MICRO-SCALE GEOSTATISTICAL ANALYSIS OF THE LEVEL OF DEVELOPMENT. CASE STUDY: MOUNTAINOUS AND SUB-CARPATHIAN AREA OF IALOMIȚA HYDROGRAPHIC BASIN

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ABSTRACT:

Researches concerning territorial differentiation of the level of development usually focus on the macro-scale (counties and regions). This study employs similar analyses at the micro-scale level using administrative-territorial units, i.e. circa 40 communes covering the mountainous and sub-Carpathian space of an average sized hydrographic basin. The algorithm uses data consisting of selected indicators referring to the density of population, its dynamics and migratory increase, population aged over 65, natality, unemployment, share of population working in agriculture, number of people who completed high school education, the number of physicians per 1000 people, and inhabited area per person (square meters). Data are analyzed using factor analysis to build an aggregated index of development. Consequently, spatial prediction via ordinary kriging is used to determine its spatial distribution. The results indicate that there are two 'rich' zones, one in the mountainous region and another adjacent to the plain area, while the poorer ones range in between. Their spatial distribution is perturbed by major communication routes and differentiated accessibility.

Keywords: *factor analysis, kriging, GIS, index of development, modeling.*

1. INTRODUCTION

The analysis of micro-scale level of development represented a challenge for the scientific community, provided the lack of consistency of the indicators utilized. In order to implement the intra-regional policies of development, one must know the territorial variation of the level of development. Large gaps between the elementary reference units (communes) and especially the low overall level of development determine the orientation of macro- and mezzo-level policies to the local ones, where in fact interventions are made.

Starting from the idea phrased in the middle of the previous century by *Paul Rosenstein-Rodan (1943)*, regarding the launch of local economies by what he called then "big push", and the application of Francois Perroux's theory of growth poles (1955) at this scale, one could find methods to be used for diminishing the time needed to reduce the gaps. Therefore, conceiving territorial development at this level as a succession of imbalances (*Hirschman, 1958*), where non-economic activities play an important role in addition to the economic ones (*Myrdal, 1963*), the change could occur due to a cumulative and causal process through oriented sectoral and global policies (*Ianoş, 2010*).

The current European vision, expressed explicitly in the Hanover European Conference (2000) and the Ljubljana meeting of European spatial planning ministries (2003), as well as the ESPON programs, clarified sustainable spatial development in Europe; this is particularly noticeable at the macro-scale and to a lesser extent at local and supra-local

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levels. Moreover, the European vision has shaped a spatial dimension of sustainable development, the sustainable spatial development, defined as "development providing for a territorial balance of economic, social and ecological needs of present and future generations at the same rate" (*Petrişor, 2008*).

Opposing the continental or national vision, more in-depth knowledge of lower levels is needed, as the local development could diminish the effect of generalizing macro-scale averages on territorial development. Our option for a methodological approach at this scale aims to prove two hypotheses; firstly, that the general macro-scale methodology can be adapted and used at the micro-scale, and second, that the indicators existing in the detailed statistics provide valuable information, able to substantiate intra-regional policies of development.

The additional pillars of development (social, ecological and spatial) determine a particular need for using specific indicators to measure the achievement of development goals in general and in different territorial units in particular. Researches concerning territorial differentiation of the level of development usually focus on the macro-scale (counties and regions). In addition to the simple indicators, aggregated indices are computed based on arithmetic operations applied to the individual indices, according to the statistical principle enounced by Paul Benzecri: giving up some information for a gain in relevance (*Dragomirescu and Drane, 2009*).

One of the most commonly utilized methodologies is based on the utilization of Geographical Information Systems (GIS), defined as "decision support system involving the integration of spatially referenced data in a problem solving environment" (*Cowen, 1988*). However, the use of GIS can be strengthened if used in conjunction with statistical procedures (*Tache et al., 2010*).

This aim of this study was to utilize a similar methodology for micro-scale level analyses of administrative-territorial units, i.e. circa 40 communes covering the mountainous and sub-Carpathian space of an average sized hydrographic basin, in an attempt to identify the most relevant indicator of development, even artificially built, and map its spatial distribution.

2. METHODOLOGY

Based on the geographical location in the mountainous and sub-Carpathian space of the Ialomița river basin, 36 base administrative units (communes and cities) of Dâmbovița County were selected. The corresponding database contained records on fifteen indicators: (1) total population, (2) resident population, (3) livable area per inhabitant, (4) incoming migration, (5) outgoing migration, (6) number of people with a TV set, (7) number of pharmacies, (8) number of physicians, (9) population employed in the industry, (10) total number of employed people, (11) total number of unemployed people, (12) population employed in the agriculture, (13) active population, (14) population age 65 and over, and (15) number of high school graduates.

The first step consisted of using factor analysis based on principal components extraction in SPSS to identify the most important indicators: the number of high school graduates and the population employed in agriculture. Based on the weights computed by the software ratioed to 100% (82%, respectively 18%), an aggregated index was built based on the indicators identified in the first step. Subsequently, the spatial distribution of the raw values of the indicator was analyzed in the 36 administrative units, by mapping it in ArcView, version 3.X.

The next step consisted of reducing each polygonal surface corresponding to the administrative limits of the territorial units to their centers using the X-Tools extension of ArcView, version 3.X. Ordinary kriging, a interpolation technique assuming that the spatial distribution of a variable depends only on the location of sampling stations (*Johnston et al., 2001*), was performed using the Geostatistical Analyst extension of ArcGIS to interpolate the centers based on the value of the previously built indicator.

3. RESULTS AND DISCUSSIONS

The results of factor analysis based on the extraction of principal components are displayed in **Table 1** and **Table 2** below.

Table 1. ***Results of factor analysis based on the extraction of principal components used to identify the most relevant indicators accounting for the overall level of development in the base administrative units of Dâmbovița County located in the mountainous and sub-Carpathian space of the Ialomița river basin***

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %
1	10.385	69.231	69.231	10.385	69.231	69.231
2	1.245	8.298	77.529	1.245	8.298	77.529
3	1.061	7.071	84.600	1.061	7.071	84.600
4	0.717	4.783	89.383			
5	0.589	3.924	93.307			
6	0.394	2.628	95.935			
7	0.311	2.071	98.007			
8	0.132	0.882	98.889			
9	0.066	0.439	99.327			
10	0.048	0.321	99.648			
11	0.031	0.204	99.852			
12	0.019	0.125	99.977			
13	0.003	0.020	99.997			
14	0.000	0.003	100.000			
15	0.000	0.000	100.000			

Table 1 presents the process of identifying the principal components based on the total variance explained. The results indicate that three components account together for 84.6% of the spatial variation of the 15 indicators. To identify the actual indicators corresponding to them, **Table 2** displays the correlations between each indicator and the three components identified before; the components correspond to the indicators with which they have the strongest correlation.

The results indicate that two variables, the number of high school graduates and the population employed in agriculture, account for 84.6% of the total variation. The first one explains 69.2% of the variation, and the second, 15.4% of it.

In order to build an aggregated index, the weights have to be ratioed to 100% instead of 84.6%. Consequently, the new weights are 82%, respectively 18%. Therefore, the aggregated index is simply 0.82 × the number of high school graduates + 0.18 × the population employed in agriculture. The spatial distribution of the aggregated index is displayed in **Fig. 1**, and the distribution of its interpolated values using ordinary kriging in **Fig. 2**.

Table 2. ***Correlations between the principal components and indicators used to identify the most relevant indicators accounting for the overall level of development in the base administrative units of Dâmbovița County located in the mountainous and sub-Carpathian space of the Ialomița river basin. The gray shading identifies the strongest correlation between each component and the indicators***

Variable	Component		
	1	2	3
Total population	0.938	-0.058	0.070
Resident population	0.937	-0.059	0.074
Livable area per inhabitant	0.940	-0.055	0.087
Migrations in	0.630	-0.322	0.420
Migration out	0.701	-0.337	0.089
Number of people with a TV set	0.911	-0.136	0.133
Number of pharmacies	0.825	0.041	-0.211
Number of physicians	0.874	0.016	-0.177
Population employed in the industry	0.892	0.225	-0.220
Total number of employed people	0.937	0.253	-0.169
Total number of unemployed people	0.884	0.256	-0.295
Population employed in the agriculture	-0.089	0.707	0.681
Active population	0.875	0.460	0.026
Population age 65 and over	0.663	-0.294	0.361
Number of high school graduates	0.959	-0.138	0.081

Regardless of the methodology utilized, all maps suggest that there are two 'rich' zones, one situated in the mountainous region and another adjacent to the plain area, while the poorer ones range in between. Slight differences based on the methodological approach refer to the size and overall level of development of these areas. Their spatial distribution is also perturbed by major communication routes and differentiated accessibility.

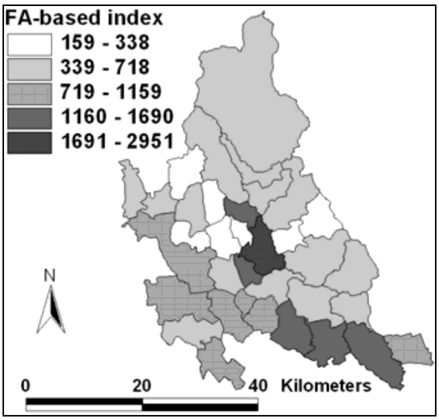

Fig. 1 Showing the spatial distribution of the general index of development derived using factor analysis in the base administrative units of Dâmbovița County located in the mountainous and sub-Carpathian space of the Ialomița river basin

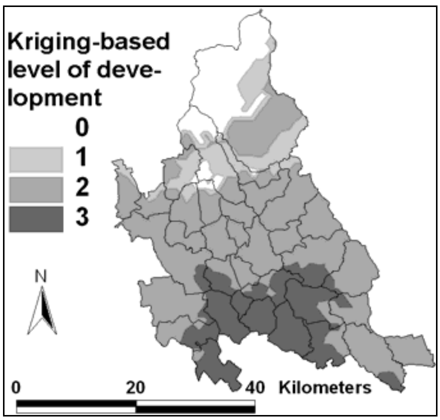

Fig. 2 Displaying an ordinary kriging interpolation of the values of the general index of development derived using factor analysis in the base administrative units of Dâmbovița County located in the mountainous and sub-Carpathian space of the Ialomița river basin

4. CONCLUSIONS

The study using a representative sample of communes, constituting altogether a varied space, prove that the geostatistical analyses are relevant at the smallest level. Thus, the influence of the major structuring axis represented by communication routes and Ialomița River is crucial, since most settlements close to it exhibit higher levels of development. The anomalies are due to the small local influences of small cities (Fieni and Pucioasa). The map obtained using ordinary kriging underlines the influence of Târgovişte city, situated in the south of the studied area (note the concentration of high values in the southern part).

The analysis validates the hypothesis according to which the methodologies used at the macro-scale level can be used at the micro-scale too, even without major adjustments. Moreover, the methodology is relevant for individualizing the levels of development, allowing for predictions on long term spatial development. Even though there are doubts concerning the relevance of the indicators utilized, the results confirm that they express the territorial reality.

REFERENCES

Cowen D. J., (1988), *GIS versus CAD versus DBMS: What Are the Differences?*, Photogrammetric Engineering and Remote Sensing 54, pp. 1551-1555.

DG Regional Policy, (2004), *Third Interim Territorial Cohesion Report (Preliminary results of ESPON and EU Commission studies)*, Office for Official Publications of the European Communities, Luxemburg, pp. 3.

Dragomirescu L., Drane J. W., (2009), *Biostatisticcs for dummies*, Vol. I. Descriptive biostatistics, 6th revised edition, Editura CREDIS, Bucharest, Romania.

Hirschman A., (1958), *The strategy of Economic Development*, Yale University Press, New Haven, CT.

Ianoş I., (2010), *Spatial pattern of the regional uneven development. Romania as case study*, Revista Română de Geografie Politică 12(1), pp. 5-14.

Johnston K., Ver Hoef J. M., Krivoruchko K., Lucas N., (2001), *Using ArcGIS Geostatistical Analyst*, ESRI Press, Redlands, CA, pp. 138.

Myrdal G., (1963), *Economic Theory and Underdeveloped Regions*, Harper and Row, New York.

Nordic Centre for Spatial Development, (2005), *ESPON 1.1.1. Potentials for polycentric development*. Final Report, NORDREGIO, Sweden, pp. 3.

Perroux F., (1955), *Note sur la notion de pole de croissance*, Economie appliquée, 8, pp. 307-320.

Petrişor A.-I., (2008), *Towards a definition of sustainable spatial development* [in Romanian], Amenajarea Teritoriului şi Urbanismul 7(3-4), pp. 1-5.

Rosenstein-Rodan P., (1943), *Problems of Industrialization of Eastern and South-Eastern Europe*, Economic Journal 53, pp. 205-216.

Tache A., Tache M., Petrişor A.-I., Manole S. D., Pârvu E., (2010), *Geospatial systems for sustainable development in Romania*, Editura CREDIS, Bucharest, Romania.