GIS TECHNIQUES FOR ASSESSING THE LINK BETWEEN HUMAN ACCESSIBILITY AND TERRITORIAL DISTRIBUTION OF THE POPULATION IN HUNEDOARA COUNTY

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ABSTRACT. – GIS Techniques for Assessing the Link between Human Accessibility and Territorial Distribution of the Population in Hunedoara County. The accessibility of an area has a very important role in the territorial distribution of the population in an area. In the present study, in order to determine the human accessibility index, some physical-geographical factors were taken into account. A link between accessibility and population density was established, based on data and maps obtained using GIS techniques. These links match or differentiate, depending on the area of analysis.

Keywords: Hunedoara, accessibility, territorial-administrative units, population, road.

1. INTRODUCTION

Studying the human accessibility of a given territory represents an important part, especially in determining the territorial planning, so that it can be efficiently employed by human society. Scientific papers in Romania have approached urban accessibility in terms of routes compared with building density. Serious imbalances were observed referring to the fast development of residential areas in contrast with an underdeveloped road network, such as Pipera neighborhood in Voluntari city (Costache and Tudose, 2012). Other subjects are related only to the general layout of transport routes and corridors, for a maximal efficiency of space (Cârjan and Ghiţuleasa, 2011). Internationally, issues referring to human accessibility of geographic environment were studied by Lincoln and Friedland (1978), Selivestrova (2006), Kadri Semm and Hannes Palang (2010). The present study aims to analyze the relationship between human accessibility and population density in Hunedoara County. To determine human accessibility, physical and geographical factors such as altitude, slope, river density and temperature were taken into account. Temperature represents an essential factor for a person (it is important for humans to avoid extreme temperatures). From a social and economic point of view, the density of road network was considered an essential factor, being very important in determining human accessibility in a given area (Jakimavicius and Burinskiene, 2007).

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2. STUDY AREA

Hunedoara County is in central-western Romania (fig. 1) in the Western Development Region. It has an area of 7063 square kilometers (Ghinea, 2000) and a population of 396,253 people in 2011 (INS, 2011). However, the population is unevenly distributed within the county, due to the presence of favorable and restrictive factors, depending on area. These factors, as we mentioned in the introduction, refer to: altitude, slope, river network density, climatic conditions, in particular temperature, and density of the road network as a socio-economic factor.



Fig. 1. Location of Hunedoara County in Romania

The landscape is mostly mountainous (68% of the county), having an altitude generally between 153 m, in Vărădia Depression corresponding to Mureș Valley, and 2519 m (fig. 1) in Parângul Mare Peak, located in the Southern Carpathians, Parâng Group (Ghinea,

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2000). The higher the altitudes are, the lower the accessibility is. Regarding the slope of the relief, it is clear that there is an inverse correlation between slope and accessibility. The morphology of Hunedoara records slopes between 0 and 68 degrees. The lowest values occur in Vărădia, Ilia and Bulza depressions and Deva and Vântului Corridors, while slopes over 45 degrees appear in crystalline mountain areas of Parâng and Retezat (Roșu, 1980). Fragmentation with high values appears as a favorable factor for human accessibility in a given territory. In Hunedoara case, high values of this morphometric parameter of over 3 km / km² occur along major river junction nodes (Mureș, Strei, Cerna, Crișul Alb, Jiul de Est and Jiul de Vest). In these areas, the highest values of population density are recorded (Erdeli and Dumitrache, 2010).

Average multiannual temperature in Hunedoara registered important variations, because of altitudinal heterogeneity. Thus, the highest average multiannual temperature of 10.16 degrees Celsius (Clima României, 2008), was registered in Vărădia Depression along the Mureş River, while negative temperatures below -2.5 degrees Celsius (fig. 2, c) occur on the highest peaks of the Southern Carpathians. In socio-economic terms, human accessibility in Hunedoara is facilitated by the presence of a high length of road network. The most important roads that cross the county are: DN 7 with connection between Deva and Arad, DN 66 with connection between Deva, Hunedoara and Petroşani and continued with DN 76 connecting between Deva, Alba-Iulia and Cluj-Napoca (fig. 1).

At a first sight, depression and valley areas should be those with a high population density, while mountain areas should register low values. In this respect, the link between human accessibility and human density will be analyzed, based on current data.

3. METHODOLOGY

In order to determine the human accessibility of the areas in Hunedoara County and to compare it with the degree of occupation of these areas, in the first phase, the Human Accessibility Index (HAI) was proposed, calculated and spatialized using a proper methodology. This index was obtained in the GIS environment by integrating two kinds of factors: physical-geographical and socio-economic. The physical-geographical factors are: relief altitude, slope, fragmentation density of the relief and multiannual average temperature (fig. 2). The determination and spatial distribution of the factors was based on the Digital Terrain Model, with a resolution of 30 meters, obtained from the interpolation of contours vectors from the 1:50000 Topographic Map of Romania (geospatial.org). Using these factors, human accessibility was obtained from a physical-geographical point of view. To build the HAI using physical-geography factors, raster data were introduced and reclassified in ArcGis 9.3 program corresponding to mean annual temperature, terrain altitude, slope and fragmentation density. According to the reclassification process, each factor received evaluation notes from 1 to 5 depending on how it affects accessibility values. The first class of evaluation designates areas with a very low potential of accessibility, while the fifth class shows the most accessible areas in the study area. Reclassification factors in GIS environment and evaluation marks were done depending on the standard deviation values corresponding to the spread of values for each of them.



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Fig. 2. Physical-geographical factors used to determine HAI in Hunedoara:

a) Slope, b) Altitude, c) Density of fragmentation, d) Average annual temperatures

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The road accessibility index values were also grouped into five classes, from 1 to 5 (table 1), to be integrated in the calculation to obtain the final index of human accessibility.



Fig. 3. Road accessibility index (RAI)

RAI (fig. 3) received a share of 60% in the final index, while the other four physical-geographical factors represented each 10% (table 1). The shares were set as such, because it is considered that the favorable factor represented by a road is more important and can compensate unfavorable characteristics of the geographical environment such as high altitudes, in terms of accessibility in an area.

The densities were obtained using data from the National Statistics Institute, in order to compare the obtained values with those of the HAI.

Table 1.

Parameters					
Altitude(m)(10%)	> 2018	1556.01 - 2018	1085.01 - 1556	625 - 1085	< 625
Slope [_] (10%)	> 25	15 - 25	7 - 15	3 - 7	< 3
Temperature (⁰C) (10%)	-2.5 - 0	0 - 3	3 - 6	6-9	9 - 10.2
Density of fragmentation	< 0.36	0.361 - 1.26	1.261 – 2.09	2.091 - 2.94	> 2.94
(km/km²) (10%)					
Road Accessibility	0 - 0.22	0.221 - 2.12	2.121 - 3.75	3.751 - 6.59	6.591 - 79.08
index(RAI) (60%)					
Score given	1 (very low)	2 (low)	3 (medium)	4 (high)	5 (very high)
Human Acceaibility	< 18	18 - 26	26.01 - 34	34.01 - 42	.> 42
Index (HAI)					

Classification of physical-geographical and socio-economic parameters for obtaining human accessibility index

4 RESULTS AND DISCUSSION

Due to applying the methodology described above, the Human Accessibility Index (HAI) was determined and spatialized for Hunedoara County with values ranging from 10 to 50 (fig. 4).

Values over 42 of HAI (fig. 4) indicate an area with a very high degree of favorability for housing and human activities. This kind of areas represent 8% of the county area and are located along the valleys, such as the Jiu Valley, Strei Valley, Mureş Valley, areas transited by important roads (E79, E68, or Şoimuş-Simeria motorway). Also, inhabited perimeters of cities in Hunedoara, such as Deva, the capital of the county, are included here. This city is located in an area with a very high accessibility due to flat terrain, the presence of Mureş River and favorable climatic conditions (approximately 600 mm / year and average annual temperatures of 8-10°C) (Ghinea, 2000). The population density is very high, over 915 people / km² (fig. 6). Similar situations are found in Hunedoara (532 people / km²), Hateg or Brad. Other factors favor high densities, besides accessibility. Jiu Valley cities have high densities as a result of coal reserves, while in Brad due to the presence of silver and gold reserves and coal.

Areas with high accessibility (HAI = 34.01 to 42) represent 23% of Hunedoara County and are located in depressions and river valleys, but also in the river valleys of the foothills and mountainous areas (Râul Mare Valley, Orăștie Valley, Geoagiu Valley), where the terrain is slightly sloped and natural resources can support human activities. Major roads pass through these areas, such as DN 68 and DN 74. There are some areas where, although accessibility is high, the population density is below the county average (56 inhabitants / km²), namely southern Depression Hateg (Sântămăria-Orlea, Bretea Română), Crișul Alb Valley (fig. 6). Lands in those areas are either covered with pastures and hayfields, or were cultivated with cereals and other crops.



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Fig. 4. Distribution of human accessibility index (HAI) in Hunedoara County

In areas with average accessibility (HAI = 26.01 to 34), approximately 29% of the county area, population density is average and low (Metaliferi Mountains, Poiana Ruscăi Mountains, hills in the center of Hunedoara). In those areas, water resources are limited due to low discharge or because villages are located far from the rivers.

The rest of the areas with low (32% of the county) and very low accessibility (8% of Hunedoara), represented on the map with blue and dark blue register values less than 10 inhabitants / km^2 , or even less than 1 inhabitant per square kilometer in mountain areas, where altitudes exceed 1500 meters, relief is almost inaccessible and the terrain is rugged. The forest roads are the only way of accessing those areas (Vâlcan Mountains, Metaliferi Mountains, Şureanu Mountains). The only settlements are very small villages with scattered houses (Harțăgani, Guguiata).

Fig. 5 represents the distribution of average accessibility index of the administrative units. These include the built-up perimeters of villages, where theoretically the location is accessible, but also the periphery zones with a less accessible terrain.

Totești village has the highest value of the HAI per administrative territorial unit (fig. 5), because it lies along the Râu Mare River, near a lake (Păclișa) in Hațeg Depression, where the terrain is horizontal, is transited by a national road and population density is between 50 and 100 inhabitants / $\rm km^2$ (fig. 5). So, there is a similarity between accessibility and density.

In territorial administrative units of Deva, Călan, Hunedoara, Haţeg, the average index of human accessibility shows values between 35 and 40. These values are high (fig. 5), due to the location of cities near rivers, major routes and with densities of over 100 inhabitants / $\rm km^2$. Again, we have a correlation between accessibility and density. Besides favorable accessibility factors, the causes that led to high densities in those areas are the vertical arrangement of buildings, the rural migration and migration of people from other parts of the country in these cities until 1989 due to the economic (mainly industrial) attraction.

Although they registered a low score in terms of accessibility, Petrila and Petroşani cities are populated as a result of coal resources that are required for human activities (Ghinea, 2000). This has helped the cities develop. Thus, in a relatively small space, buildings with vertical development led to a high population density, especially until 1989. In this case we have an imbalance in terms of accessibility and population density index.

Villages with average densities and medium index values (30-35) are Şoimuş, Hărău or Sântămăria-Orlea (fig. 5). These territorial administrative units include flat favorable areas and less accessible areas with slopes.

Municipalities with a low average index value of accessibility and small densities are Bătrâna, Bunila or Lunca Cernii de Jos located in Poiana Ruscăi Mountains or Bulzeștii de Sus in Apuseni (fig. 5).

In villages there are inconsistencies in terms of accessibility index and population density. Thus, Balta, Baru or Luncoiu de Sus have a small accessibility index and very small densities (under 10 inhabitants / km²), while Bucuresci shows a very low index and a small population density. Lupeni and Vulcan cities have densities over 100 inhabitants / km², although they have an average accessibility according to the index.

At county level, the average accessibility index is 37.08. This means that Hunedoara is relatively accessible. However, population density is not high, with only 56.1 inhabitants / km^2 in 2011 (INS 2011). Cities from Jiu Valley present large discrepancies between population density and the average index of accessibility. So, the terrain is not the only cause influencing an area to be populated. In addition, other factors are natural resources, economic attractiveness, the birth rate of population. Also, in urban areas population density is high, even if the accessibility index is smaller.



Fig. 5. Average human accessibility index of territorial administrative units

Fig.6. Average population density of territorial administrative units

5. CONCLUSIONS

The study aims to present a link between the accessibility of a land and the population density. The accessibility index was obtained using certain factors such as roads, temperature, fragmentation density, slope and altitude. Thus, in low areas such as valleys and depressions, HAI is high. However, population density is high only in some portions of these areas, such as cities. Areas with low accessibility are either foothills or mountains. The population density is very low due to the high slopes. In cities like Petrila and Petroşani the density exceeds 100 inhabitants / km² but the index of these administrative units is low. In the future the average index of accessibility is expected to grow because infrastructure becomes more diverse, but population will decrease because of the low birth rate, migration and economic transition.

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