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Changing human-environment interactions in medium mountains: the Apuseni Mts (Romania) as a case study

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Abstract: The study of human-environment relationships in mountain areas is important for both theoretical and practical reasons, as many mountain areas suffer similar problems, such as depopulation, unemployment and natural hazards. Medium mountains constitute a special case within mountains, because they are more populated but less attractive as tourist destinations than high mountains. In this context, the Apuseni Mts (Romania) are considered as a case study. In this paper, we apply GIS-based, quantitative methods to characterize the strength and dynamics of human-environment interactions, taking into consideration some environmental factors (elevation, relative height, slope, river distance, lithology, land cover, natural attractions) as well as historical population and recent tourism data. We found that population density has strong (r^2>0.8) relationships with all relief factors (elevation, relative height, slope, river distance), and that best-fit functions are nonlinear. We outlined the varying demographic scenarios by elevation zones and interpreted the historically switching sign of population change versus elevation relationship. We demonstrated that lithology also has an impact on the spatial distribution of population, although it is not independent from the relief effect. The land cover of the mainly cultural landscape is very strongly correlated with relief parameters (especially slope), which suggests good adaptation. We pointed out the dominance of karst objects in the natural tourism potential of the Apuseni Mts and also explored further components of real tourism (spas, heritage, towns). Finally, we concluded that the environmental settings investigated do in fact constrain the spatial framework of society, but socio-economic changes in history can be explained from the side of society, which conforms to the theory of cultural possibilism.

Keywords: Human-environment relations; Apuseni Mountains; Geographical information system (GIS); Possibilism; Tourism; Karst

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Introduction

People living in mountain areas face challenges every day. Relief, harsh climate and natural hazards constrain the land that is suitable for settling and cultivation, but there are also possibilities in the form of mineral resources, better hydrological conditions and, in present days, tourism. The habitability of mountain areas depends on the specific climatic zone, the elevation and ruggedness of the mountain and the biogeographical domain. However, all of these settings only partly determine human establishment, because this is also influenced by changing human-environment interactions. Human-environment relationships have always been at the centre of geographical thinking. At the beginning of the 20th century, geographical determinism was the mainstream theory due to the works of Ratzel and Huntington, but this was later replaced by the cultural possibilism of Sauer and other theories with varying approaches to human-environment relationships (cf. Judkins et al. 2008; Brondízio and Moran 2013; Kőszegi et al. 2015). Nowadays, neo-determinism has once again gained in popularity (Diamond 1997), but its acceptance is strongly critiqued (Sluyter 2003; Judkins et al. 2008). The GIS-based, quantitative study of these relationships is a modern approach (Cohen and Small 1998; Meybeck et al. 2001; Song et al. 2007; Patterson and Doyle 2011), and as Small and Cohen (2004) stated, a "*necessary first step to understand the spatial distribution of the population is to quantify its relationship with other factors that may influence it*". Thus, we have also taken this approach and used a GIS-based statistical analysis of human-environment interactions in our earlier works (Telbisz et al. 2014, 2015) and in the present paper as well. By doing so, we are able to numerically express the strength of the relationships and the temporal changes as well.

Nevertheless, the study of human-environment relationships is important not only for theoretical reasons, but also from a management point of view, since there are typical problems concerning mountain areas (e.g. depopulation, unemployment, natural hazards; as mentioned by Pejnovic and Husanović-Pejnović 2008, Milošević et al. 2010, 2011, Telbisz et al. 2015, Constantin et al. 2015, and many others). The first step towards developing good management is to explore the problems. After recognizing the problems, several countries have moved to give mountain areas a special status in law, budget and development plans (Castelain et al. 2006; Pantic 2015).

At this juncture, we would emphasize that medium mountains constitute a special case within mountain areas. Although English literature rarely discusses medium mountains separately (Price 1986), they extend over large areas of Europe and are frequently mentioned in German ("*Mittelgebirge*"), French ("*moyennes montagnes*") and other European geographical studies. Medium mountains are sometimes defined by their elevation, but the essence is that their upper level does not reach the treeline and that they were not glaciated during the Quaternary. These facts determine much of their geomorphological, hydrological and biogeographical properties. Thus, medium mountains provide relatively better conditions for human settlement, but are usually less attractive from the viewpoint of modern tourism.

The Apuseni Mts (Romania, part of the Carpathians), with an area of 16,730 km², have diverse relief and geological conditions which provide a good opportunity to study the variability of human-environment relationships. This is why the Apuseni Mts were the subject of several recent geographical papers studying the relationship of people and their environment at both the local and regional scale (e.g. Abrudan and Turnock 1999; Surd and Turnock 2000; Buza et al. 2001; Boţan 2010; Tătar 2013). Cocean (2001) pointed out the importance of karst terrains in the environmental system of the Apuseni Mts. Demographic changes of the area were studied by Drăgan (2010).

In this paper, we examine the dynamics of the relationships between some selected environmental factors (relief and its derived parameters; land cover; natural attractions) and population, taking into consideration population data since the end of the 19th century and tourism data from the 21st century.

1 Data and Method

Delineation of the study area was carried out basically according to the natural boundaries of the Apuseni Mts, but the precise borders were adjusted to the administrative units (communes). In order to perform the quantitative analysis, we created an integrated GIS database using the following data:

- Relief (the NASA SRTM digital terrain model (DTM); for further details, see Rabus et al. 2003; Figure 1). Its horizontal resolution is approximately 90 m, which is suitable for the scale of this study. Slope values were derived from the DTM using standard GIS methods. Here we would note that the slope values calculated from 90 m resolution pixels are slightly less than the real values (Kienzle 2004). Relative elevation ("*height*" in the followings) was calculated as the difference between the actual elevation of a given pixel and the elevation of the lowermost point in the 5 km neighbourhood of that pixel.

- Geology (based on the 1:200,000 scale geological maps of Romania; Figure 2). After digitizing these maps, we categorized the lithological units by age and main rock type into Quaternary (Q) sediments, Tertiary (T) sediments, Mesozoic (M) sediments, Paleozoic (P) sediments, Plutonic, Volcanic, and Metamorphic rocks. Furthermore, we separated terrains with karstic, partly karstic and nonkarstic rocks taking into consideration the hydrogeological description of the Apuseni Mts (Orăşeanu and Iurkiewicz 2010).
- Drainage network: rivers and streams were digitized from topographic maps and locally significant rivers were selected. We consider a river significant if it has a relatively large valley with higher level roads and occasionally railways. Thereafter, using GIS methods we determined for each pixel the Euclidean distance to the closest selected river (this value is called "*river distance*" in the following; Figure 3).

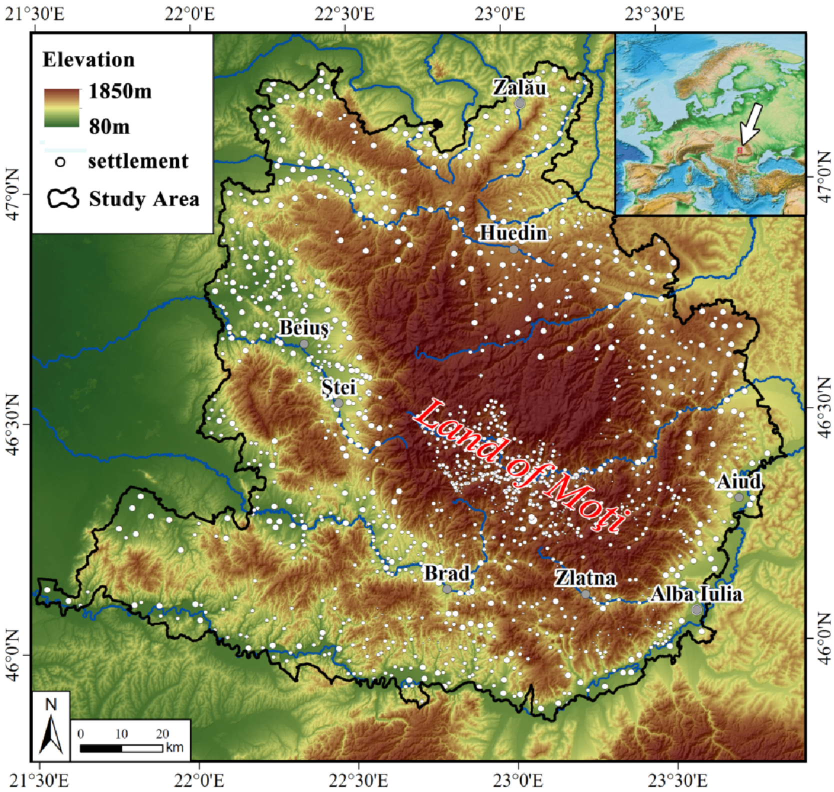

Figure 1 Relief and settlements in the Apuseni Mts. Inset map shows the location of the Apuseni Mts within Europe.

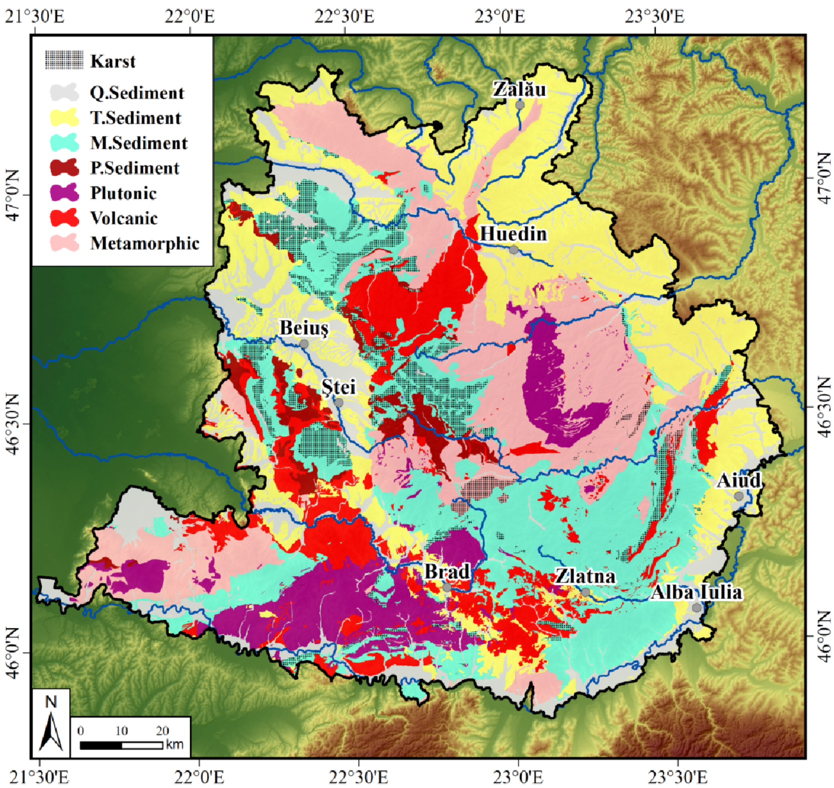

Figure 2 Simplified geology of the Apuseni Mts (Q: Quaternary, T: Tertiary, M: Mesozoic, P: Palaeozoic).

- Land cover data originate from the 1:100,000 scale European Corine CLC2006 database. This database is the result of a joint project of European countries. Corine was planned to provide quantitative, reliable and comparable land cover data for the member countries. Data collection was based on manual interpretation of ortho-corrected SPOT-4 and/or IRS LISS III satellite images. The CLC apply 44 land cover classes in 3 hierarchical levels (Büttner et al. 2004, 2010). We simplified these categories by omitting the missing classes and unifying similar categories. The final classification used in this study included the following classes: arable lands, artificial surfaces, bare surfaces, complex agriculture, forests, grass and shrub areas, mines, pastures, water (Figure 4).
- Population data for each settlement. The last census data (2011) comes directly from the National Institute of Statistics of Romania, whereas the data of earlier Hungarian and Romanian censuses (1880; 1890; 1900; 1910; 1920; 1930; 1941; 1956; 1966; 1977; 1992; 2002) were taken from the summarizing work of Varga (2002). In this regard, we mention that the Apuseni Mts belonged to Hungary before the Paris (Versailles) Peace Treaty in 1920. There were several country border changes during World War II, but after the war, the 1920 status was restored, which means that the whole study area has belonged to Romania since then. Moreover, there is one important inhomogeneity in the data: the small sized, scattered settlements were declared separated units after World War II, which resulted in an increase of approximately 50% in the (virtual) number of settlements, and also a (virtual) increase in the population number of the mountain areas since the new, separated units was mainly found at higher elevations. This fact is very important in the

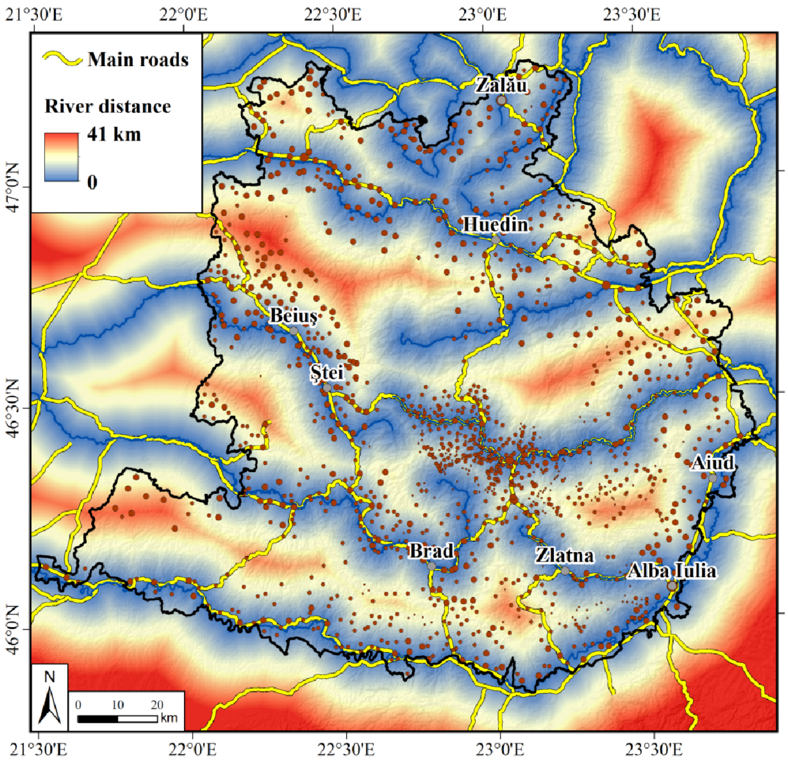

Figure 3 River distance, road network and settlements in the Apuseni Mts.

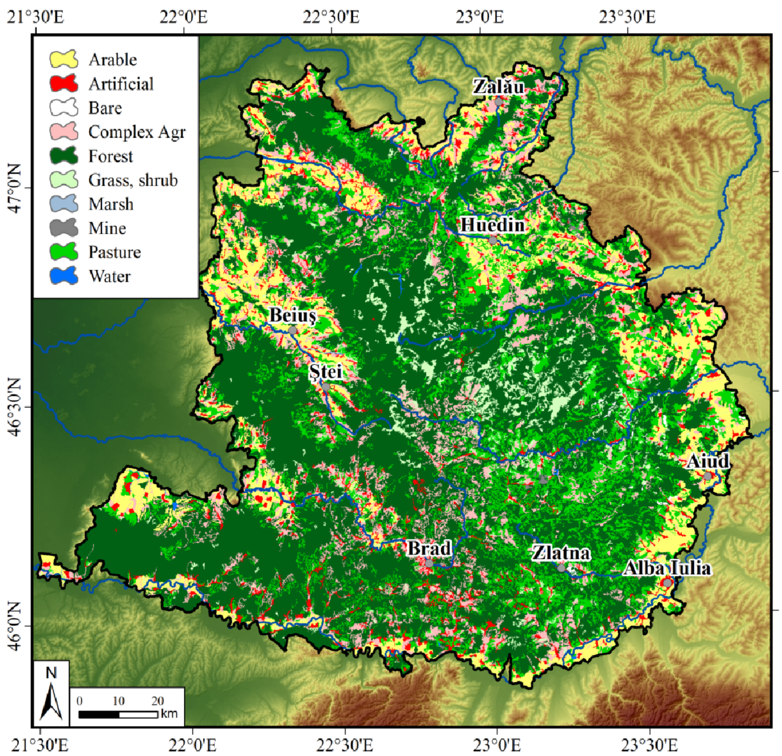

Figure 4 Land cover map of the Apuseni Mts (after CLC2006 data).

interpretation of data.

- Tourism data (the number of overnight stays from 2001 to 2014) is also from the National Institute of Statistics of Romania. Data cover tourism accommodation establishments with an existing capacity of 5 beds and more. The identification of natural attractions was based on the tourist maps covering the area, and partly on our field experience. Map scales were mostly between 1:30,000 and 1:60,000, except for some touristically ignored parts, where the best map is of 1:100,000 scale. We marked each and every point, which can be considered a natural attraction (panorama point, spectacular rock, cave, waterfall, etc.). We categorized them into 4 categories based on their significance (1-local, 2-regional, 3-national, 4-international significance) and determined if they are on karst or not.

Based on the GIS database, we calculated the population centroids (by elevation, by height, by slope, by river distance) and depicted their changes. We classified raster type environmental data (elevation, height, slope, river distance) into defined interval zones and calculated statistics (total number of people and settlements, population and settlement density, land cover proportions) for each zone. Elevation and height class intervals are 50 m, slope intervals are 1°, and river distance intervals are 1,000 m. Thereafter, we used linear and nonlinear regression analysis in order to study the relationships between different factors.

2 Results

The total study area is 16,730 km². The elevation of the Apuseni Mts ranges from 105 m to 1849 m (asl), with the most extended zone between 350 m and 400 m. Above this level, the surface extension (i.e. pixel frequency) decreases logarithmically. The climate is continental at the lower levels and mountainous in the higher terrains. The annual mean temperature varies between 11.0°C to 4.3°C, whereas the annual sum of precipitation ranges from 531 mm to 1134 mm as a function of elevation.

There are 1381 settlements (in 181 communes) and 658,954 people live in the study area, thus the mean population density is 39.4 people per km². The size of settlements is well characterized by the fact that 477 people is the mean settlement population, moreover, as the population distribution by settlement is lognormal, the median settlement population is even smaller, 178 people. The largest town within the study area is Alba Iulia (55,924 people), but the most important, larger cities (Cluj Napoca, Oradea, Arad), which exert a strong influence on the people of the Apuseni Mts are outside the study area.

2.1 Population versus relief and time

We selected four parameters in connection with relief, which are not fully independent from each other, but characterize the surface in different ways. The most often used parameter is elevation, which implies differences mainly in climate. The slope expresses the terrain ruggedness, which has a strong impact on building or cultivation potentials. The height is also connected to ruggedness and denotes transport difficulties with a vertical dimension. Finally, river distance reflects the remoteness of a given settlement, the distance to the main arteries of transport.

We examined the relationship strength between the above factors and settlement and population density (Table 1). As we are interested not only in the actual relationship, but in the temporal changes as well, we calculated determination coefficients (r^2) using all 13 census data. The results demonstrate relatively strong correlations with all 4 parameters and it is observed that temporal changes in r^2 exist, but these are usually relatively small within this time range (except elevation vs. settlement density, and slope vs. settlement density). The type of best-fit function is nonlinear for all cases, but it varied according to the studied relationship. Furthermore, the function type is generally stable in time for a

Table 1 Determination coefficients (r^2) between settlement density (SD), population density (PD) and relief parameters. Minimum and maximum values of the studied period (1880-2011) and the best-fit function type is given.

	Elevation	Slope	Height	River distance
SD	0.26-0.91 (exp)	0.57-0.92 (exp)	0.89-0.96 (ln, pow)	0.73-0.80 (exp)
PD	0.79-0.87 (exp)	0.81-0.89 (exp)	0.78-0.91 (ln, pow)	0.74-0.87 (pow)

selected relationship. Settlement density can be best modelled by height. However, its correlation with elevation is rather weak due to the fact that there is a special landscape in the heart of the Apuseni Mts, the Land of Moţi (Figure 1), which is an area with many tiny, scattered settlements found at high elevation. Population density has similarly good correlation with all relief parameters, Up to 1966, slope and height (i.e. terrain ruggedness) result slightly better correlations, but since 1977, river distance (i.e. remoteness) has the strongest correlation with population density.

The temporal population changes are presented in Figure 5. As for the total, we see an increase at the end of the 19th century. This trend is broken by World War I, but afterwards it is compensated, the increase is prolonged up to World War II, and total population peaks in 1941. After World War II, there is a slower rate, fluctuating decrease, and then after the political change of regime in 1990 a faster reduction of population occurs. Nevertheless, this total is the integration of varying population histories at different elevation zones. Thus, we examined population changes in each 100 m interval elevation class. This approach pointed out that a long-standing, significant population increase took place only in the nearly lowermost 200-300 m zone. In this zone, the most remarkable growth occurred during the last two decades of the communist regime, but later on, it was followed by a drastic decline. In all other elevation zones up to 800 m, growth is observed only till 1910, and after the decline of World War I, this population level was hardly restored by 1941. Thereafter, a slightly fluctuating, but more or less uniform rate of population decrease can be observed. As for the zones higher than 800 m, their situation is somewhat special, because an abrupt increase occurred between 1941 and 1956. However, this change is only virtual, as it is connected to the administrative reform mentioned in the Data and Method chapter. Until 1941, the population living at higher elevations were attributed to their lower elevation communal centres, but since 1956 they are counted where they really live. During the last two decades of the communist regime, there was an intense (and real) decline, but a slower rate decrease continued in the post-communist era. It clearly demonstrates how the population flowed from upper to lower parts of the Apuseni Mts in the two decades before the change of regime, and how people moved outside the Apuseni Mts to larger cities and even abroad after the change of regime. The aforementioned changes are properly reflected in the movement of population centroids (Figure 6) as well. It is observed that before 1941, population centroids were relatively stable, i.e. the natural increase and migration balance of the higher terrains were of similar order than population increase of lower terrains. Then the administrative inhomogeneity between 1941 and 1956 is clearly recognizable in the elevation and height centroids, but not in the slope and river distance centroids. The reason is that even on the higher terrains, the settlement locations are on low-slope areas, and that due to the upstream part of Arieş river in the Land of Moţi, river distances are also small.

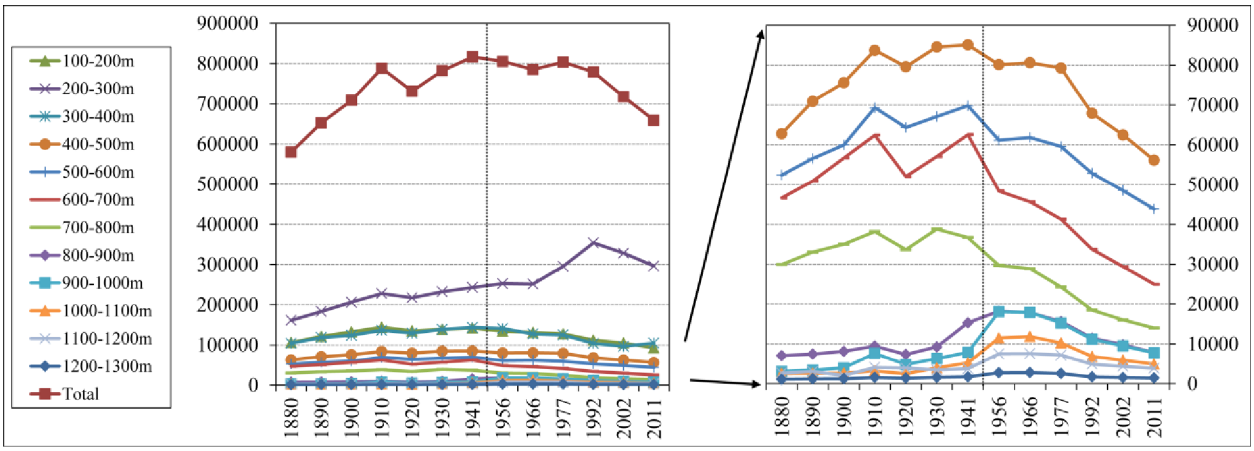

Figure 5 Population changes in the Apuseni Mts (1880-2011) as a total, and by 100 m vertical interval elevation zones. The right graph zooms to the upper elevation zones; note that the right population scale is 10-fold the left scale! Dashed line marks the administrative inhomogeneity of data between the censuses in 1941 and 1956. See text for further explanation.

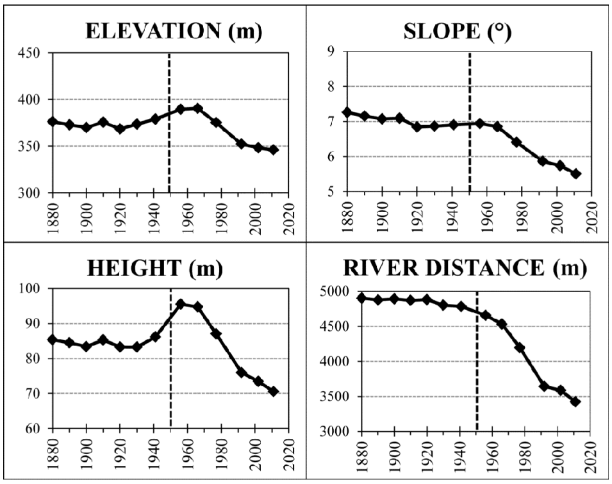

Figure 6 Changing population centroids by elevation, slope, height and river distance. Dashed line marks the administrative inhomogeneity of data between the censuses in 1941 and 1956. See text for further explanation.

However, from 1966, the population centroids moved at a faster rate, while after 1990 at a slower rate towards terrains which are lower and less rugged, smaller in height and closer to significant rivers.

Population change rates were also calculated (Table 2). These rates have moderate or weak correlations with elevation, but the most important observation is the switching sign of the correlation. The strongest positive correlation (r=0.59) refers to the period between 1900 and 1910, when the population of higher elevations had higher growth rates, marking an expansive period, when mountains were increasingly used by humans. (In fact, the 1956 correlation is even higher, but it is the result of the aforementioned administrative inhomogeneity.) The strongest negative correlation (r=-0.84) portrays the one and a half decade before the change of regime, when the population of higher terrains declined strongly. This is the period of withdrawal, when better living conditions (due to mining revenues, urban services) attracted people to move downwards. Therefore, it is argued that socio-economic changes are influenced by relief, but the way of impact changes with time, which means that it is dependent on the actual social situation. This is an observation that is in agreement with the thinking of cultural possibilism.

2.2 Population versus lithology

The geological units and the corresponding population and settlement statistics are shown in Table 3. Although only 15% of the total area is covered by Quaternary sediments, 68% of the population lives on these terrains, and consequently the population density is relatively high there (180 people per km^2). At the other end of the spectrum are the magmatic (plutonic and volcanic) terrains where population density is lower than 7 people per km^2. However, this low density may also be the result of the fact that magmatic rocks are mostly found at higher elevations. The population density of karst terrains is similarly low (8.4 people per km^2). Furthermore,

Table 2 Linear correlation coefficient (r) between population change and elevation (1890-2011). *means statistically significant at the 5% level.

year	1890	1900	1910	1920	1930	1941	1956	1966	1977	1992	2002	2011
r	-0.39	-0.43	0.59*	-0.44	0.32	0.42	0.71*	0.47	-0.62*	-0.84*	-0.66*	-0.37

Table 3 Distribution of population and settlements according to geology (A: Area, P: population, S: Settlement, D: Density).

Rock type	A (km^2)	A (%)	P	P (%)	PD (km^{-2})	S	S (%)	SD (km^{-2})
Q. Sediment	2497	15%	448861	68%	179.8	461	33%	0.185
T. Sediment	3665	22%	112244	17%	30.6	251	18%	0.068
M. Sediment	3993	24%	46738	7%	11.7	344	25%	0.086
P. Sediment	419	3%	3700	1%	8.8	46	3%	0.110
Plutonic	1328	8%	9089	1%	6.8	44	3%	0.033
Volcanic	1747	10%	10172	2%	5.8	62	4%	0.035
Metamorphic	3081	18%	28150	4%	9.1	173	13%	0.056
Karst								
Non-karst	14232	85%	616552	94%	43.3	1213	88%	0.085
Mixed karst	1534	9%	34306	5%	22.4	125	9%	0.082
Karst	964	6%	8096	1%	8.4	43	3%	0.045
Sum/Mean	16730	100%	658954	100%	39.4	1381	100%	0.083

if population densities are compared for each 50 m interval elevation class, it is found that the population densities of karst terrains are the lowest in almost all classes (except 3 zones), and their population density is only 41% of the population density of nonkarst terrains on the average.

Settlement density values are less extreme. This is due to the fact that even the rarely inhabited terrains have relatively large number of settlements, although these settlements have usually few inhabitants only. Here we note that even the geological settings are not independent from relief, as the more cultivable, quaternary sediments are basically found at lower elevations (and heights) near the rivers, and thus the geological impact in some way amplifies the relief effect.

2.3 Land cover versus relief

Land cover is influenced by nature in varying degree, but when a cultural landscape is considered (as in the case of the Apuseni Mts), the human impact is very high, and land cover reflects how the humans utilize the landscape (e.g. Zhang et al. 2003; Mao et al. 2014). Thus, the relationships between land cover proportions and relief parameters also demonstrate the strength of human-environment interactions. A strong correlation reflects good adaption of humans to environmental conditions.

The land cover of the Apuseni Mts is distributed among the following categories: half of the study area is covered by forests and 17% by pastures, while arable lands occupy only 12%, complex agriculture 11%, artificial areas 5%, grass & shrub 4%, and all other categories are negligible. We established determination coefficients (r^2) between these land cover categories and relief parameters using several function types (linear, exponential, logarithmic, power, 2nd or 3rd order polynomials; Table 4; Figure 7). The relationships proved to be very strong in most cases (r^2>0.9, except with river

Table 4 Determination coefficients (r^2) between land cover proportions and relief parameters with best-fit function types.

	Arable	Artificial	Complex agriculture	Forest	Grass & shrub	Pasture
Elevation	0.90 (exp)	0.90 (exp)	0.78 (lin)	0.77 (poly)	0.90 (exp)	0.91 (poly)
Slope	0.94 (exp)	0.96 (exp)	0.96 (poly 3rd)	0.97 (poly)	no corr.	0.45 (poly)
Height	0.92 (ln)	0.90 (exp)	0.89 (lin)	0.92 (poly)	0.96 (exp)	0.86 (poly)
River distance	0.42 (ln)	0.57 (poly)	0.64 (poly)	0.76 (poly)	0.43 (poly)	0.79 (poly)

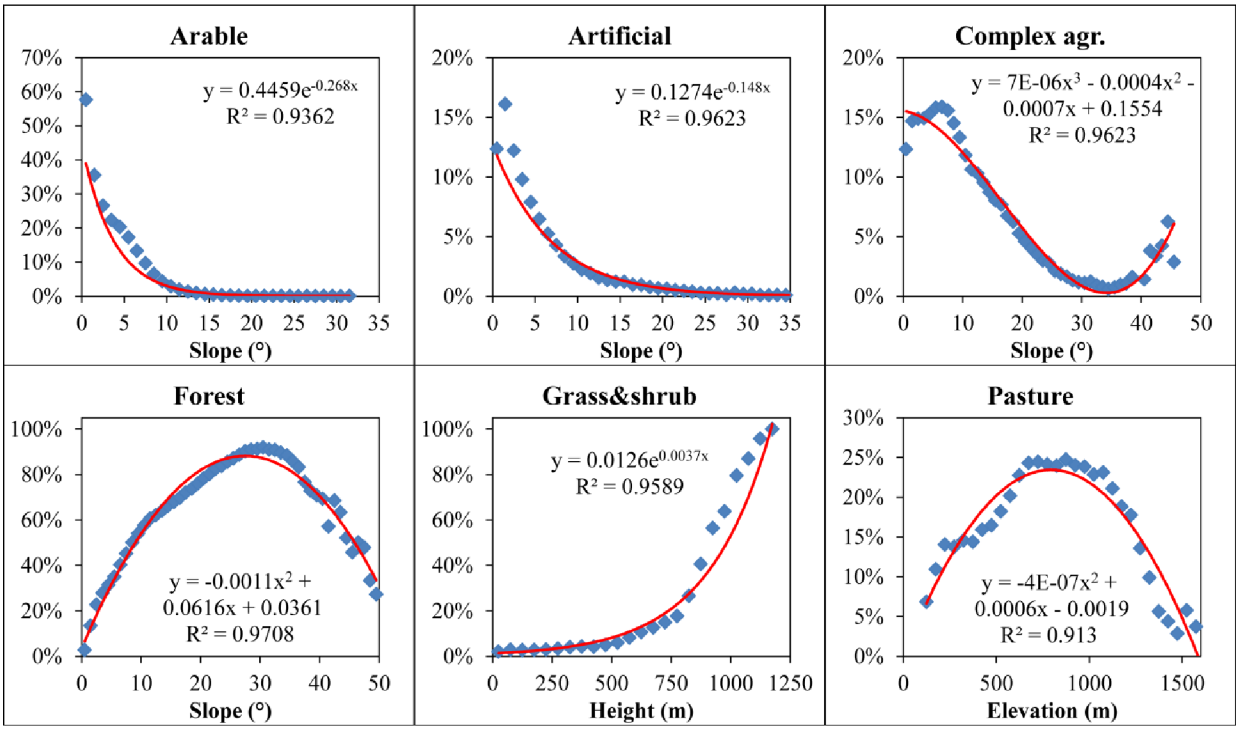

Figure 7 Functional relationships between land cover proportions and relief parameters.

distance), which indicates that land use in the Apuseni Mts is well adapted to the relief conditions. Most categories (arable lands, artificial lands, complex agriculture, forests) have the highest correlation with slope, but the grass & shrub category is determined the best by height, and pastures by elevation. 2nd order polynomial functions describe relationships where an optimal value exists, i.e. as the given relief parameter grows higher or lower than this value, the proportion of the given land cover proportion decreases. Or the opposite is true (Figure 7). An example for the optimum value type is the proportion of forests, whose optimal slope angle is roughly 30°, or the pastures with a peak at 800 m elevation. Another example for the opposite (i.e. local minimum) type is the proportion of complex agriculture with a minimum at 35°. This latter is surprising at first and is due to the fact that complex agriculture has a growing proportion in the steeper slope categories, which is connected to the intensive land use management of the dissected terrain in the Land of Moţi.

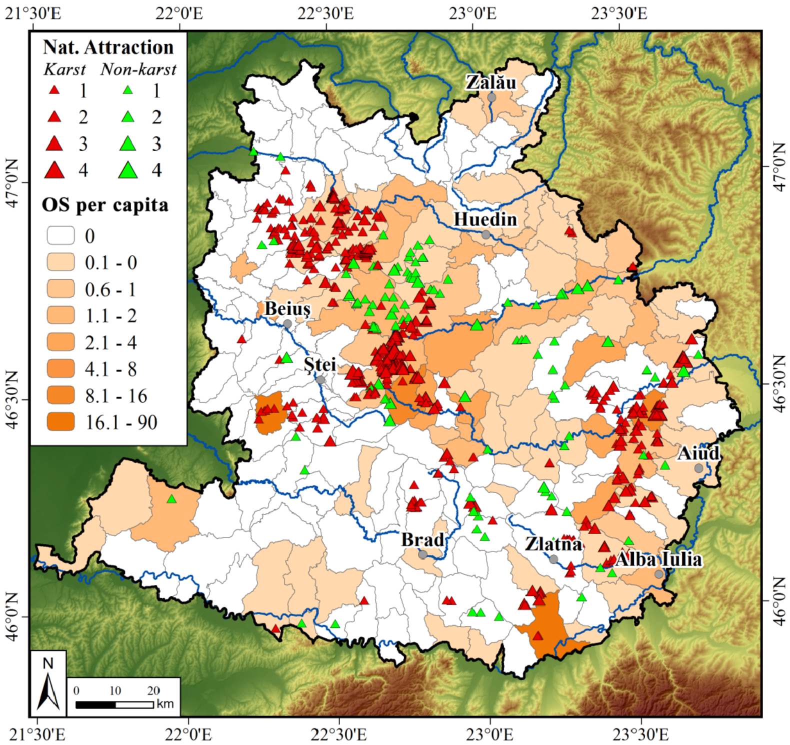

Figure 8 Spatial distributions of natural attractions (with significance: 1-local, 2-regional, 3-national, 4-international) and overnight stays (OS) per capita.

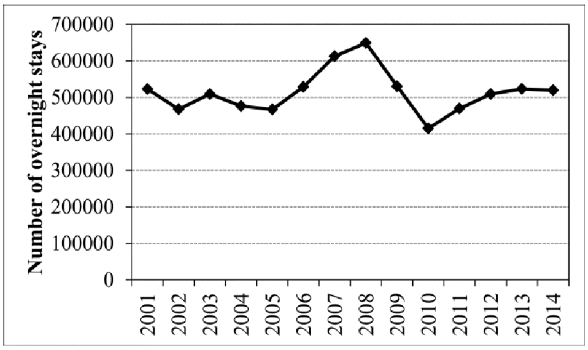

Figure 9 Changes of numbers of overnight stays from 2001 to 2014.

2.4 Tourism potential of natural attractions versus real tourism

Identification of potential natural attractions in tourist maps yielded 599 objects, of which 81% (487 objects) were of karstic origin (Figure 8). This high proportion is especially large if one takes into account that karstifiable rocks represent only 6% of the Apuseni Mts. The most significant, internationally renowned attractions (Cheile Turzii, Padiş Plateau, Piatra Secuiului) are all karstic objects. Based on the above results, it is stated that karsts are of outstanding importance from the viewpoint of nature-based tourism, at least if the potential is considered. This is in agreement with the results of other researchers, who pointed out that the geomorphological, geological and hydrological heritage of karstlands provide important tourism potential (e.g. Kiernan 2011; Simić et al. 2014).

Subsequently, we examined the spatial distribution of real tourism using the number of overnight stays (Figure 9). The statistics show that today the number of overnight stays is at a similar level as in the first year of this century (2001). Before the 2008 economic crisis, there was a period of prosperity (partly due to Romania joining the EU in 2007), followed by a setback and a recovery later on.

The spatial distribution of real tourism only partly overlaps the karst terrains, and there is no

Table 5 Tourist targets in the Apuseni Mts. Top list by the number of overnight stays and by the overnight stays per capita (data for year 2014). H: heritage, K: karstic, M: Mountain tourism , T: town with cultural attractions.

Settlement	Overnight stays	Attractions	Settlement	Overnight stays per capita	Attractions
1. Geoagiu	133658	spa, K	1. Moneasa	90.0	spa, K
2. Moneasa	84770	spa, K	2. Geoagiu	23.5	spa, K
3. Alba Iulia	78336	T	3. Arieseni	10.9	ski, M, K
4. Zalau	38460	T	4. Rimetea	8.6	H, M, K
5. Floresti	22519	T (Cluj satellite)	5. Belis	3.7	M, lake
6. Arieseni	19107	ski, M, K	6. Albac	3.4	H, M, K
7. Gilau	10817	H, M, T (Cluj satellite)	7. Pocola	3.1	M, K (cave)
8. Rimetea	9282	H, M, K	8. Salciua	2.8	M, K (cave)
9. Albac	7461	H, M, K	9. Garda de Sus	2.5	M, K (cave)
10. Aiud	7183	T	10. Intregalde	2.3	M, K
11. Baciu	5708	T (Cluj satellite)	11. Baisoara	2.2	ski, M
12. Budureasa	5257	M, K	12. Vidra	2.0	H, M, K

correlation between the number of overnight stays and the number of karstic objects at the commune level. However, the list of the most important tourist destinations (Table 5) helps to explore the reasons of attractiveness. Of course, towns have an advantage when absolute numbers are considered, but if overnight stays per capita is taken into account, the natural attractions become more obvious. An important fact is that both lists are headed by spas (Moneasa, Geoagiu), which are also connected to favourable hydrogeological (and partly karstic) settings. In this regard, we would note that Geoagiu was a notable spa even in antiquity (Figure 10). The per capita statistics clearly demonstrate the significance of mountain location and of karst in tourism.

Figure 10 Remains of the antique spa in Geoagiu (photo by Telbisz).

Nonetheless, it should be noted that the overnight stays statistics include only tourism accommodation establishments with an existing capacity of 5 beds and more. Furthermore, our field experience and booking websites also suggest that official statistics underestimate the real number of tourists. Discount accommodations (tourist chalets, guestrooms) probably provide less reliable data than larger hotels. However, the spatial distribution, which is important to us, reflects the real picture, notwithstanding the above minor distortion, and communes with high numbers of overnight stays are in accordance with the well-known tourist targets. Besides, we emphasize that a significant number of tourists stay in the neighbouring larger cities (Cluj Napoca, Oradea, Arad), which are located outside the study area, and visit the natural attractions of the Apuseni Mts on day-trip programs.

3 Discussion

In order to correctly interpret the above statistical results describing the relationships of environmental and social factors, it is necessary to briefly take into account the changing social and historical context of the Apuseni Mts.

Three important natural settings can be highlighted that provided (or still provide) the economic bases of people living in the Apuseni Mts during different periods of history. First, we mention the traditional land use management, which is characterized by a harmonic balance between grazing, complex agriculture around the houses and forest management. Notwithstanding some smaller, sporadic settlements, the human occupation of the mountainous area probably began in the Middle Ages due to the overpopulation and wars in the neighbouring basin territories. First, people settled at the bottom of valleys, then moved to higher terrains in the 18th-

19th century (Rușdea et al. 2005; Surd and Turnock 2010). This population increase and upward movement continued also in the period studied statistically in this paper, up to 1941.

The second important natural basis of economy in the Apuseni Mts is mining. It was already present in antiquity (e.g. Roșia Montană: Roman gold mines), and it became really important in the Middle Ages, when the precious metals mined here contributed significantly to the economy of the Hungarian Kingdom. Small mining settlements were the foci of population in the mountains. However, the real boom in mining took place in the 20th century, when modern transport capabilities (railways and later roads) were created. The communist era and the planned economy highly favoured mining, that implied relatively better life conditions in the mining towns. These better conditions and urban services attracted the inhabitants of the higher elevation, scattered, agrarian settlements to move down into the valleys, at first periodically (commuting), later (by the next generation) permanently. This implied the depopulation of the higher elevation and remote settlements (Boţan and Ilovan 2006). However, the mining industry collapsed upon the change of regime, and a number of settlements became severely disadvantaged areas. Therefore, not only the higher terrains but the valley settlements also began to decline and emigration out of the Apuseni Mts increased (Constantin et al. 2015). Here we briefly mention the situation of Roșia Montană, where a large international project was initiated to reopen the gold mine, but environmental concerns (because of cyanidation technique and other reasons) were strongly articulated by environmental groups that prevented this project from being realised (so far).

The third natural basis for living is (or could be) tourism. As demonstrated above, spas are the most valuable resources in this context today, but an important and still partly untapped possibility is connected to karst areas. Apparently, this has been recognized recently, and the infrastructure development has started, partly due to EU support. New asphalt roads leading to natural attractions have been built, caves were equipped with show cave facilities, and accommodation possibilities were increased. However, this is only the beginning, and good marketing would be also necessary. Nonetheless, it still remains a question whether tourism will be capable of providing a solid basis for maintaining the population and ensuring sustainable development.

As for tourism, it has another important cultural (not natural) basis as well. Romanians living in the Apuseni Mts rose in several rebellions during the 18th and 19th century that became very important as a historical heritage (Tătar 2013). This heritage is combined with the fact that the remaining, still active mountain communities continue a traditional way of life close to nature, thus providing a basis for today's heritage and ecotourism (Surd and Turnock 2000). However, a ponderous question is whether there remain people living in the tiny mountain settlements to continue this way of life, or the tourist arriving here can merely experience the phases of extinction (Figure 11).

Figure 11 Abandoned traditional moţi house in an extinct settlement, Poieni in the Land of Moţi (photo by Telbisz).

We also compared our results to the global analysis of hypsographic demography. Meybeck et al. (2001) stated that "*population density at the global scale is not primarily linked to relief types*". It may be true globally, because the influence of climate variations as well as the proximity of seas may potentially overwrite relief factors. However, Small and Cohen (2004) came to partly contradictory conclusions: "*human population is more localized with respect to the physiographic parameters than with respect to the climatic parameters considered here*". It demonstrates that global scale answers are not unambiguous. Thus, we do not want to extrapolate our results to a global scale, but it is simply argued that regional studies have their merit in finding local human-environment relationships, and the real impact of relief factors can be better observed in the scale of our study, as the climate is more homogeneous for smaller regions and our study area is far from coastlines. Another result of Meybeck et al. (2001) that "*at the global scale, population density seems to be closely linked or proportional to water runoff*". It is more similar to our results, but while in the global context it is interpreted as access to water resources, in our study the river distance is more an expression of remoteness, i.e. the distance to the main transport pathways.

4 Conclusions

The GIS-based, quantitative analysis proved to be a useful tool for exploring the strength and dynamics of human-environment relationships. The advantage of regional studies with respect to global analysis is that the impact of certain environmental factors can be more obvious in smaller, more homogeneous units. Furthermore, even today, better resolution data are available for certain factors in regional studies, e.g. worldwide geological, land cover or population databases are still of lower resolution or accuracy.

Using the Apuseni Mts as a case study for continental medium mountains, we found that environmental settings (namely elevation, relative height, slope, river distance, lithology, hydrography) have a relatively strong impact on the spatial distribution of human population and on land cover as well. This impact can be best described by nonlinear relationships. The best explaining factor for population density and for most land cover categories was the slope angle, i.e. terrain ruggedness.

One of the novel features of our study is that we used this quantitative approach for temporal changes as well. This way, we pointed out that even if the relationships of a given moment are strong, there are changes in time, and for instance, the relationship of population change and elevation switched sign during the studied period. As the natural settings of the Apuseni Mts were more or less stable during the studied period, the changes can be explained from the side of society, which conforms the theory of cultural possibilism. Remoteness can be an advantage in periods of social turbulence, but it is a disadvantage in the modern, centralized economy. Mining can produce higher revenues, but mineral resources may run out and mining quite often cause environmental problems. Living on karst is usually more disadvantageous due to water scarcity and poor soil fertility, but it may offer a significant tourist potential in the modern world. Ultimately, it is concluded that although environmental settings constrain the spatial framework of society, conscious or unconscious decisions drive how society utilizes the natural environment.

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