12. Spatial structures and functional organization of Belgrade

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The study of the structural and functional organisation of Belgrade, in this chapter, has been limited on the territory of the General Plan (GP). The decision was made by taking into consideration the qualitative information basis of the space defined in such a way – the relative accessibility of the documentary, statistical and cartographic materials. The detailed urban study means gathering information and their studying on the level of small territorial units - statistical circles (total 434). The basis of the chapter represents the approach which is similar to the factor ecology. The usage of the quantitative methods in the studies of the urban structures we have considered justified, among others, because the influence of the social theory on the so-called post modern urban literature was too fast in emphasizing the contemporary socio-cultural changes, disregarding the stability that could be present in the spatial structure of the city (Danielson & Wolpert, 1994). Even though the urban theory tends to be removed from the spatial determinism, the numerous researches point to the steadiness of the spatial forms, originated in the link with the previous processes of urbanisation (Wyly, 1999). Additionally, just when the dynamic development of the information technology and GIS enable the promotion of the mathematical-statistical and cartographic methods, the rejection of the positive results acquired using factor ecology, seems absurd. The indexes which exceed the sphere of the traditional factor ecology have been used in the chapter. The traffic-functional organisation of the city, expressed through the indexes of the accessibility of place of work and place of residence, has been taken as a relevant input parameter, which is partly or completely disregarded in the researches of the similar character. Moreover, the contemporary local indexes of isolation have been used as relevant factors (Ratkaj, 2007a). The method of the factor analysis, in most of the urban studies, is exclusively applied with the aim of determining the factors that act within the frames of the social structures. This deficiency has been overcame by the systematic inclusion of the physical structure of the city. Moreover, the use of different methods of the multi-variation analysis could also advance the traditional comprehension of the urban ecology.

12.1. Factor analysis of Belgrade

Most variables, necessary for the application of the factor analysis in the area of the General Plan of Belgrade, on the level of the statistical circles, were derived by a special analysis of the results of 2002 census (Statistical Office of the Republic of Serbia, 2002). In the factor ecology the census data have usually been used (e.g.: Murdie, 1969; Knox, 1987; Le Bourdais & Beaudry, 1988; Wyly, 1999). The census results contain important information on the population and its structures, households, as well as different characteristics of the resided structures. These data are deprived of the subjective interpretation, so

that as such they can be considered as reliable, and what is also important, spatially and temporally comparable. The part of variables, referring to the connections between the transportation and city organisation, as well as the ethnical segregation, has been obtained by the analysis in the previous papers of the author (See: Ratkaj, 2007b; Ratkaj, 2008). Finally, as the source of information on the land purpose, the map on The Existing Land Use (2001) of Urban Planning Institute of Belgrade (UPIB, 2002) is used, which is integrated with the map of the statistical circles.

In the factor analysis of the territory of the GP of Belgrade, we are going to use 60 variables - 28 in the part which is related to the social space, while the rest of 32 in the analysis of the physical space of the city. The variables are chosen from the initial set of over 300 variables. They are partly based on the tradition of the factor ecology, and partly on the characteristics of the examined area, as well as the census material.

12.2. Indexes of social areas of Belgrade

The variables, which are used in the analysis of the social areas, can be classified approximately into four categories: demographic characteristics, characteristics of households and families, social structure of population and standard of residence. Because of the need for the tabular review of the factor analysis results, the abbreviated term of each variable is given near the description.

Demographic characteristics are measured using the following variables: 1) index of population ageing (ageing index); 2) share of population aged between 15 and 64 in total population (mature population); 3) proportion of the number of children aged to 4 and female population aged between 15 and 44 (fertility); 4) spatial index of isolation of Romany population (Romany isolation); 5) share of the inhabitants who did not change the place of residence from their birth in total population (autochthonous population); 6) share of population migrated from 1991 in total population (migrants of 1991).

The first two variables are reflected directly or indirectly in the shares of the base age categories of the population. The third variable is taken as the conditional index of the fertility. The ethnic structure of the population is expressed through the local index of the Romany isolation. The analysis of the ethnic housing segregation in Belgrade preceded the selection of this variable, based on the innovative concept of the neighbourhood, i.e. the approaches of Wong, Reardon and O'Sullivan (Wong, 2003; Reardon & O'Sullivan, 2004) (see: Ratkaj, 2007b). The last two variables enable the distinguishing of the migration passive and recently attractive city zones.

Variables measuring the characteristics of households and families are: 1) share of single households in total number of households (single households); 2) share of aged households in total number of households (aged households); 3) average size of households (size of households); 4) share of married couples with children aged to 25 in total number of families (pairs with children); 5) share of incomplete families with children aged to 25 in total number of families with children (incomplete families with children); 6) share of married population older than 17 in total population older than 17 (married); 7) share of divorced population older than 17 in total population older than 17 years (divorced); 8) share of households with agricultural farm in total number of households (households with farms).

The first three variables relate to the size and age of the households, while the following four to the characteristics of the families and marital structure of the population (where population older than 17 has been taken into consideration, due to tendency of late marriages in urban areas). The share of incomplete families and divorced can be treated as the consequence of urbanisation and the acceptance of the contemporary model of behaviour, but also as the possible source of the social problems. The last variable, although it is the characteristic of the household, points indirectly to the economic structure of the population.

Social structure of population is represented by the following variables: 1) share of population older than 14 who reached maximum primary education, and who discontinued further education, in total population older than 14 (primary education); 2) share of population older than 24 reaching higher education in total population older than 24 (higher education); 3) share of employed in the primary sector of activities in total employed population (I sector-employed); 4) share of employed in the secondary sector of activities in total employed population (II sector-employed); 5) share of employed in the tertiary sector of activities in total employed population (III sector-employed); 6) share of employed in the quaternary sector of activities in total employed population (IV sector-employed); 7) share of employed in total active population (unemployed); 8) share of retired persons in total population (retired persons); 9) share of children, pupils and students as dependent persons, in total population (children, pupils and students); 10) share of housewives in female population older than 14 (housewives).

The first two variables are partly changed in relation to the standard statistical indexes. The share of conditionally insufficiently educated population (completed maximum primary education), can be defined more precisely if the population that continued further education is excluded from it. The share of highly educated population is calculated for older than 24. The next four variables represent the shares of employed population by the sectors of activities. The share of unemployed can be the significant index of the social problems. Children, pupils, students and housewives can be distinguished from the contingent of dependent population and economically active population. The share of housewives in female population older than 14, is also reflected in degree of women's emancipation.

Standard of residence is measured on the basis of the following variables: 1) average number of persons per apartment house (density of residence); 2) share of persons who live in apartments for permanent residence of the first category in total number of residents (residence – I category); 3) share of persons who resided rooms in need, in total number of residents (residence - need); 4) average area of resided apartment per person (size of apartment per person).

In regard of the indexes of the standard of residence and according to the recommendations of the Statistical Office of the Republic of Serbia, all permanent residents are included in the number of persons who live in apartment, but also the persons who are in the place of the census temporarily due work or education, since they also burden the housing fund. Although the population density is included into the standard of residence indexes in many studies, we are of the opinion that the index is more appropriate to the analysis of the physical space. Instead of it, the average number of residents per apartment house has been included here, as the density which inhabitants notice and

feel more. The following variables reflect the standard of residence. For the needs of the analysis, all apartments are selected arbitrarily into three categories: apartments of the first category are those with bathroom, toilet, kitchen, electricity, outside walls of solid material, water supply and sewerage system and they have either central heating or gas line system; apartments of the second category have all characteristics of the first one, with a difference that they have neither central heating nor gas line system; all other apartments belong to the third category.

12.3. Indexes of physical space of Belgrade

The variables in the factor analysis of the physical space are classified into four categories: land purpose, location and spatial organisation, characteristics of function of labour and characteristics of function of residence.

Land purpose has been measured by the 1) share of residential tissue and land aimed for residence in total land (residential tissue); 2) share of land under cultivation and structures, experimental agricultural properties and farms in total land (agricultural areas); 3) share of economic zones and land aimed for conducting activities in total land (economic zones); 4) share of commercial zones and urban centres in total land (commercial zones); 5) share of public facilities, complexes and land aimed for public services in total land (public services).

Every analysis of the physical space of the city should contain data on the land purpose. Although we consider them unavoidable, the reliability of these variables should be treated with reserve. For example, land purpose does not include information about floors, while the public and commercial capacities, as well as residence, often physically (spatially) coincide.

Location and spatial organisation have been measured by the following variables: 1) population density (population density); 2) density of work places (density of work places); 3) concentration of population (concentration of population); 4) concentration of work places (concentration of work places); 5) proportion of number of work places and population number (work places/population); 6) temporal distance from city centre (distance from centre); 7) temporal accessibility of work places (accessibility of work places); 8) temporal accessibility of places of residence (accessibility of places of residence).

The first five variables relate to the spatial distribution of places of residence and work places. We also consider the concentrations of the basic urban functions as important indexes of labour organisation, and thus their mutual relationship. The data on the centrality of the statistical circles, as well as the accessibility of work places and places of residence are obtained on the basis of the detailed traffic-functional analysis (Ratkaj, 2008). The dispersal of the residential zones, on one side, and relative concentration of the urban functions, on the other side, is the significant problem of the transportation system of Belgrade. The evolution of the accessibility enables the balanced approach to the transportation analysis and calls attention to the alternative strategies with an aim of solving the problems.

Variables representing the characteristics of functions of labour are: 1) share of work places in the primary sector of activities in total number of work places (I sector - work places); 2) share of work places in the secondary sector of activities in total number of work places (II sector - work places); 3) share of work places in the tertiary sector of activities in total number of work places (III sector - work places); 4) share of work places in the quaternary sector of activities in total number of work places (IV sector - work places); 5) concentration of work places in the primary sector of activities (I sector - concentration); 6) concentration of work places in the secondary sector of activities (II - concentration); 7) concentration of work places in the tertiary sector of activities (III - concentration); 8) concentration of work places in the quaternary sector of activities (IV - concentration).

This category of variables contains data on the spatial structure and concentration of work places grouped into four sectors of activities.

Characteristics of function of residence is measured by the: 1) share of apartments for permanent residence built to 1918 in total area of apartments for permanent residence (apartments to 1918); 2) average age of apartments for permanent residence (age of apartments); 3) average size of an apartment house, i.e. total area of apartments for permanent residence in the building (size of building); 4) share of individual houses in total number of apartments for permanent residence (individual house); 5) average area of an apartment for permanent residence (size of an apartment); 6) share of apartments for permanent residence of the first category in total area of apartments and other resided rooms (apartments - I. category); 7) share of apartments for permanent residence of the second category in total area of apartments and other resided rooms (apartments - II category); 8) share of apartments for permanent residence of the third category in total area of apartments and other resided rooms (apartments - III category); 9) share of apartments in total area of apartments and other resided rooms (apartments); 10) share of resided business rooms in total area of apartments and other resided rooms (resided business rooms); 11) share of rooms resided in need in total area of apartments and other resided rooms (resided in need).

The first five variables relate to, conditionally said, the area of an apartment in the narrower sense, i.e. apartments for permanent residence: their age, size and building density. The following six variables point to the qualitative structure of the total space which is used (or it can be used) for residence: the shares of apartments for permanent residence of the certain category, the apartments for all purposes, resided business rooms and rooms resided in need.

12.4. Factor ecology of social space of Belgrade

One of the first steps in the factor analysis is the calculation of the matrix of coefficients of correlation among the chosen variables, the values of which have previously been standardised. In this chapter, the matrix has satisfied the criteria which contribute to the reliability of the factor analysis results (the matrix is not singular, the KMO index of the sample adequacy is calculated and the Bartlett's test is carried out). The characteristic roots and "screen" diagram have been used in selecting the number of factors. The selection of five factors has been considered as acceptable, taking also into consideration the part of the overall variance that would be explained by that model - 72.06 % (Table 34).

Table 34: Significance of selected factors in non-rotated and rotated matrix of factor load (for the social space of the city).

	Non-rotated matrix			Rotated matrix		
Factor (comp.)	Character. root	Variance (%)	Cumulative Variance (%)	Character. root	Variance (%)	Cumulative variance (%)
1	11,4167	40,77	40,77	7,7291	27,60	27,60
2	3,2111	11,47	52,24	4,4812	16,00	43,61
3	2,1753	7,77	60,01	2,8391	10,14	53,75
4	1,7791	6,35	66,37	2,6715	9,54	63,29
5	1,5936	5,69	72,06	2,4550	8,77	72,06

The rotated matrix of the factor load (Table 35) shows the strength of the correlation among all variables and rotated factors. In this chapter, the factor loads, the absolute values of which are higher than 0.400 are considered to be relevant. The highest factor load for each variable is highlighted in bold. In spite of the Varimax rotation, the secondary loads are present with the absolute values higher than 0.400. The last column in the Table 35 represents the communality which points to the part of the variable variance which is explained by the given structure of factors. An extremely low value of the communality appears only in the share of employed in the tertiary sector. In spite of that, this variable is kept in the analysis as the relevant index of the social space of the city. The terms of the selected factors are partly adapted to the traditional terms in the factor ecology, while they also partly reflect the characteristics of the concrete urban area.

Table 35: Rotated matrix of factor loads and communality (for the social space of the city).

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Commun.
Index of ageing	-0,278	0,822	0,165	0,053	-0,178	0,814
Mature population	0,056	-0,780	0,061	0,128	-0,269	0,704
Fertility	0,279	-0,214	-0,111	-0,074	0,585	0,484
Romany isolation	0,089	-0,052	-0,052	0,041	0,766	0,602
Autochthonous population	-0,016	0,142	-0,191	-0,882	-0,063	0,839
Migrants 1991.	0,231	-0,203	-0,075	0,725	0,236	0,681
Single households	-0,827	0,296	0,035	-0,212	-0,053	0,821
Aged households	-0,542	0,721	0,069	-0,142	-0,183	0,872
Size of households	0,897	-0,253	-0,161	0,011	0,161	0,920
Pairs with children	0,413	-0,703	-0,217	0,210	0,195	0,793
Incomplete families with children	-0,777	0,235	0,035	-0,331	-0,023	0,770
Married	0,842	-0,218	-0,053	0,195	0,069	0,802
Divorced	-0,744	0,199	-0,152	-0,129	-0,019	0,633
Households with farms	0,770	0,235	-0,281	-0,156	-0,117	0,765
Primary education	0,717	-0,118	-0,508	0,095	0,298	0,883
Higher education	-0,658	0,424	0,459	-0,186	-0,038	0,860
I sector employed	0,708	0,217	-0,145	-0,407	-0,006	0,735
II sector –employed	0,324	-0,312	-0,402	0,540	-0,152	0,678
III sector –employed	-0,019	-0,365	-0,032	0,135	0,072	0,158
IV sector employed	-0,739	0,240	0,436	-0,156	0,003	0,818
Unemployed	0,229	-0,017	-0,486	0,574	-0,174	0,649
Retired persons	-0,619	0,576	0,323	-0,079	-0,247	0,887
Children, pupils and students	0,020	-0,709	0,055	-0,072	0,512	0,773
Housewives	0,667	-0,012	-0,346	0,287	0,412	0,816
Density of residence	-0,014	0,089	0,767	0,086	-0,080	0,611
Residence - 1. category	-0,303	0,152	0,776	-0,056	-0,148	0,743
Residence - need	-0,084	-0,118	-0,035	0,125	0,738	0,582
Size of apartment per person	-0,135	0,562	0,259	-0,224	-0,171	0,481

Factor 1 - Traditional social status: This structurally very complex factor is characterised by large households, with the insignificant share of single households. Moreover, it is directly proportional to the share of married, and inversely proportional to the share of divorced adult persons. In accordance with, conditionally said, a traditional way of life, the share of incomplete families with children is also low, whereas the shares of households with agricultural farm and employed in the primary sector of activities are high. Consequently, the factor correlates negatively with the share of employed in the quaternary sector. In the educational structure, the high positive correlation is expressive with the share of insufficiently educated population, while it is negative with the share of highly educated population. Young population and low share of retired persons characterise the traditional status. This factor also shows the high correlation with the share of housewives, which speaks in favour of the insufficient emancipation of women. Additionally, there are also two secondary high factor loads: the share of aged households has negative load, whereas the share of married couples with children to 25 years old has positive load.

Factor 2 - Phase in life cycle (family status): This factor is characterised by the high positive correlation with the index of ageing and the share of aged households, but the negative correlation with the share of mature population and children, pupils and students (as dependent population categories). The share of married couples with children shows high negative load, while the positive one is at the size of an apartment per resided person. Moreover, there are two secondary positive loads: the share of highly educated population and retired persons.

Factor 3 - Standard of residence: The high standard of residence is characterised by the high average number of persons per apartment house, as well as high share of persons resided in the apartments of the first category. Even though the factor 3 has been determined to the greatest extent by these two variables, the influence of five variables with the secondary factor loads, which determine the social structure of the population, is not minor either. The negative correlation is expressed in the share of population with completed maximum primary education, while the positive one is in the share of highly educated. Moreover, the variables referring to the economic structure of the active population influence the factor 3: the shares of employed in the secondary sector of activities and unemployed have the negative loads, whereas the share of employed in the quaternary sector has the positive load.

Factor 4- Migration mobility: The high degree of migration mobility characterises the share of population migrated after 1990 and small share of the autochthonous population. The high positive factor loads also have the shares of unemployed and employed in the secondary sector. The share of employed in the primary sector has the secondary negative load.

Factor 5 - Housing segregation: The segregation is only noted at Romany population, while other communities are well integrated into the major Serbian population. The very high positive correlation of housing segregation has the share of persons who live in structures resided in need, as well as the spatial isolation of the Romany population. This factor also shows the high positive correlation with the variable that has been chosen as the indicator of fertility in this study. Two variables, referring to the dependent population category, show the secondary positive factor loads.

12.5. Factor ecology of physical space of Belgrade

The matrix of coefficients of correlation among the standardised values of 32 variables has pointed to the reliability of the results that can be obtained by the factor analysis. Moreover, it was decided to select six factors in the analysis of the physical space of the city, which explained 70.51 % of the variance of variables. That could be considered as a very good result (Plane & Regerson 1994).

Table 36: Significance of selected factors in non-rotated and rotated matrices of factor loads (for the physical space of the city).

	Non-rotated matrix			Rotated matrix		
Factor (comp.)	Character. root	Variance (%)	Cumulative Variance (%)	Character. root	Variance (%)	Cumulative variance (%)
1	10,0465	31,40	31,40	9,1233	28,51	28,51
2	3,6468	11,40	42,79	3,2816	10,26	38,77
3	2,8807	9,00	51,79	2,7199	8,50	47,26
4	2,3161	7,24	59,03	2,5983	8,12	55,38
5	2,0811	6,50	65,54	2,5892	8,09	63,48
6	1,5929	4,98	70,51	2,2519	7,04	70,51

The rotated matrix of the factor loads is given in the Table 37. The value of the communality points that some of the chosen variables are not explained sufficiently by the factor structure, concretely: work places/population and I sector - concentration. In the urban analysis, one should not avoid the index which determines the dominant function of the given spatial unit. Moreover, other indexes of the concentration of employed by the sectors have high communalities.

Table 37: Rotated matrix of factor loads and communality (for the physical space of the city).

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Commun.
Housing tissue	0,714	-0,253	-0,329	0,033	-0,149	-0,101	0,716
Agricultural areas	-0,868	-0,098	-0,067	-0,042	-0,092	-0,055	0,781
Economic zones	0,023	0,245	0,097	-0,040	-0,104	0,648	0,503
Commercial zones	0,254	0,003	0,562	-0,161	-0,103	-0,002	0,417
Public services	0,279	0,302	0,173	-0,026	0,685	-0,167	0,696
Population density	0,898	-0,211	0,032	0,116	0,040	-0,023	0,868
Density of work places	0,881	0,014	0,256	-0,062	0,235	0,060	0,904
Concentration of population	0,148	-0,117	0,049	0,744	-0,063	0,140	0,614
Concentration of work places	0,236	0,140	0,711	0,187	0,467	0,275	0,910
Work places / residents	-0,006	0,326	0,061	-0,085	0,188	-0,059	0,156
Distance from centre	-0,853	-0,045	-0,205	0,132	-0,181	-0,006	0,822
Accessibility of work places	0,825	0,028	0,285	-0,229	0,192	-0,070	0,857
Accessibility of places of residence	0,895	0,035	0,232	-0,105	0,156	-0,043	0,893
I sector – work places	-0,617	-0,185	0,051	-0,200	0,075	-0,141	0,483
II sector – work places	0,002	-0,083	-0,190	0,006	-0,115	0,864	0,804
III sector – work places	0,140	0,081	0,264	0,156	-0,768	-0,258	0,778
IV sector – work places	0,478	0,129	-0,064	0,045	0,639	-0,373	0,798
I sector – concentration	-0,228	-0,155	0,257	-0,078	0,048	0,025	0,151
II sector – concentration	0,099	-0,078	0,256	0,147	0,221	0,810	0,807
III sector – concentration	0,205	0,075	0,833	0,185	-0,018	0,031	0,776
IV sector – concentration	0,219	0,255	0,484	0,107	0,688	-0,073	0,838

Table 37: Continued

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Commun.
Apartments to 1918.	0,296	-0,043	0,180	-0,555	0,013	-0,005	0,430
Age of apartments	-0,600	0,032	-0,186	0,641	-0,107	0,067	0,823
Size of apartment house	0,238	-0,083	0,364	0,554	0,030	-0,104	0,515
Individual house	-0,832	0,064	-0,229	-0,223	-0,056	0,018	0,801
Size of apartment	-0,555	-0,379	-0,026	-0,018	0,212	-0,116	0,511
Apartments – 1. category	0,558	-0,153	0,211	0,647	0,100	-0,051	0,811
Apartments – 2. category	0,693	-0,103	-0,037	-0,454	0,022	0,082	0,706
Apartments – 3. category	-0,877	-0,061	-0,160	-0,178	-0,097	-0,011	0,840
Apartments	0,011	-0,962	0,005	0,023	-0,070	-0,048	0,934
Business rooms	-0,009	0,895	-0,014	-0,025	0,169	0,030	0,831
Resided in need	-0,011	0,884	0,008	-0,016	-0,064	0,063	0,790

Factor 1 - Centrality, accessibility and building of space: In this factor, the share of land aimed to the housing function has positive load, while the share of agricultural land is characterised by an extremely high negative load. Nevertheless, the existence of floors has to be emphasized, i.e. the spatial coincidence of different urban capacities - there is a high share of partly apartment houses in the zone of high accessibility and building, wherein the function of labour is also performed on lower floors. The statistical circles with high results in this factor are characterised by high population densities and work places, i.e. the intensive land use. The height of the factor results is directly proportional to the levels of the transportation accessibility of places of work and places of residence, while the distance from the city centre has extremely high negative factor load. In the structure of work places, the negative factor load is shown by the share of work places in the primary sector. Moreover, there is a relevant secondary factor load of the share of work places in the quaternary sector. The factor 1 shows the negative correlation (of the secondary character) with age of apartments – highly centralised and accessible territorial units have high share of old housing units. The negative loads of the shares of individual houses and average sizes of apartments give more detailed picture on the characteristics of the housing function. This factor also shows the positive correlation with the share of apartments of the second category, but the negative one with the share of apartments of the third category of quality. The secondary positive factor load also appears in the share of apartments of the first category. Such structure of the housing fund speaks on the domination of apartments with public water supply and sewerage system, which also satisfy the criteria on the issue of building material, connecting to power system, possessing bathroom and kitchen, etc. However, taking into consideration that it is the older structures about, the share of apartments without central heating and gas system has still been very high.

Factor 2 - Substandard housing space: This factor reflects very bad housing conditions by the negative correlation with the share of apartments, as well as the positive correlation with the share of resided business rooms and rooms resided in need in total area of rooms that can (or have to) be used for residence. Nevertheless, relatively high positive loads of variables should also be noticed, which point to the share of land aimed to public services and the share between the number of work places and the population number. Hence, this factor, which mainly reflects the characteristics of the housing space, also explains indirectly the relationship among the basic functions of the city.

Factor 3 - Function of labour with orientation to the tertiary sector: The concentration of work places in the tertiary sector of activities has the highest load which determined the name of the factor itself. The total concentration of work places has very high positive load, and also (a little lower) the share of commercial zones and centres in total land purpose. The concentration of work places in the secondary sector has the positive secondary load. In other words, the height of the factor result reflects the significance of the statistical circle in the spatial distribution of the servicing sector, but also the functions of labour as a whole.

Factor 4 - Function of residence: The highest positive correlation this factor shows in the concentration of function of residence, and also with the share of apartments of the first category of quality, average age of apartments and size of an apartment house. These four indexes, basically, determine the character of the function of residence. Moreover, the high factor results reflect the small share of the oldest housing structures (built to 1918). The share of apartments of the second category of quality has the secondary negative factor load.

Factor 5 - Function of labour with orientation to the quaternary sector: The shares of public sector in total land purpose and the concentration of the quaternary sector of activities have high positive loads. The positive correlation of the secondary character is also shown in the concentration of work places as a whole. The spatial distribution of the results of this factor makes the explanation difficult by its high negative correlation with the concentration of work places in the tertiary sector. That means that the statistical circles with the significant role of the quaternary sector of activities or the function of labour as a whole have the high values of the factor results, as well as those with a small share of the tertiary sector.

Factor 6 - Function of labour with orientation on the secondary sector: three variables have high factor loads here: the share of work places in the secondary sector of activities has the highest positive load and then the concentration of the work places. The high positive correlation of the factors with the shares of economic zones and land aimed for conducting activities is in accordance with it. The negative load of the share of employed in the quaternary sector of activities should also be taken into consideration during the explanation of the factor results.

12.6. Zoning of social and physical space of Belgrade

The factor analysis represents good basis for the application of the method of multivariation analysis – the method of grouping. The aim is the defining of relatively homogeneous groups (or zones) on the basis of the characteristics of the composite factor results. Ward's method of hierarchical grouping has been applied in this study with square of Euclid distance as the index of similarity. There are several ways of how to define the number of the homogeneous groups that should be selected. Besides the a priori defining of the number of groups, the analysis of the developments of the coefficients of fusion has mostly been used (Kovačić, 1994), so that this method will be applied in the chapter.

12.6.1. Zoning the social space of Belgrade

The distribution of zones of the social space is shown on the Figure 46. The mean values of the factor results by selected zones serve as the basis for their explanation (Table 38).

Table 38: Mean values of factor results by zones of social space.

Factor	Zone of social space				
	Zone of extremely urban social status	Zone of transitional social status with high standard of resicence	Zone of suburban migration social status	Zone of rural social status	Zone of housing segregation
Φ 1 – Traditional social status	-0,81	0,09	0,64	2,54	0,13
Φ 2 – Phase in life cycle (family status)	0,34	-0,42	-0,32	0,97	-0,75
Φ 3 – Standard of residence	-0,15	1,34	-0,50	-0,60	-0,38
Φ 4 – Migration mobility	-0,34	0,09	0,83	-1,70	-0,43
Φ 5 – Housing segregation	-0,11	-0,28	-0,12	-0,11	3,51

The first selected homogeneous social zone is the zone of an extremely urban social status. It includes the greatest number of the statistical circles - 186, comprising 4.44 % of the territory with 26.61 % of total population. The selected zone has the lowest mean value of the traditional social status. Furthermore, the term traditional should be explained in the context of the previously defined complexity of the factor 1. This zone is also characterised by relatively older population, as well as the smaller share of families with children. The migration mobility is low, while the standard of residence and the level of the housing segregation are slightly below the average. The zone spreads over two old urban cores - Belgrade and Zemun. From the Belgrade core, it spreads radially in the direction of more significant lines of communications. The only statistical circle of this zone, located peripherally, is in the municipality of Voždovac, spreading over the part of the Jajinci settlement.

The second defined group is the zone of transitional social status with high standard of residence (or the zone of social chances), with 82 statistical circles, 15.54 % of the territory and 47.08 % of total population. This zone is characterised by the highest standard of residence. Consequently, the lowest value of the housing segregation has been dem-

onstrated. Besides above mentioned, the zone is characterised by the higher share of young and families with children. The levels of the migration mobility and the traditional social status are average. The selected zone is the largest by population, formed around the zone of an extremely urban social status. Two statistical circles of this zone, selected and periphery located, are in Dobanovci (the spatial unit which is irrelevant by population) and Borča.

The third zone – the zone of the suburban migration social status with 124 statistical circles, i.e. 67.01 % of the territory and 23.26 % of the population, has the highest degree of the migration mobility which is also its dominant characteristic. However, it is characterised by the expressive traditional social status, low standard of residence, as well as relatively younger population with higher share of pairs with children. The housing segregation is not typical for this zone of the social space which spreads over, proportionally, the greatest part of the territory of the GP of Belgrade, in the broad belt, formed around the zone of the high standard of residence.

The fourth selected zone is the zone of the rural social status. It spreads over 24 statistical circles, i.e. 9.69 % of the territory and only 1.11 % of the population. This zone has the extreme values in regard of the traditional social status (positive) and migration mobility (negative). Moreover, it is characterised by the highest mean value of life cycle and the lowest standard of residence. The housing segregation is insignificantly below the average for the territory of the GP of Belgrade. Generally, this is an extremely peripheral zone with low level of urbanisation, manifested through the traditional social status, high share of autochthonous population without noticeable immigration process, with extremely old population and low standard of residence. These indexes are also followed by bad educational structure and high share of the population employed in the primary sector, while proportionally the great part of households has its own agricultural farm. The zone of the rural status spreads over the area along the right bank of the Danube, from Višnjica in the north to Ritopek in the south, then Zuce, the parts of the settlements of Pinosava, Rušanj, Ovča and Borča.

The last zone is the zone of the housing segregation with 17 statistical circles, i.e. 3.32 % of the territory and 1.94 % of the population. The mean value of the factor results of the housing segregation is very high – even 3.51. The space is also characterised by the lowest mean value concerning the phase in the life cycle which points to the high share of young population, families with children, but also bad educational structure of the population. Except these extreme indexes, the selected zone is also characterised by the low standard of residence and small migration mobility. The index of the tradition of social status is slightly above the average. The zone of the housing segregation has, basically, the polycentric spatial distribution.

12.6.2. Zoning the physical space of Belgrade

The mean values of factor results by selected zones, as the basis for the further analysis of the physical space of the city, are given in the Table 39. The spatial distribution of the zones of physical space is shown on the Figure 47.

Table 39: Mean values of factor results by zones of physical space.

Factor	Zone of physical space					
	Old urban core	Suburban housing zone	Suburban rural zone	Industrial zone	Business centres	Zone of substandard housing conditions
Φ 1 – Centrality, accessibility and building of space	0,79	0,24	-1,32	0,19	0,35	-0,12
Φ 2 –Substandard housing space	-0,12	-0,11	-0,15	-0,16	-0,18	6,24
Φ 3 – function of labour with orientation on tertiary sector	-0,21	0,20	-0,20	-0,06	3,85	-0,12
Φ 4 – Function of residence	-0,39	1,62	-0,22	-0,10	-0,83	-0,20
Φ 5 – Function of labour with orientation on quaternary sector	0,17	-0,24	-0,18	0,28	-0,31	0,52
Φ 5 – Function of labour with orientation on quaternary sector	-0,28	-0,08	-0,19	2,87	-0,12	0,27

Figure 46: Zones of social space of Belgrade.

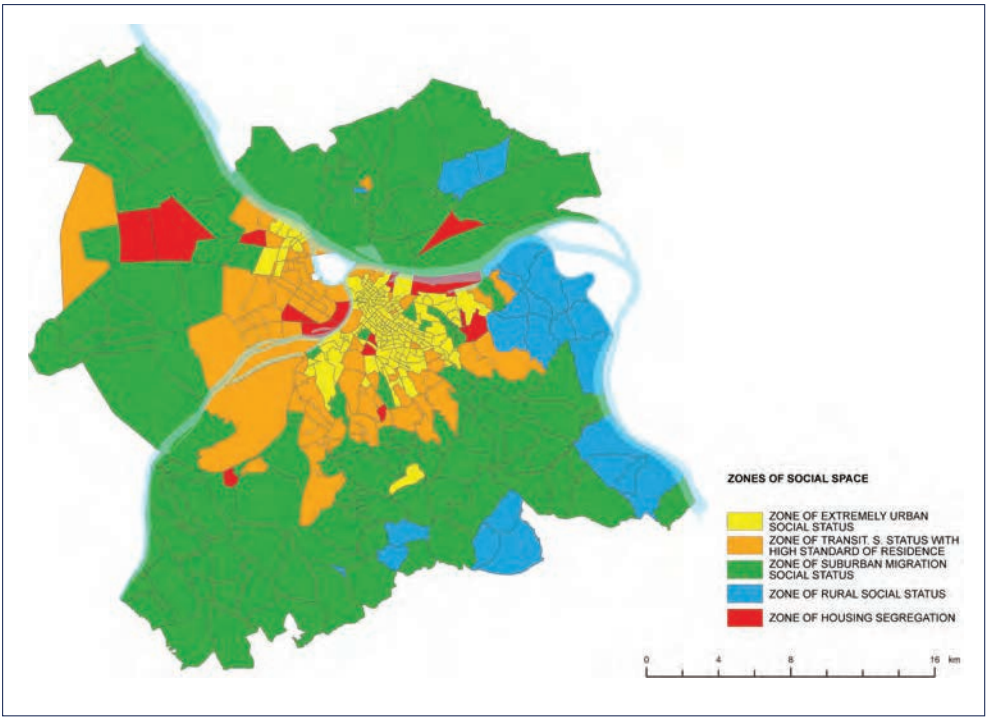
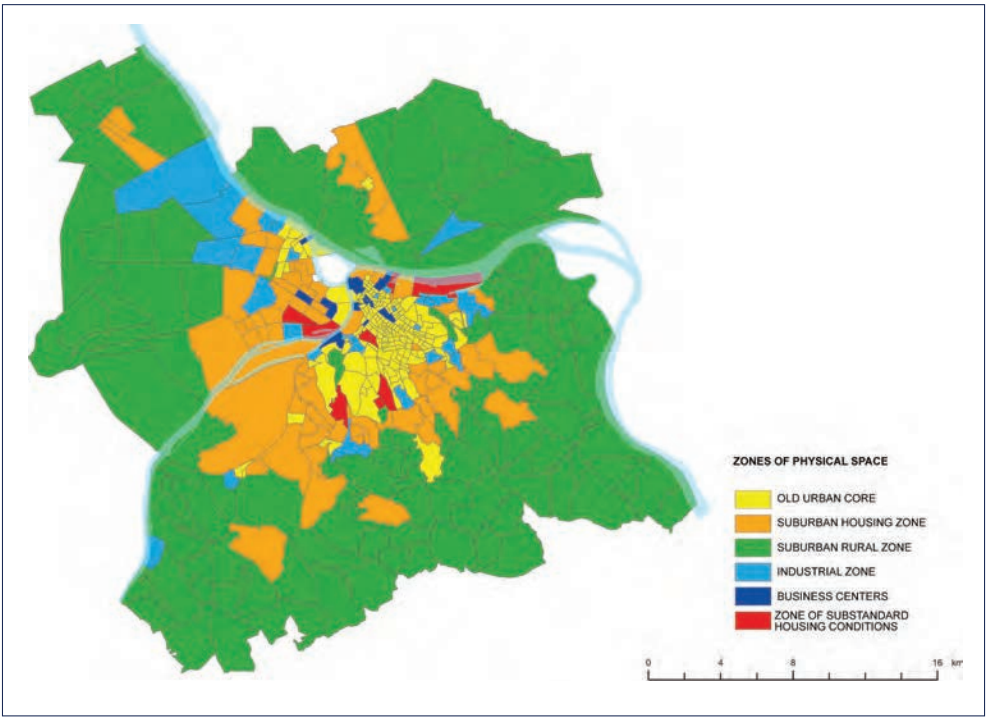


Figure 47: Zones of physical space of Belgrade.



The first selected zone of the physical space is old urban core. This zone includes the largest number of statistical circles (182), i.e. 4.63 % of the territory, 24.69 % of the population and 41.04 % of the work places. It has the highest degree of centrality, accessibility and building of space - it is characterised by high densities of work places and residence, with the insignificant share of agricultural areas, and the domination of housing areas. In the structure of activities, the quaternary sector is most common. Older buildings dominate, while the apartments are smaller on average, mainly of the second category of the quality (50.17 % of the area aimed for residence). This zone also has the lowest values of the function of labour for the secondary and the tertiary sector which corresponds to the small share of economic and commercial zones in the land purpose, as well as the small share and concentration of work places in these sectors. The relatively low function of residence speaks on low concentration of the population and the small share of larger apartment houses. The value of the substandard housing space is slightly below the average, while the functions of labour with the orientation to the quaternary sector are above the average. The cause of relatively low concentration of the functions of labour (except for the quaternary sector) and residence has been the shortening of spatial units in spite of their high densities. In the zone of the largest number of work places, the proportions of the sectors are: 0.53 % of the primary sector, 16.31 % of the secondary, 27.50 % of the tertiary and 55.67 % of the quaternary sector. The old urban core spreads over the inner central parts of Belgrade and Zemun, as well as the smaller, older part of New Belgrade. The zone expands from the centre of the city towards east and south, along the radial lines of communications. The peripheral statistical circles are at Kumodraž, the Rakovica settlement, old part of Žarkovo, Železnik and Borča.

The second selected zone is suburban housing zone with 71 statistical circles, 16.76 % of the territory, 52.13 % of the population and 21.97 % of the work places. It is characterised by high concentration of the population, the higher share of apartments of the first category (72.94 % of housing area) and large, newly built, housing constructions. The level of the centrality, accessibility and building of space is slightly above average, as well as the concentration of work places in service sector, but the concentration of work places in the quaternary sector is slightly below average and the share of land aimed to public services is low. The values of the substandard housing space and the functions of labour with the orientation to the secondary sector are insignificantly below the average. This zone, which is the largest by population, though situated mainly between the defined central zone and the periphery one, includes more distant spatial units with the higher concentration of the population (in Batajnica, Borča, Sremčica, Kaludjerica, etc.).

The third zone is suburban rural zone with 129 statistical circles, 71.73 % of the total territory, 12.98 % of the population and only 5.11 % of the work places. It has far lowest level of the centrality, accessibility and building of space. This zone, the largest by territory, represents the space of the low intensity of land use, with small densities of work places and places of residence, the lower share of housing tissue, whereas the share of agricultural land is higher. Moreover, 43.18 % of the total number of work places in the primary sector is located in it. In the structure of housing fund, individual houses dominate, often of the third category (83.63 % of the housing area). The suburban rural zone forms a wide periphery ring around other selected zones. The statistical circles that encroach into the central parts of the city are rare. Those are the areas of low population densities and densities of work places, with the very low share of housing tissue – the southern part of Senjak with Topčider Park, the part of Zvezdarska šuma, small areas in New Belgrade and Banjica.

The fourth zone is industrial zone with 28 statistical circles, 5.48 % of the territory, 8.22 % of the population and 13.71 % of the work places. Its main characteristics are defined by extremely high mean value of the function of labour in the secondary sector. As observed by the statistical circles, the share of the secondary sector of activities in the structure of work places ranges from 53.45 % to 92.39 % (averagely 70.62 % for the industrial zone as a whole). The influence of other factors is of much less importance, considering that their mean values ranges in the interval from -0.16 to 0.28. The quaternary sector of activities is the second by the significance in this zone, but with only 15.43 % of the total number of work places. Generally, the industrial zone has a dispersive arrangement, with higher concentration in the municipalities of Zemun and Palilula, while it also spreads over the peripheral spatial units (e.g., the part of Umka with cardboard factory). The largest continual space extends from Kolonija 'B' Zmaj to Zemun-polje.

The fifth zone of business centres includes 14 statistical circles, i.e. 0.43 % of the territory, 1.74 % of the population and even 13.64 % of work places on the area of GP of Belgrade. These centres are characterised by the extreme domination of labour function of the city over the housing function. The tertiary sector dominates in the structure of work places (which has high concentration in this zone) with 50.70 %, while the quaternary sector is the second according to the significance, with 36.59 %. These characteristics of business centres are caused by the highest mean value for the composite factor 3.

The lowest function of residence is also in accordance with the basic (labour) function of these centres. Other factors are of less significance. The mean value for the factor 1, which is above average, speaks on the central and more accessible position of the zone, as well as on the intensive usage of the space. Business centres also have the lowest mean value of the substandard housing space and the mean value of work places concentration in the industrial sector which is below average. The low mean value for the factor 5 should be explained in the context of a lower concentration of the quaternary activities and higher share of the tertiary activities. The business centres include the part of Donji grad in Zemun (where a community building of the Zemun municipality stands, market, etc.), blocks 32 and 29 (with the YAT, Post Office and Mobtel buildings, shopping centre, etc.), as well as blocks 19, 20 and 21 (with the Hyatt, Intercontinental hotels, Sava Centre, etc.) in New Belgrade. In the inner core of Belgrade, the business centres include the statistical circles wherein the bus station "Lasta" and Kalemegdan are situated, then the area between the "Danube" quay and Dunavski kej Street (where the companies of City Transportation "Belgrade", "Belgrade" Port, "Kompresor" are situated, etc.), area from Knez Mihailo Street, over Terazije to Nikola Pasic Square, area between Takovska, Kraljica Marija and Ruzvelt Streets and Kralj Aleksndar Boulevard, as well as the area among Nemanjina, Knez Miloš, Sarajevska, and Miloša Pocerca Streets (all three with many structures of the tertiary and quaternary sector of activities, such as retail markets, tourist agencies, shopping centres, faculties, embassies, sports centres). The last selected business centre includes Belgrade fair.

The sixth zone is the zone of substandard housing conditions. It includes 9 statistical circles, with 0.98 % of the territory, 0.24 % of the population and the significant 4.53 % of the work places. The most important characteristic of this zone has been very high mean value of the substandard housing area (6.24). In contrast to other zones of the physical space, in which the share of apartments in total area aimed for residence is 100 % approximately, the share is only 33.89 % in the zone of the substandard housing conditions. The resided business rooms dominate with 38.5 %, while the proportion of rooms resided in need is 27.54 %. The high mean value of the factor 6 is reflected in the average share of the quaternary sector in the structure of work places with even 76.37 %. Nevertheless, the significance of this factor is considerably less than the factor 2, so that there are territorial units of different structures of activities in the zone of the substandard housing conditions. The statistical circles with the dominant industrial sector include Ada Huja (with cardboard factory) and New Belgrade block 69 (with shipyard "Belgrade"). The servicing sector has the major share in the statistical circle, including blocks 66, 66a, 67, 67a and 42 (the traffic section of the City Transportation "Belgrade", the technical services of "Peugeot" and "Mercedes", etc.). The quaternary sector has the highest share in four statistical circles where Medical Centre of Serbia and Faculty of Veterinary Medicine are situated (in the Savski Venac municipality) and Military-Medical Academy and sports centre "Banjica" (in Savski Venac and Vozdovac). Two statistical circles do not have the significant function of labour: near the quay of "Dunav" and in Kosutnjak.

12.7. Relations between social and physical component of Belgrade

The canonical correlation is the method of the multi-variation analysis, which gives us the possibility to determine and quantify the relations between the two sets of variables (factors, in our case). This method has rarely been applied in the urban ecology, despite the need for explaining the relations between the social and physical subsystems of the city. In this analysis, two sets of variables are transformed into the orthogonal canonical vectors – the pairs of canonical variables. Each vector results with two canonical results respectively for each spatial unit. The essence of the canonical correlation lies in the optimisation of relations between two sets of variables, but not within those sets. As observed from that aspect, the canonical analysis is considered to be the logical continuation of the factor analysis.

The canonical coefficients reflect better the reality of the urban system through the complex relationships of interdependence than the simple or complex correlation. The results of the canonical analysis, in which the social and physical factors are used as variables, are given in the Table 40. The number of vectors that are going to be analysed should be defined before the interpretation of the results. In making a decision, the following indexes can be applied:

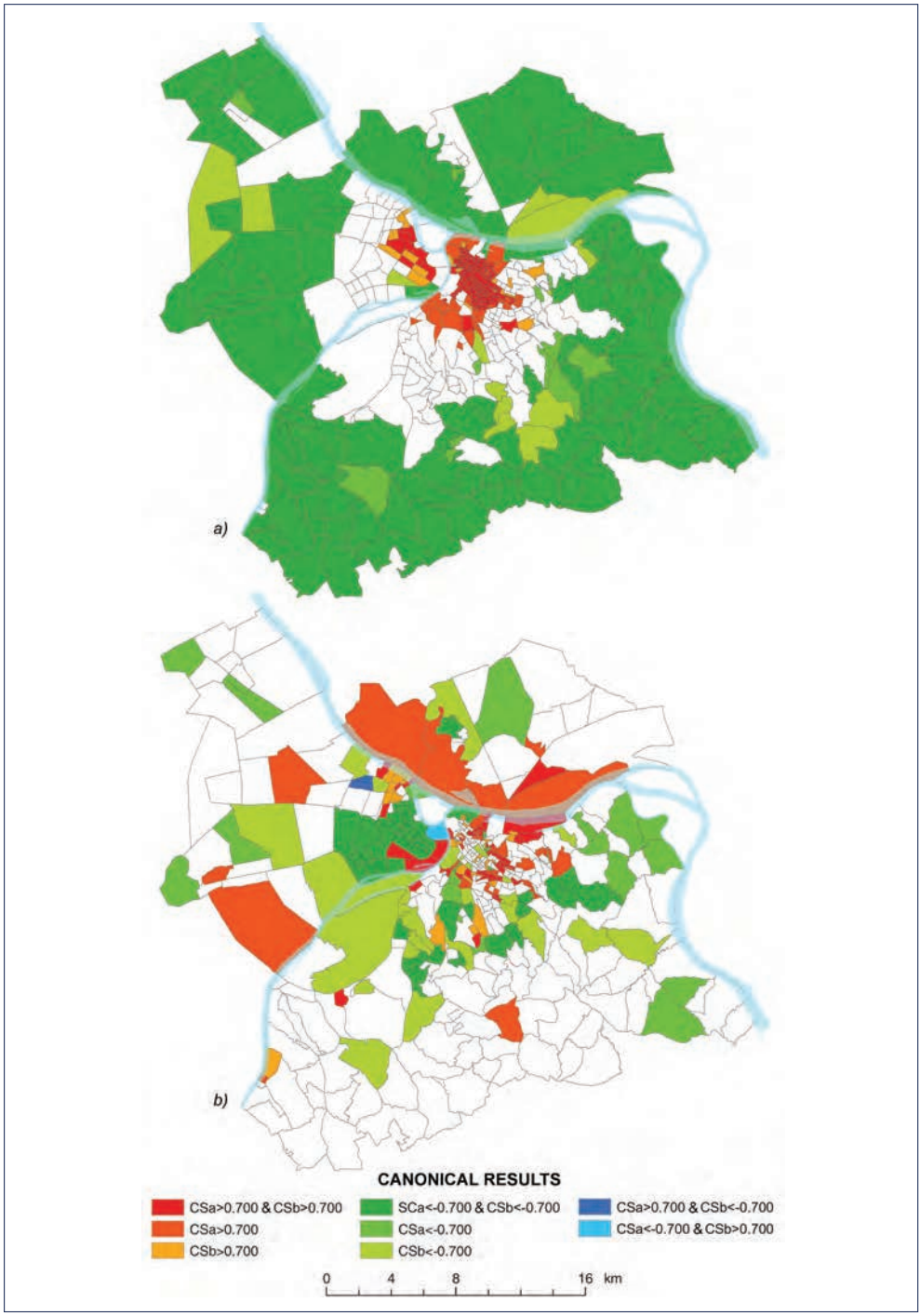
1. the level of statistical significance; 2. the height of canonical correlation; 3. the coefficient of redundancy. However, even the criteria on the a priori defined minimum values of all three suggested indexes are satisfied, the condition of the reasonableness of the defined connection among the sets of the original variables has to be satisfied in the canonical analysis (Kovačić, 1994). Otherwise, the statistical criteria are not enough for the acceptance of the validity of the vector. Moreover, there are opinions that only the first vector should be analysed as the most important for the explanation of the relations among the groups of variables.

The first pair of the canonical variables reflects the connection of the traditional social status (having in mind its negative sign) on one side, and the centrality, accessibility and building of space, on the other side. The influence of weighting of the standard of residence is a little lower, but still significant. The zone of high canonical results for both variables can be defined as the zone of urbanised social status and relatively higher standard of residence of population, which is also the zone of high centrality, accessibility and building of space. The second extreme, with the negative canonical results for both variables, is presented by the peripheral zone with the dominant rural social status of population and lower standard of residence, as well as low accessibility and density of building of space. The first pair of the canonical variables enables the clear separation of the centre and the periphery on the territory of the GP of Belgrade. The canonical results in this vector show the high degree of the spatial coincidence – out of 291 statistical circles with the absolute results higher than 0.700, even 219 have high values for both canonical variables. The clearer differences among the results of the variables are also obvious in the part of New Belgrade and Zemun, which is singled out as densely built area of high centrality and accessibility, but with insufficiently urbanised social status. Moreover, the zone with only the urban social status and higher standard of residence can be distinguished around the inner core of Belgrade. The similar transitional zones have also been present when it is the extremely negative canonical results about.

Table 40: Canonical coefficients and canonical correlations between social and physical factors.

Original factors	Canonical vectors				
	1	2	3	4	5
Social space of city					
Factor 1 – Traditional social status	-0,861	-0,391	0,138	-0,256	0,148
Factor 2 – Phase in life cycle (family status)	0,204	-0,083	0,403	-0,676	-0,577
Factor 3 – Standard of residence	0,387	-0,816	-0,363	-0,148	0,174
Factor 4 – Migration mobility	-0,243	-0,136	-0,460	0,331	-0,776
Factor 5 – Social segregation	-0,095	0,394	-0,690	-0,588	0,118
Physical space of city					
Factor 1 – Centrality,accessibility and building of space	0,955	0,164	-0,065	0,202	-0,074
Factor 2 – Substandard housing space	-0,058	0,398	-0,820	-0,388	-0,074
Factor 3 – Function of labour with orientation on tertiary sector	0,212	-0,232	-0,018	-0,438	-0,073
Factor 4 – Function of residence	0,048	-0,825	-0,498	0,227	0,019
Factor 5 – Function of labour with orientation on quaternary sector	0,179	-0,166	0,147	-0,560	0,710
Factor 6 – Function of labour with orientation on secondary sector	-0,066	0,228	-0,234	0,502	0,692
Canonical correlation	0,933	0,801	0,707	0,243	0,074

Figure 48: Canonical results: a) for the first pair of canonical variables; b) for the second pair of canonical variables (CSa - canonical results of factors of social space; CSb - canonical results of factors of physical space).



The first pair of the canonical variables reflects the connection of the traditional social status (having in mind its negative sign) on one side, and the centrality, accessibility and building of space, on the other side. The influence of weighting of the standard of residence is a little lower, but still significant. The zone of high canonical results for both variables can be defined as the zone of urbanised social status and relatively higher standard of residence of population, which is also the zone of high centrality, accessibility and building of space. The second extreme, with the negative canonical results for both variables, is presented by the peripheral zone with the dominant rural social status of population and lower standard of residence, as well as low accessibility and density of building of space. The first pair of the canonical variables enables the clear separation of the centre and the periphery on the territory of the GP of Belgrade. The canonical results in this vector show the high degree of the spatial coincidence – out of 291 statistical circles with the absolute results higher than 0.700, even 219 have high values for both canonical variables. The clearer differences among the results of the variables are also obvious in the part of New Belgrade and Zemun, which is singled out as densely built area of high centrality and accessibility, but with insufficiently urbanised social status. Moreover, the zone with only the urban social status and higher standard of residence can be distinguished around the inner core of Belgrade. The similar transitional zones have also been present when it is the extremely negative canonical results about.

The second pair of the canonical variables emphasizes the connection between the standard of residence, as the social factor, and the function of residence, as the physical factor (but both factors have negative signs). Both housing segregation and substandard housing space have relevant coefficients with positive signs. The high positive results for both canonical variables of this vector define the zone of low standard of residence of population, with emphasized housing segregation, where the substandard housing space dominates, while the housing function itself is weakly prevailing. The spatial units with high standard of residence and the dominant housing function, without more significant housing segregation have been the second extreme. In contrast to the previous pair of variables, the second pair does not show the high degree of the spatial coincidence - out of 202 statistical circles with high canonical results, only 95 have high results for the both variables. The specific, and at first sight, contradictory results have appeared in three statistical circles. Two statistical circles, closer to the centre of the city (near the business centre of "Ušće" in New Belgrade and between Pop-Lukina and Brankova Streets at Stari Grad), have low results for the social canonical variable and high for the physical canonical variable. It is the area where a small number of inhabitants live, so that the factor result has been extremely low concerning the function of residence. Moreover, the function of labour is much more significant than the function of residence, while the structure of the resided area itself is not favourable, which causes the high results concerning the substandard housing space. On the other side, the housing segregation has not appeared and most part of the population lives in more qualitative apartments (making a smaller part in total housing fund). In Zemun, one statistical circle has high result for the social canonical variable and low for the physical canonical variable. The isolation of the Romany population has been the main reason of it, causing high factor result of the housing segregation on one side, and high concentration of the inhabitants, i.e. the important function of residence, on the other side.

The strong influence of the social theory on the urban literature and severe criticism of the traditional ecologic approach have marked the last decades. With the radical social geography, the opinion spread that the progress in the quantitative methodology, manifested through the factor ecology, has just called attention to technical and empirical issues of the spatial distribution, thus steaming up the social processes that are in the basis of changes of the spatial structure of the city (Pratt & Hanson, 1988; Gottdiener, 1985). Many authors (Castells 1977; Harvey, 1973; Minigione, 1981; Scott, 1980) examined the specific urban issues concerning the broader social processes and historical situations, discussing the historical manifestations of the urban planning and their social consequences, the reproduction of labour, collective consumption, social division of labour and urban conflicts. However, it was gone too far even in the radical approach, which is partly the consequence of fear from the "fetishism of space" - giving space too much powerful and autonomous influence in the materialistic history and society. It was approached to the unnecessary limitation and the conceptualisation of space and spatial relations, straying from the theory on the interdependence and mutual supplementation of the urban society and urban space in the "socio-spatial dialectics". Among other effects, that was leading to the wrong interpretation and the rejection of important contributions of the members of the critical approach in the study of the city structure (Soja, 1980; Knox, 1991).

Urban, but also social geography as a whole, experienced relative fall in the quantitative and positivistic approaches. In the studies of the urban residential structure, the dominant quantitative methods of 1960s and 1970s were greatly changed by the qualitative and the so-called 'case study' approaches. There were not many attempts, with several exceptions (Davies & Murdie, 1991; Perle, 1981, 1982, 1998), to evaluate systematically the changes in the residential differentiation, considering that the ecological studies reached its zenith several decades ago. What has been ironical is that the removing of the factor ecology began just in the period of the increasing popularity of the factor methods in the specialised private sector and planned researches, especially owing to GIS and corresponding data bases. In this chapter, we have supported the reaffirmation of the quantitative analyses in urban geography, which would be based on the tradition of the factor ecology, but it would contain at he same time the important innovations, theoretical and methodological improvements, realised through the act of integrating the social component with the transportation, but also the overall physical component within the frames of the unique functional urban system. We are also of the opinion that the irrefutable fact is that the factor ecology, despite all limitations, gives widely acceptable method of the classification of the spatial units in the cities, as well as excellent starting point for further researches.