„Babeş-Bolyai" University Cluj-Napoca
Faculty of Geography

PhD Thesis

(Summary)

GEOGRAPHICAL STUDY OF TRANSPORTATION NETWORKS IN THE CENTRE DEVELOPMENT REGION OF ROMANIA

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Contents

Key words: transport network, Central Development region, accessibility, catchment area, traffic, economic development

I. Introduction

I.1. Research Motivation

Transport system involves all modes of transport that include passenger transport and the transport of goods, as well as, the infrastructure pertaining to these activities. Spatial mobility (change of place) serves as a basis for most human activities; thus, transport system exerts a direct influence on the development of human civilization. Nowadays, the question of accessibility has become more and more actual since it affects economic development and defines people's opportunities. In my doctoral thesis, I applied a geographical approach in order to attempt an analysis of the transport system of the Central Development Region, laying stress upon the spatial structure of the transport networks, on the one hand, and the relationship between the transport system and the settlement network, on the other.

I.2. Research Project and Hypotheses

From a territorial point of view, my research focuses on a single region (NUTS 2 level) made up of six counties: Alba, Braşov, Covasna, Harghita, Mureş, and Sibiu. The regional units used in my research are the administrative units, according to which, 57 towns (out of which 20 municipia) and 357 communities make up the Central Development Region. Due to the physical geography conditions of the region, railway, road, and air transport networks have developed – they represent the topic of my research.

Hypotheses:

1. The historical development of transport systems has an influence on the actual form and structure of these networks;
2. The features of the terrain have an immense impact on the structure of the Central Region's transport networks;
3. Regarding the equipment of the transport infrastructure, several significant discrepancies can be observed in respect of the six counties;

4. The level of development of the transport infrastructure has a serious effect on the spatial-temporal accessibility of the settlements;
5. As a consequence of the realization of The International Braşov-Ghimbav "Iosif Silimon" Airport Project, there is an expected growing competition on the air transport market.;
6. The designed motorways and expressways will have a relevant impact on the catchment areas situated near the elements of this infrastructure;
7. There is a connection between the settlements' accessibility and their economic state of development.

I.3. Introducing the Central Development Region

The 25 degrees longitude and the 46 degrees latitude cross over the Central Development Region, which is situated in the central part of the country. With its area covering 34,100 km2 – this amounts to 14.3% of the whole country' territory –, the Central Development Region is the fifth largest region out of the eight that can be found in the country. On January 1st 2010, the population of region was 2,524,418 strong, which makes up 11.8% of the total population of Romania. The average population density is 74 people per square km, which is below the national average. There is also a low urban population ratio while the rural population ratio is above 40%. The most important urban centres are: Braşov, Sibiu, and Tg. Mureş. The development of the railway and the public road system was greatly influenced by the varied features of terrain and the water supply network.

II. The Present Situation of the Literature on the Subject

Transport geography is an integral part of economic geography and its objective is to analyse the transport activities as well as examine the effects of the transport on the socio-economic system. The new wave of transport geography researches offers the accessibility issue a central role. The results of transport geography are also utilized in the regional development. Some of the well-known international representatives of transport geography are worth mentioning, such as the works of Henry Patrick White (White H. P. 1991), Jean-Paul Rodrigue (Rodrigue J. P. et al. 2009), and Edward James Taaffe (Taaffe E. J. et al.

1996). The representatives of the national literature are Gr. P. Pop (1984), Tălângă C. (2000), Vlăsceanu Gh., and Negoescu B. (2004). In the modern era, the question of transportation has gained an interdisciplinary character, thus leading to an extension of the research topics.

The transport system (Subchapter II.2.2) may be defined as the totality of transport routes, elements of infrastructure, as well as, the means and trends of transport. The transport system is made up of several subsystems that complement one another, and its function is determined by the relationship between supply and demand.

The definition of accessibility (Subchapter II.2.3) is quite varied in the literature, which brings about several methods of defining accessibility. According to some researchers, accessibility can be interpreted as (1) the totality of opportunities accessible in a given place through the transport networks, (2) the level of regional interactions, or (3) it might as well be the "product" of the transport system itself.

Subchapter II.3 discusses the typical characteristics of the means of transport. The applied technology and the concomitant functional characteristics endow transport means with typical features, which restrict the range of their harnessing possibilities, the economic profitability, and eventually, the competitive advantages of a means of transport over the others.

The phenomenon of space-time compression is a derivative of the revolutionary development of telecommunication and the IT sector. Physical contact ceased to be the single method for real-time information exchange. The low costs of transmitting codified information has lead to the depreciation of geographical distances resulting in the "death of distance" (Cairncross F., 1997). Other researchers (Morgan K., 2001) suggest that exploiting the advantages provided by telecommunication is dependent on the ability of codifying/interpreting the information; in addition, due to the spatial development of physical infrastructure elements, spatial localization remains to be an important factor further on. Although in the case of passenger transports and shipments, the compression of time dimension can be attributed to the increase in the average speed of covering distances (motorways, rapid transit system, and airplanes), this phenomenon is of a much lesser order of magnitude than the processes that take place inside the info-communication networks.

III. Research Methodology

III.1. Transport Infrastructure Endowment

The assessment of transport infrastructure involves specific indices that reflect the quantitative and qualitative characteristics of the various means of transport. Such simple indices used during the assessment are the total length of infrastructure elements by categories (e.g. length of electrified routes) or the number and size of airports. The complex indices consist of and are calculated mathematically from several simple indices. One of these indices is the regional density of infrastructure elements (e.g. motorway density in 100 km per km2) or the ratio of infrastructure elements according to certain technical characteristics (e.g. ratio of electrified railroads). As for the more complex indices, they also consider the size of the regional unit under examination and the size of the population that is served by the transport network.

III.2. Traffic Analysis

Traffic is the transport of all the goods and passengers realized on a given route, by making use of given means of transport, in a given time unit, and under certain conditions.
Traffic congestion in a road section or intersection makes progress more difficult and it may also lead to situations of traffic jam when the process of transport is temporarily interrupted. A national traffic survey is carried out every five year in order to obtain/update data concerning the size of road traffic. In my thesis, I made use of the data showing the annual average daily traffic for 2005 – the assessment was carried through by the Romanian National Company of Motorways and National Roads (RNCMNR).

III.3. Applying Graph Theory in Traffic System Research

Graph theory is a frequent topic accessibility studies resort to since it helps them handle road network issues uniformly. The literature on the subject records plenty of applications of the graph theory, which aim at assessing and quantifying the principal characteristics of the transport networks. Graph theory is also used in the comparison of the transport networks of different regional units, as well as, for assessing the effects of new infrastructure elements (Ore O. 1968; Haggett P. - Chorley R. 1969; Simon I. 1978 and 1984;

Tíner T. 1981; Taaffe E.J. - Gauthier H.L. 1973). Through mapping the transport network into graph, we can make a model of the actual system's complex structure in such a way that relevant information is preserved. Settlements represent the vertices while the communication links among the settlements constitute the edges. Traffic between two settlements takes place in both directions (there is also the special case of the urban street network), which encouraged me to adopt undirected graphs in my research.

The simplest matrix mapping of a graph can be achieved via creating the matrix of direct connections. The values of a matrix provide the connection between one node and another in binary encoding, where "1" stands for the direct link between two adjacent nodes and "0" is applicable in a reverse case. The analogue method elaborated by Taaffe (1993, 1996) for the creation of value matrix is made up of five subsequent steps that presuppose the performance of the necessary calculations. Due to the high number of the nodes under examination (414 entities) in our research, an algorithmization of the process has become indispensable. In my research, I made use of the so-called StartUtility programme, which was originally created for this very purpose. In the case of the Schimbel distance matrix (D_m), I assigned a value of 1 to the existent adjacency between the examined node and the rest of the nodes. Relying on the basic information, the programme created the Dm matrix, which provides the topological distance between each pair of points.

$$A_i = \sum_{j=1}^{n} d_{ij}$$

- where: -Ai is the total distance from vi network node to all the other nodes;

- dij is the shortest path from vi node to vj network node (i j);

- n is the number of rows in a Dm matrix.

If we consider the inequalities between the different connections, a more correct mapping of the real world connections will become attainable. In order to achieve this, I resorted to the creation of network mapping value matrixes where the quantification of the connections was achieved based on the network distance values (L_d matrix) and/or the time (L_t matrix) necessary for performing the change of place. So that I can realize a quantification of the connections, I made use of network distances (km) in the case of the railway system and the time (min) necessary to cover the distances in the case of road connections. As for public road systems, the adopted average speeds were the following: 110km/h for motorways, 95 km/h for express roads, 85 km/h for national roads, 75 km/h national secondary roads, 60 km/h for other asphalt roads, 40 km/h for non-modernized roads, 50 km/h for roads passing through settlements, and 25 km/h for minor (dirt) roads. After performing all the calculations and transformations described in the literature, the elements (L_t or L_d) of the final matrix will provide the shortest distance or the least time necessary to cover that distance between the different pairs of points. The sum of the rows ($\sum_{j=1}^{n} l_{ij}$) provides the minimum duration necessary for accessing all the other nodes from any given optional node. The sum of the rows ($\sum_{i=1}^{n} \sum_{j=1}^{n} l_{ij}$) also provides the least amount of time necessary for covering all network distances (accessing every node from all the other nodes). The same applies for the matrix (L_d) created based upon the distance values.

II.4. Applying GIS Technology in Accessibility Investigations

The spatial information software adopted in the research is the ArcGIS Desktop 9.2 programme pack and its Network Analyst extension. The digital database was created through digitalizing all infrastructure elements (road, railway, and aerial), settlements, and administrative boundaries. The cartographical basis for data digitalization was a map of Transylvania (published by Dimap Ltd in 2009) on a scale of 1:400,000. After modelling the public road system with the ArcGIS Network Analyst, several special GIS analysis methods have become accessible. In order to verify the created model, I applied the New Route tool. The New Service Area function served for determining the catchment areas of airports and county towns, taking into account the categories of travel time/road distance. The New Closest Facility function made possible to determine every town of more than 30,000 inhabitants situated the closest to each of the nodes. Finally, the OD matrix (origin-destination matrix) function let us define (depending on the network distances and travel times) the optimal routes between the 414 settlements under investigation, taking into consideration the principle of the "shortest path" in assessing the connection between each pair of points. GIS toolkit was also employed to analyse the effects of the new motorway projects. Since expressways can be accessed exclusively through special nodes (driveways), the production of a multimodal network has become essential. In this network, the common roads as well as the expressways form separate layers between which the sole connection possibility is an accessibility point (exit). After creating the multimodal network, the aforementioned functions have all become serviceable.

IV. Railroad Transport

IV.1. The Romanian Railway System

After a longer prosperous period that lasted up to the late ‘80s, the role of the railway was exposed to a gradual depreciation due to the strengthening of the capitalist system. As a consequence of the railway infrastructure elements’ gross wear-out, the average speed of trains underwent a drastic decrease. Therefore, while throughout 27% of the whole network, the maximum speed limit was reduced to 50 km/h, 39% of the network could not allow a speed limit higher than 80 km/h (National Development Plan: 2007-2013). During the last nineteen years, the total length of the railway lines in use has decreased with 564 km, out of which the total length of the standard-gauge lines amounts to 231 km; as opposed to this, the total length of the electrified lines has increased from 3,680 km to 4,002 km. Private capital makes its début on the market of railway transport in 2001, offering competitive services.

IV.2. The Railway System of the Central Development Region

The process of the railway system’s development is described in Subchapter IV.2.1. The territory of the Central Development Region was endowed with the very first railway lines between 1871 and 1918. The majority of the narrow-gauge lines were built in the 20th century together with the electrification and duplication of the busy main lines.

IV.2.2. The Characteristics of the Railway System

Three main railway lines cross the region (main lines 200, 300, and 400), branching off to side lines. The railway component of the Pan-European Corridor IV crosses the region along the Şibot – Vințu de Jos – Coşlariu – Sighişoara – Braşov axis, which plays an essential role: this is how Romania joins the international railway system.

If we take the total length of the railway lines in use, the Central Development Region is in the fifth place from among the eight development regions country-wide (1,336 km in 2009). Compared to base year 1990, the total length of the Central Development Region’s railway lines decreased by 426 km in 2009, which amounts to a 24.1% decrease over nineteen years.

With its 39.2 km/1,000 km2 railway line density, the Central Development Region is found below the national average (45.2 km/1,000 km2). Regarding railway services, there are vast territories extending over the region that are isolated from an accessibility point of view– such are the surroundings of the Apuseni Mountains or the vicinity of Agnita on the Târnavelor Plateau.

V.3. Topological Analysis of the Railway System

IV.3.1. The Analysis of the System – A Topological Approach

This analysis confines itself to railway junctions, terminals, and towns involved in train service – thus 55 junctions are concerned altogether. Results achieved upon adopting the graph theory showed that Copşa Mică stands in the most favourable position from a topological point of view, followed by the stations situated along the Braşov-Teiuş line. The fact that all the stations occupying the first eight places are situated along the 300 main line gives an extra stress to its importance.

IV.3.2. Network Analysis Based on the Distances Between the Junctions

Considering the distances between the junctions, the results of the first analysis will be somewhat altered: the most favourable positions are still the due of the 300 main line (Sighişoara – Teiuş) and the 208 side line (Sibiu – Copşa Mică). Results demonstrated that the most isolated main line is the 400. The total amount of distance values from a given junction to all the others is the smallest in the case of Copşa Mică (7,389 km). The difference between the station found in the first and the one in the last place (Praid) is 5,714 km, which means a 77% surplus as compared to the most advantageous position.

IV.5. Network Dysfunctions

Due to the terrain of the region, the number of railway terminals, and the low number of train services in north-south direction, relevant differences can be observed between several pairs of points as compared to the ideal theoretical distance. The maximum deviation from the ideal curve takes place between Odorheiu Secuiesc and Miercurea-Ciuc, and it is of 528%. In Subchapter IV.5.2, I examined the effects on network connectivity exerted by the railway lines planned between Târgu Mureş – Sighişoara and Miercurea Ciuc – Odorheiu Secuiesc, respectively. In case these two lines were built, Sighişoara would become a significant railway junction while the accessibility of Târgu Mureş would be improved a lot, as well.

IV.6. Railway Traffic

In 2009, there was a fourteen-million passenger traffic recorded at the stations pertaining to the RTFC Braşov catchment area. Considering the train passings in both directions, the most crowded sections were the following: Podu Olt – Tălmaciu – Sibiu, Copşa Mică – Mediaş, Vânători – Sighişoara, and Şibot – Vinţu de Jos – Teiuş – Războieni.

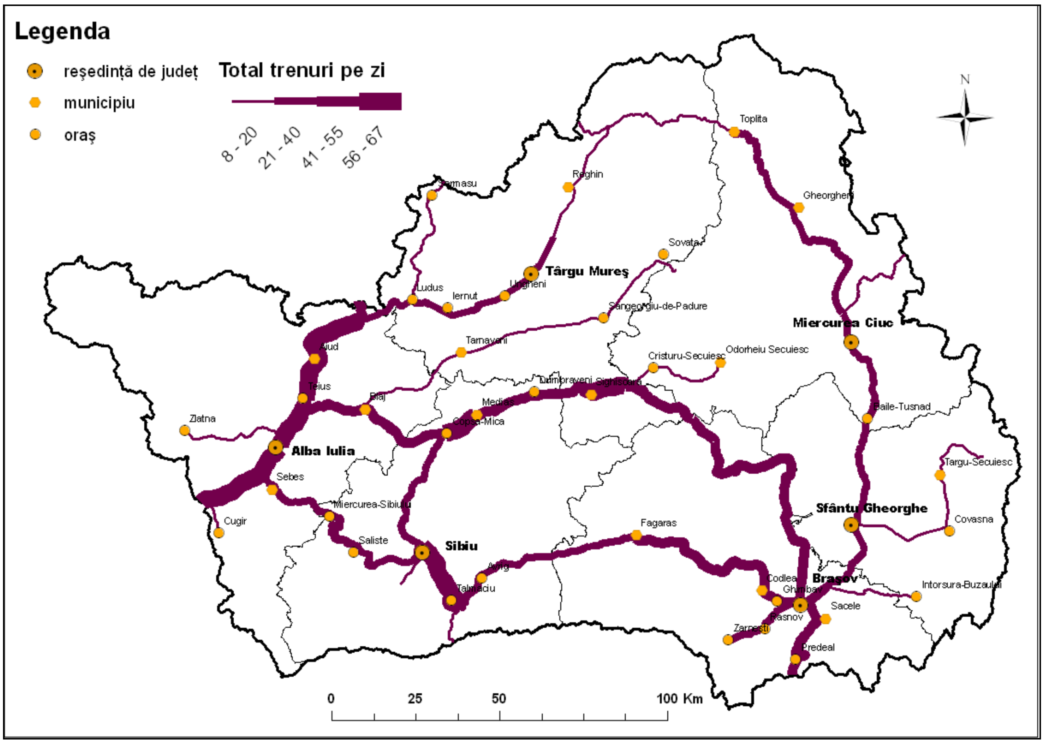

Fig. 1. The number of daily train passings carried out in both directions

V. Public Road System

V.1. The Development of the Public Road System

This subchapter treats the main aspects of the public road system development starting from the ancient times to the present day. Beginning with the 20th century, an intensive quantitative and qualitative development can be observed. The total length of the public roads within the territory of the Central Development Region increased by 1,800 km between 1990 and 2009, which means a 20.2% increase as compared to the base year.

V.2. Echiparea teritoriului cu infrastructură rutieră

In 2009, the total length of the Central Development Region's public road system was 10,709 km, which is 13.1% of the national network. The distribution by the different road categories is formed as follows: modernized roads (31.8%) – 3,406 km roads, light asphalt roads – 2,384 km (22.3%), paved roads – 3,259 (30,4%), and dirt roads (15,5%) – 1,660 km. The 17.2-km-long first stretch of motorway (Sibiu relief road) was put into circulation in year 2010. The public road density of the region (31.3 km/km2) is below the national average (33.5 km/km2). The ratio of non-asphalt roads and the lack of expressways represent the biggest problems. Considering low-quality roads, Alba, Mureş, and Harghita counties are found in the most unfavourable situation.

V.3. Projects for Developing the Public Road System

At national level, the main objective of the public road system's development strategy is the construction of new stretches of motorway: more specifically, the utmost priority is due to the motorway that is to be built along the Pan-European Corridor IV. According to the development project, the Central Development Region will be crossed by the following motorways: A1 motorway shall be situated south-west, A3 motorway shall cross the region diagonally in the north-west – south-east direction, and A4 motorway shall pass through the region in the west-east direction. In the second phase, the connection between the A1 and A3 motorways will be realized through the expressways that are to be built along the Sibiu – Făgăraş and Sebeş – Turda axis. Presently, work has already started on the Orăştie – Sibiu (82 km) section of A1 motorway – for one reason or another, the rest of the motorway sections in the region are still in the preparatory/planning phase. Due to the cancellation of the contract signed with the construction company called Bechtel – which was entrusted with the construction of the so-called Transylvania motorway (the Oradea – Braşov section of A3 motorway) –, there will be an expected delay as for the materialization of the motorway sections that would fall to the Central Development Region. The financial problems are the sore spots in planning the Braşov – Comarnic section that pertains to the A4 and A3 motorways.

V.4. Level of Motorization

In the last two decades, vehicle parks have undergone an intensive development. Considering passenger cars, the car stock of 177,000 in 1990 (62 vehicles per 1,000 inhabitants) grew to 507,000 cars in 2010, which is a 186% growth compared to the base year. In the counties that make up the Central Development Region, the ratio of vehicles/1,000 inhabitants ranged between 232 and 286 in 2010. As for vehicle endowment, Braşov County is found in the most advantageous situation, followed by Sibiu (280 vehicles/1,000 inhabitants) and Covasna (271). In not more than ten years' time, the number of vehicles registered in the region has witnessed an increase of 118,500. According to 2010 data, the county-level values of passenger car registrations/1,000 inhabitants fell between 16.5 and 21.3. In the light of all this, we can state that vehicle endowment has undergone a drastic quantitative change in ten years' time, which affects the increase of road traffic (Subchapter V.6) as well as the deterioration of the transport security indices discussed in Subchapter V.5.

V.7. Public Road Accessibility

The accessibility of the settlements may be considered as a key issue. I carried out an accessibility analysis of the administrative units' central settlements with the help of the ArcGIS Network Analyst programme, relying on the network distances between these settlements and the travel time necessary to cover these distances. The outcome of the analysis is an accessibility matrix consisting of 414 rows and columns – it contains 171,396 public transport routes – illustrated graphically.

The settlement-level public road accessibility determined by the total number of network distances shows a tight connection with the geographical position. Although the accessibility analysis based on the travel times necessary to cover the public road distances – where I considered the value of the different average speeds deriving from the various technical parameters of the routes – reveals some changes, it does not result in significant restructuring regarding the accessibility values.

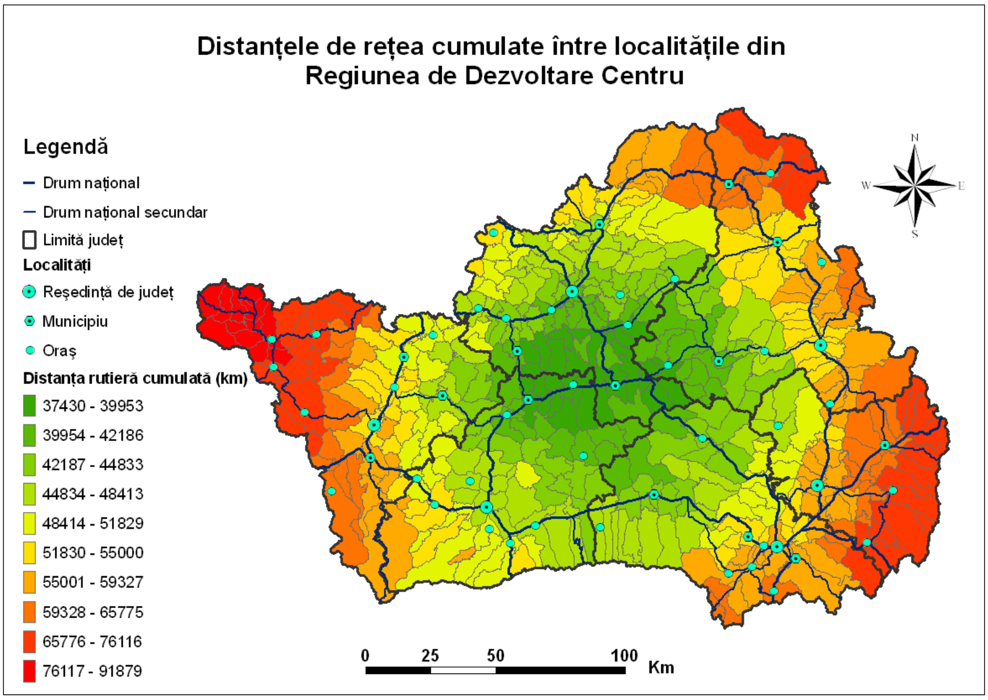

Fig. 2. Summing up the public road distances (by administrative units) between the towns and community centres situated in the Central Development Region.

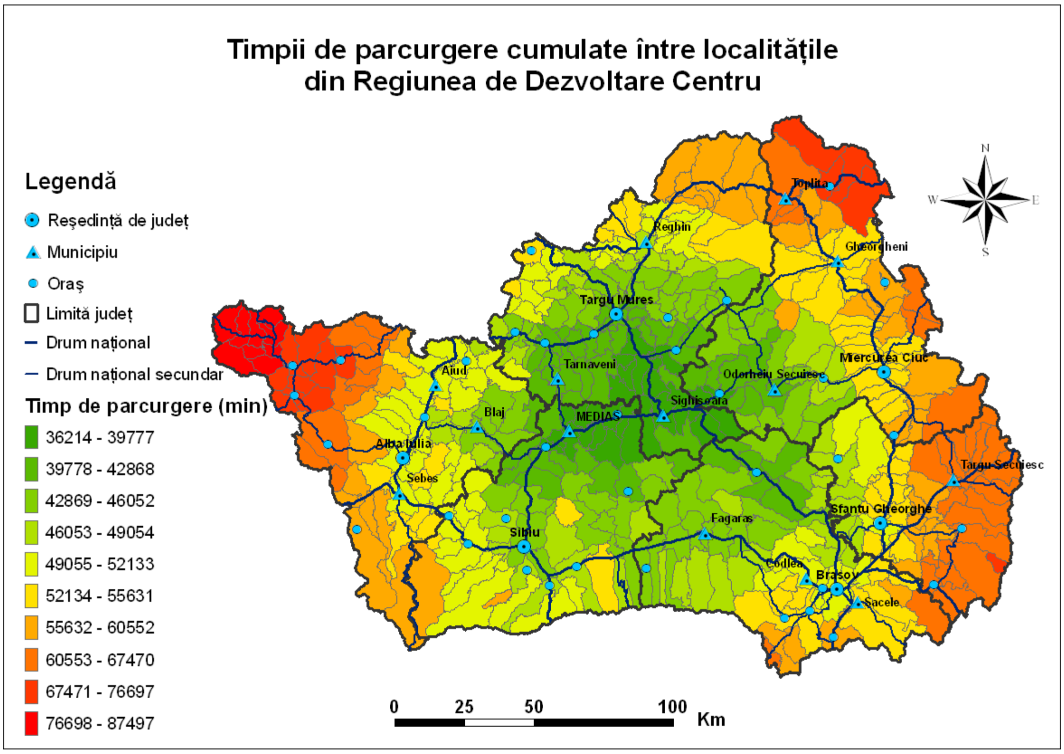

Fig. 3. Summing up the travel times (by administrative units) necessary to cover the public road distances between the towns and community centers situated in the Central Development Region.

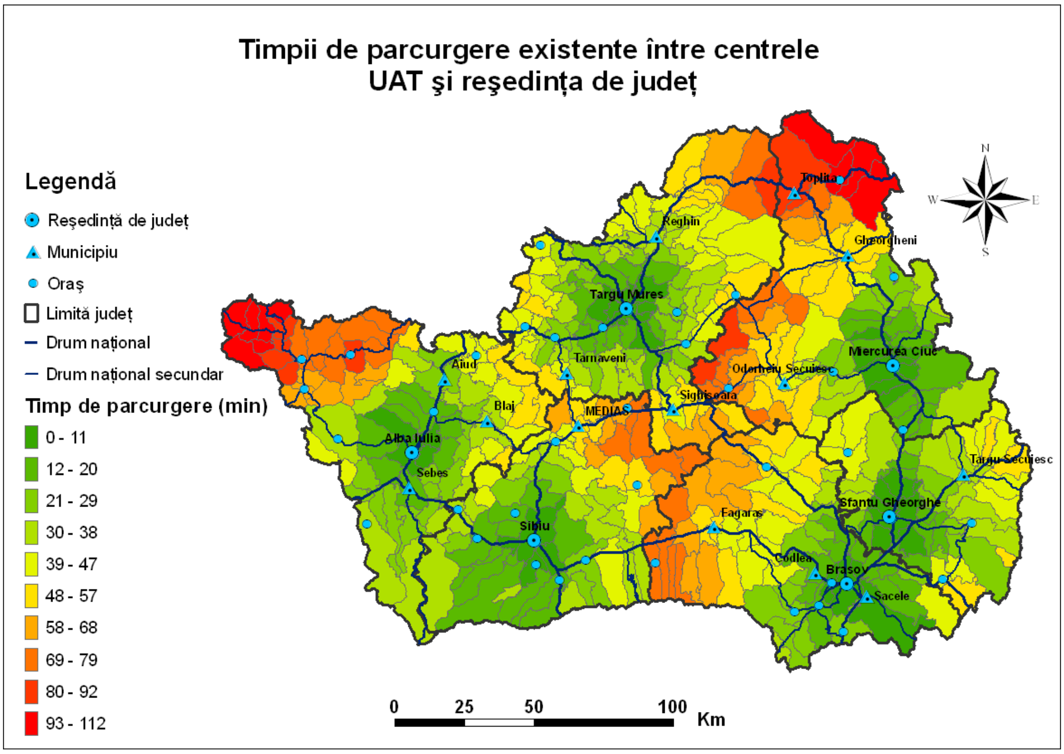

Fig. 4. Travel times (by counties) between the centers of administrative units and the county towns.

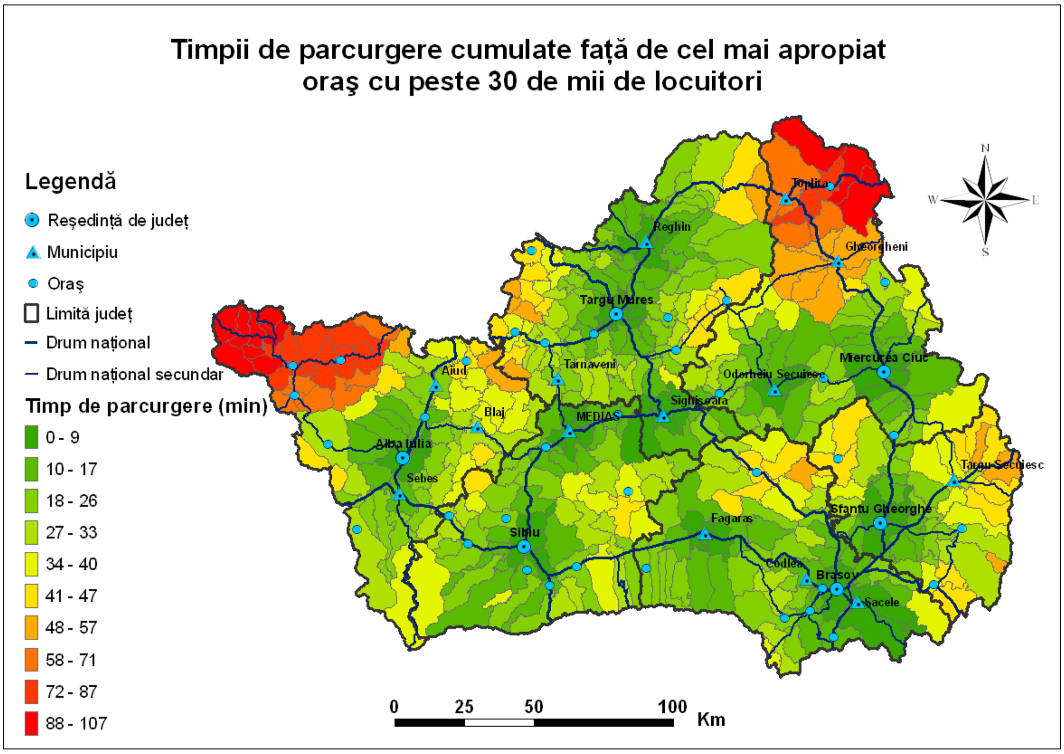

Fig. 5. Travel times between settlements and the closest closest town of above 30,000 inhabitants.

The analysis based upon the travel times necessary to cover the public road distances between the county towns and the administrative units demonstrates the negative effect the terrain factor has upon the quality of the connections, as well as, it draws attention to the issue of the peripheral position within a county of some county towns. It reveals the disadvantageous situation that there are nearly 25,000 inhabitants in the Central Development Region living in administrative units situated more than ninety minutes away from the closest county town; moreover, an additional 150,000 inhabitants live in regions defined by a 60-90-minute interval (Chapter V.7.7).

There are 33 administrative units altogether in the Central Development Region that are situated more than sixty minutes away from the closest town of above 30,000 inhabitants. From this perspective, the settlements in Harghita County, situated north of Gheorgheni, as well as, those found west of the Trascăului Mountains, in Alba County (Chapter V.7.3), are all considered underprivileged.

V.7.5. The Accessibility of Administration Units Based on the Gravitational Potential

When adopting the gravitational potential model, we hypothesized that the importance of the valid connections between a given settlement and the rest of the settlements in the region is not identical; therefore, we should somehow consider a rational approach to the potential changes of place.

This method draws on the analogy of Newton's law of universal gravitation, which means that the gravitational potential is in direct proportion to the population of the target settlement and in indirect proportion to the travel time raised to the second power between two settlements. Based on the analysis results, we can ascertain that the settlements situated around the cities dispose of the largest catchment areas. However, in the central area of the region, along the Agnita – Vlăhița axis, several administrative units provided low values, just as the western and northern border regions where the peripheral location is further worsened by the lack of the cities.

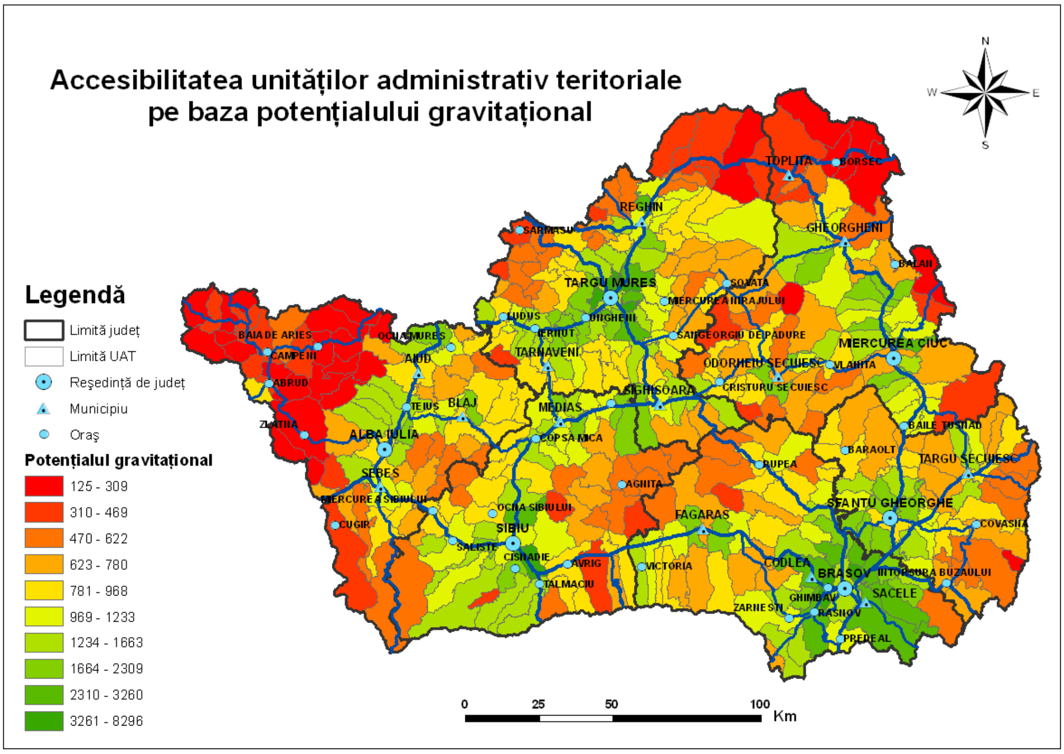

Fig. 6. Spatial Distribution of the Potential Catchment Areas by Administrative Units.

V.7.8. The Effects of the Planned Motorway Sections on the Central Development Region's Public Road System

In this subchapter, I created three scenarios that would help me determine the effects of the expressways planned in the region. The trace of the modelled expressways shows a high degree of parallelism with the already existing infrastructure elements; therefore, this will hardly have a beneficial outcome in respect of the public road system's degree of connectivity. However, the travel time of the expressways necessary to cover some of the public road distances will result a spectacular improvement. The first scenario I used to model the effects of A1 motorway revealed its slight chances of affecting the development of intraregional connections; however, it will play an essential role in the development of the region's international and interregional connections. The second scenario where I assessed the effects of A1 and A3 motorways represents a transitional phase to the third scenario; results show small differences. The third scenario that I used to model the effects of A1 and A3 motorways, as well as, two expressways disclosed vital differences regarding the extension of Braşov, Târgu Mureş, Sibiu, and Alba Iulia municipia's delimited catchment areas by on travel time interval. The hierarchy based on the constant size of population that can cover the distance range of below 60 minutes around the towns is led by Târgu Mureş (575,088 inhabitants), followed by Alba Iulia (525,055 inhabitants), Sibiu (505,966 inhabitants), and finally, Braşov (499,716 inhabitants).

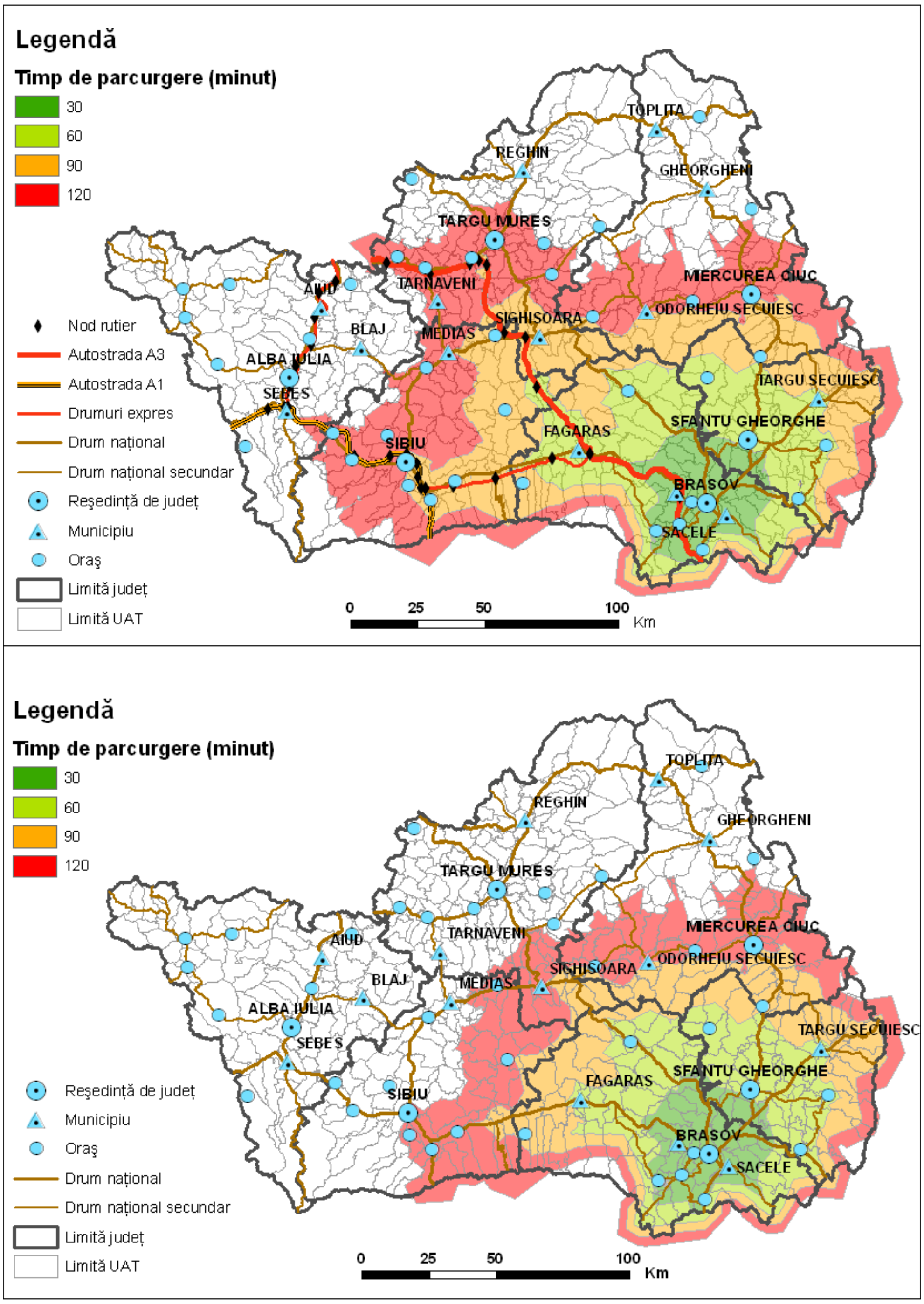

Fig. 7. The catchment areas of Braşov delimited by travel times after the present situation (see below) and the construction of the expressways.

As for the distances range coverable below 90 minutes, Sibiu (1,124,307 inhabitants) takes the lead, followed by Alba Iulia (982,058 inhabitants), Târgu Mureş (972,711 inhabitants), and finally, Braşov (961,713 inhabitants). Considering middle-distance connections – travel time is between 60 and 90 minutes –, the greatest increase will be achieved by the number of inhabitants found in the catchment areas of Sibiu and Braşov (290,000 inhabitants more); thus, they can be regarded as the laureates of the development project. However, the vulnerable point of the development is that the inhabitants of Harghita and Covasna counties may expect only indirect benefits from the near future what can be just partly ameliorated by the construction of the A4 motorway. In this summary, I use the example of Braşov in an attempt to illustrate a modification of the catchment areas delimited by travel times.

VI. Air Transport

VI.2. Regional Characteristics of Air Transport

At the moment, the Sibiu and Ungheni airports are the only ones functioning within the territory of the Central Development Region. The infrastructure of both airports makes possible the handling of Airbus 320 and Boeing 737 airplane categories. In the case of both airports, the passenger and airplane traffic have both undergone a significant development in the past few years. Sibiu International Airport recorded a 300% increase in passenger traffic in the period between 2005 and 2010 – all-time traffic record achieved in 2010 (198,743 passengers). In 2007, Transilvania Airport had a passenger traffic of 157,000 travellers. Passenger traffic is in tight connection with the widening range of travel destinations. Transilvania Airport operates regular flights to destinations in Hungary, United Kingdom, Spain, France, Germany, and Denmark. International flights accessible from Sibiu without any change are operated to Madrid, Munich, Vienna, and Stuttgart – these are complemented by the direct flights operated by Carpatair to Italian, German, and Greek airports.

VI.3. The Accessibility Analysis of the Airports

Based on the constant size of population living in catchment areas delimited by travel times below 60 minutes, the Târgu Mureş Airport is found in the more favourable situation with 660,768 inhabitants as opposed to the Sibiu Airport that has a 483,656 strong catchment area. The situation is the same with the population living in areas delimited by travel times between 0-120 minutes: Târgu Mureş attracts 968,482 inhabitants while Sibiu 758,349.

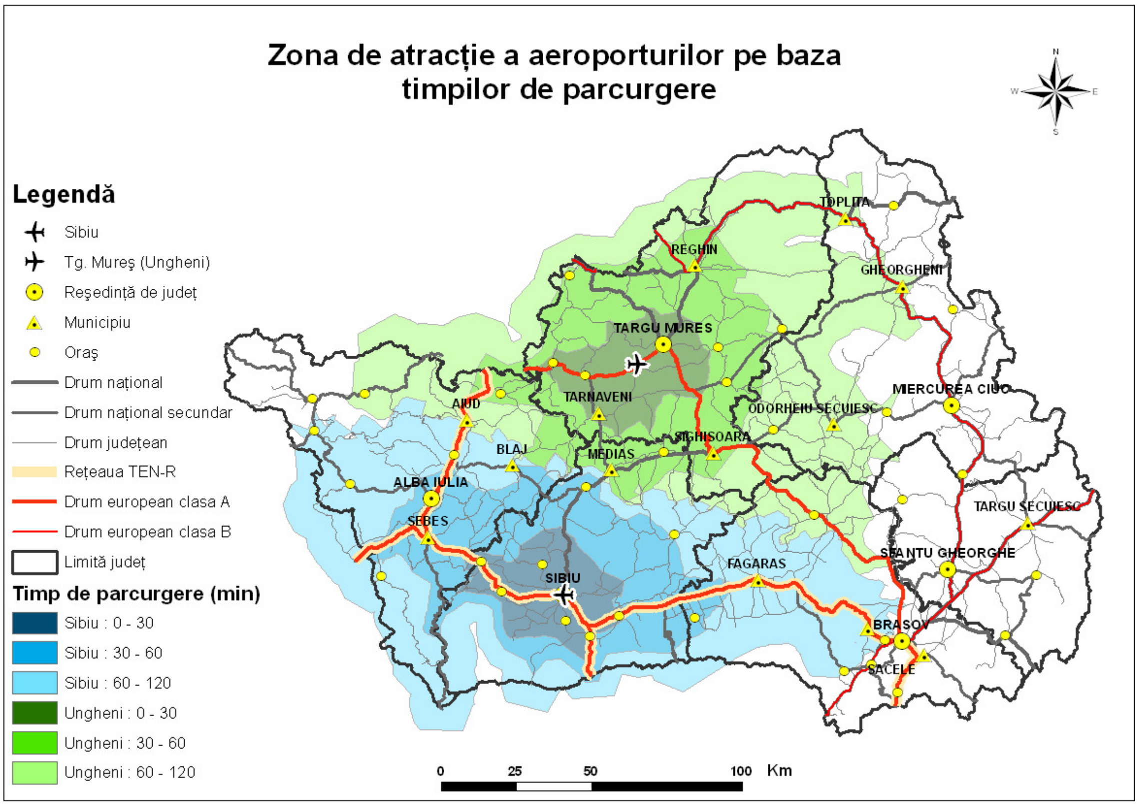

Fig. 8. Airport accessibility by travel times

VI.4. Development Projects and Their Effects on Air Transport

The effect of the Iosif Şilimon International Airport in Ghimbav will mostly emerge in the transformation of areas delimited by travel times between 60-120 minutes. Considering the travel times between 30-60 minutes, the new airport – with its 245,205 strong catchment area – will take the second place after Târgu Mureş, though preceding it in the case of the 60-120-minute travel times with its 250,310 strong catchment area. The airport at Ghimbav is of overriding importance for the inhabitants of Covasna and Harghita counties since presently, they are in a disadvantageous situation in respect of air service accessibility.

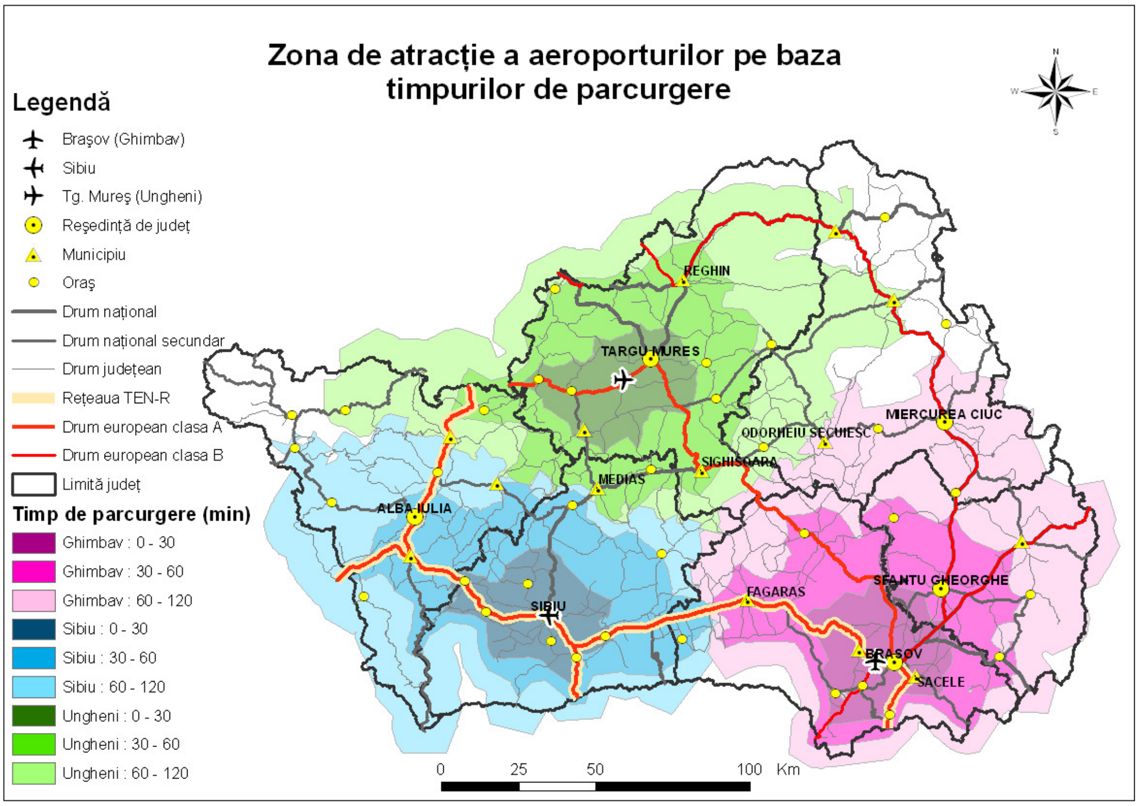

Fig. 9. The accessibility of the three airports by travel times

VII. Intermodal Transport

Due to the physical-geographical conditions, intermodal transport in the Central Development Region is mainly realized via the interaction of railway and road transport. The following intermodal terminals operate in the region: Braşov (Braşov Marshalling Yard), Sibiu (Sibiu Marshalling Yard), Alba Iulia, Târgu Mureş (Târgu Mureş South), Târnăveni (Târnăveni West), Mediaş, and Miercurea-Ciuc.

The development strategy of the Târgu Mureş Airport involves the construction of a new cargo terminal at Ungheni, which would serve the intermodal freight traffic (road and air transport). Similarly, the Sibiu Airport also carries out freight traffic. From a financial point of view, the air transport of goods can only be sustained in the case of high value-added, small unit sized, and small-volume products. The National Spatial Plan (PATN) includes making the reaches of River Mureş found under Alba Iulia navigable all the way to the country borders, and creating new fluvial piers at Alba Iulia, Deva, and Arad. As a consequence, there is a slight chance for the materialization of the fluvial-road transport in the region. Water transport would be nothing new in the region since it has been adopted throughout centuries for salt and wood transport.

VIII. The Economic System of the Region

VIII.1. Settlement-Level Economic Development

In order to determine the economic development on the settlement level, I made use of the possibilities offered by the factor analysis (principal components method), and I created a complex development indicator. The basic input data of the factor analysis were made up of the 11 basic indices (Table 43) recorded in the statistical data sheet of the settlements. Subsequent to the analysis, I obtained a dominant factor (99.5 proportion of variance explained). Considering the development level of the region's administrative units, the obtained results revealed massive territorial differences.

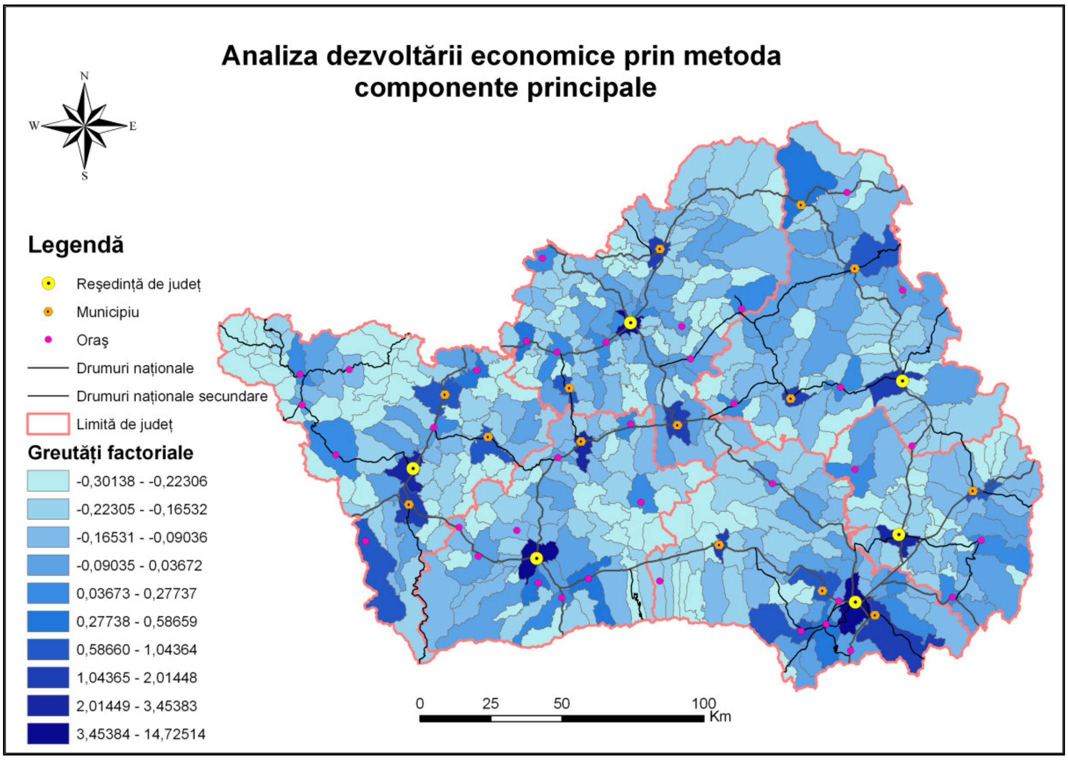

Fig. 10. The settlements' level of development based on the factor analysis results

VIII.2. The Connection Between the Economic Development of the Settlements and Their Accessibility

The correlation study carried out with the SPSS programme showed no significant connection between the settlements' degree of accessibility and the factorial value of their complex economic development. The results obtained via the factor analysis showed a high dispersion due to the high values of the larger cities; in order to secure a decrease, I carried out another factor analysis, this time, narrowing it down to the community level (357 entities). The analysis determined three factors and the first component compacted 39% of the entire information set. The correlation study showed a weak connection between the results of the first factor and the communities' accessibility to the nearest town exceeding 30,000 inhabitants.

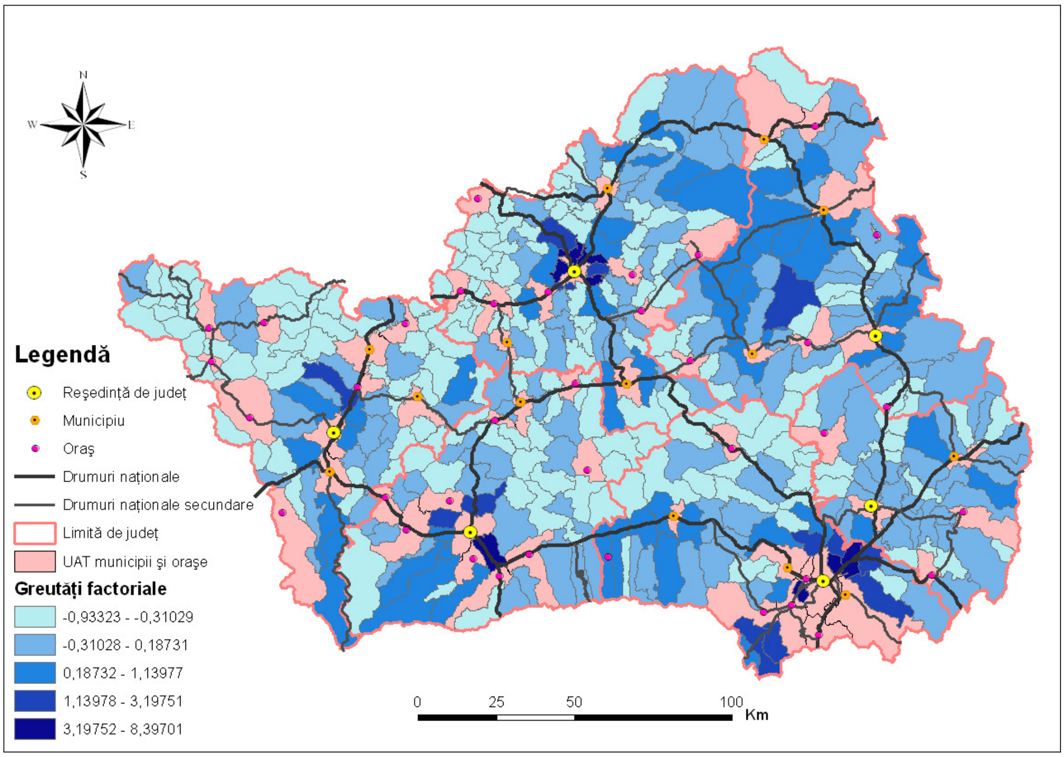

Fig. 11. Communities' level of development based on the factor analysis results.

There is also a weak connection between the accessibility of the administrative units by travel times and their economic development level. Therefore, we can say that the present conditions of transport represent a huge obstacle to the economic development of the settlements, on the one hand, and this situation generates a competitive disadvantage in the system of relations of the globalized economic processes, on the other hand.

Conclusions

The very fact that the region is geographically situated in the central part of the country it confers a geostrategic position, which has always had its effects in the past and will expectedly affect the development of transport infrastructure in our future, as well.

Due to the high construction costs, the terrain of the region has become a strongly restricting factor in the development of the railway and public road system. Both the features of the terrain and the direction of riverbeds lead to the underdevelopment of the north-west directed connections.

Considering the railway system, the problems are posed by the large number of dead-end lines and the significant multiple network distances existing between the railway connections as compared to the ideal bee-line distance. Topological problems are further worsened by the high degree of wear-out in respect of the railway infrastructure. The appearance of private capital had a vitalizing effect on railway services – this is what kept train service alive on several side lines. Despite the expected improvements on the TEN-R network of the railway system, railway transport still has to deal with a difficult situation.

The acutest problem of the region's public road system is represented by the lack of expressways and the high ratio of non-asphalt roads. The expressways designed in the region will result in the development of the public road connections between the most important towns of the region, on the one hand, and they will also entail the modification of these town's catchment areas by travel time, on the other. However, the construction of the expressways cannot serve as a remedy for the settlements and areas exposed to unfavourable accessibility conditions. Considering public road accessibility, the most disadvantageous situation is due to the settlements situated in the north-east as well as the western mountainous area of the region.

Everything points to the fact that road and air traffic will continually show a growing tendency. The new international airport under construction at Ghimbav will cause a serious re-arrangement on the regional air transport market, which will eventually heat up market competition among the airports. Owing to the new airport, the accessibility of Braşov, Covasna, and Harghita counties to air traffic services will undergo an essential improvement.

Presently, we can hardly demonstrate any serious effects that public road accessibility has on the settlements' development level. Due to indirect influences, transport system may be considered one of the key components of economic development, which gives grounds for the development of the transport infrastructure and the transport services alike.

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