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Measuring Spatial Segregation in Roma Neighbourhoods of Northern Bulgaria

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ABSTRACT

The Roma represent a significant ethnic minority in post-communist Central and Eastern European countries, often residing in segregated areas resembling slums, inaccurately referred to as "ghettos." What is special about the Roma ethnic group is that their spatial segregation is both ethnic and social, economic and cultural, which further intensifies the observed negative consequences. Spatial segregation becomes a major cause of social segregation and reproduction of accumulated disadvantages. This study examines ghettoized Roma neighbourhoods in selected towns of Northern Bulgaria, aiming to assess their level of spatial segregation using a set of spatial, demographic and infrastructural indicators. The study's primary hypothesis is that Roma neighbourhoods experience varying levels of spatial segregation, which directly correlates with broader social segregation. The hypothesis is tested through two complementary approaches to measuring segregation, using a set of quantitative and qualitative indicators. The selection of seven ghettoized urban structures GUSs in Northern Bulgaria was based on data availability at the time of the research, as well as on the diversity of towns. The results show significant variation in segregation levels across the studied neighbourhoods, from low to very strong depending mostly on the values of the so-called primary indicators used for the proposed spatial segregation index. The suggested indices represent a comprehensive way of measuring the differences between deprived neighbourhoods, by using generally accessible data, which is a key factor in studying that type of urban structures. The study fills an existing gap in the research of deprived urban areas by proposing a universally applicable index that can be easily adapted to local conditions.

1. INTRODUCTION

One of the main challenges that modern European cities face is related to increasing inequalities in society and socio-spatial polarization, which is directly related to the desired social integration and inequality reduction processes. Reducing inequalities is integral to the global sustainable development agenda and to local city policies (Kit et al., 2012). There are new patterns of socio-spatial polarization based on income inequality and ethnicity (Weclawowicz, 2002).

In general, cities in the former socialist countries in Europe are characterized by a lower degree of residential segregation compared to other European countries. This can be explained by the socialist period policy, which aimed to achieve social equality and minimal income differentiation. The above statements, however, were not valid for all groups of residents, especially those who identify as Roma (Sýkora, 2009; Szelenyi, 1983; Toušek, 2009; Marcińczak, 2007). A growth of Roma ghettoized structures in post-socialist cities is observed in a number of cases, particularly in areas increasingly affected by depopulation processes. The reasons for the observed processes are related to the higher rates of Roma population growth, the socio-economic transformation of the post-socialist economies, the entry of the neoliberal model of state development, the withdrawal of the welfare state, the high levels of unemployment, social exclusion, etc. In most cases, the Roma either settle in the existing Roma neighbourhoods in the cities, or form new ones, which makes it even harder to solve one of the most important problems of Bulgarian society – the integration of the Roma population. Some newly developed impoverished urban areas have evolved into urban ghettoized structures over time. These urban structures share many characteristics, but they differ in many other ways, as well, such as how severely segregated they are. Regardless of the country or the region, urban space is always socially defined. According to Heckmann (2009) the socio-spatial structure of a city can be read as a map that records the structure of society. According to the Polish scholar Marcinczak (2012), the “divided city” implies the existence of different areas within a single city. Van Kempen (1994, 2007) clarifies the relationship between the divided society and the divided city – if a society is divided, so will the corresponding urban space. As a result, many scholars (Peach, 1981; Massey and Denton, 1993) maintain the opinion that patterns of spatial segregation are indicative of the intensity of assimilation or integration processes in general. According to Francini (2013), the formation of “ethnic enclaves” in cities can threaten the social, cultural and spatial integrity of the city.

2. THEORETICAL FRAMEWORK

2.1. Spatial segregation

In scientific literature, there are various perspectives on the issue of spatial segregation, making it challenging to find a precise and widely recognized definition. Marcuse (2005) defines spatial segregation as a process of forced grouping of a certain group of the population in a limited spatial scope. For example, in the case of ethnic spatial segregation, the separation of a given ethnic community in a certain space is observed, while in the case of social segregation, a high concentration of a given population with the same social status is noted. What is special about the Roma ethnic group is that, in their case, spatial segregation is both ethnic and social, economic and cultural, which further outlines the observed negative consequences.

Depending on the country or the region, the inner differences in the urban structure, urban morphology and urban fabric are often a result of some type and level of segregation, which can be either entirely social (low-income residents occupying certain neighbourhoods), entirely ethnic, or a combination of both. The latter is the most common type of urban segregation in cities across Europe, while in post-communist countries the ethno-social segregation is related mostly to the Roma community, which is often the largest ethnic minority in those countries. In Bulgaria, spatial segregation is solely related to the Roma neighbourhoods, which, in some cases, cover a significant part of the urban space and thus represent a functional barrier to the urban development. In many instances, the Roma population is distributed throughout the urban settlement, but this ethnic group preponderantly resides in specific neighbourhoods, colloquially referred to (by the general population) as Roma “ghettos”. Even though those neighbourhoods share many characteristics, they are distinct and show varying degrees of segregation. The objective of this study is to suggest a method which allows for the measurement of the level of spatial segregation of Roma neighbourhoods, based on actual examples from that type of urban structures in Northern Bulgaria.

Spatial segregation can be defined as a *multifaceted spatial phenomenon pertaining to the spatial concentration of a specific group of individuals based on socio-demographic, socio-economic, or ethnic criteria, such as race or ethnicity*. In addition to direct or indirect coercion, discrimination, financial limitations, social exclusion, etc., spatial segregation is the consequence of voluntary choices (internal factors), external factors, or a combination of both. Spatial measures of segregation began to be developed in the 1980s (Morgan, 1981; Reardon and O’Sullivan, 2004; White, 1983; Wong, 2003). However, most empirical research uses non-spatial indices because they do not require the collection of geographic information, which is much more difficult to find and employ in calculations.

Spatial segregation has a significant impact on social segregation, as it reflects and reinforces the uneven distribution of social groups within a geographic space, often leading to unequal access to resources, services, and opportunities (Rasse, 2019).

Although spatial segregation is difficult to define precisely, a clear distinction needs to be made between two perspectives on measuring the level of spatial segregation: a) measuring the *level of spatial* *segregation of an entire urban settlement* (city) where segregated communities exist, i.e. what the level of segregation of city A, city B, etc. is, where one or more segregated communities exist (Ilieva et al., 2020); b) measuring the *level of segregation of a given segregated urban structure* (neighbourhood) and/or its population, i.e. how segregated neighbourhood X and its residents are (which neighbourhood happens to be in city A, where other segregated neighbourhoods (Y, Z) also exist, and which of the three is the most segregated).

This paper proposes a particular approach, that of measuring the segregation level of neighbourhoods (X, Y, Z) and not of cities (A, B, etc.). This methodological approach aligns with recent developments by Ilieva et al. (2025), who applied similar segregation indices in a case study of Roma neighbourhoods in Ruse, Bulgaria, reinforcing the relevance of these indicators in the national context.

2.2. Slums, deprived areas and informal settlements

Informal settlements are typically described as places with inadequate basic infrastructure, substandard housing, illegal habitation, non-secure tenure, high urban density, poor sanitation, poverty, and marginalization (Gilbert and Gugler, 1982). Surd et al. (2015) examine the spatial distribution and socioeconomic disparities between urban cores and peripheries in Romania, particularly emphasizing the impact of political decisions on wealth gaps. The authors highlight the absolute spatial segregation between these groups, with poor peripheries often located near waste disposal sites and rich peripheries in more affluent, green spaces. On the other hand, the role of transport corridors in reducing spatial disparities and stimulating regional development has been emphasized in the Romanian context (Opriş-Sîrca, 2024).

Defining informal settlements, slums and deprived areas is an extremely complex task, especially with regard to disentangling which of the variables distinguish the formal settlements from the informal ones. Most authors emphasize the need for more variables in defining the informal settlements. Kohli et al. (2012), define several morphological characteristics, which are taken into consideration when defining deprived urban areas (Table 1).

Taubenböck and Kraff (2015) conclude that regardless of the general physical characteristics, there are no universally valid parameters. The same authors summarize several variables used by a number of authors to define informal settlements (Samper et al., 2020; Samper, 2014; Fernandes, 2011; Gilbert and Gugler, 1982; UN-HABITAT, 2006; Kibwana, 2000; Hurskainen and Pellikka, 2004; Taubenböck and Kraff, 2014; Kamel et al., 2014; Patel et al., 2019).

Table 1. Morphological features typical for slum areas.

Features	Slum areas	Formal built-up areas
Size	Small buildings / huts	Larger building sizes
Density	High roof coverage density	Low to moderate building density
	Lack of public (green) spaces	Provision of public (green) spaces
Pattern	No orderly infrastructure arrangement	Regular and planned infrastructure
Site characteristics	Hazardous locations (flood prone or steep slopes)	Land has basic suitability for built-up areas

Source: Kohli et al. (2012).

The ontological framework for conceptualizing slums developed by Kohli et al. (2012) reflects the traits of poor neighbourhoods in developing countries (the remote sensing and urban planning experts involved in this survey were from Asia, Sub-Saharan-Africa and Latin America), which are similar in some morphological and social characteristics, but significantly differ from Roma neighbourhoods in post-socialist countries.

Kohli et al. (2012) developed a slum ontology based on Hofmann et al. (2008b), which consists of three spatial levels (object, settlement and environs). For each level, indicators identify specific physical slum characteristics. That ontology, however, needs to be *adapted to local conditions, as not all indicators are relevant to a specific context for mapping purposes* (Kuffer et al., 2016). For instance, Roma neighbourhoods in post-socialist countries are similar to urban spatial formations perceived as deprived areas, slums, etc., yet carrying their own specific features. Therefore, *local adaptation and implementation are needed due to the diversity in the characteristics of slums and informal settlements as not all indicators would apply to all areas*.

The current study provides an opportunity to integrate local knowledge by selecting appropriate parameters (indicators) adjusted to local conditions.

2.3. Roma ghettoized urban structures (RGUSs)

In order to describe segregated Roma neighbourhoods, this research employs the term “ghettoized urban structure” (GUS). Ghettoized urban structures are defined by Asenov (2018, p. 77) as: “*a distinct ghetto-like settlement, which is a section of the urban space, representing a city neighbourhood, district, micro-district, or hamlet, usually with fixed boundaries and characterized by: a) poor, missing or unregulated street, housing, electrical, social, etc.*

infrastructure; b) a population primarily defined by social, cultural, racial, or ethnic traits; c) relationships within the settlement are frequently governed by pre-modern social norms; d) the inhabitants are distinguished by their own subculture".

Roma ghettoized urban structures (RGUSs) are easily recognizable in the urban space due to their specific morphological characteristics. When delineating RGUSs, different criteria are adopted, such as: ethno-cultural – the share of the ethnic group; socio-economic – higher than the average unemployment, poverty and infant mortality rates, high employment in the grey economy, low professional and educational qualifications of the residents; deteriorated characteristics of the housing stock, technical and social infrastructure, hindered public transport access, randomly located housing units, high percentage of illegal buildings, etc. Very often, RGUSs are located near industrial sites and/or in urban areas with long-term negative trends in their socio-economic development, or increased degree of environmental risks.

The identification and mapping of RGUSs represents a challenge related to the extraction of data, including spatial data. There are two main problems that concern Roma neighbourhoods in Bulgaria in particular: 1) lack of a clear, generally accepted and normatively determined definition of Roma neighbourhoods, and 2) lack of sufficient knowledge and awareness of their location and characteristics at national (central authority) level (Tomova and Stoychev, 2022).

For the purpose of this study, a total of 7 RGUSs have been selected, located in five urban settlements (towns/cities) in Northern Bulgaria (Fig. 1).

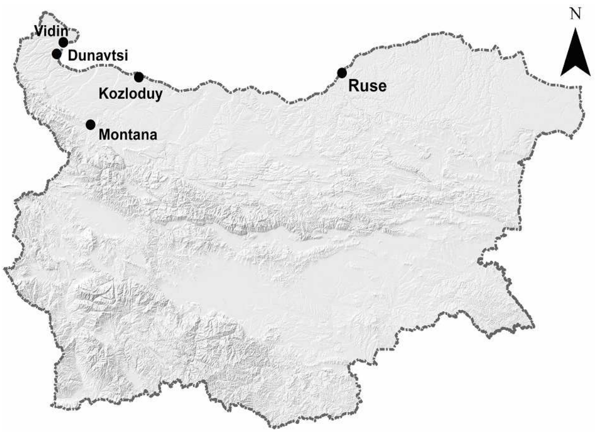

Fig. 1. Location of the urban settlements selected for spatial segregation level measurement of RGUSs.

These towns vary in size and administrative functions: very small with no administrative functions (Dunavtsi); small municipal (LAU 1) centres (Kozloduy); medium (NUTS 3 regional centres – Montana and Vidin) and large (NUTS 2) regional centres – Ruse).

3. METHODOLOGY OF THE RESEARCH

3.1. Selection of indicators

To a large extent, spatial segregation is associated with access to various resources and facilities provided by the city and the place occupied by the ghettoized structure in the urban space. For this reason, an array of access indicators have been selected, such as location in the urban space, access to school, kindergarten, public transport, healthcare facilities, and public parks. Indicators related to public transport access were included based on evidence linking mobility patterns with social segregation (Yang et al., 2025), highlighting how spatial barriers translate into differentiated life opportunities. The main characteristics of segregated urban areas outlined by a number of authors have been considered, and the selection was based on a specific set of quantitative and qualitative indicators that can be quantified. Although the selection was made according to the suggestions of various authors, some indicators that are typical of Roma ghettoized structures were considered more appropriate and, therefore, included in the selection, while others were disregarded for being less appropriate, or because related data was not available at the local level. In order to be eligible for a subsequent calculation of the spatial segregation level, all indicators must have ordinal values which can be assessed from worst to best – for example *residential area per inhabitant* can vary from 5 to 50 m², where 50 is a better value than 5, since the larger the value of that particular indicator, the better, whereas *share of buildings with no ownership documents* can be 10% or 90%, where 10% is a better value than 90%, etc. Some of the indicators do not have numerical values, but still can be given a score, based on existence or lack thereof, thus receiving a score of 1 and, respectively, 3. For the purpose of spatial segregation assessment, a total of 26 such indicators have been used in this study. These indicators can be divided into 2 categories: *primary indicators* (a total of 10) and *secondary indicators* (16). The selection of indicators has been done according to suggestions forwarded by various authors (Kohli et al., 2012; Baud et al., 2010; Lilford et al., 2019; Ezeh et al., 2017; Friesen et al., 2018; Thomson et al., 2020; Taubenböck and Kraff, 2014; Samper et al., 2020; Taubenböck et al., 2018; Fallatah et al., 2022; Lehner and Blaschke, 2019; Lehner et al., 2018; Kohli et al., 2016). While some indicators have been deemed more suitable and have been included, others have been removed. Primary indicators are considered relatively more indicative for Roma GUSs in Bulgaria, while the secondary indicators have been assigned less significance, not necessarily typical for Roma GUSs only, but typical for substandard city areas. As a result, the selected set of primary and secondary indicators is described in Table 2.

Table 2. Selected indicators and reasons for selection.

PRIMARY INDICATORS	JUSTIFICATION / REASONS FOR SELECTION
Location in the urban space	RGUSs are usually located at the periphery of the city
Access to primary school	Crucial for social integration of Roma children
Access to kindergarten	Highly important for learning basic Bulgarian language needed for later school attendance
School segregation	Attending Roma segregated school is a common feature of children residing in RGUSs
Access to public transport	Lack of sufficient means of public transportation is a common feature of RGUSs in Bulgaria
Proximity to anthropogenic hazards and potential pollution sources	RGUSs are often located near hazardous areas – landfills, railway tracks, industrial zones
Access to tap water	Substandard supply of tap water is a common feature of RGUSs in Bulgaria
Population density	RGUSs exhibit higher population density than formal neighbourhoods
Residential area per inhabitant	RGUSs exhibit substandard values (less residential area per inhabitant) compared to formal neighbourhoods
Share of buildings with no ownership	The vast majority of buildings in Roma GUSs lack documentation – indicative of illegal construction
SECONDARY INDICATORS	**JUSTIFICATION / REASONS FOR SELECTION**
Access to emergency medical care	Located at the city periphery along with substandard street network can jeopardize ambulance access
Access to outpatient care	Considered vital for Roma integration into the healthcare system
Access to public parks	Being located at the periphery of the city, RGUSs are often beyond the distance to public parks provided by national legislation
Natural hazard risk	RGUSs are prone to natural hazards such as floods, landslides, etc., due to their location and substandard housing
Proximity to major transport axes	RGUSs are often located along major road/railway axes without having actual access to them, while, at the same time, are exposed to accident risks and pollution
Sewerage	Insufficient or lack of sewerage, including waste water sewerage, is a typical feature of the RGUSs
Waste collection	RGUSs are often deprived of waste collection services
Green areas for public use	RGUSs are often deprived of access to open green spaces due to dense illegal housing
Children's playground	Unlike formal neighbourhoods, RGUSs generally lack designated spaces for children
Built-up area dynamics	RGUSs exhibit a more dynamic horizontal and vertical expansion of the residential area compared to formal neighbourhoods
Spatial expansion	In many cases RGUSs exhibit significant spatial expansion in shorter periods of time compared to formal neighbourhoods
Morphology of the urban space	RGUSs often exhibit chaotic street network, due to lack of urban planning
Open space for public use	Unlike formal neighbourhoods, RGUSs generally lack public squares and open spaces, because of dense housing and no urban planning
Population dynamics	RGUSs exhibit more dynamic population number change (increase or decrease) compared to formal neighbourhoods, because of specific natural reproduction and migratory behaviour
Housing and sectoral policies	Unlike formal neighbourhoods, RGUSs are often deprived of housing and sectoral policies provided by local authorities
Built-up area density	Built-up area density in RGUSs is much higher than in formal neighbourhoods, because of illegal housing and non-compliance with construction standards

3.2. Calculation of the selected indicators' values and scores

Detecting a deprived urban area and *defining the limits* of a potentially segregated urban structure (neighbourhood) is the first step in the process of calculating the values of the selected indicators. Since the area of the polygon which the RGUS represents in the urban fabric is needed for the calculation of several indicators, such as population density, residential area per inhabitant, the delineation of the exact limits is of major significance.

The methods used for that purpose can be *remote (satellite/aerial imagery* – Mahabir et al., 2018; Kuffer et al., 2016; Hofmann et al., 2008a; Badmos et al., 2019; Bachofer et al., 2019; Liu et al., 2017; Duque et al., 2017; Wurm et al., 2019; Ma et al., 2019; Wu et al., 2018; Fallatah et al., 2022; Zhao et al., 2019; Taubenböck and Kraff, 2014; Baud et al., 2010; Duque et al., 2015; Pan et al., 2020; Lu and Weng, 2007), *terrain methods*, or a *combination of both*. In some cases, fieldwork and sociological survey among local authorities/residents is required in order to establish the limits of an RGUS.

Establishing the *number of population* of the already delineated RGUS is considered to be another issue, since the national statistics do not always provide public access to population number data at a neighbourhood level. In case that data is available, it is required to verify that the limits of the neighbourhood encompass the same residential area as the one defined by the researcher, which, unfortunately, is rarely the case, and the number of population is usually only approximately established. In most situations, in this study, the population number and dynamics of the selected RGUSs have been calculated based on a combination of election data and National Statistics Institute (NSI) census data for the share of population aged 0-17 by ethnicity. The *population density* has been calculated based on the population number as of 2023 and the area of the previously defined polygons representing the RGUSs was calculated in GIS environment. The *built-up area* of the RGUSs and its dynamics have been calculated in GIS environment, based on Google Earth Pro satellite imagery for 2004 and 2024. All indicators referring to *proximity* (to city centre and civic services, schools, kindergartens, hazardous or potentially hazardous areas, etc.) have been calculated using the ORS tool in QGIS (isodistances from point/line).

Table 3. Score assessment of the primary indicators' values.

PRIMARY INDICATORS / SCORE	SCORE 1	SCORE 2	SCORE 3
Location in the urban space	Centre/broad centre	Centre periphery	City periphery/outside city limits
Access to school	Entire RGUS area within regulated access (600 m)	Less than 50% of RGUS area	Entire RGUS area outside regulated access
School segregation	Roma are minority and equally distributed	Over 50% of the students are Roma	All students are Roma
Access to kindergarten	Entire RGUS area within regulated access (600 m)	Less than 50% of RGUS area	Entire RGUS area outside regulated access
Access to public transport	More than one means of transportation from the R GUS to the city	One means of transportation (for example – one bus line)	No access to public transport
Proximity to anthropogenic hazards and potential pollution sources	No such sources next to, or in close proximity to the RGUS	One or more such sources in close proximity to the RGUS	Such source(s) right next to or within the RGUS limits
Access to tap water	Yes, good supply	Yes, substandard supply	No tap water supply
Population density	Less than twice higher or lower than the city average	Around twice higher than the city average	Over twice higher than the city average
Residential area per inhabitant	Similar to or lower than the city average	Around twice lower than the city average	Over twice lower than the city average
Share of buildings with no ownership documents	Less than 10% of all	Up to 50% of all	More than 50% of all

Source: authors' synthesis and calculations based on Google Earth Pro satellite imagery (2004 and 2024); GIS-based spatial analysis conducted in ArcGIS; National Statistical Institute census and statistical data (NSI, 2022; 2025); spatial and cadastral data from the Geodesy, Cartography and Cadastre Agency (GCCA, 2025); primary data obtained through sociological fieldwork and consultations with municipal representatives (2024); and policy and planning documents, including Municipal Action Plans for Roma Equality, Inclusion and Participation and Municipal General Development Plans, as well as the District Strategy for Roma Inclusion (Ruse, Vidin, Kozloduy and Montana municipalities).

Data from the Geodesy, Cartography and Cadastre Agency (GCCA) has been used for calculation of the *residential area per inhabitant and share of buildings with no ownership stated*. The images of cadastral plans, orthophoto images, and high-resolution satellite images have been georeferenced and digitized in a GIS environment. Based on that remote-sensing data, each individual building in each RGUS has been digitized as a separate polygon.

GIS technologies are also used to calculate various urban planning indicators such as *spatial expansion, built-up area, built-up area dynamics, and residential area per inhabitant*. The calculated data were later attached as attributive information to the relevant layer.

The *sociological survey* conducted in 2024 (interviews/questionnaires) among the local communities and local authorities has been used for verifying RGUSs limits, as well as for assessment of some *non-numerical indicators* used in the calculation of the spatial segregation index (e.g. housing and sectoral policy, as well as waste collection).

According to the proposed methodology in this study, *all indicators initially receive a score between 1 and 3 depending on their values, where score 1 stands for best values, 2 for average values, and 3 for worst values*. The way the calculation of the scores of the primary indicators is done can be seen in Table 3.

The secondary indicators' scores are assigned in a similar manner, but still vary from indicator to indicator, depending on the nature of the indicator: indicators that have numerical values (e.g. built-up aerial dynamics, spatial expansion, etc.) receive a score depending on how high/low the value is – either based on national standards, or depending on the range (minimum/maximum values). Secondary indicators that are not numerical (e.g. waste collection; housing and sectoral policies) are scored depending on the local community assessment established through social survey (interviews/questionnaires). Indicators regarding existence or lack thereof are scored 1 and 3 only.

3.3. Spatial Segregation Index *(SSI)*

Based on the scores of the selected indicators, a *spatial segregation index (SSI)* is calculated. The index was initially designed and described in detail by Ilieva et al. (2025). The main idea of the *SSI* is to establish the level of spatial segregation *based on two groups of indicators which have a different weight (significance).* The *SSI* has a numerical value which varies between 0.33 and 1.0. Depending on that value, and the intervals adopted, the levels of spatial segregation are illustrated in Table 4.

Table 4. Spatial segregation level according to a three-interval and a five-interval division of the *SSI*.

***SSI* values**	**Spatial segregation level**
3-interval division of the SSI values	
0.33 - 0.55	low
0.56 - 0.77	average
0.78 - 1.00	strong
5-interval division of the SSI values	
0.33 - 0.46	very low to no segregation
0.47 - 0.60	low
0.61 - 0.73	average
0.74 - 0.87	strong
0.88 - 1.00	very strong (hypersegregation)

3.4. Calculation of the spatial segregation index without divisioning of the indicators into primary and secondary *(modified SSI_m)*

The *SSI* takes into consideration a set of selected indicators which are divided into two groups depending on their significance regarding spatial segregation. *In case no such division of indicators is possible, or required*, the problem with selection and justification of indicators as being more significant (primary) and less significant (secondary) can be solved by an approach where *all indicators are considered equally important*, regardless of their number. For example, only the primary indicators (or a selection of equally important indicators, which are considered the most indicative regarding spatial segregation in the given conditions) can be used. In that case too, the above-mentioned division of segregation levels can be adopted (a 3-level, or a 5-level division, if required). Given that a justified selection of equally important indicators has been done, the segregation level can be measured based only on *the sum of the score values of the selected indicators* in each studied neighbourhood. The result will be an ordinal scale of the sum values, where the lower the sum value, the less the segregation level, and vice versa (the higher sum value, the higher the segregation level). In order to turn the initial integer values of the score sums into decimals, we need to calculate the SSI_m value using the formula below:

$$SSI_m = (S_{sum} - S_{min}) / N \qquad (1)$$

where:

SSI_m – the modified spatial segregation index value, ranging from 0.0 to 1.0;

S_{sum} – the sum of scores for each indicator (in this case, ranging from 12 for Kozloduy RGUS to 27 for Nov Pat RGUS);

S_{min} – the minimum sum of scores possible (in this case – 10);

$N = S_{max} - S_{min}$

The difference between the sums of the values between the maximum (S_{max}) and minimum (S_{min}) possible values.

The SSI_m values can then be used to establish the spatial segregation level as shown in Table 5.

Table 5. Spatial segregation level according to a three-interval and a five-interval division of the SSI_m.

SSI_m values	**Spatial segregation level**
3-interval division of the SSI_m values	
0.0 - 0.33	low
0.34 - 0.66	average
0.67 - 1.00	strong
5-interval division of the SSI_m values	
0.0 - 0.20	very low to no segregation
0.21 - 0.40	low
0.41 - 0.60	average
0.61 - 0.80	strong
0.81 - 1.00	very strong (hypersegregation)

The main advantage of the SSI_m is that it does not require justification of which indicators should be considered primary, which is also its main disadvantage – it regards all selected indicators as equally important. However, the SSI_m may be considered more appropriate than the *SSI* in some circumstances.

4. RESULTS AND DISCUSSION

As a result of the suggested calculation of indicators' scores, the RGUSs selected for the purposes of this study, received the following scores by indicator (Table 6). As a result of the respective scores for each indicator, the following values of the SSI of the selected RGUSs were received (Fig. 2).

Table 6. Indicator scores by RGUS.

INDICATORS/ RGUS	KZ	NP	KS	DU	SL	TR	TG
PRIMARY INDICATORS							
Location in the urban space	1	3	3	2	2	2	3
Access to school	1	2	2	2	3	3	3
School segregation	1	3	3	1	1	1	1
Access to kindergarten	3	3	3	3	3	1	3
Access to public transport	1	3	2	2	2	1	2
Proximity to anthropogenic hazards and potential pollution sources	1	3	3	1	2	3	2
Access to tap water	1	1	1	1	2	2	2
Population density	1	3	3	1	3	3	1
Residential area per inhabitant	1	3	3	1	3	1	2
Share of buildings with no ownership documents	1	3	3	1	3	2	1
SECONDARY INDICATORS							
Access to emergency medical care	2	3	3	2	3	3	3
Access to outpatient care	2	3	3	2	3	3	3
Access to public parks	1	3	3	1	3	2	3
Natural hazard risk	1	1	1	1	1	1	1
Proximity to major transport axes	1	2	3	1	2	1	3
Sewerage	1	3	3	1	2	1	1
Waste collection	1	2	3	3	3	3	3
Green areas for public use	1	3	3	2	3	1	1
Children's playground	1	3	3	1	3	1	3
Built-up area dynamics	1	3	3	1	3	1	1
Spatial expansion	1	3	3	1	3	1	1
Morphology of the urban space	1	3	3	1	3	2	1
Open space for public use	2	3	2	1	3	3	3
Population dynamics	1	3	3	1	1	1	1
Housing and sectoral policies	1	1	3	1	3	3	3
Built-up area density	2	3	3	1	3	3	1

Legend: KZ – Kozloduy RGUS, NP – Nov Pat RGUS in Vidin, KS – Kosharnika RGUS in Montana, DU – Dunavtsi RGUS, SL – Selemetya RGUS in Ruse, TR – Traktsia RGUS in Ruse, TG – Trite Galaba RGUS in Ruse.

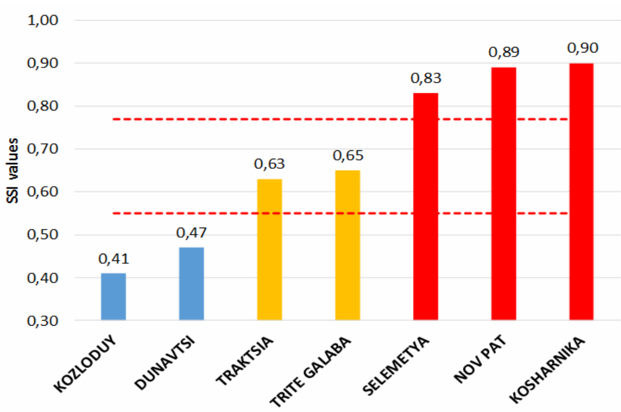

Fig. 2. Spatial segregation index (SSI) for selected RGUSs in Northern Bulgaria.

As it is seen in Figure 2, two of the selected RGUSs exhibit a low level of spatial segregation, two of them exhibit an average level, and three – a strong segregation level. In the case of a 5-level division, however, Kozloduy RGUS will fall into the "very low segregation" level, while Dunavtsi will be in the "low" segregation level. Nov Pat and Kosharnika, on the other hand, will belong to the "very strong" segregation level, while Selemetya will remain in the "strong segregation" level. It is, therefore, recommendable that the researcher considers the local (at national level) specifics of the studied segregated communities, so that the division of the SSI applied (a 3-level, or a 5-level division) reflects the objective reality in the best way possible, and meets the objectives of the study, or the policy-making requirements. In the case of Bulgarian RGUSs, a 3-level division of spatial segregation is deemed appropriate enough for the purposes of studying the Roma communities, as well as for policy application purposes.

The RGUS with *the highest SSI value* (strongest spatial segregation) – Kosharnika (Fig. 3) is one of the two existing Roma GUSs located just outside the town of Montana – a regional (district) centre of a NUTS 3 region – between an industrial zone and the town's graveyard. The neighbourhood has an area of 45.2 ha and a population of approximately 2,300 people. The high segregation level observed for this RGUS is due to the largely low scores of all indicators – primary and secondary, while the only indicators where this RGUS exhibits score 1 are *access to tap water* and *natural hazard risk*. Kosharnika is a typical Roma neighbourhood, which has all features an RGUS usually exhibits, but happens to be in an area not prone to natural hazards risks, and supplied with tap water, as a result mostly of being a part of a regional centre. Among the primary indicators, the neighbourhood scores 2 in terms of access to school, and public transport access – again, mostly due to the relatively high administrative function of Montana.

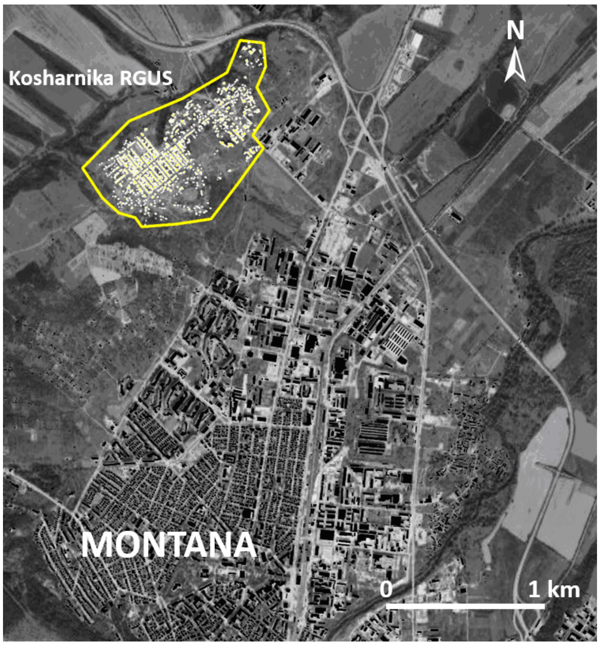

Fig. 3. Kosharnika RGUS in the town of Montana.

The RGUS with *the second-highest SSI value* – Nov Pat – is a large RGUS located just outside the town of Vidin (Fig. 4), and is the largest RGUS of all seven selected for the purposes of this study, by both area and population (50.8 ha; population of around 6,000 people). Similar to Kosharnika RGUS, Nov Pat exhibits score 3 with the vast majority of indicators, once again with the exception of access to tap water and natural hazards risk. This RGUS, however, scores 1 regarding the *housing and sectoral policy* indicator, meaning that, according to the local authorities and the local Roma population, the measures taken for improving the overall conditions in the RGUS yielded positive results. Waste collection, as well as some other indicators, also score better than in the case of Kosharnika, which results in a slightly better SSI value.

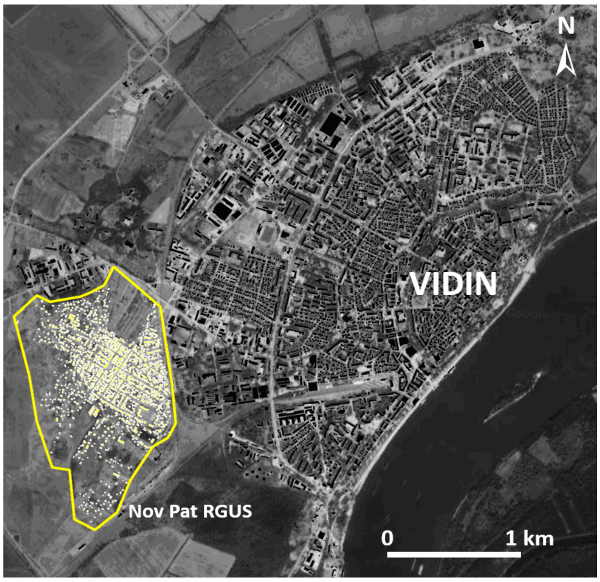

Fig. 4. Nov Pat RGUS in the town of Vidin.

The third RGUS falling into the group of RGUSs exhibiting *high level of spatial segregation* – Selemetya – is located at the periphery of the largest city among the selected ones – Ruse (Fig. 5).

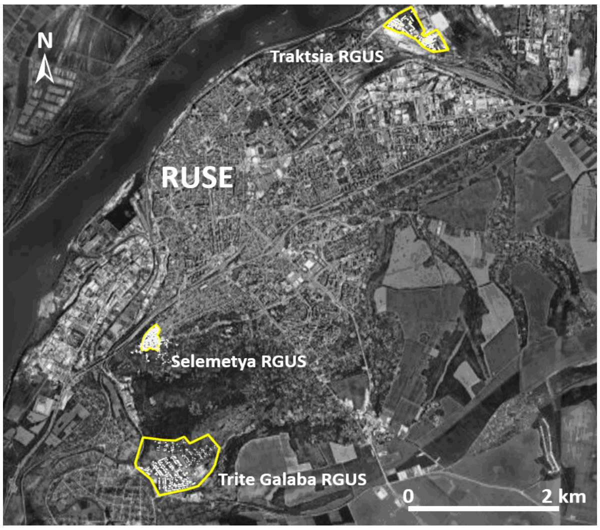

Fig. 5. Location of Selemetya, Traktsia and Trite Galaba RGUSs in the city of Ruse.

The neighbourhood is the smallest by area RGUS – of just 6.3 ha, but the second most populous among the selected RGUSs (around 4,000 people). It is also the most segregated RGUS, and, therefore, the most typical RGUS in the city of Ruse. The fact that Selemetya RGUS exhibits average scores (2) regarding 4 of the 10 primary indicators is mostly due to the fact that it is part of a large city (Bulgarian standards), and, as such, it *scores better in indicators which are related to access*, but receives worse scores regarding the indicators related to housing – *high population density, low residential area per inhabitant, very high share of illegal housing*. The latter indicators and their extreme poor values make Selemetya a typical RGUS in a large city.

The two RGUSs showing *average SSI values* – Trite Galaba and Traktsia – are also located in the city of Ruse (Fig. 5), and are very different from Selemetya, as well as from each other. Traktsia is a typical peripheral RGUS in a large city, surrounded by industrial zones and major transport axes, with good public transport connectivity to the city centre. The neighbourhood scores 1 regarding four primary indicators, which excludes the possibility of being a highly segregated community. The most untypical features of Traktsia RGUS are the *lack of spatial expansion, built-up area dynamics, and population growth*, as well as the high value of the *residential area per inhabitant* indicator – all of which normally receive worse scores in most segregated RGUSs.

Trite Galaba, on the other hand, is the most distinct of all RGUSs in discussion, since it resembles a village, or a weekend-home area, rather than a city neighbourhood, or an RGUS. Being well outside the city, however, results in poor access indicators' scores, at the expense of *best scores regarding within-neighbourhood indicators* such as *population density, morphology of the urban space,* etc., while it is also the RGUS with *the lowest share of illegal construction*. Trite Galaba, therefore, is a unique case, since it is regarded as an RGUS mainly because its population is predominantly Roma, but otherwise exhibits features any rural neighbourhood outside the city would generally show. The two RGUSs with *the lowest SSI index values*, or the least segregated, are located in the smallest towns in the group – Kozloduy (Fig. 6), and Dunavtsi (Fig. 7).

The RGUS of Kozloduy scores 1 regarding all primary indicators but one – *access to kindergarten*. The RGUS of Dunavtsi exhibits average scores in the case of some primary indicators, while *access to kindergarten and waste collection* are the only indicators scoring 3 among all 26 indicators.

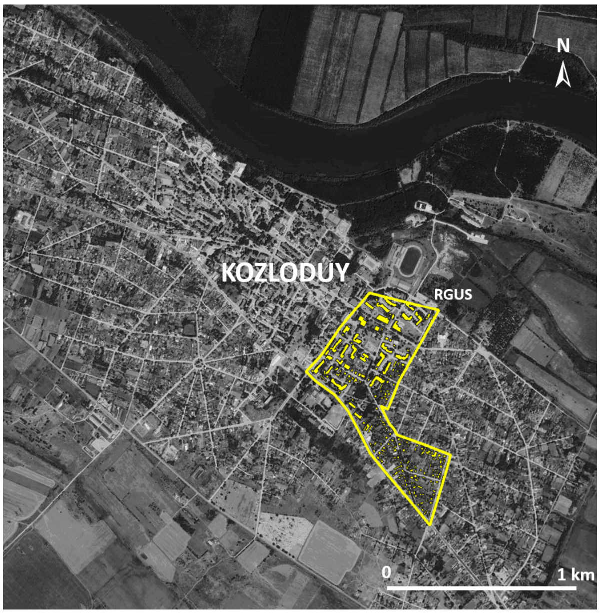

Fig. 6. The RGUS in the town of Kozloduy.

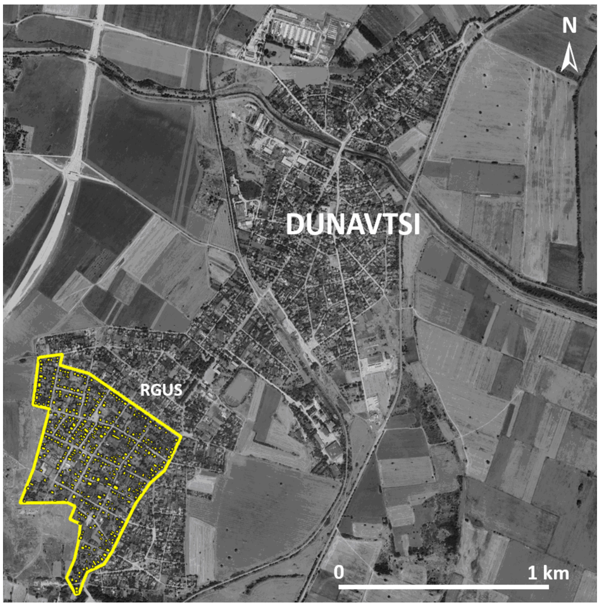

Fig. 7. The RGUS in the town of Dunavtsi.

All in all, those two RGUSs can be regarded as *conditionally segregated,* i.e. not really segregated, since they exhibit the features of just any other urban, non-Roma neighbourhood. The two RGUSs do not really exhibit the typical features of an RGUS (with some exceptions regarding some access indicators) such as densely-populated areas with a high share of illegal housing, low residential area per inhabitant, spatial expansion, population growth, etc. None of those are observed in the RGUSs of Kozloduy and Dunavtsi. Thus, it does not mean that the smaller the town, the less segregated a Roma community is – our ongoing research on the topic shows that some small towns in Bulgaria do have highly segregated RGUSs, and it is not the size of the city/town which is the leading factor for the level of segregation.

In case the spatial segregation level is calculated by applying the *modified spatial segregation index (SSIm)*, the level of spatial segregation of each RGUS remains practically the same (Fig. 8). The similarity between the results from the application of both indices is to be expected, since the SSI gives priority to the primary indicators (amplified weight in the formula).

As it can be observed in Figure 8, based on the score values of the 10 primary indicators only, the 3-level division of the spatial segregation level replicates to a great extent the results from the application of the SSI approach, and again places Kozloduy and Dunavtsi in the low segregation level, Traktsia and Trite Galaba in the average segregation level, and Selemetya, Kosharnika, and Nov Pat in the strong segregation level. Unlike the *SSI, the* SSI_m exposes *Nov Pat, and not Kosharnika, as the most segregated RGUSs*. That, of course, and the fact that Selemetya is just at the border between the "average" and the "strong" segregation level, is a result of the use of the primary indicators only, when the SSI_m is calculated. Should a 5-level division be applied, again, Kozloduy will be the only RGUS falling into the "very low to no segregation" interval (0.0 – 0.20), whereas Dunavtsi will be in the "low" segregation level interval (0.21 – 0.40). According to the 5-level division of the SSI_m values, *Nov Pat will be the only RGUS of a "very strong" segregation level.*

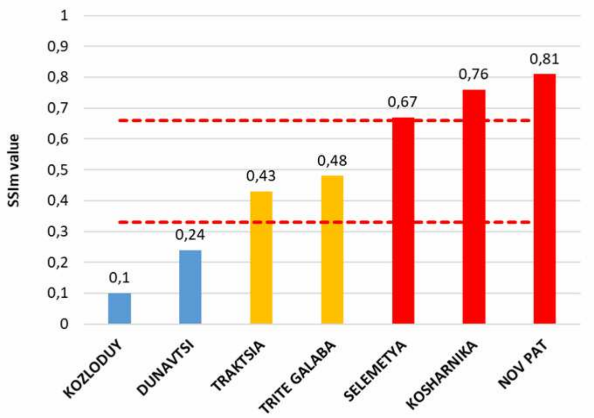

Fig. 8. Modified spatial segregation index (SSIm) for selected RGUSs in Northern Bulgaria.

The analysis of the primary indicators' score values shows that the RGUSs exhibiting strong/very strong segregation level *all have around half or more than half of the primary indicators scoring 3*, whereas the opposite is observed in the "average" segregation RGUSs. In the case of Kozloduy – the least segregated RGUS among the studied ones in this paper, only one primary indicator has a score of 3 (access to kindergarten).

Access to kindergarten, population density, residential area per inhabitant, and share of buildings with no ownership documents are the four primary indicators exhibiting score 3 in all RGUSs of strong segregation. It should be noted that while access to school may be assessed as very good (score 1) in case there is a school in the RGUS itself, the chances that the school is segregated are practically 100%, thus resulting in a score 3 regarding the *segregated school* primary indicator, putting those two primary indicators into *inversely proportional dependence* regarding their scores. Scores 1 for both of these indicators are observed in the case of Kozloduy only. Generally speaking, the "low" segregation level RGUSs exhibit worst scores (3) with one or two primary indicators, while the rest of the indicators receive score 1, and some of them – score 2.

The "average" level of spatial segregation, on the other hand, is related to a *mixture of scores regarding the primary indicators*, where some of them exhibit score 3, but those are less than 1/3 of all primary indicators. Comparable trends were observed by Ilieva et al. (2025) in their analysis of Ruse, where high spatial segregation coincided with pronounced social exclusion, supporting the broader applicability of such indicator-based assessment.

5. CONCLUSIONS

The study reaffirms the hypothesis that Roma neighbourhoods – as a type of segregated urban structures – exhibit significant disparities regarding their spatial segregation. The primary objective of the research was to suggest and test two similar indices *(SSI and SSI_m)* for measuring the levels of spatial segregation, using a set of quantifiable indicators, allowing for cross-comparisons between cities, regions, and countries showing similar ghettoized structures. Despite the lack of universal definitions of both spatial segregation and deprived areas/slums etc., the selection of indicators for spatial segregation level measurement can be done using both indices, with the necessary adaptation of the selected indicators to local conditions.

The results obtained for the spatial segregation index *(SSI)* by employing the calculation methodology proposed by Ilieva et al. (2025) confirm that, while similarities exist between segregated areas, variations in the severity of segregation are evident, and those variations can be calculated and quantified. The newly proposed modified index *(SSI_m)* confirms the levels of spatial segregation established by the *SSI*, although a limited number of indicators have been used (the 10 primary only, i.e. without the 16 secondary indicators). The modified index can be used in cases where all selected indicators are regarded equally important, or in cases where not all indicators can be used because of lack of sufficient data. Although challenges such as limited data availability at a low spatial level exist, the indices proposed in this study prove to be a valuable tool in categorizing and understanding the degree of spatial segregation in Roma neighbourhoods or similar urban areas. This understanding is essential for developing targeted policies to address spatial and social inequalities, contributing to broader efforts toward social integration of marginalized communities. The results of this study can be used for urban planning, social and housing policies aimed at the improvement of the living conditions in the worst segregated RGUSs, as the latter face the most urgent problems.

In addition, the authors of this study believe that some of the indicators need to be revised, and either replaced by others, more appropriate, or such that can be quantified based on a more perceivable threshold value, or completely removed from the selection. In subsequent studies, we propose adding a new indicator – "access to hospital" – to the list of secondary indicators and eliminating others, such as "housing and sectoral policy", since the latter is more challenging to be given a score between 1 and 3, as the nature of the indicator has no numerical measurement. The waste collection indicator can remain, provided that an objective quantification of its values is possible. The selection of indicators itself is as important as the methods used for calculating the indicators' scores. Using inappropriate indicators, although quantifiable, can lead to mathematically correct results which, however, may not represent the objective reality to a full extent.

While the current study applies a set of single-scale indicators, future research could benefit from multiscale analytical approaches, such as those proposed by Neira et al. (2025), which allow for a more nuanced understanding of segregation dynamics at different spatial levels.

6. ACKNOWLEDGEMENTS

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