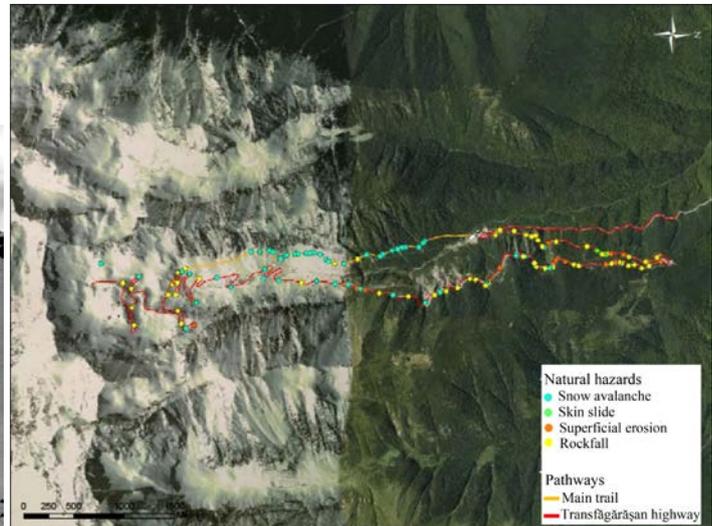


Figure 5. Natural hazards in the Bâlea glacial area

Table 3. Evolution of Bâlea glacial area tourist management (Bălăceanu & Cristea, 1984; Baticu & Țițeica, 1984; Berbecaru & Botez, 1977; Borda, 1979; Florea, 1998; Popescu, 2010b)

Period	Tourist management of Bâlea glacial area
1880-1914	Siebenbürgischer Karpatenverein (SKV): construction of the first chalet, Podragu, and creation of the first hiking trails in the valley. Construction of a small stone shelter for the shepherds (1907) and reconstruction of the shelter in wood (1912).
1930-1940	<b>National club of Romanian Tourism:</b> restoration of old lodging infrastructures and construction of new chalets and alpine shelters.
1950-1970	<b>National Organization of Tourism:</b> modernization of lodging infrastructures.
1970-1985	<b>Communism regime:</b> construction of the Transfăgărășan highway (1970-1974), hunting chalet (now called Cabana Paltinu hotel) (1970) and of the cable car (1973). <b>Sibiu department:</b> Bâlea glacial area <i>ski resort</i> project, which was not functional (1972).
1990-2000	<b>Transport, Construction and Tourism Ministry (1999):</b> Implementation of seven laws aiming at managing the cost of tourist infrastructures according to their quality. <b>Private owner:</b> construction of Bâlea Lake hotel (hotel/restaurant) (2000).
2006-2010	<b>Private owner:</b> launch of the event of the Ice hotel and Church in the glacial cirque (2006). Construction of Bâlea Lake hotel (second hotel) (2007). <b>Regional Development and Tourism Ministry:</b> creation of this new Ministry (2008). Creation of <i>Inferno</i> ski and snowboard competition (2010). Launch of <i>Explore the Carpathian Garden</i> (2010).

Adventure and sports tourism have grown in popularity over the last decade, which has facilitated the introduction of this type of tourism to the valley. In fact, the privileged access to alpine sites from the Transfăgărășan highway, the infrastructure already in place and growing popularity has led to the fast development of holiday tourism. Fonai & Silaghi (2009) claimed that the next step to continue this expansion was government policy. The Romanian Carpathians and its protected areas, including Bâlea glacial area are promoted in several documents (Geacu et al., 2012; Kozak et al., 2011; Weiß & Streifeneder, 2011). Mountain tourism (rock climbing, backcountry skiing, off-piste skiing, hiking) is particularly promoted through the beautiful landscapes that can be admired from the road, hiking trails or the cable-car. Various activities are offered throughout the year, targeting a wide range of tourism. This territorial marketing project seeks create a territorial identity. Curiously, although the government promotes Bâlea glacial area, the income produced goes to private owners of the infrastructures (Table 4). Other media were also found at the regional scale. In Sibiu, promotional leaflets of the Bâlea Lake hotel, leaflets of hiking trails and tourist guides were collected. On the website of the city there is a digital tourist guide in seven languages, where the waterfall and the glacial lake are rapidly presented. They promote only backcountry skiing. No other

English language websites were found promoting the valley. Several temporary stalls offered road and hiking maps of the valley. These had titles in three different languages; however the inside content was only in Romanian. Some posters were found promoting the ice hotel and Bâlea Lake hotel. All of these media had a weak external spatial diffusion since they are only available in the Transylvanian region. A trend toward improvement is perceptible in terms of quality and profitability, as shown by the presence of new activities and events in the valley, such as the Inferno ski competition. Only 20% of all tourists to Romania tourists go to the Southern Carpathians, which occupy a third of the country (Popescu, 2010a). Since tourism development is directly influenced by national and international activities, it should be the responsibility of the Romanian government to manage the rapid tourism expansion (Nistor et al., 2010).

#### 4.4. State of infrastructures

The state of all infrastructures (touristic, highway and hazard protection) is also an important element to consider. Their evaluation (Table 5) revealed that tourist infrastructures were minimally restored and that they were below European standards.

Table 4. State of Bâlea glacial area infrastructures in May 2011  
(Key of the state of the infrastructures: 1. Excellent 2. Good 3. Functional 4. Damage 5. Abandoned)

	Infrastructures	Year of construction	Restoration, maintenance and commentary	State
Tourist infrastructures	Cable-car	1973	2004 : cable replacement	3
	Bâlea Hotel	1990	2010 : restoration of rooms, dining room and hall	2
	Paltinu Hotel	1970	1995 : restoration of some rooms	1
	Bâlea Lake 1 hotel	1907	1907 : shepherd's stone shelter constructed 1912 : shepherd's wood shelter constructed 2000 : hotel and restaurant constructed	1
	Bâlea Lake 2 hotel	2009	None	1
Protection infrastructures	Snow shed tunnels	1975	None, some are heavily damaged or partially destroyed, evidence of water infiltration	3
	Râteliers avalanche protection structures	1975	None	4
	Snow shed walls	1975	None, chemical erosion and water infiltration	2
	Wall of tires	n.a.	None	5
Highway	Transfăgărășan	1960-1974	Regular maintenance a lot of rockfall and snow avalanche deposits on it	1
Security	Salvamont emergency team building	2008-2009	New	1
	Old Salvamont building	1968	None, antique, but nice in the landscape	2
	Meteorological station	1980	None	1
Other	Electric and cable-car poles	1973-1986	N.A., always located in the deposit zone of snow avalanche corridors	2
	Old construction workers' house	1960-1974	None	5
	Signs	-	Signs which forbid skiing or camping are written in Romanian, and almost illegible paths and touristic marks	4 3

#### 4.5. Risk management

Protection infrastructures, such as snow sheds and others avalanche protection infrastructures, were set up when the Transfăgărășan highway was built in the 1970s.

The Transfăgărășan highway is affected by avalanches both in its alpine and forest zones. For the safety of cars and tourists, the Transfăgărășan highway is temporary closed between October 1 and July 1, as determined by the Roads National Authority (Voiculescu, 2009). In order to protect the Transfăgărășan highway and to highlight the risk management in sectors which are the most vulnerable to snow avalanche, some measures have been applied (Voiculescu, 2009). They are based on two strategies: duration of protection - preventive temporary or permanent measures (snow pack

support structures, drainage system to reduce roughness surface of avalanche moving, closing of Transfăgărășan highway) and passive and active defense points of intervention (snow sheds, wall support, deflecting dike, splitter to protect electricity poles) (Fig. 6). These structures are usually adapted to a limited quantity of snow, but this is not the case in the valley. There is almost no protection against rockfalls, with the exception of some metallic nets for small boulders. According to our observations, these protection infrastructures were poorly maintained or restored. This negligence is a sign of the probable disregard of the decision-makers with regards to natural hazards. This may be due to lack of funds or of scientific skill. Since the 2004-2005 season, according to European scale, PN-NAM issued danger levels (Fig. 6).

Table 5. Impact of geologic and mass movement hazards on the touristic infrastructure

	Geologic hazards (earthquake)	Geomorphic hazards			
		snow avalanches	landslides	rock falls	erosion processes
Bâlea hotel	+ (possible)	-	-	-	-
Paltinu hotel	+ (possible)	+ (1997 event)*	-	-	-
Bâlea Lake 1 hotel	+ (possible)	+ (possible)	-	+ (possible)	-
Bâlea Lake 2 hotel	+ (possible)	-	-	-	-
New Salvamont building	+ (possible)	-	-	-	-
Old Salvamont building	+ (possible)	+ (1996 event)*	-	+ (possible)	-
Weather station	+ (possible)	-	-	-	-
Paths and tourist marks	-	+	-	+	+
Transfăgărășan highway	+ (possible)	+	+	+	+
Cable-car	-	-	-	-	-
Electric and cable-car poles	-	-	-	-	-

\* according to Sibiu MRPS

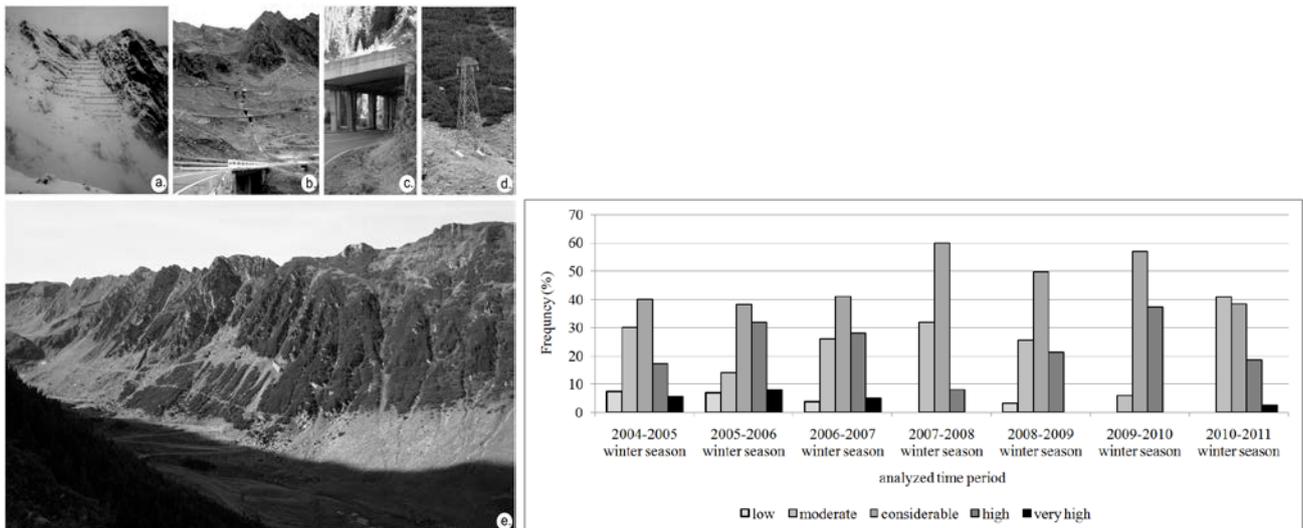


Figure 6. Structures of avalanche hazard management (on the left): (a) snowpack support structures, (b) drainage système, (c) snow sheds, (d) splitter to protect electricity poles and (e) deflecting dike and the frequency of danger levels (on the right) (according to National Administration of Meteorology, 2004-2005, 2005-206, 2006-2007, 2007-2008, 2008-2009, 2009-2010, 2010-2011)

In Făgăraș massif at over 2000 m elevation the highest rate recorded in March, sometimes in April but even in May, when the snow depth is the greatest. Unfortunately, the implementation of standardized pennons according to French system, especially within Balea ski field (where the ski pistes number and type or off pistes would be stated) and to implement warning panels, according to European or North-American Systems, are not still current (Voiculescu, 2009). In this context is necessary the location (according to the North American system and European) of display panels which read, for example, “No Stopping” or “Avalanche Area” along the roads or in the ski areas where snow avalanche hazard is imminent. On the other hand, the management of crisis situations (present emergencies and future misfortunes) needs to be prepared and also the blue-prints of the territory need to be revised, by making snow avalanche zoning maps and other thematic maps of exposure to natural risk phenomena. And last but not least, Romania needs to achieve international standards through the provision of a good education regarding the understanding and management of natural hazards or risk phenomena (Voiculescu, 2009).

## **5. DISCUSSIONS**

### **5.1. Impact of tourism on the natural environment**

#### **5.1.1. Infrastructure presence**

The transformation of the natural environment is often accompanied by some underestimated impacts which should be considered. According to the results, rockfalls are found to have occurred mainly along the Transfăgărașan highway, more precisely on the eastern hillslopes in the mountain zone and at the second topographical threshold. Furthermore, this highway seems to create superficial erosion. This process takes place in the same area as the rockfalls. Despite the lower associated risk in comparison with the rockfalls, it should not be neglected. Over the long-term, this process can evolve and become a rockfall by exposing the bedrock, such as has been reported by Urdea et al., (2009), who claim that the Transfăgărașan highway is one of the most destabilized infrastructures in the valley. It cuts the eastern hill slope at 90° and exposes the bedrock, expediting gravitational processes.

#### **5.1.2. Tourism activities**

The impacts of tourism have been found to be

significant. First, hikers destroy the vegetation by stepping on it. A few, unmarked trails have been created by hikers off the main one. This can “initiate and intensify the gullying and erosion processes” (Urdea et al., 2009, pp. 26), which can indeed be observed around the road. Furthermore, unofficial parking’s lots were found in the three bioclimatic zones, where vegetation growth cannot be expected to recover. Several illegal camping sites have also been observed, with campfire remnants and waste all around, although this activity is forbidden. As previously mentioned, mountaineering, backcountry and off-piste skiing are very popular in the glacial cirque and valley. However, these activities are considered to be avalanche starters (McClung & Schaerer, 2006). Therefore, the infrastructure presence and the tourism activities have major impacts on the natural environment and hazards, at varying levels of importance.

### **5.2. Consequences of natural hazards on tourism development**

Natural hazard impacts were divided into three categories: the number of accidents, infrastructure damage and valley perception. In table 5 is summarized the impact of geologic and mass movement hazards on the tourist infrastructure.

#### **5.2.1. Number of accidents**

Several tragic events have been reported since tourism development began in the glacial area. The worst one occurred in 1977, resulting in the deaths of 23 skiers (Voiculescu, 2002b, 2009). According to Sibiu MRPS, to Bâlea WNL and to Sibiu RWFS database statistics, from 1974 to 2011, the average annual fatalities were 1.07/year (0.51/year for the Făgăraș, massif and 0.56/year for the Bâlea glacial area), and for injuries 0.70/year (0.11/year for the Făgăraș, massif and 0.59/year for the Bâlea glacial area) (Voiculescu, 2014). In the Bâlea glacial area 40 fatalities and 42 injuries were recorded (Fig. 7).

The vast majority of fatalities (67.5%) and 7.1% injuries was recorded in the Bâlea glacial cirque while the rest, 32.5% fatalities and 92.9% injuries in the Bâlea glacial valley. According to Voiculescu (2014) the large majority of fatalities and injuries is represented by backcountry skiers, off-piste skiers and climbers (100% in the Făgăraș massif and 95% in the Bâlea glacial area). These values are similar to those recorded in the European Alps or in North America ((Schweizer & Jamieson 2001; Schweizer & Lütschg, 2001; Zweifel et al., 2012).

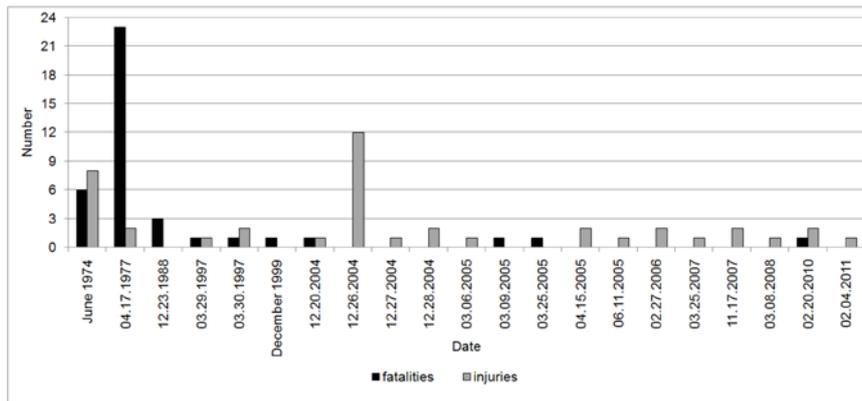


Figure 7. Fatalities and injuries situation in the Bâlea glacial area

The backcountry skiers and off-piste skiers are especially at risk because the main hiking trail crosses several snow avalanche paths. Even if there are many avalanche paths on the west side, fewer accidents occur on it because of the closure of the Transfăgărășan highway between November and June or July each year and also due to the presence of snow sheds.

### 5.2.2. Infrastructures

In the valley, many infrastructures are at risk (Fig. 8). The electrical and cable car towers are located in the avalanche run-out zone. Should an extreme snow avalanche happen in the glacial cirque, where three hotels, the weather station and the Sibiu MRSP buildings are located, these would be at the forefront and subsequently isolated. The 1997 event already demonstrated the vulnerability of the hotels. Rockfalls damage the Transfăgărășan highway every year by destroying the guardrails, creating large holes and even destroying the artificial drainage network.

### 5.3. Valley perception

Over the long-term, accidents resulting from

natural hazards could deteriorate potential tourists' perception of Bâlea glacial area. This risk perception varies among stakeholders. Indeed, several specialists are convinced that natural hazards occur throughout the valley and should be taken seriously by increasing the number of studies. However, some key actors are not involved in the decision making process (Scheaua & Duc, 2007). Until 2007, the Ministry of environment did not show any interest about avalanche risk management. Therefore, the misunderstanding of the natural environment of the valley and the lack of investment into protection infrastructures increases the vulnerability of the valley. Furthermore, security measures are not up to date. In fact, the MRPS consists of only three teams for the entire 80 km wide Făgăraș massif. According to these rangers, they have to walk all the way to the accident zone with limited and old equipment. In summary, the number of accidents, the inappropriate infrastructure location (Fig. 9) and the potential negative perception of the Bâlea glacial area could hinder future projects if concrete actions and policy are not combined so as to improve the situation.

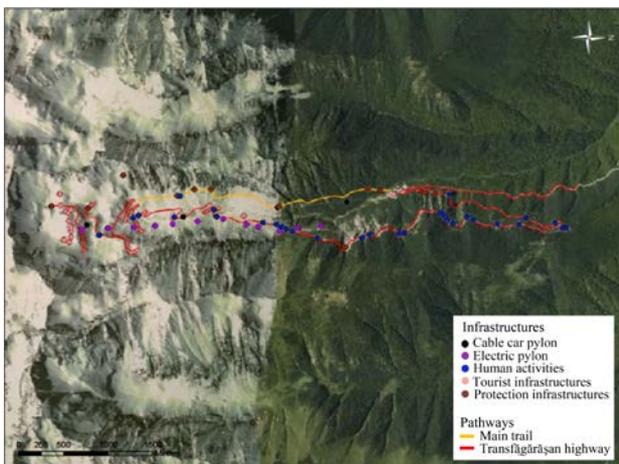


Figure 8. Current transport infrastructure

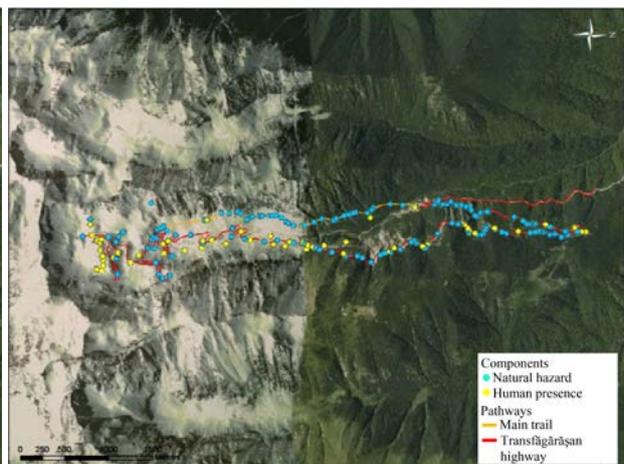


Figure 9. Relationship between natural hazards and current transport infrastructures

## 6. SUMMARY AND CONCLUSIONS

According to our findings, Bâlea glacial area is prone to a fragile geodynamic context, where tourism occupies a growing place. It has been demonstrated throughout this study that tourism development and natural risks are strongly interrelated. Natural hazards restrict the potential for mass tourism, because an increase in tourism infrastructures would exceed the environmental carrying capacity and natural hazards would be expected to occur more often.

Moreover, tourism activities are also limited by the lack of security measures with regards to the natural hazards, which further prevents optimal tourism development. Studies regarding the development of tourism in natural areas seek alternative, sustainable and responsible solutions to combine these two elements. Better location of the infrastructures, accounting for natural hazard “hot spots” is a necessary precaution in view of possible tourism development, as is regular inspection of the protection infrastructures intended to provide security. In order to achieve this, the involvement of all actors and their multilateral cooperation could be the first steps toward the sustainable development of tourism in Romania. Moreover, additional studies on natural hazards in the valley could help provide new mountain risk management strategies including novel prevention measures. For example, in several alpine regions, the use of artificial avalanche triggering is required (McClung & Schaerer, 2006; Stoffel & Schweizer, 2008). Furthermore, collaboration with experts from various alpine regions could help to improve risk management in the Bâlea valley. For example, seven Alpine countries: France, Switzerland, Italia, Germany, Austria, Liechtenstein and Slovenia tries to develop protective measures against natural hazards (Veulliet et al., 2009). This group aims to implement global measures to identify good practices toward reducing natural hazards and toward creating a risk-integrated management program. Such measures should be considered so as to prevent the environmental deterioration as well as the degradation of the image of Bâlea glacial area internationally, and in so doing encourage the sustainable growth of tourism in Romania.

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