S T U D I A G E O G R A P H I C A 7 4

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III

LANDSCAPE STRUCTURE MEASUREMENT: ON EXAMPLE OF AREA IN PART OF LIPTOV

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III-l INTRODUCTION

The aim of this work is to employ mathematical description of the landscape structures of the part of Liptov together with their physico-geographic and socioeconomic parts. We will concern ourselves mainly with establishing the main territorial features, their quantification, but also regionalization of the research region within two periods of time (the year 1961 and 1976).

In the model territory, which takes part of the Liptov basin between Ružomberok and Liptovský Mikuláš and reaches also to fringe parts of Choc mountains and Low Tatras, there exist on one hand relatively stable natural complexes of forests (Choc mountains and Low Tatras) and on the other there are rapidly changing regions of the basin's bottom where was also created the river dam called Liptovská Mara. The construction network, settlement structure, power distribution network and further interventions. If we compare land use in the year of 1961 to the year 1976 we can conclude that also from this point of view there came to an extensive change mainly of the northern part of the experimental territory, where under the influence of reorienting agriculture towards the meat production, large areas of arable land were changed to pastures.

III-2 INPUT DATA AND WORK TECHNIQUE

In order to be able to measure and compare basic spatial components we divided the territory into equal geometric shapes. We chose squares with their side measuring 1 km. The research territory is 18 km long and 8 km wide, that is, its area represents 144 km^2. We have obtained input data for territorial units depicted at outline, informative map (Fig.III-1). With regard to the fact that we attempted simultaneous comparison of two periods of time, years 1961 and 1976 we had to limit ourselves to such a data which could be obtained for both years.

The following parameters were considered:

P 1 - Temperature sum for periods above 10°C (1931 - 1960)
P 2 - Length of snow cover (1931 - 1960)
P 3.- Average precipitation sum in mm (1931 - 1960)
P 4 - Average January temperature in °C (1931 - 1960)
P 5 - Average number of foggy days per year (1951 - 1960)
P 6.- Dolomites and dolomitic limes (area)
P 7- Chemically impure limestone’s and whinstone’s (area)
P 8- Travertine’s (area)
P 9- Sandstone - clays late colayers of t he central-carpathian paleogene (area)
P 10- Clay slate series of the central - Carpathian palaeogene (area)
P 11- Slope and loess clay (area)
P 12- Riverines sediments (area)
P 13- Terrace sediments (area)
P]4- Coefficient of mineral substrate strength
P 15 - Coefficient of substrate permeability
P 16- Maximum altitude above the sea level (in m)
P 17- Minimum altitude above the sea level (in m)
P 18- Relative altitude segmentation (in m)
P 19- Medium altitude; above the sea level (median in m)
P 20- Medium slope angle (in degrees)
P 2]- Length of water flows (in km)
P 22- Wood (area)
P 23- The share of conifers from the total wood area (%)
P 24- The share of foliates from the total wood area (%)
P 25- Meadows (area)

P 26- Pastures (area)
P 27 - Arable land (area)
P 28 - Built-up area
P 29 - Water area
P 30 - Number of bus stops
P 31 - Employement in production branches
P 32 - Employement in non-production branches
P 33 - Lenght of railroads
P 34 - Lenght of the 4th category roads
P 35 - Bus routes loading
P 36 - Number of bus courses
P 37 - Lenght of the 1st to 3rd category roads
P 38 - Lenght of bus routes
P 39 - Lengt of the high voltage electricity distribution networks
P 40 - Number of inhabitants
P 41 - Number of houses
P 42 - Facilities

B choosing the above mentioned data we wanted to present an uniform description of the physico-geographic and socioeconomic components of the landscape. The physico-geographic parameters represent all the basic components of the physico-geographic sphere such as the climate, relief (landscape), waters and biocomponent. The parameters P 14 and P 15, coefficient of mineral strenght, or else coefficient of mineral permeability, are specifix. The coefficient of the substrate mineral strenght;, representing actually its bioenergetic potential is an indicator of the substrate's quality with respect to biocomponent. Thus, it indirectly characterizes also the pedocomponent of the country. The technique of substrate mineral stranght coefficient preparation was taken over from the work by J. Stejskal (1974). Percentage representation of the four main mineral nutritives (CaO, K_2O, MgO) needed for the calculation of the index (coefficient) of substrate mineral strenght was obtained by analysis of the individual substrate picked up m the terraine complemented by some published results of substrate analysis from this territory. The substrate permeability coefficient characterizes permeability of the watered- up layers and the underground water circulation. The data were applied from the work by A. Porubsky (1977) with complementing the author at some specific substrates of the model territory. The characteristic of every territorial unit in accordance with the mineral strenght coefficient or permeability corresponds with the type or combination of types of substrate found within the territorial unit. In case, the whole area is filled by one type of substrate, the mineral strenght coefficient (permeability) is determined unequivocally by the corresponding value of its own. If there are more substrate types with differing values of the mineral strenght (permeability) coefficients within the territorial unit,, then the coefficient value of the territorial unit is calculated by the weighed substrate value averages according to their areal configuration. The areal parameters were evaluated planimetrically.

The parameter choice of the socioeconomic sphere was limited, as mentioned above, by their accessibility over both investigated years 1961 and 1976.

The principal component analysis appears to be a good method for setting the multi-variant group dimension. It was not possible to use the program for a complete component scheme solving, since the solving for correlation matrix of the 42x42 type would require approximately 28 kilobites and the WANG 2200 computer installed at the Geographic Institute SAV possesses only 20 kilobites. Therefore, we used the gradual component separation method. The basis criterion limiting the number of main components is the eigenvalue equal to one. Therefore, we did include into the analysis all the components whose eigenvalue exceeded one. The component system was rotated by the varimax method. In order to calculate the standardized component score we used the accepted way used in the R - technique of the component, or else factor analysis.

The second data processing stage was realized by a regionalisation approach similar to the numerically - taxonomic technique of the complete linkage analysis (R. Abler, J. S. Adams, P. Gould, 1972, p.158-163). In order to determine the taxonomies distance of two areal units A and B when regionalizing we used the relationship:

$$D_{AB} = \frac{1}{K} \sum_{i=1}^{K} \text{ABS}\,(X_{Ai} - X_{Bi})$$

Where

D_{AB} = taxonomic distance of areal units A and B

K = number of components

X_{Ai}, X_{Bi} = standardized component score of the areal unit A,B in the i's component.

If the D_{AB} value equals zero then the areal unit A structure equals the structure of areal unit B. The bigger the taxonomic distance D_{AB}, the biggers is also the difference between areal unit structures A and B. The numerically - taxonomic grouping is most oftenly depicted by the aid of a dendrogram. Such a graph can readily submit information concerning the class composition (in our case that of regions) at various levels of the whole group categorizing.

In order to determine the main region signs we did calculate the mean square of Euclidian distance for the aggregated groups of areal units also the appropriate component score from the component coordinate system center which does represent the average properties regarded from the aspect of all the chosen parameters. The bigger is such a distance coefficient, the more specialized becomes the region structure (in tables depicted by the symbol T^2). We have used this property of component space in order to describe the dynamics of region structure changes (to balanced, or else special). By placing the coordinate system center from the year 1961 into the coordinate system center from the year 1976 we can obtain a target graph. In order to be able to compare the development by such a manner we had to aggregate some regions into higher regional entities in such a way as to keep them equal for the years 1961 and 1976.

III-3 CORRELATION ANALYSIS

It sould be possible to ponder, in this part, each and every one of the various 861 correlation coefficients. We will limit ourselves however, only to main correlation matrix features (Tab. III-l, III-2) calculated for both periods.

If we divide the correlation matrices to sectors in accordance with the nature of parameters we find that, there do exist strong correlations within the climatic sector parameters (P 1 - P 5) and also within the morphometric sector parameters (P 1G - P 20) just as well as between the both sectors. Thus, the strong causative relationship between parameters of both sectors in being confirmed, that is with the above the sea altitude increase and increase of the absolute altitude differences there quickly change also the climatic conditions. Correlation coefficients within the sector of socioeconomic parameters (P 27 - P 42) to which also the parameter P 21 (length of waterways) can be added are worth of noticing. This fact confirms that the socioeconomic activities are concentrated in the model region along water-ways and positive values of all correlation coefficients within this sector of parameters rent to show that all the socioeconomic parameters are in effect or are not simultaneously in regional units.

The source of knowledge regarding changes in model territory can be represented by the comparison analysis of correlation matrices for years 1961 and 1976. Therefore, it is necessary to pay attention to the P 26 (pasture area) parameters because of the above mentioned aspect. The same goes for the P 27 (arable land area) parameter. These parameters had the most changed distribution as mentioned in the introductory notices. When comparing the correlation parameters P 26 and P 27 to other parameters it comes out that the most pronounced changes of the arable land to pastures occurred in the warmer regions of the territory upon sandstone - clayslate layer systems.

III-4 PRINCIPAL COMPONENT ANALYSIS

The principal components separated from correlation matrices calculated for the years 1961 and 1976 represent main dimensions of the model territory structure. On the basis of magnitude and weight orientation in the rotated component matrix (Table III-3, III-4) we interpreted the individual components (Table III-5, III-6).

TAB. III - 3 MATICA HLAVNÝCH KOMPONENT ROK 1961

	KMP1	KMP2	KMP3	KMP4	KMP5	KMP6	KMP7	KMP8	KMP9	KMP10	h^2
P 1	-0,915										0,931
P 2	0,911										0,908
P 3	0,939										0,934
P 4	-0,939										0,944
P 5	0,926										0,919
P 6	0,234					0,746					0,650
P 7	0,873						0,205				0,873
P 8					0,208				0,763		0,744
P 9	-0,435		-0,309	-0,648			-0,307				0,880
P 10	-0,374			0,764			-0,209				0,829
P 11	-0,364	0,223			0,221		-0,326	-0,215		0,397	0,570
P 12	-0,320	0,289	0,839								0,914
P 13	-0,477			0,317			0,610				0,771
P 14	0,305						0,826				0,869
P l 5	-0,306		0,891								0,936
P 16	0,932										0,973
P 17	0,884		-0,200								0,881
P 18	0,860					0,256					0,896
P 19	0,937		-0,200								0,972
P 20	0,868					0,258					0,910
P 21		0,352	0,423			-0,304				0,483	0,714
P 22	0,873	-0,207				0,283					0,939
P 23	0,317			-0,638							0,616
P 24	0,345					0,602					0,533
P 25	-0,334					-0,486		-0,529			0,720
P 26							-0,238	0,830			0,854
P 27	-0,786	0,210						-0,307			0,859
P 28	-0,236	0,924									0,947
P 29			0,854						-0,236		0,862
P 30	-0,246	0,722	0,271		0,317						0,792
P 31					0,759				0,278		0,757
P 32		0,719			-0,244				0,298		0,702
P 33			0,710						0,554		0,849
P 34	-0,440									0,728	0,765
P 35	-0,333	0,563	0,423		0,442						0,850
P 36	-0,358	0,546	0,531		0,245						0,809
P 37	-0,286	0,773	0,348		0,239						0,896
P 38	-0,309	0,468	0,567		0,414				-0,255		0,383
P 39	-0,518	0,247	0,274		0,283			-0,313			0,647
P 40		0,936									0,948
P 41		0,926									0,931
P 42		0,760			0,336						0,781
∑	13,06	6,52	4,55	1,81	1,68	1,66	1,57	1,45	1,45	1,18	34,98
XDSP	31,10	15,52	10,85	4,31	4,00	3,95	3,75	3,46	3,45	2,82	83,28

KMP =KOMF'ONENTA
h^2 =KOMUNALITA
E1G =HLAVNA HODNOTA
XDSP =PERCENTO DISPERZIE
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III – 4 MATICA. HLAVNÝCH KOMPONENT ROK 1976

	KMP1	KMP2	KMP3	KMP4	KMP5	KMP6	KMP7	KMP8	KMP9	h^2
P 1	-0,916									0,923
P 2	0,916									0,905
P 3	0,943									0,924
P 4	-0,936									0,940
P 5	0,926									0,914
P 6	0,275							0,804		0,746
P 7	0,868									0,879
P 8						0,764				0,655
P 9	-0,426		-0,235		-0,676				-0,250	0,800
P 10	-0,393		-0,203		0,604		-0,421			0,769
P 11	-0,391					0,307	-0,298			0,390
P 12	-0,333	0,323	0,778							0,893
P 13	-0,477				0,504		0,518			0,804
P 14	0,324	0,224					0,804			0,827
P l 5	-0,322		0,834							0,909
P 16	0,944									0,969
P 17	0,881									0,877
P 18	0,882							0,209		0,895
P 19	0,946									0,967
P 20	0,886							0,204		0,907
P 21		0,357						-0,251	0,683	0,737
P 22	0,888							0,244		0,933
P 23	0,306				-0,584		0,254			0,582
P 24	0,499							0,561		0,594
P 25	- 0,421						-0,354	-0,354		0,467
P 26	0,422				-0,643					0,671
P 27	-0,651				0,523					0,774
P 28	- 0,281	0,908								0,926
P 29			0,781							0,736
P 30	-0,210	0,650		0,427						0,707
P 31		0,276		0,309		0, 553			-0,276	0,601
P 32		0,781		- 0,266						0,709
P 33	- 0,247		0,408			0,588			0,245	0,694
P 34	- 0,399		-0,429						0,535	0,668
P 35	-0,369	0,442		0,714						0,876
P 36	-0,401	0,475	0,254	0,595						0,845
P 37	-0,342	0,658		0,522						0,852
P 38	-0,332	0,359		0,768						0,887
P 39	-0,471	0,201		0,204		0,338			-0,234	0,503
P 40		0,942								0,942
P 41	-0,201	0,945								0,947
P 42	-0,203	0,818				0,241				0,814
∑	13,50	6,14	2, 72	2,46	2,31	1,77	1,62	1,51	1,30	33,37
XDSP	32,14	14,63	6,48	5,86	5,52	4,23	3,86	3,60	3,11	79,47

KMP =KOMF'ONENTA
h^2 =KOMUNALITA
E1G =HLAVNA HODNOTA
XDSP =PERCENTO DISPERZIE
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TABLE III-5 INTERPRETATION SCHEME OF ROTATED PRINCIPAL COMPONENTS

Year 1961

Comp.	Characteristic	eigenvalue	% disp
1	Territory segmentation	13,06	31,10
2	Socioeconomic activity	6,52	15,52
3	Flood plains and fundamental communications	4,55	10,85
4	Clayslate layer systems	1,81	4,31
5	Employement in production branches	1,68	4,00
6	Limestones and dolomites with foliage wood	1,66	3,95
7	Terrase sediments rich in minerals	1,57	3,75
8	Pastures	1,45	3,46
9	Travertines and railroads	1,45	3,45
10	Intensive land use and the length of waterways	1,18	2,82
x	Sum	34,98	83,28

TABLE III-6 INTERPRETATION SCHEME OF ROTATED PRINCIPAL COMPONENTS
Year 1976

Comp.	Characteristic	eigenvalue	% disp
1	Territory segmentation	13,50	32,14
2	Socioeconomic activity	6,14	14,63
3	Flood plains	2,72	6,48
4	Road communications	2,46	5,86
5	Clayslate layer systems and terraces	2,31	5,52
6	Travertines and railroads	1,77	4,23
7	Terrase sediments rich in minerals	1,62	3,86
8	Limestones and dolomites with foliage wood	1,51	3,60
9	Lenght of waterways and in-tensive land exploitation	1,30	3,11
x	Sum	33,37	79,47

The interpretation of obtained components was only symbolic before the rotation (according to the largest component loading), since it was not possible to find integral naming for component bound parameters. The component matrices are easier interpreted after the rotation. The individual components are caal through the component score upon the actual model territory. The Eig. III-2 to III-20 contain the component score drawn by the both mentioned years. As it comes out from the component loading tables as well as the interpretation scheme it is evident that some main territorial structure dimension have charged. The component number did also change. As far as the first: two components are concerned there did not happen pronounced parameter loading changes as well as change of their overall dispersal. The component No.3 from the year 1961 did change. The main communications did pass through the Vah riverine in this period of time. Since, there
has been built the water dam Liptovská Mara the main communications had to be replaced. This lead to lowering of the quantitative (correlation) bind between these parameters and tin; whole scheme of principal competent became discrupted (correlation coefficients P 12 . P 37 for the year 1961 = 0,59 and for the year 1976 = 0,48). The correlations binds amongst. the parameters of bus transportation intensity which also signify main communications did change too.
The second serious territorial change which is evident also from the component matrices is the change in distribution and quantity of pastures (this dimension does not appear in the year of 1970). This is resulting from such a pasture dispersal in the year of 1961 as to not exhibit the force of coherence to tha geologic underneath (substrate) and thus appear as an independent spatial component. However, the situation did change to the year of 1976. The orientation of agriculture to the production of meat did cause changes in land exploitation. Arable land did change to a large extent to pastures due to properties of sloping and erosion prome sandstone - clayslate layer systems in the northern part of the valley territory. The pasture; component did disappear because of this reason and was incorporated in the year of 1976 into the No.5 component (equal component loading orientation with the sandstone - clayslate layer systems). Also the component: No.5 from the year 1961 did disappear because of the overall dicreasc of employments within the production branches of the investigated territory.

III-5 REGIONAL CLUSTERING

Regional clustering procedure is depicted by the dendrogram form for the both followed years. Before the clustering every territorial unit can be understood as an individual region. If we will divide the territory, we will obtain after the firs, grouping 122 regions for the year 1961 and 114 regions for the year 1976. The division after the third clustering appeared to us as the most optimal since we obtained 25 regions in both the cases. They did rather well characterize; the spatial differentiation. The are depicted by capital lettering at the; dendrograms and overall region map. Subregions were obtained by dividing the territory after the second grouping. They are marked by numbers.
Based upon the previous region division comparisons in the year 1961 and 1976 it comes out that: the territory was more homogenous in the year 1976 than in the year 1961. This will be confirmed also by the table of clustering indices calculated according to Š. Poláčik (1977) from dendrogram (Table III-7).

Table III-7 Index of clustering

Degree of clustering	Year 1961		Year 1976	
	Absolute	relative	absolute	relative
1	41	0,4	55	0,5
2	408	3,9	835	8,1
3	2795	27,1	3414	33,1
4	4302	41,8	4464	43,3
5	9454	91,8	9871	95, 9
6	10296	100,0	10296	100,0

from the indices of clustering it is evident that there is at every aggregation level always a bigger number of grouped together territorial units in the year of 1976 than in the year of 1961.
When looking at the gradual division from the above, that is from the model territory as a whole, we can see which territorial units differ the most from their surroundings, from the dendrogram depicting the gradual territory division also from the above it is evident that an explicitly specialized structure is exhibited by the territorial unit 7,2, that is the region V in the year of 1961 and Z in the year of 1976 we will label it as V (61), Z (76). Similarly, the mutual regions T and U (61) , X and Y (76) did keep extremely special structures. Whereas the regions X,Y,Z (61) did "become close" with their respective surroundings when aggregating already at lower levels in the year of 1976, L.G., Y (61) as C (76) and Z (61) as I (76) already at the fourth level, or else X (61) as V (76) at the fifth one. There were calculated specific signs (Tables III-8 and III.-9) for every one of the 25 regions. By their use and also by accounting for the basic series of 42 parameters and principal component matrices we can characterize regions
(Tables III-3, I1I-4).
Coefficients T^2 are contained in principal region sign tables described quantitatively. High specialty have in both years regions T (61) - X (76), U (61) - Y (76), V (61) - Z (76) and Y (61) - C (76). Those are the territorial units characterized by socioeconomic parameters. On the other hand, regions J (61) - N (76), A (61), E (61), F (61), A (76), B (76), G (76) either do not, posses specific signs or are characterized by largely physico- geographic parameters. Since, they are the most closely placed near the center of component coordinate system they can be considered as the most representative regional units of the whole territory.

III-6 CHANGES IN TIIL STRUCTURE 0F LANDSCAPE

In order to depict regional changes we utilized the properties of the center of the space of components. By placing the centre of the space of components in the year of 1961 into the one from the year 1976 we obtained graph (Eig.III-22) which is divided into 4 sectors. There, by its use we can identify regions (or their sums) which are stable, or dynamic. According to the development direction of their structures we cen divide them into such which are developing towards special structures or to such which are characterized by parameters of the whole model territory.
Amongst stable regions there do exist only two sums of regions which are developing towards a biased (average) structure. This is mainly due to changes in land utilization. Bigger changes towards a balanced structure can be found in some regions which were expressively socioeconomic as V (61) - Z (76), Y (61) - C (76), M (61) - K (76). This reality is due to lowering of the rate of employment within the productive branches especially in the mentioned region. Reverse changes, towards special structures were directly or indirectly caused by the river dam Liptovská Mara construction. These parts of the model territory exhibit the highest reconstruction rate. Arable land, built-up areas were changed to water areas. Also the communication network, electricity distribution network etc. were changed.
Considering stable regions /placed in the right upper quadrant of the target graph), the distance from the component coordinate system center did change only a little (less than 0,5). Those are largely regions from the southern part of the model territory which were not too much influenced by the water river dam construction.

year 1961

REGIÓN	KOMP.1	KOMP.2	KOMP.3	KOMP.4	KOMP.5	KOMP.6	KOMP.7	KOMP.8	KOMP.9	KOMP.10	T^2
A	1,9521					1,3223					0,6452
B							-1,0924				0,8424
C	1,5917	1,2286		-1,1364						2,0804	1,7602
D	-1,5948			-1, 1984		3,5675	-1,0225			-1,1450	2,0095
E				-1,3162							0,6594
F	1,5411										0,6651
G		-1,1724	2,3985							1,1812	2,4769
H				1,3241							0,7819
I		2,1336			-1, 1253		1,4842			-1,3059	3,5496
J				-1,0841							0,4452
K				1,4519						-1,1073	0,7453
L				1,3981			1,6280				1,7380
M					1,2668	-1,9122	1,6127	2,6803			2,9220
N		1,3849		1,2102			1,1829			-1,0558	2,0211
O	-1,7085									2,1208	1,0295
P			1,8971						-1,1765		1,7730
Q			2,2562								2,0250
R					1,6160					1,3203	1,9551
S				1,0088			1,2923	-1,1416		-1,3139	1,5339
T					1,0968				3,0383		5,6067
U			1,0064	1,3087			-1,3088		2,3734		3,9223
Y				-1,5727	3,2004						5,7226
X			1,1720	-1,0535		-1,2896		-1,6715	1,6852		2,8917
Y	2,2368	2,2217	-1,1013		-1,1500			2,5917	1,2524		5,1021
Z		1,5416			-1,2374		1,0837				2,6198

year 1976

REGIÓN	KOMP.1	KOMP.2	KOMP.3	KOMP.4	KOMP.5	KOMP.6	KOMP.7	KOMP.8	KOMP.9	T^2
A	1,4331							1,3444		0,6482
B										0,8108
C	2,4954	1,8312		-1,5076	-1,2088			1,2989	1,373	3,6907
D							-1,3212	-2,4846	-1,1231	1,1556
E			1,1277						-1,3675	1,5733
F			1,0334		-1,3057				-1,045	1,5708
F	1,6294									0,7257
H			-1,0148	1,0087						1,1029
I	-1,0472	1,7453		-1,153	1,198					2,9103
J	-1,395				1,9155		1,2265			1,7436
K							1,7437	-2,5819		1,1802
L					1,S801			-1,3839		1,03
H							-2,2032			1,2717
H	-1,4003	-1,1177			-1,3306					0,541
O	-1,8021	-1,1908					1,0819			1,5721
P		2,4831		-1,491			1,2312			4,3594
0				1,7873	1,1092		1,0844		-1,0369	1,8711
R		1,3294			1,4528					2,1611
S			1,5747	1,2608					2,097	2,8393
T				1,8244				1,1647	1,2647	2,1293
U			3,1691			-1,112				4,5363
V						1,1208			1,1459	1,6584
X						2,9282			-1,0103	5,8086
Y						2,381	-1,356		1,1092	4,2867
Z				1,9459	-1,2281	1,028			-2,0295	4,0931