Land Use Relationships
in Rural-Urban Regions

Module 2

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PERI-URBAN LAND USE RELATIONSHIPS – STRATEGIES AND SUSTAINABILITY ASSESSMENT TOOLS FOR URBAN-RURAL LINKAGES, INTEGRATED PROJECT, CONTRACT NO. 036921

Report on response functions for economic development and work places

D2.3.6

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SIXTH FRAMEWORK PROGRAMME

Contents

Abstract

Objectives

The present deliverable report documents the work carried out within Work Package 2.3 (Land use relationships in rural-urban regions) and focuses on interrelationships between socioeconomic development and land use patterns.
The objective of the report is to develop response functions in which, according to the DPSIR framework, the socioeconomic development indicators are considered as measures of the pressure on land use change, specifically, the intensity of land occupancy for human settlement. The latter is represented by the share of artificial surfaces in total land area.

Methodology

In the present study interrelations between economic development and land use characteristics were examined by applying principal component analysis as well as regression analysis. The analysis was carried out at NUTS-3 level for EU-27, and was based on more than 20 variables. For the purpose of regression analysis the following independent variables were selected: total employment rate, time-distance to the unit's centre, population density, GDP per capita, GDP in Purchasing Power Parity terms.

Results

In the course of the analysis four composite indicators were identified, accounting for nearly 56 percent of the total variance. These include: spatial development intensity component, spatial accessibility component, structural maladjustment component, and industrial employment component,
With regard to the distribution of component values, substantial differences were found among the six types of rural-urban regions (cf. PLUREL's RUR typology). Among others, the NUTS units contained in regions of type one – very large monocentric, and of type four – urban polycentric, are characterized by relatively small variations in the component values, while the biggest variations pertain to type six, i.e. rural regions.

Results of the regression analysis show that differences between individual land use classes, as determined according to the share of artificial surfaces, are especially large in the case of GDP per capita values. Namely, the GDP values for the highest artificial surface category (i.e. highly urbanized areas) are more than twice the respective median values for the remaining classes. On the other hand, the statistical relation between the share of artificial surface and population

density is extremely regular. The latter variable can in fact be used as a proxy for the share of artificial surface, if the data on the latter are not available.

Popular science description

Economic development and the related social change comprise the main factors, i.e. the driving forces of urbanization. This process is expressed, among others, in a growing share of the so-called artificial surfaces within total land area.

In this deliverable report statistical association between economic development and land use indicators is analyzed for the set of NUTS-3 units, covering the area of EU-27 countries. Positive association is confirmed between the urbanization level and such measures as: Gross Domestic Product per capita, total employment rate, and time-distance to the unit's centre.

The distribution of economic development indicator values was studied for several types of rural-urban regions. Relatively small variations in this respect were found among the large metropolitan areas across the European Union. Conversely, the differences remain quite large in the case of predominantly rural regions. Also, the results of the analyses show that differences in income levels, as expressed in GDP values, between urban and peri-urban areas on the one hand, and rural areas on the other, were increasing during the 1996-2006 period.

Keywords: Socioeconomic development indicators, land use response functions, principal component and regression analyses, RUR typology.

Classification of results/outputs:
For the purpose of integrating the results of this deliverable into the PLUREL Explorer dissemination platform as fact sheets and associated documentation please classify the results in relation to spatial scale; DPSIR framework; land use issues; output indicators and knowledge type.

Spatial scale for results: Regional, national, European	European
DPSIR framework: Driver, Pressure, State, Impact, Response	Driver - Pressure - State
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	Non-agricultural land uses (artificial surfaces)
Scenario sensitivity: Are the products/outputs sensitive to Module 1 scenarios?	No
Output indicators: Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions	Statistical relationships between socio-economic indicators and land use structure
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	Response functions; GIS-based maps; Tables and diagrams;

How many fact sheets will be derived from this deliverable:	**2**

Introduction

The present report pertains to one of the tasks within Work Package 2.3, on: Land-use relationships in rural-urban regions. The work focuses on relationships and pressures concerning economic development, in particular its intensity (as measured by GDP indicators), the employment rates and employment composition, as well as spatial accessibility patterns.

In the first section of the report reference is made to basic underlying concepts and assumptions, as applied in the present analysis. Section two contains an overview of relevant data sources and an evaluation of the statistical data used. Basic dimensions of territorial differentiation of socioeconomic – land use relationships, as identified via principal components analysis, are discussed in section three. In particular, distribution of component values by individual types of rural – urban regions, according to the RUR typology, is looked into. Section four focuses on economic development – land use response functions. Several socioeconomic variables are selected and compared with respect to their statistical interdependence with the measure of land occupancy. Conclusions and some questions for further investigation are put forth in section five.

1. Concepts and Assumptions

In the analysis of interdependence between economic development and land use change it is appropriate to refer to classical theory of location of economic activity (see: Hoover 1948, Isard et al. 1956), as well as to some of its more recent extensions (Vernon 1966, Lasuén 1973, Porter 1990, Krugman 1995). The set of location factors, restricted initially to such basic categories as soil fertility, transfer costs and labour costs, has over time been considerably extended, so as to include rules relating to scale and agglomeration economies, innovation diffusion, human capital, the product and process life cycles, the formation of industrial clusters, and the integration of industrial with producer services sector.

These concepts help to explain why some economic activities tend to locate in large, rather than small cities, or in high rather than low population density regions. They are resorted to in attempts at answering questions concerning relocation of economic activities among cities and regions in response to evolving configuration of attractive and repulsive location factors. In the same vein, economic location theory needs to be employed when the question of interrelations between the urban, peri-urban, and rural zones of rural – urban regions, i.e. the core problem tackled in PLUREL, is addressed.

In the PLUREL's work programme, research objectives concerning patterns of economic development in rural – urban regions are broadly defined. Economic development, along with population growth, is considered as a major driving factor of land use change in rural – urban regions; more specifically, it accounts for the growing share of artificial surfaces in the total land area. This link is conceptualized in the DIPSIR framework, the concept elaborated in the European Environmental Agency (see: Ravetz 2009), and applied in constructing land use change projections for 2015 and 2025, using the RUG model (Rickenbush 2009), following alternative global development scenarios. The effects of economic development are investigated as to their interrelations with patterns of spatial accessibility, transportation networks and commuter flows (Helminen, Ristimaki, Kontio and Vuori 2010), as well as population change and its composition (Loibl, Kostl 2010).

Research on contemporary relationships between economic development and land use change in rural – urban regions, conducted at the regional level, i.e.

pertaining to individual case study regions, could be oriented towards a number of more specific, both theory and policy relevant issues. A set of such issues, as outlined in: Korcelli (2008), includes: interdependence of residential mobility and redistribution of jobs; spatial range of economic spread versus backwash effects; trends in formation and relocation of enterprises in peri-urban and rural zones; location patterns of high ranking, metropolitan functions within the rural – urban regions. In addition, questions related to spatial patterns of amenity rent, to the role of public policy in shaping land values, and to the nature and resolution of land use conflicts are among the important ones in the framework of land use theory and practice.

In this contribution, that pertains to a broader, transnational level, covering the set of European rural – urban regions, the focus is put on economic development – land use generic response functions (see: Zasada and Piorr 2009). The aim of the study is to arrive at statistical measures of interrelation between uni-dimensional (by using simple regression analysis), as well as composite indices (via principal component analysis) of socioeconomic development level (and the change thereof) on the one hand, and the intensity of land occupancy on the other. The results are to be used as an input to alternative scenario – specific projections that, in turn, serve as a basis for the iIAT – the Interactive Impact Analysis Tool, the results of which are presented at both the aggregate (i.e. European), and the region - specific level (Zasada and Piorr 2009).

Aside from measuring statistical relationships between economic development and land use intensity indicators for the set of spatial units (NUTS-3 regions) included in the analysis, an attempt is made in the present study to identify major dimensions of differentiation of this interrelation. One of such dimensions refers to the morphological typology of European rural – urban regions – the PLUREL RUR typology, as defined by Loibl, Köstl and Steinnocher (2009).

2. Data Sources and Data Limitations

The linkages between economic development and land use change can assume various forms, even though their very existence represents a trivial problem. In fact, certain indicators express two sides of the interdependence at the same time. A list of relevant variables, to be assembled for statistical analysis, may include three types of measures. The first type consists of “pure” land use indicators, such as shares of individual land use categories in the total land area, rates of transition between these categories, the size of homogeneous land use plots, or the frequency of neighborhood between various land uses. The second type are “non – spatial” economic variables referring mainly to production, distribution, employment and consumption. Data of the third type pertain to infrastructure and settlement. This is the area where the overlap occurs. There is little doubt that such indicators as density and structure of road networks, or of energy supply systems represent economic development and land use characteristics at the same time.

In our attempt at collecting an appropriate data base, all these types of variables have been included. In the course of the analysis, data from the following sources were used: Eurostat, ESPON (1.1.2; 1.2.1; 1.2.2; 1.3.1; 2.1.1; 2.2.2; 3.1; 3.2) projects and ESRI. It should be emphasizes that data availability still constitutes a bottleneck in the investigations of spatial change and its correlates. Data for European NUTS-3 regions are still incomplete, i.e. there are gaps in both their thematic and temporal dimensions. The data borrowed from the ESPON data base that refer to the period of 1996 -2002, are based on previous NUTS-3 divisions; therefore, they had to be processed in order to be integrated with those available within the up-to-date administrative systems. Conversely, data from the ESRI (.shp file) were complete and did not require adjustments. Lacking in particular are comparable data for more than one point in time. This limitation seriously restricts possibilities of tracing land use change and its correlates.

In the data base collected for the purpose of the present analysis several NUTS-3 units were not represented. Hence, these units were disregarded in the statistical analyses. It has to be admitted that variations in the size of NUTS-3 units between individual countries have an impact upon the results.

3. First – step Analysis of Spatial Association between Economic Development and Land Use in Rural – Urban Regions

At this first stage interrelations between economic development and land use characteristics were examined by applying principal components analysis which is generally used for data reduction and structure detection. The purpose of data reduction is to remove redundant (i. highly inter-correlated) variables from the data file, and to replace them with a smaller set. The purpose of structure detection is to examine the underlying, or latend relationships between the variables. The method application resulted in the identification of several components. The four main components account for nearly 56 percent of the total variance. The initial list of indicators included 24 variables (see Table 2.). Statistics relating to the main components are given in Table 1.

Table 1. Rotation sums of square loadings for the main components

Rotation Sums of Squared Loadings			Component
Total	% of Variance	Cumulative %	
4.775	19.895	19.895	1
4.666	19.442	39.337	2
1.985	8.270	47.608	3
1.943	8.096	55.703	4

PLUREL

Table 2. The data set used in the principal components analysis

	components			
	1	2	3	4
ARSU96N3 - share of artificial surfaces (E 1.1.2)	0.773	-0.347	0.279	-0.144
UFL296N3 - share of urban fabric	0.757	-0.369	0.268	-0.138
ALL296N3 - share of arable land	-0.145	-0.237	0,465	0.367
PCL296N3 - share of permanent crops	-0.247	-0.058	-0.243	-0.534
NCA01N3 - number of commercial airports (E 1.2.1)	0.041	0.160	-0.150	-0.235
LRO01N3 - length of road network (km)	-0.211	0.050	-0.042	-0.033
LR01N3 - length of railway network (km)	-0.157	0.145	0.233	0.107
CCA01N3 - Connectivity to commercial airports by car to the capital or centroid (in hours)	-0.304	0.653	0.125	-0.076
CM01N3 - time to the nearest motorway access or to the NUTS centroid by car (in hours)	-0.183	0.534	0.148	-0.166
ACME01N3 - potential accessibility multimodal	0.455	-0.631	-0.079	0.213
TMROP297N3 - time to market by road	-0.102	0.897	-0.001	0.077
TMRAP297N3 - time to market by rail	-0.125	0.881	0.051	0.127
TMRRP297N3 - Accessibility time to market by rail and road; half-life mesoscale	-0.109	0.897	0.014	0.099
SMWH04 - sum of all weighted hazard values (E 1.3.1.)	0.147	-0.371	-0.241	0.323
POPDENSN30 - population density	0.671	-0.234	0.202	-0.211
DAVGPOP950 - development average population 1995-2003 in %	-0.160	-0.212	-0.550	0.017
GDPPH02N3 - GDP in Purchasing Power Parities per inhabitant	0.,811	-0.180	-0.402	0.064
GDPEH02N3 - GDP in Euro per inhabitant	0.821	-0.200	-0.386	0.092
UNRT01N3 - unemployment rate total	-0.118	0.039	0.728	-0.126
UNRT98N3 - Development of unemployment rate 1998-2001	-0.122	0.242	0.386	0.166
AHFF_%e - employment (agric., Hunt., fore., Fish.)	-0.491	0.540	0.063	-0.280
Indus_%e - Industry - employment	-0.213	-0.077	-0.126	0.813
serv_%e - Services - employment	0,566	-0,370	0.050	-0.439
all_emp_1 – employment/1000 inhabitant	0.784	-0.009	-0.145	0.125

The first component identified is highly correlated with such variables as GDP per capita, absolute values (.82), GDP per capita calculated using Purchasing Power Parity index (.81), total employment per 1000 inhabitants (.78), the share of artifical surface in the total land area (.77), and the share of urban fabric (.75). This component can be termed *spatial development intensity component.* The spatial pattern of differentiation of its values is presented in Figure 1. Medium values are the ones that fall between minus one and plus one standard deviation from the mean level; high and low scores are those above and below the median category, respectively.

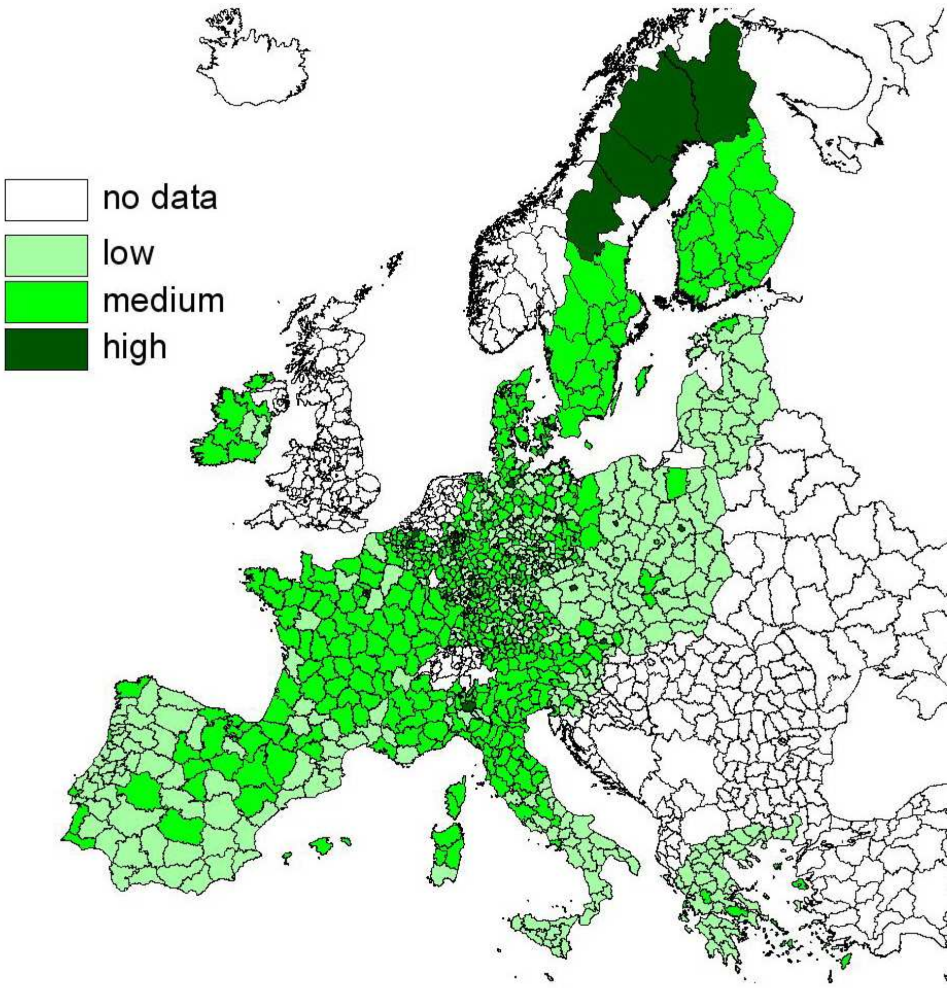

Figure 1. Spatial Distribution of Component 1 scores

The second component is correlated mainly with measures of spatial accessibility, such as time – distance to market (NUT's main centre) by road and rail (.88). It is therefore defined as spatial accessibility component. The distribution of its values is highly sensitive to the size of spatial units of reference (see: Figure 2). High component scores indicate longer time – distance to centres of NUTS-3 units.

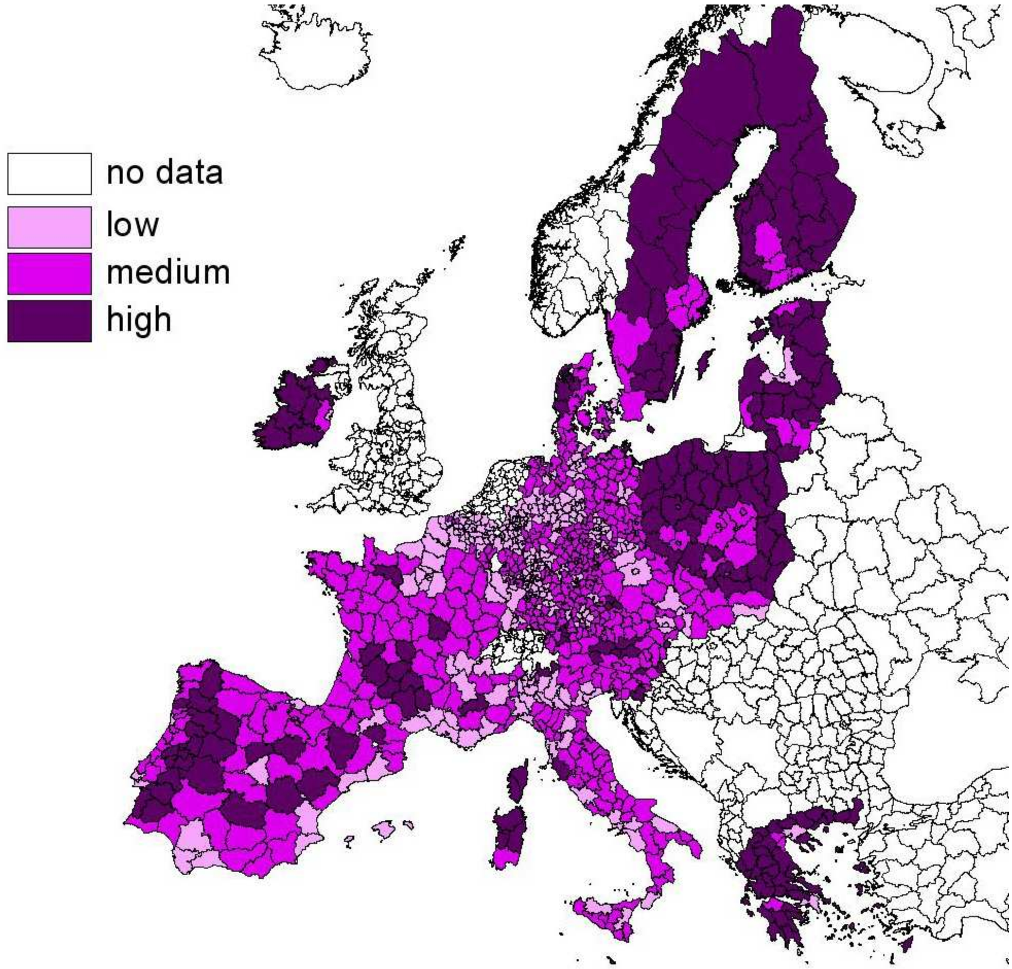

Figure 2. Spatial Distribution of Component 2 scores

The third component, highly correlated with the rate of unemployment, is identified as *structural maladjustment component* (see: Figure 3). The fourth component is mostly related to the share of industry in total employment (.81), and is therefore identified as *industrial employment component* (Figure 4).

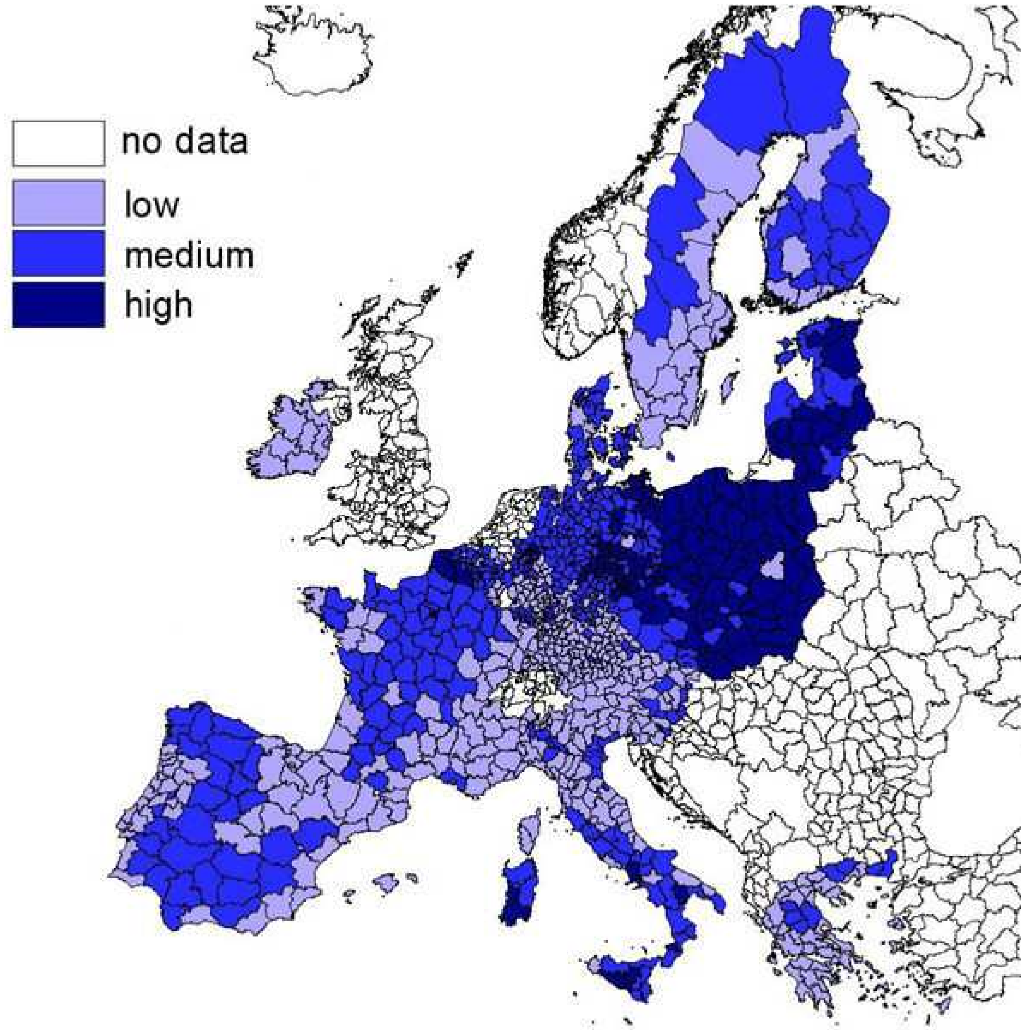

Figure 3. Spatial Distribution of Component 3 scores

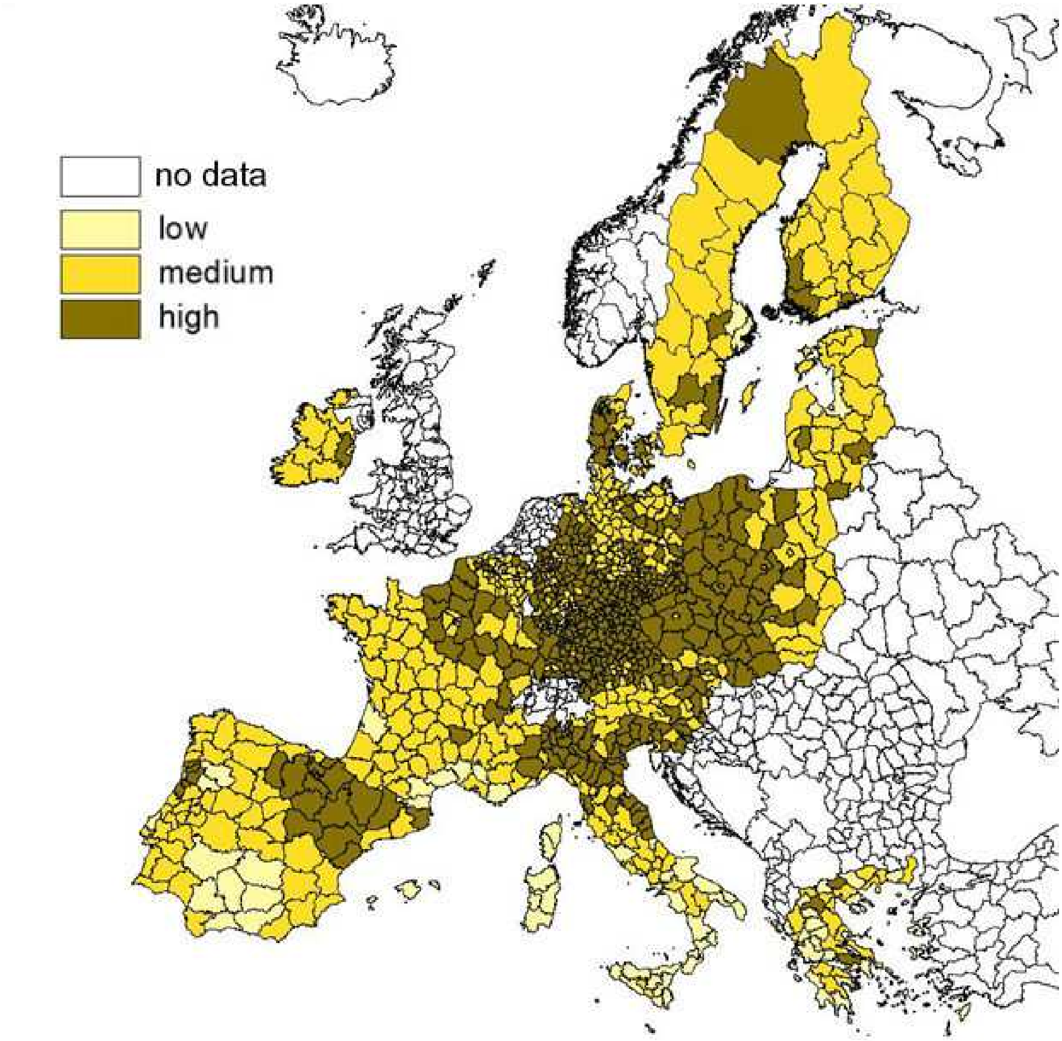

Figure 4. Spatial Distribution of Component 4 scores

The next step in the analysis was an attempt to identify differences between individual RUR types in terms of distribution of component scores within the respective sets of NUTS-3 units. This is illustrated by Figure 5 which shows distribution patterns of component one scores. Its standardized values are marked on y axis. The flat distributions indicate relatively small differentiation of component values within the class of NUTS-3 units belonging to a specific RUR type. High gradients reflect large differentiation. The latter is clearly a characteristic of rural regions. Conversely, regions of type 1 (very large monocentric) and type 4 (urban polycentric) display a considerable degree of homogeneity in terms of the distribution of component scores. It should be emphasized that similar differences in the patterns of component scores are found in case of the remaining components.

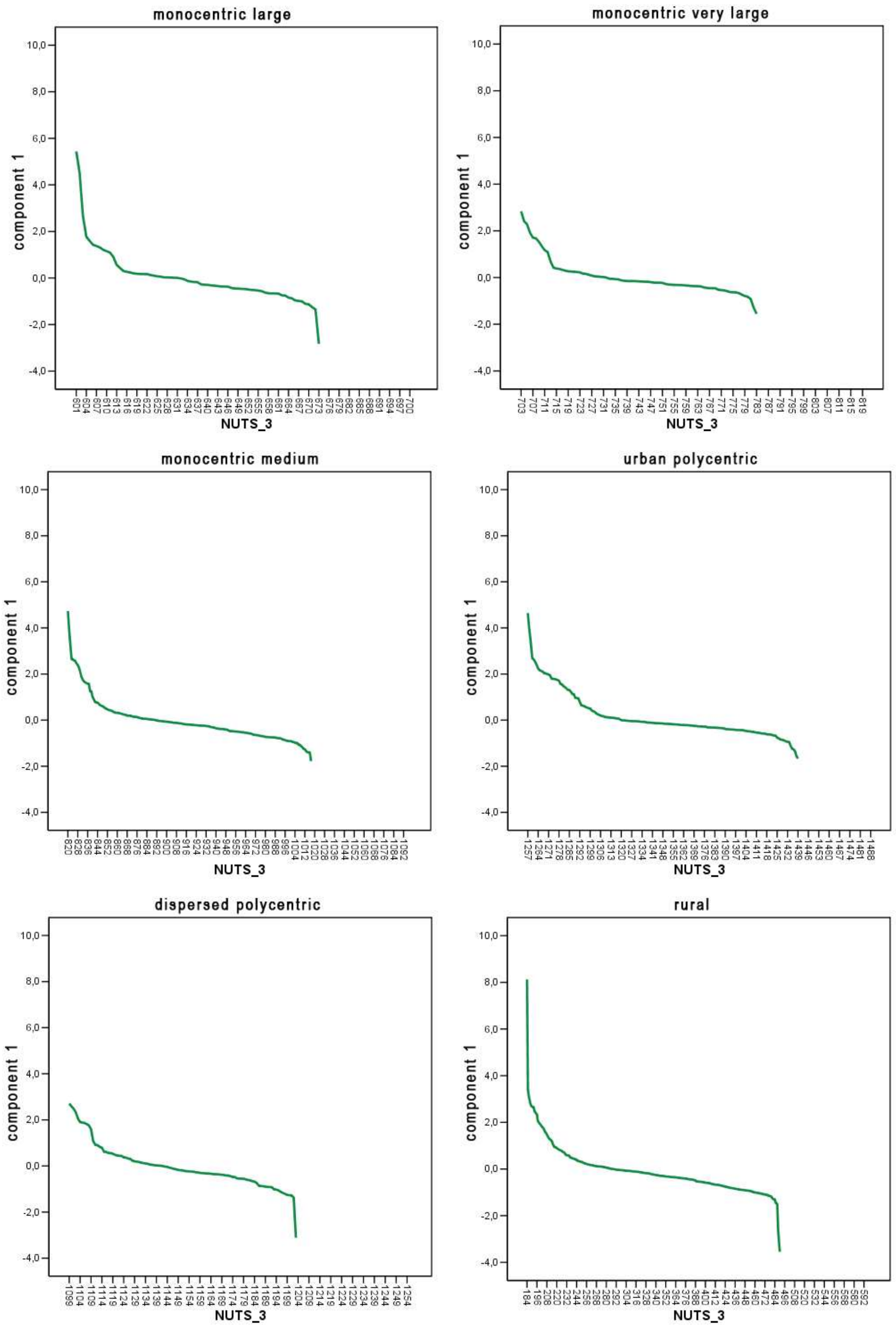

Figure 5. Distribution of Component One scores by RUR types

4. Economic Development – Land Use Change Response Functions

At this stage, on the basis of correlation analysis, several variables were selected, with the aim of identifying the economic development – land use response functions. The variables chosen were the ones that exhibited relatively high correlation (r = 0.6 - 0.8) with the intensity of land used for settlement, here represented by the share of artificial surfaces in the total land area. These variables were the following: number of persons employed (total employment) per 1000 inhabitants; spatial accessibility – time-distance to the unit's main centre; population density; GDP per capita. An additional variable used was change of GDP per capita, between 1996 and 2006, calculated in Purchasing Power Parity terms. Also, in order to illustrate the range of differences in economic productivity of a unit of land, the share of artificial surfaces was regressed against GDP value per square km.

In the regression analysis the shares of artificial surfaces, for individual NUTS-3 units, were converted into natural logarithm values. For the purpose of graphic presentation the spatial units (1289 observations) were assembled into 20 five-percentage-point classes, from 0-5 to 95-100 percent of the share of artificial surface within total land area. The use of bar diagrams, in place of more conventional scatter diagrams seems to have an advantage of avoiding the heavy clustering of dots in a situation when the overwhelming majority of observations fall into low-value sectors (see Table 3). The length of individual bars reflects median values of independent variables for the respective land use classes (the distribution of values within individual classes tends to be highly skewed).

As the results show (see Figures 6 -11), differences between the land use classes identified on the basis of the share of artificial surfaces are especially pronounced in the case of GDP per capita values (not to speak of GDP per sq. km disparities which could be easily anticipated). Such a relation is also fairly regular, and statistically significant in the case of the other variables, i.e. the total employment rate and spatial accessibility (in the latter case correlation is negative). In should be noted that the statistical relation between the share of artificial surface and population density is extremely regular. This suggests that population density could actually be used as a proxy for the share of artificial surface when data for the latter are not available.

Table 3. Share of artificial surfaces categories by NUTS-3 units

Classes of NUTS_3	Class ranges	Frequency	Percent	Percent valid	Cumulative percent
1	0-5%	649	48.6	50.3	50.3
2	5-10%	301	22.5	23.4	73.7
3	10-15%	77	5.8	6.0	79.7
4	15-20%	44	3.3	3.4	83.1
5	20-25%	52	3.9	4.0	87.1
6	25-30%	25	1.9	1.9	89.1
7	30-35%	25	1.9	1.9	91.0
8	35-40%	21	1.6	1.6	92.6
9	40-45%	11	.8	.9	93.5
10	45-50%	19	1.4	1.5	95.0
11	50-55%	15	1.1	1.2	96.1
12	55-60%	7	.5	.5	96.7
13	60-65%	4	.3	.3	97.0
14	65-70%	7	.5	.5	97.5
15	70-75%	9	.7	.7	98.2
16	75-80%	3	.2	.2	98.4
17	80-85%	8	.6	.6	99.1
18	85-90%	7	.5	.5	99.6
19	90-95%	2	.1	.2	99.8
20	95-100%	3	.2	.2	100.0
Total		1289	96.5	100.0	
no data		47	3.5	no data	
Grand total		1336	100,0	Grand total	

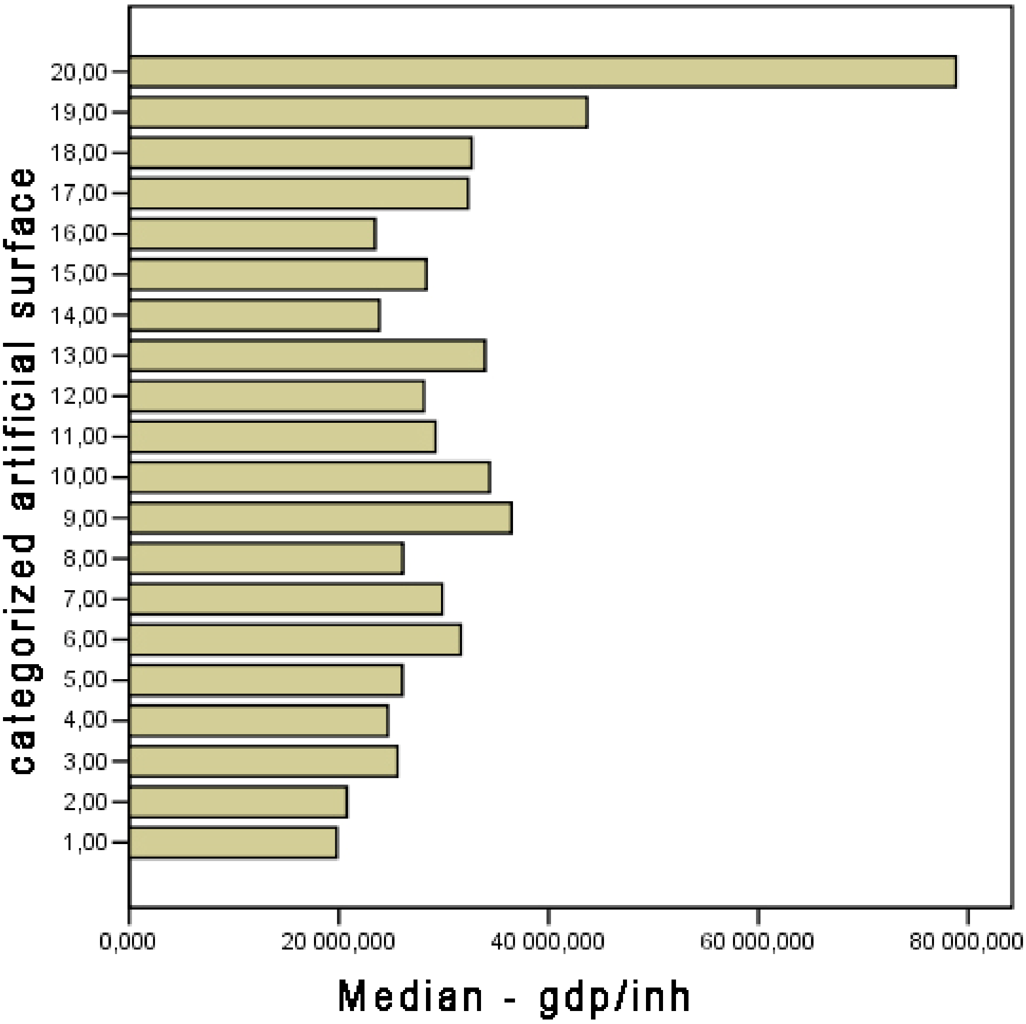

Figure 6. Relationship between categorized *artificial surface* share and median GDP per capita

Table 4. Regression function statistics: *artificial surface* share and GDP per capita

Model		Non-standardized rates		Standardized rates
		B	Standard error	Beta
1	(const.)	.671	.075	
	gdpinh	4.310E-05	.000	.365

Y[ln(arsu96n3)] = 0.671 + 4.310E-05(gdpinh)

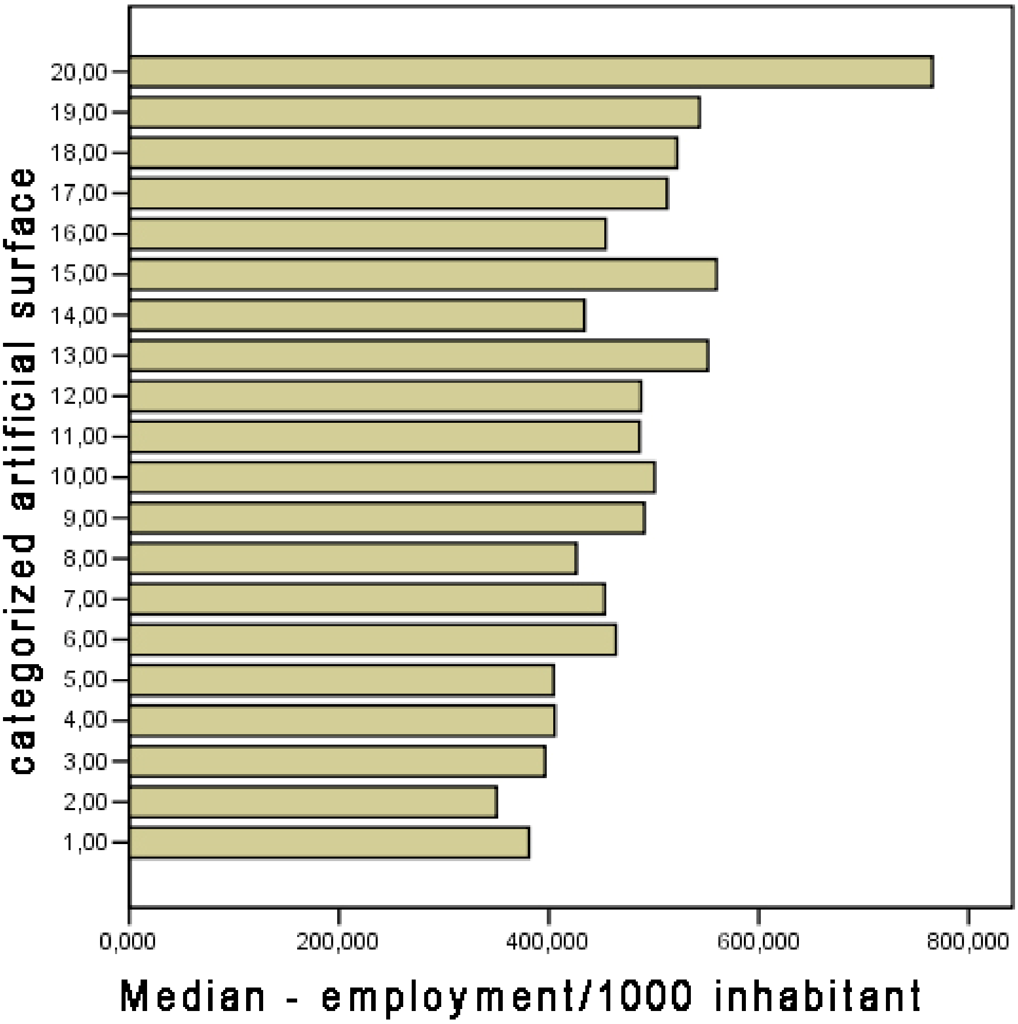

Figure 7. Relationship between categorized *artificial surface* share and employment per 1000 inhabitants

Table 5. Regression function statistics: *artificial surface* share and employment per 1000 inhabitants

Model		Non-standardized rates		Standardized rates
		B	Standard error	Beta
1	(constant)	.499	.143	
	emp1000	.003	.000	.219

Y[ln(arsu96n3)] = 0.499 + 0.003(emp1000)

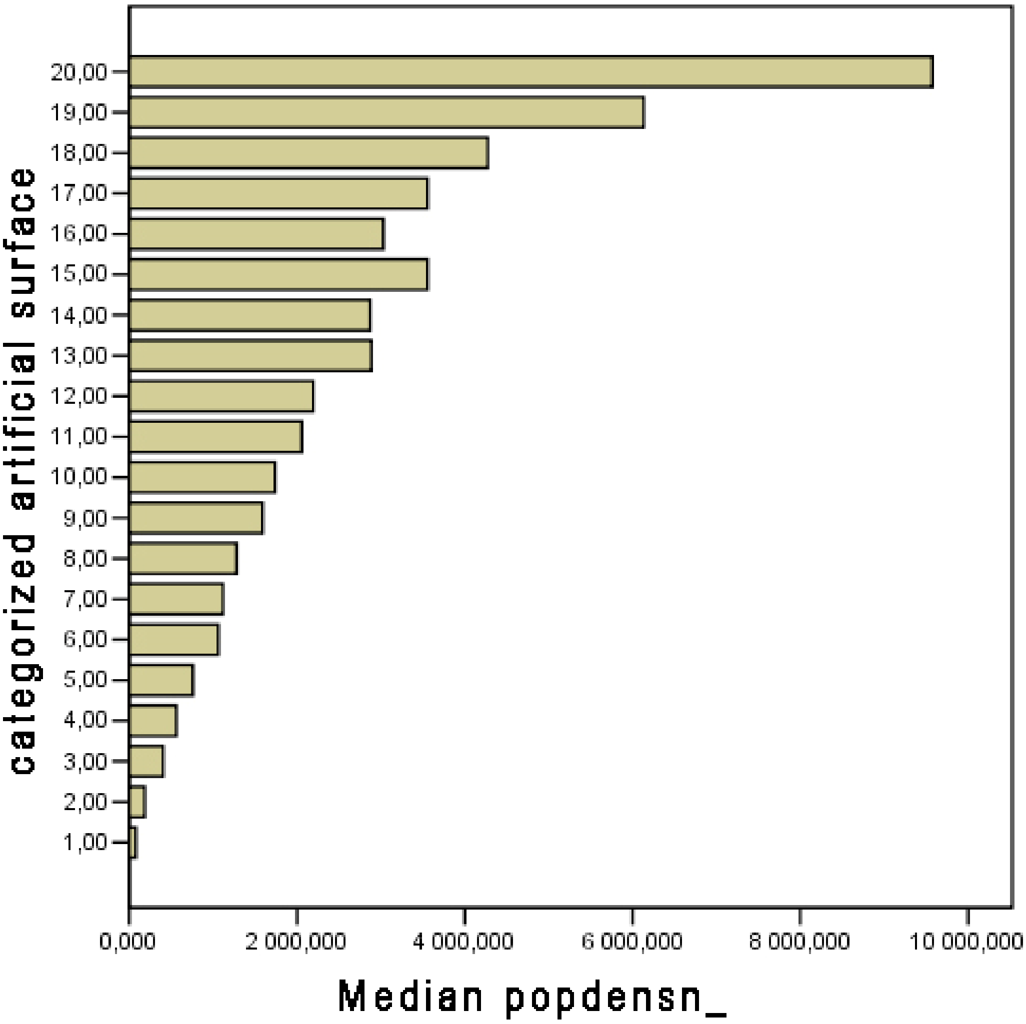

Figure 8. Relationship between categorized *artificial surface* share and population density

Table 6. Regression function statistics: *artificial surface* share and population density

Model		Non-standardized rates		Standardized rates
		B	Standard error	Beta
1	(cons)	1.281	.033	
	popdensn_	.001	.000	.572

Y[ln(arsu96n3)] = 1.281 + 0.001(popdensn)

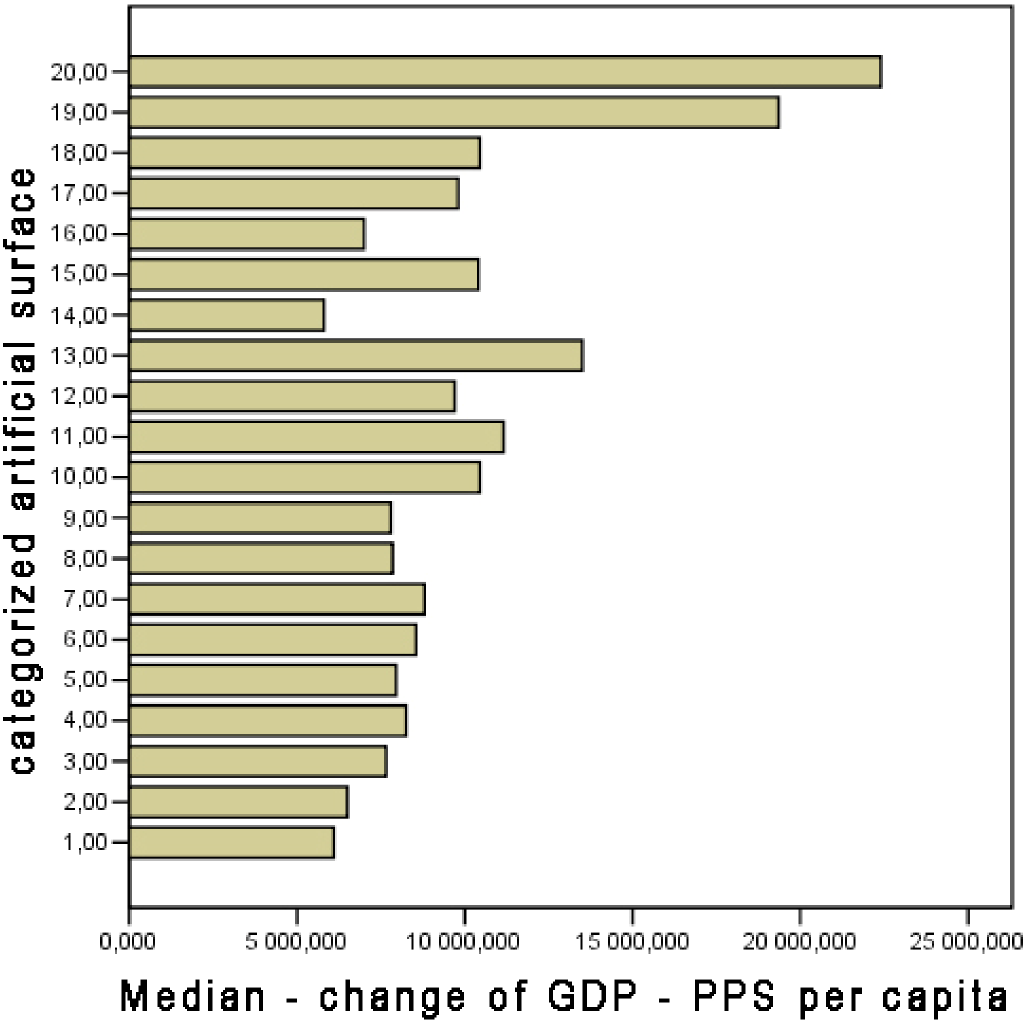

Figure 9. Relationship between categorized *artificial surface* share and change of GDP - PPS per capita

Table 7. Regression function statistics: *artificial surface* share and change of GDP - PPS per capita

Model		Non-standardized rates		Standardized rates
		B	Standard error	Beta
1	(const)	.957	.080	
	ch_GDPpp	9.550E-05	.000	.299

Y[ln(arsu96n3)] = 0.957 + 9.550E-05(ch_GDPpp)

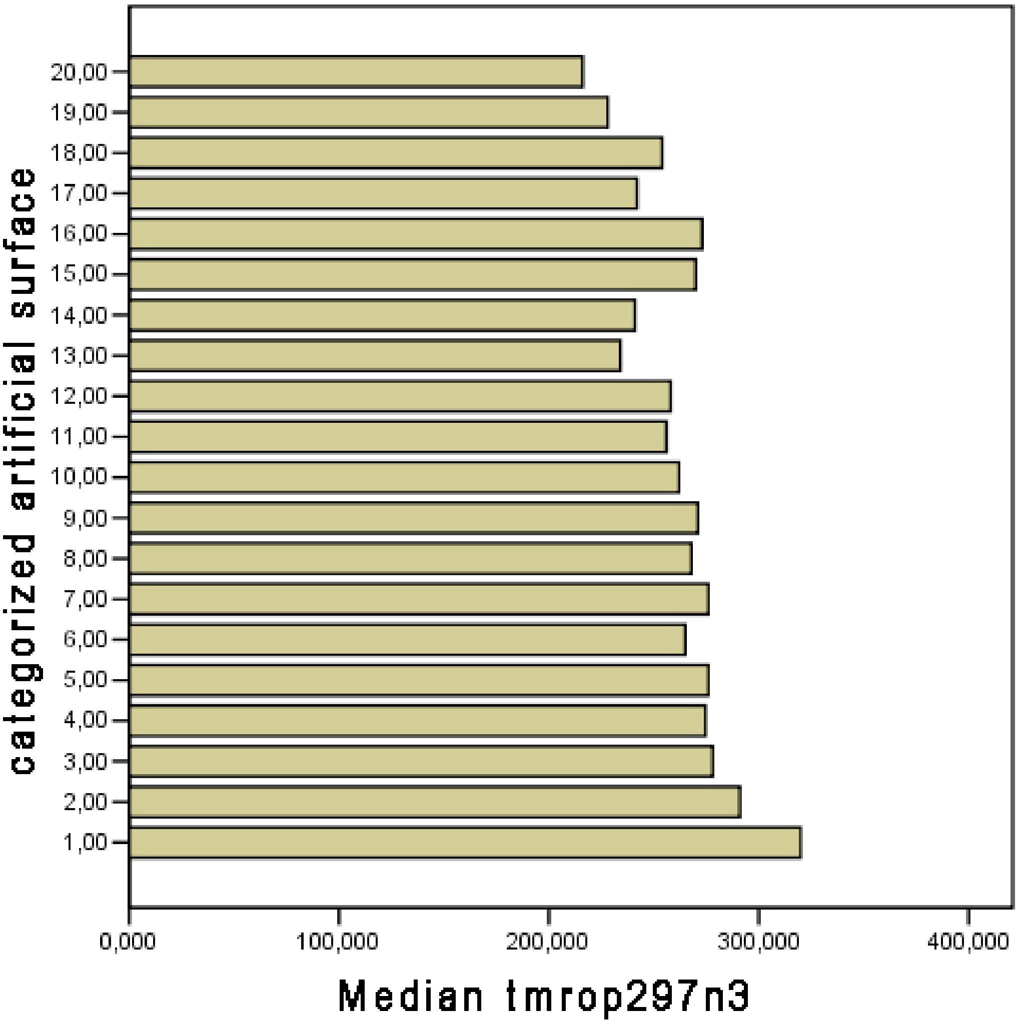

Figure 10. Relationship between categorized *artificial surface* share and accessibility time to NUTS-3 centres by rail and road

Table 8. Regression function statistics: *artificial surface* share and accessibility time to NUTS-3 centres by rail and road

Model		Non-standardized rates		Standardized rates
		B	Standard error	Beta
1	(const)	9.597	.197	
	tmrop297n3	-.026	.001	-.752

Y[ln(arsu96n3)] = 9.597 – 0.026(*tmrap297n3*)

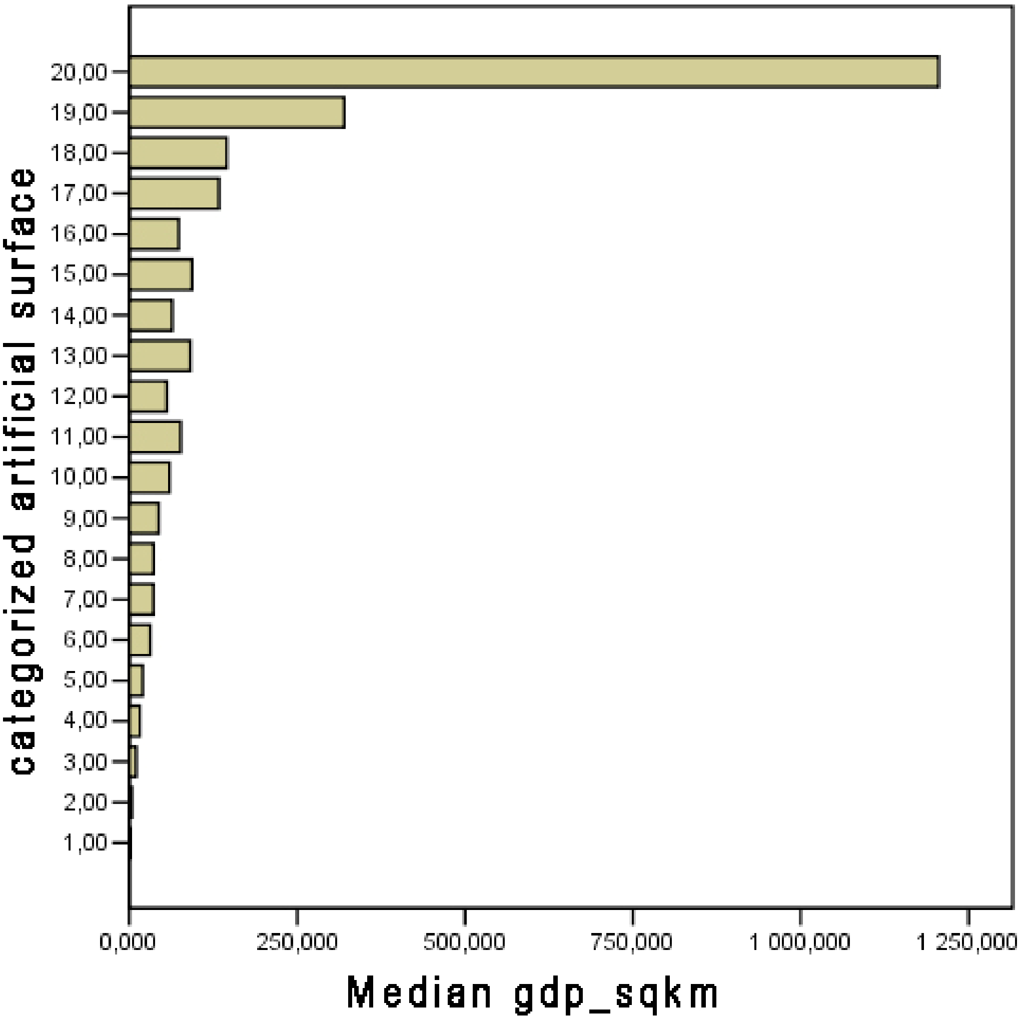

Figure 11. Relationship between categorized *artificial surface* share and GDP per sq. Km

Table 9. Regression function statistics: *artificial surface* share and GDP per sq. Km

Model		Non-standardized rates		Standardized rates
		B	Standard error	Beta
1	(const)	1.501	.035	
	gdp_sqkm	.007	.001	.360

Y[ln(arsu96n3)] = 1.501 + 0.007(GDP_sqkm)

5. Concluding Remarks

Economic development and the related social change are considered as the main driving forces of urbanization. This interdependence, when expressed in quantitative terms, i.e. response functions, changes over time and depends upon the model of socioeconomic development. In the present study interrelations between economic development and land use characteristics were examined by applying principal component analysis as well as regression analysis. The study was carried out at NUTS-3 level for EU-27, and was based on more than 20 variables.

Considerable differences were identified among the six types of rural-urban regions (cf. PLUREL's RUR typology) in the distribution of values of indicators related to economic development level. This pertains to the average level as well as variance among individual units which were assigned to separate RUR types. The units in regions of type one – very large monocentric, as well as of type four – urban polycentric, are characterized by relatively small variation of indicator values. The biggest variation pertains to type six, i.e. rural regions. This result suggests that, while the large metropolitan areas across the EU tend to display common land use and economic development characteristics, differences between the predominantly rural regions remain quite profound. It has also been found that the income gap between urban and peri-urban areas on the one hand, and rural areas on the other, has been widening. This is revealed by the analysis of interrelation between GDP per capita change, as registered for the period of 1996 – 2006, and the intensity of land used for human settlement, i.e. the share of artificial surfaces in the total land area. In general, this share is strongly related to both the GDP per capita level and total employment rate.

In further work the results should be verified by using time cross-sectional data. It would be crucial to extend the analysis into the whole decade of 2000 – 2010, in order to reflect the scope of spatial change related to metropolitan processes in Europe as a whole, as well as to systemic transformations in countries of Central and Eastern Europe.

References

Helminen V., Ristimaki M., Kontio P., Vuori M., 2010, Response Function for Commuting, PLUREL Milestone Report M 2. 3. 23.

Hoover E., 1948, The Location of Economic Activity. New York: Mc Grow-Hill. Book Company.

Isard W. et al., 1956, Methods of Regional Analysis: An Introduction to Regional Science. Cambridge, Mass.: The M. I. T. Press.

Korcelli P., 2008, Draft Response Functions of Land Use Change in Rural-Urban Regions: Economic Development, Location of Work Places (Concept, Assumptions). PLUREL Milestone Report M 2. 3. 11.

Krugman P., 1995, Development, Geography, and Economic Theory. Cambridge, Mass.: The M. I. T. Press.

Lasuén I., 1973, Urbanization and Development: The Temporal Interaction Between Geographical and Sectoral Clusters, Urban Studies, 10, 163, 188.

Loibl W., Köstl M., 2010, Exploring the Relationship between Population and Land Use. PLUREL Mailnstone Report M 2. 3. 19.

Porter M., 1990, The Competitive Advantage of Nations, London: Mcmillan Press.

Ravetz J.,2009, Proposales for smart CUBE Development. PLUREL M 5. & General.

Rickenbush S., 2009, Report on Maps of Land-use Change Projections for Europe, PLUREL D 1. 4. 3.

Loibl W., Köstl M., Steinnocher K.,2009, List of Generic Rural-Urban Region Types; Quantitative Classification. PLUREL D 2. 1. 3.

Vernon R., 1966, International Investment and International Trade in the Product Cycle. Quorterly Journal of Economics, 80, 190-207.

Zasada I., Piorr A., 2009, Response Functions and iIAT at European Level and Their Value for the Montpellier Region. PLUREL, WP 2.3.