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# The Urban–Rural Education Divide: A GIS-Based Assessment of the Spatial Accessibility of High Schools in Romania

**Angelo Andi Petre, Liliana Dumitrache *, Alina Mareci and Alexandra Cioclu**

Faculty of Geography, University of Bucharest, 010041 Bucharest, Romania; angelo.petre@s.unibuc.ro (A.A.P.); alina.mareci@unibuc.ro (A.M.); alexandra.cioclu@s.unibuc.ro (A.C.)
* Correspondence: liliana.dumitrache@unibuc.ro

**Abstract:** Educational achievement plays a significant role in the labour market, benefiting individuals and society. Graduating from high school is a key step towards better employment opportunities and a prerequisite for higher education attainment. In 2023, only 22.5% of the Romanian population graduated tertiary education, while 16.6% left education or training early. The Romanian public high school network comprises 1558 units, mostly located in urban areas. The high school enrolment rate is 83.5% in urban areas, and it drops to less than 60% in rural areas, with the country registering the highest out-of-school rate in the EU for the 15-year-old population. Spatial accessibility may influence enrolment in high schools, particularly for students living in rural or remote areas, who often face financial challenges fuelled by long distances and limited transportation options. Hence, travel distance may represent a potential barrier to completing the educational process or may determine inequalities in educational opportunities and outcomes. This paper aims to assess the spatial accessibility of the public high school network in Romania by using distance data provided by the Open Street Map API (Application Programming Interface). We examine variations in spatial accessibility based on the distribution of high school units and road network characteristics considering three variables: travel distance to the nearest high school, the average distance to three different categories of high schools, and the number of high schools located within a 20 km buffer zone. The results highlight a significant urban–rural divide in the availability of public high school facilities, with 84.1% ($n$ = 1311) located in urban areas while 49.1% of the high school-aged population lives in rural areas. Many rural communities lack adequate educational facilities, often having limited options for high school education. The findings also show that 32% of the high school-aged population has to travel more than 10 km to the nearest high school, and 7% has no high school options within a 20 km buffer zone. This study provides insights into the educational landscape in Romania, pointing out areas with limited access to high schools, which contributes to further inequalities in educational attainment. The findings may serve as a basis for developing policies and practices to bridge the urban–rural divide in educational opportunities and foster a more equitable and inclusive education system.

**Keywords:** education; high school network; spatial accessibility; urban–rural divide; Romania

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## 1. Introduction

Education is fundamental for both individual advancement and societal development, playing a multifaceted role in promoting and fostering social and economic progress. It is one of the essential services within the range of basic needs that all modern citizens should be granted access to [1]. Every person should benefit from educational opportunities

designed to meet their basic learning needs so as to improve the quality of their lives, help them make informed decisions, and promote continued learning [2].

Education attainment, measured by the years of schooling an individual has completed, significantly impacts the labour market, enhancing employability and earning potential [3,4]. Thus, individuals who attain higher levels of education are more likely to be employed in better jobs, be paid higher salaries, and afford better housing [5]. In modern societies, upper secondary education is commonly seen as the minimum needed for successful labour market participation [6], as high school attainment has long been considered to positively influence individuals' employment chances and lives [7].

High school serves as an extended platform for all young people to further develop the knowledge and skills needed in civic society and provides many young people with qualifications for the labour market and further learning [6]. While all educational cycles build up to obtaining a well-rounded education [8], high school represents a mandatory level to be completed in order to accede tertiary education, which plays an even more prevalent role in societal and economic advancements [9].

Despite the importance of having at least a high school education, sizeable shares of young adults still leave the educational system without having completed it. In Romania, 22% of the 25–34-year-old population lacks an upper secondary qualification, which is above the OECD average of 14%. OECD statistics show that in Romania, only 71% of the high school-aged population (15–19 years old) was enrolled in any form of education in 2022–2023, with the lowest value of 61% registered in the southern part of the country [10]. Early dropout from any form of education remains very high, with 15.6% of people aged 18–24 leaving the educational system early compared to the 9.6% EU average [11]. Also, 22% of young adults aged 18–24 years are not enrolled in formal education, employment, or training (NEET). Reducing NEET rates among young adults is particularly important, as those who become NEET have poor labour market prospects later in life [12]. Romanian school dropout occurs mainly in lower and upper secondary education and negatively affects society, including individuals' inability to socially integrate or enter the labour market [13]. Factors influencing early school leaving have been linked to socioeconomic characteristics, familial situations, and school-related aspects, with some studies exploring the relationship between family processes and school absenteeism or dropout, while others reveal that children's involvement in household activities and lack of parental engagement in their education also contribute [14–16]. The 2015 *Strategy of reducing early leaving from school in Romania* listed the spatial accessibility of the school network, especially in remote rural areas, as a leading factor influencing early school leaving [15]. This was also observed in the case of students living more than 30 km from school in settlements surrounding Bucharest [16]. Thus, in addition to the psychological, social and individual factors determining absenteeism, when studying early school leaving or school dropout in Romania, the spatial accessibility of educational infrastructure needs to be considered [17]. Unfortunately, few studies in Romania have focused on spatial factors, which are often linked to geographic location, infrastructure, or access to resources, with many of them building their findings on local study cases, selective questionnaires, or qualitative analyses.

Spatial accessibility is the ease by which an individual can access a service [18]. It has been assessed for services ranging from healthcare and commercial activities to recreation [19–22]. In terms of education accessibility, measurements usually consider travel distance or travel time to evaluate spatial accessibility [23]. Some studies have integrated both measures, while others consider only *travel distance*, using road networks and providing a more realistic measure, or *travel time*, estimating how long it takes to reach school using different transport modes [24]. The type of distance used in the analysis is

important: while Euclidean distance imposes several errors, the street network distance offers more accurate results and is easy to access via API codes [25].

School availability is an important dimension of accessibility, influencing school choice or preference, and in a system based on selection, stratifying students according to their performance can lead to inequities and academic segregation [26]. In many cases, the perceived quality or performance of a high school attracts a larger number of students [27]. Commuting to school is a daily routine for millions of students worldwide. Depending on the mode of transportation, distance, and time, this commute can have a consequential impact on students [28]. Thus, in large cities, with multiple options and a wider range of educational services, travel time and personal preferences prevail over commuting distance [29]. Different studies investigate travel time in assessing the spatial accessibility of educational facilities [30,31]. Even if travel time is more commonly used to investigate the effects of commuting, the results of both commuting distance and time are similar [28].

Home-to-school distance may represent an important spatial barrier [32,33] influencing school attainment or leading to the decision to drop out [34,35]. The configuration of a school network and the spatial distribution of education units impact home-to-school distance. In many cases, a lack of reliable public transportation can increase difficulties in accessing school, as this often translates into high transportation costs, which can be a financial burden for families [36,37], negatively influencing students' performance or number of years of schooling [38]. This scenario mainly affects people living in rural or remote areas [39], often underserved, with disparities in service provision [40]. Thus, distance plays an important role, especially in rural areas with limited educational facilities and choices, while in urban areas, travel time and diversity in transport modes may influence students' educational pathways [41].

Studies on the spatial accessibility of educational facilities are still emerging as an increasing number of scholars pay more attention to the geographical aspects of the school network. The accessibility and availability of educational facilities in near proximity represent important aspects of societal development [42–44]. Spatial and non-spatial factors have been integrated to analyse education accessibility [45,46]. The spatial characteristics of educational inequalities have been analysed through complex measurements of attainment, enrolment, and years of schooling, as well as social and economic factors [42,47].

The spatial accessibility of educational facilities is analysed through numerous types of measurements and methodologies. For example, Wang et al. [29] proposed a multi-mode Huff 2SFCA considering different modes of transportation and school quality in the City of Wuhan, China. Xu et al. [27] calculated a complex index comprising distance to school, opportunity, and affordability to evaluate accessibility in Nanjing, China. Han et al. [48] created a framework for optimising the location of compulsory educational units to ensure education equity by developing a model of spatial accessibility (MH3SFCA) with a special focus on rural areas in Changyuan, China. Sharma and Patil [49] used the Gini coefficient to evaluate accessibility in Greater Mumbai (India).

Established distance thresholds tend to be higher when looking at rural-centred studies. In urban areas, where distances are generally less than 4 km, students use public transportation, private cars [50], bicycling [51], or walking [52]. In rural areas, where high school proximity falls beyond walking distance, students mainly depend on public transportation or personal cars [53]. For walking, distances usually are set under the 2–3 km threshold and increase together with the age of students [54–56]. Other studies consider 5 km as a threshold for school accessibility, with 6.78 km as the mean distance to travel to the nearest secondary school [57]. Lotfata et al. consider that the optimal walking time for reaching school is 20 min, while Rekha et al. consider that the catchment area of a school is equivalent to 30 min [45,58]. Moreover, it seems that the catchment radius for

educational services is different based on the level of education or the scale of the analysis. For high schools, some scholars consider a 45 min driving time by personal car or public transportation [29]. Thus, there is a lack of consensus on the optimal distance to school, and results vary greatly by country, age characteristics of the students, and area of residency (urban, suburban, or rural), but there is an increased interest in delineating the catchment areas of educational facilities [59,60].

Many studies on the accessibility of education services focus on primary and secondary schools in urban areas or their surroundings [27,29,57,61]. Other studies include education when evaluating the accessibility of basic services [62,63]. A limited number of studies focus on the accessibility of educational services in rural areas, with findings showing lower accessibility scores for all services [40,64–66].

This has created a gap in country-level studies focused on spatial education accessibility regarding specific institutional levels. Romania, in particular, lacks such research. The country is facing problems regarding the spatial accessibility of educational facilities, but a limited number of studies focus on access to education, and no study integrates distance as a measure of accessibility [67]. Education, similar to other services publicly offered in Romania, is prone to dysfunctionalities brought by numerous reforms and budget cuts that highlight specific gaps in its functionality. The Romanian educational system is highly centralised. It is coordinated by the Ministry of Education through the 41 County Scholar Inspectorates and the Bucharest Municipality Scholar Inspectorate [68]. The educational cycles comprise pre-school (children 3–5 years old), primary school (6–10 years old), lower secondary or gymnasium (11–14 years old), and upper secondary education or high school (15–18 years old) [69]. All of these are compulsory and free, supported by national legislation [70].

High schools in Romania are divided into theoretical, vocational, and technological. Under Law no. 4030/2018, theoretical and vocational high schools with great educational performances are awarded a national college title. Admission is based on students opting for different categories of high schools and profiles but is conditioned by their scores on the National Evaluation exam. Usually, students with the highest scores are admitted to national colleges, which are more prestigious, well-equipped, and internationally connected. There are 212 such units in Romania, but they are located in Bucharest and a few large cities [71]. The high school network consists of 1558 units located mainly in urban areas. This configuration was set up during the communist period, and its structure has mostly remained unchanged [72].

Romania's demographic decline, which occurred after 1990, shrunk the school population [73,74]. This decrease in population affected mainly rural areas, where insufficient numbers of students led to the closure of some schools, limiting high school options and increasing commuting distances for the remaining students [75,76]. In these areas, "school deserts" expanded, and accessing any form of education became challenging [77,78]. Long distances to an educational unit or a lack of such facilities can cause students to drop out or fail to attend school, which is an important social problem that Romania faces nowadays.

The present study uses geospatial analysis to examine the geographic distribution of high schools in Romania and evaluate the spatial accessibility of the high school network based on travel distance considering three dimensions: availability, proximity, and diversity. This paper stands as the first study in Romania to evaluate the spatial accessibility of educational facilities at a national level from a geographical perspective and serves as an important tool for public policymakers to bridge the gap between urban and rural settlements, as educational facilities usually underserve the latter.

## 2. Materials and Methods

### 2.1. Study Area

Romania is one of the largest countries in the EU, with a population of 21.1 million in 2024. Its total surface of 238,397 km$^2$ is divided into 3181 Local Administrative Units (LAU2) comprising 2861 communes and 320 urban centres. The urban population represents 54%, and most of it is concentrated in the capital city, Bucharest, with 2,160,169 inhabitants, and four other cities such as Cluj-Napoca, Iași, Timișoara, and Craiova, with around 300,000 inhabitants each [79].

The road network may significantly influence spatial accessibility, as its quality in Romania is classified as very low compared to that in other countries in the European Union [80]. The total length of the road network was 86,388 km in 2023. Within this network, 17,677 km are national roads, 35,046 km are county roads, and 33,665 are local roads. National roads are further divided into only 997 km of highways, 6189 km of international roads, and 70 km of express roads [81]. Also, it is important to note that the speed limitations in Romania are 50 km/h for roads inside a locality and 90 km/h outside. On highways, the speed limit is 130 km/h.

### 2.2. Data

The data used in this research are publicly available. This ensures the transparency of the results and also enables their replicability. The database of all 3181 LAU2 was retrieved from the National Agency for Cadastre and Real Estate Advertising (ANCPI) [82]. For each LAU2, the geometric centroid was determined as the origin point for this analysis [20].

*School-aged population data*: We considered the high school-aged population to be the resident population aged 15–18 years old, based on the National Institute of Statistics methodology [69]. This was retrieved from the online dataset belonging to the National Institute of Statistics for each LAU2 for the year 2023. The total high school-aged population (the 15–18 age group), which equals 900,627 inhabitants identified in Romania, is divided relatively equally between urban (50.9%) and rural (49.1%) areas.

*High school network data*: The high school network database provided by the Ministry of Education is publicly available at data.gov.ro and was used for the school year of 2022–2023. The high school network is composed of 1558 accredited upper secondary education units. Most high schools are public units (93.6%), while only a limited number are private (6.4%). Only 13.6% are categorised as national colleges, 18.7% as theoretical high schools, and 48.2% as technological high schools. The vast majority are located in urban areas (84.1%), with only 15.9% in rural areas (Table 1).

**Table 1.** The high school network in Romania and the school population.

| Category | Indicator | No. | % |
|---|---|---|---|
| High school units | Total | 1558 | 100 |
| | Public | 1458 | 93.6 |
| | Private | 100 | 6.4 |
| High school location | Urban | 1311 | 84.1 |
| | Rural | 247 | 15.9 |
| High school category | National college | 212 | 13.6 |
| | Theoretical high school | 292 | 18.7 |
| | Technological high school | 751 | 48.2 |
| | Other [1] | 303 | 19.4 |
| High school-aged population | Total | 900,626 | 100 |
| | Urban | 458,846 | 50.9 |
| | Rural | 441,780 | 49.1 |

[1] Other categories of high schools: vocational, military, special needs, private.

A total of 303 high schools that are private or have a special designation (military, for students with special needs, or vocational) were excluded from this analysis, as they do not address the general population, but they may be subject to future studies.

### 2.3. Methods

*Geocoding of high school units:* The geographical location of each high school was determined using the addresses provided in the school network database from the official website of the Romanian Government (data.gov.ro). Due to the lack of a pre-established spatial database validated by the Ministry of Education, all high schools were manually geocoded after verifying and validating addresses where a lack of data occurred.

*Modelling spatial accessibility:* An Origin–Destination Matrix (OD Matrix) was generated by considering the geometric centroid of each LAU2 as the origin and each high school unit as the destination. The Origin–Destination Matrix (OD Matrix) was calculated using the street network distance by using QGIS 3.20, the ORS (Open Route Service) plug-in, and the Open Street Map (OSM) Application Programming Interface (API) codes [22,83]. The lack of data on weighted population centroids or individual zip codes makes applying other validated accessibility methods impossible in Romania [84].

The travel distance analysed was the shortest one along the street network, which is considered more accurate and reliable in terms of accessibility than other forms of distances that might generate significant errors when measuring accessibility at the national level [85,86]. When considering the cost unit of the OD Matrix, studies have integrated both travel distance and travel time, with the latter mentioned as more important when accounting for accessibility, especially for health services because of the emergency dimension they pose [20,84]. However, as most high school students in Romania rely on public transportation solutions, for which the API code could not offer accurate results, this study uses distance as its main unit analysis. It should also be mentioned that generating the OD Matrix was not possible for some areas overlapping the Danube Delta because transportation is provided by boats. Thus, certain LAU2 were excluded from the analysis, which is explained in the respective figures and is marked with "No data" in all the tables.

This research models spatial accessibility according to three different dimensions of accessibility that were previously tested for other services: availability, proximity, and diversity [87–89].

*Availability* (*A*) was calculated by determining the number of high schools in a radius of 20 km along the road network from each LAU2 centroid. The radius of 20 km was chosen because it represents the threshold radius for a 30 min driving distance, considering the Romanian road infrastructure. The availability indicator measures the total number of possibilities students have in their proximity, as numerous options would suggest better accessibility. We spatially represented the LAU2 settlements with zero high schools in a 20 km radius, as well as those with 1–3 high schools, 3–10 high schools, 10–20 high schools, and >20 high schools.

*Proximity* (*P*) was calculated as the distance from the LAU2 centroid to the nearest high school. This evaluates the basic accessibility of upper secondary education. Distance to the closest high school is an important indicator showing the minimum effort that students need to make to access high school education. Although most of the time, the closest high school does not represent the one the student chooses to attend, it remains an important indicator of accessibility. In terms of proximity, measured as the metric distance between the centroid of a territorial administrative unit and the nearest high school along the road network, we considered the following distance intervals: <5 km, 5–10 km, 10–15 km, 15–30 km, and >30 km.

*Diversity* (*D*) was calculated as the mean distance to three different high schools based on their category: national college, theoretical high school, and technological high school. While accessibility aspects are very well delimited in the case of proximity, in the case of diversity, an indicator that assumes the average distance to three different types of high schools, the data show greater variability. This indicator was useful because it considers the possibility that a student does not choose to attend the nearest high school but has a diversity of options to choose from that are commensurate with the educational potential that the student possesses. The distance intervals for the interpretations were <5 km, 5–10 km, 10–20 km, 20–30 km, and >30 km. The ranges differ from those chosen for *proximity*. A 5 km leeway was selected to emphasise that it is, in fact, more difficult to find a higher number of units in a smaller radius, thus better evaluating the distribution of the Romanian high school network.

Education Accessibility Index (IEA)

A composite index was calculated to evaluate the spatial accessibility of the high school network and to highlight territorial contrasts. The index relies on the three dimensions (availability, proximity, and diversity) by incorporating the options that students have within a radius of 20 km. The index was created considering that the choice of high school is not only determined by proximity but also by the perceived quality or performance of a high school, as well as the educational background of each student. *The Education Accessibility Index* ($I_{EA}$) measures the ease of access to high schools considering the distance from the centroid of each LAU2 unit to the nearest high school and the number and categories of high schools in a radius of 20 km (considering the three distinct categories relevant to the Romanian education system: national colleges and theoretical and technological high schools). Each unit type received a weight in the formula: 1 for national colleges, 0.7 for theoretical high schools, and 0.5 for technological high schools. The different weights reflect the differences in the perceived importance of that category of educational unit. The $I_{EA}$ balances the impact of distances and the number of available high schools in an area (1). Higher $I_{EA}$ values indicate shorter travel distances and more high school options within a 20 km radius, while lower $I_{EA}$ values suggest longer travel distances to high school and a limited number or even a lack of high school units within a radius of 20 km. The composite index was classified into three categories: low (0–0.7), medium (0.7–3), and high (3–32.5). These thresholds are supported through a semi-quantitative rationale based on the distribution characteristics and the interpreted meaning of the index. Given the right-skewed distribution of the data, the low range (0–0.7) captures values near the lower bound of the scale, corresponding to the minimal presence of schools within the area (lowest accessibility scores based on the three accessibility indexes). These thresholds reflect a non-linear scale, where differences at the lower end are more meaningful than those at the upper end due to the compression of values.

$$I_{EA} = \frac{\sum_{i=1}^{n} w_i \cdot \frac{1}{D_i} + \sum_{i=1}^{n} w_i \cdot N_i}{\sum_{i=1}^{n} w_i \cdot \frac{1}{D_i} + \sum_{i=1}^{n} w_i \cdot N_i + \sum_{i=1}^{n} N_i} \quad (1)$$

$I_{EA}$ = education accessibility index.

$D_i$ = distance (in km) to the nearest high school from category $I$ (national college, theoretical high school, technological high school).

$N_i$ = number of high schools of type $I$ within a 20 km radius.

$w_i$ = weight assigned to each high school category.

### 2.4. Study Limits

Being one of the first studies to address the spatial accessibility of the high school network in Romania, this work is prone to study limits. One is the lack of sufficient data on education attainment, school dropout, or early school leaving, as well as the quality of the educational network at the national or LAU2 level.

The scarcity of diverse spatial data limits the results. Due to the lack of zip code data and population-weighted centroids, we assumed that the origin point of the analysis is the centre of each LAU2, as previously used in several studies at the national level in Romania [20,84]. The geocoding of such a consistent number of high schools may, in certain situations, not overlap with the exact location. In the case that an institution has several headquarters, the location of the main one, where the legal address is positioned, was used. These cases were limited to just five occurrences.

Also, the present study only investigates the spatial accessibility of the high school network by using travel distance. Integrating travel time along the travel distance may have offered a more comprehensive image of the spatial accessibility of the high school network. Future work should consider both travel distance and travel time to compare results. However, in the absence of other country-level studies allowing for comparison, this first study evaluating the spatial accessibility of the high school network represents a starting point for studies on the accessibility of educational settings in Romania.

## 3. Results

### 3.1. Spatial Distribution of the High School Network

The spatial distribution of the high school network in Romania shows a consistent urban–rural divide in terms of educational provisions (Figure 1). The capital, followed by a few large cities, has the highest number and diversity of high schools: Bucharest (93 units, out of which are 23 national colleges), Cluj-Napoca (31 units with 5 national colleges), Brașov (26 units with 7 national colleges), and Timișoara, Iași, and Constanța (26–22 units each). Small towns, as well as rural areas, have a lower number of high schools, which are mainly technological. Extended areas overlapping the Carpathians, the Danube Delta, or plains areas in south-eastern and south-western Romania have very few high school facilities and consequently limited options for potential students.

The largest urban centres and surrounding periurban areas contain almost 50% of the high school-aged population: Bucharest (70,856), Iași (13,973), and Craiova, Galați, Constanța, and Cluj-Napoca (surpassing 10,000 each). Similarly, but on a smaller scale, large rural areas from eastern and north-eastern Romania and from southern and south-eastern areas contain a significant number of high school-aged individuals.

The comparison between the distribution of the high school-age population and the high school network shows imbalances between provision and demand, highlighting many underserved areas, with the rural high school population facing difficulties finding high schools in near proximity (Figure 1).

### 3.2. Availability

High school availability, quantified as the total number of high schools within a radius of 20 km of a given LAU2, shows wide-ranging results, with Bucharest registering the highest number of high schools (93), while 548 localities have no high schools (Figure 2). The mean value was recorded at 3.992, with a median of 2 high schools and a standard deviation of 7.061.

Table 2 shows that 18% of the high school-aged population benefits from more than 20 high schools in less than 20 km, which is the case in Bucharest and Cluj-Napoca. At the same time, 6.7% of the high school-aged population cannot find any high school within a

20 km radius, which raises significant accessibility issues. While 31.4% of the high school-aged population has more than 20 high schools within 20 km in urban areas, only 5.7% falls into the same category in rural areas. Even then, most of these individuals live in peri-urban areas. For 13.5% of the rural high school-aged population, there is no high school located within 20 km.

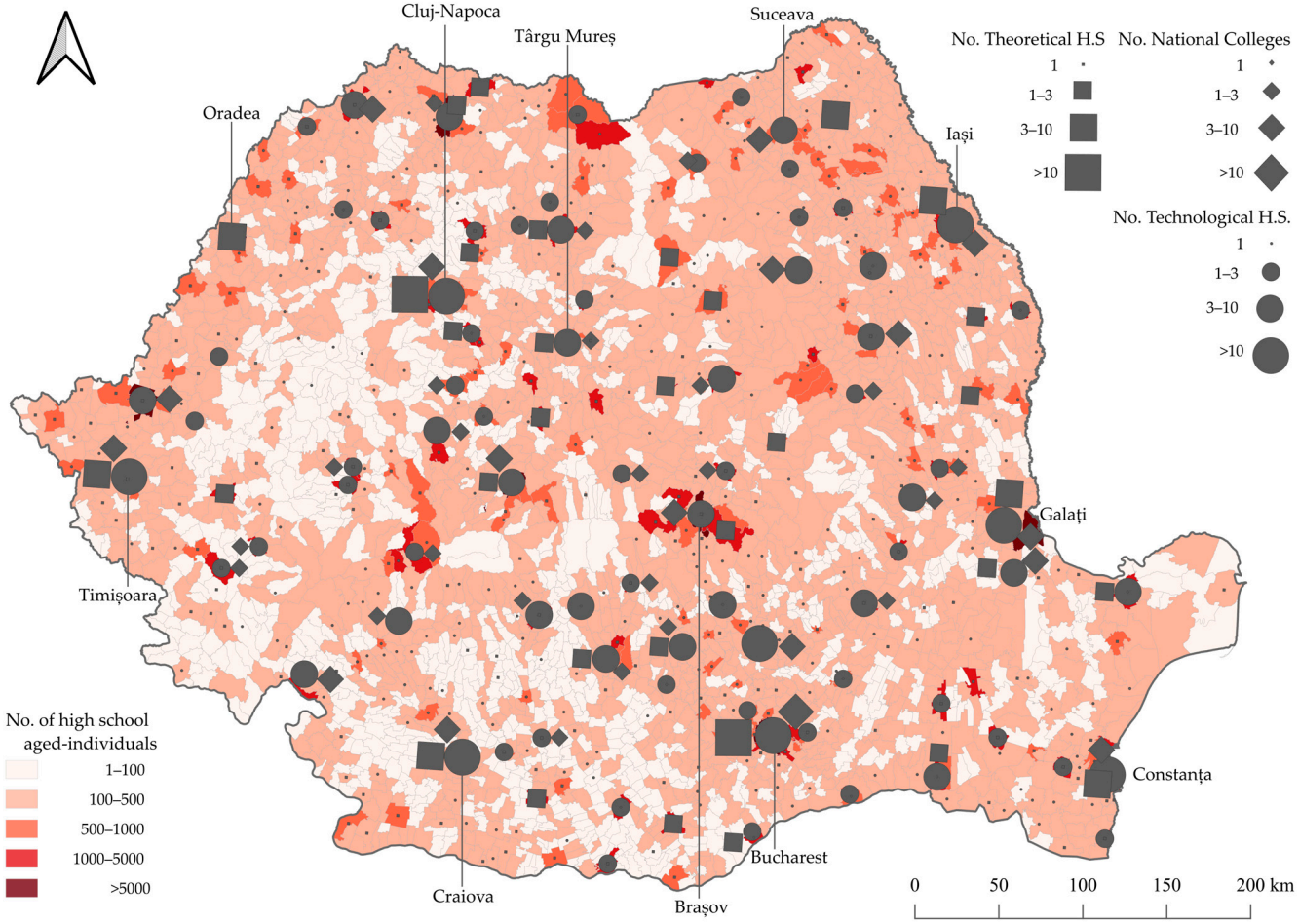



**Figure 1.** The spatial distribution of high schools and the high school-aged population.

### *3.3. Proximity*

The results show that, on average, a student has to travel 13.1 km to reach the nearest high school. The median distance for the dataset analysed is 12.3 km, with a standard deviation of 7.691. The distance values at the LAU2 level vary between 0.102 km and the maximum of 74.59 km.

The proximity map indicates high levels of accessibility around large urban centres and medium levels in rural localities where a high school still exists (Figure 3). Thus, for 49.5% of the high school-aged population, the nearest high school is less than 5 km away. For other localities in Romania, 18% of potential students have to travel distances between 5 and 10 km, while 14.6% have to travel distances surpassing 15 km or even more than 30 km (0.8%). A special case in the analysis is a part of the LAU2 overlapping the Danube Delta, for which the metric distance could not be obtained because the road infrastructure is fragmented and connectivity is maintained by boat.

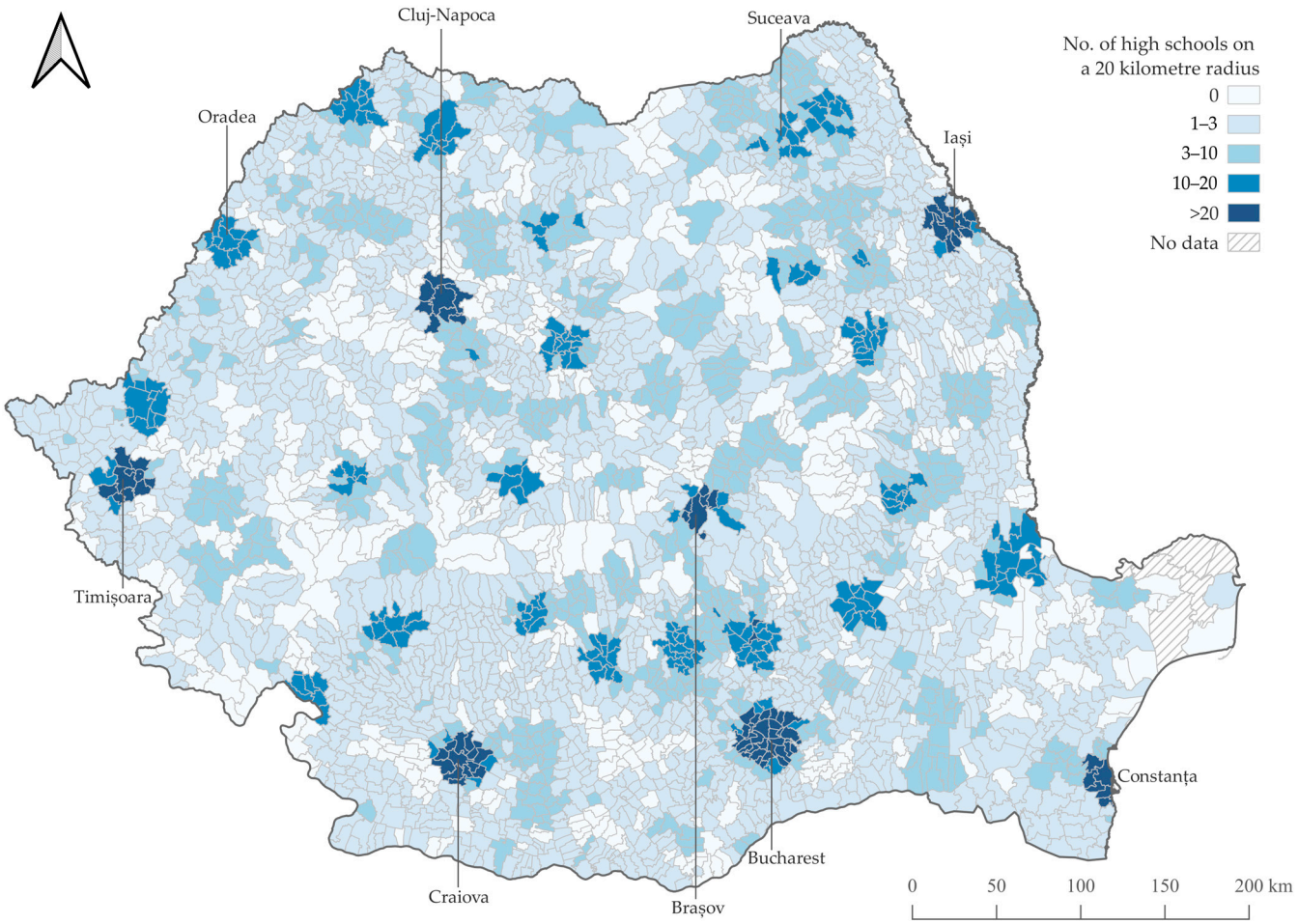



**Figure 2.** Availability map—number of high schools in a 20 km radius.

**Table 2.** Population distribution by no. of high schools in a radius of 20 km.

| No. of High Schools Within 20 km | No. of High School-Aged Individuals | | | % of the High School-Aged Population | | |
|---|---|---|---|---|---|---|
| | Total | Urban | Rural | Total | Urban | Rural |
| 0 | 59,929 | 439 | 59,490 | 6.7 | 0.1 | 13.5 |
| 1–3 | 299,067 | 90,076 | 208,991 | 33.2 | 19.6 | 47.3 |
| 3–10 | 209,847 | 109,692 | 100,155 | 23.3 | 23.9 | 22.7 |
| 10–20 | 162,158 | 114,679 | 47,479 | 18.0 | 25.0 | 10.7 |
| >20 | 169,281 | 143,960 | 25,321 | 18.0 | 31.4 | 5.7 |
| No data * | 344 | 0 | 344 | 0.04 | 0.0 | 0.08 |

* LAU2 from the Danube Delta.

However, when comparatively analysing the proportions of the high school-aged population based on residency, significant disparities are observed between urban and rural areas. While 85.5% of the urban high school-aged population can reach the nearest high school within 5 km, the value drops to only 12% in the case of the rural population. The gap between the two follows the same pattern as the distance interval increases (Table 3).

### *3.4. Diversity*

Figure 4 shows the distribution of the mean distance to three different high schools across LAU2. When considering the possibility of choosing between different categories of high school or their profiles, the options are quite limited in near proximity, particularly in rural areas, as the average distance a student has to travel in Romania to reach

three secondary schools of different categories is 23.3 km. Values range from 0.6 km to 94.5 km. The median distance in the analysed range is 22.7 km, with the dataset having a standard deviation of 9.576.

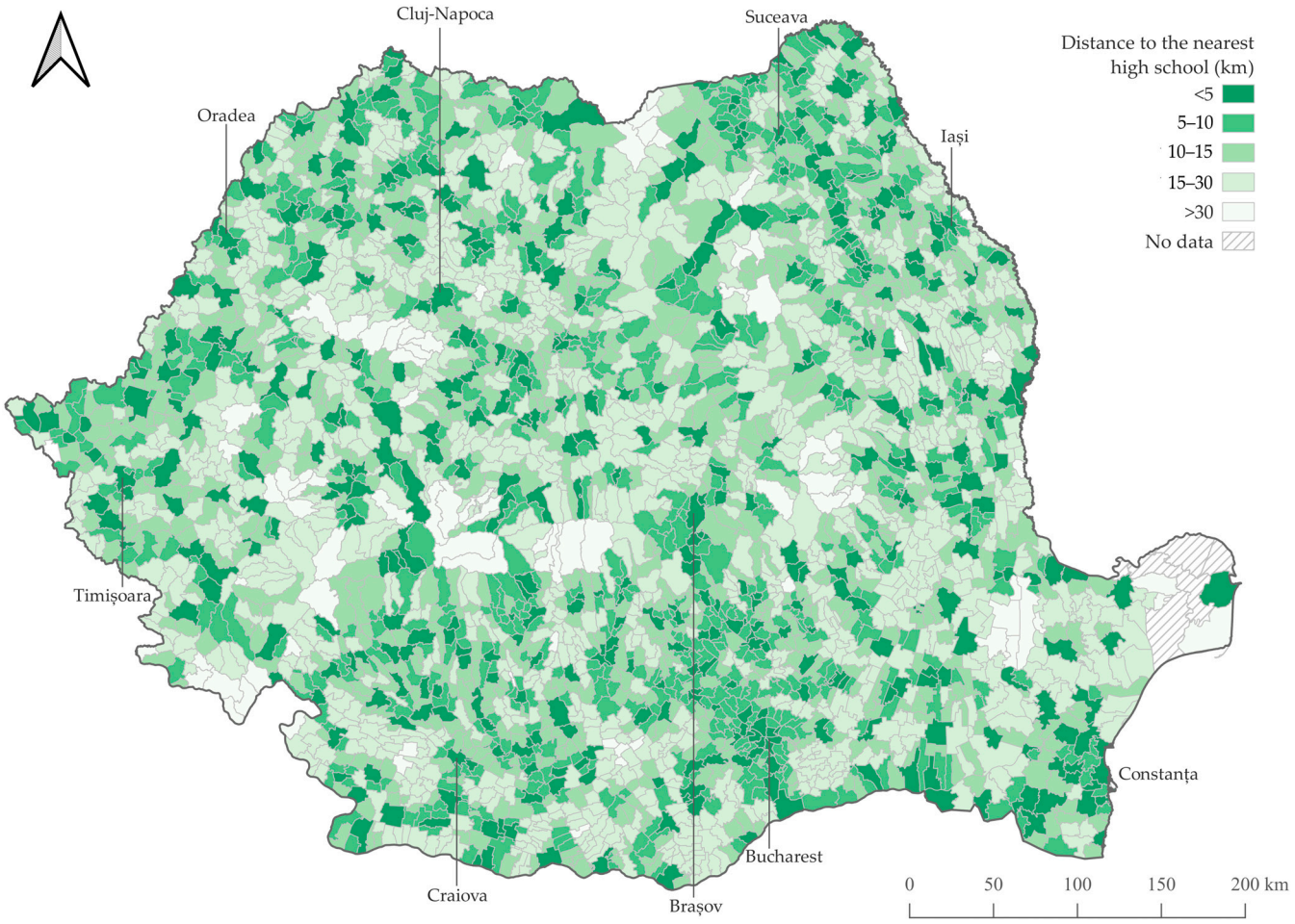



**Figure 3.** Proximity map—distance to the nearest high school.

**Table 3.** Population distribution by distance to the nearest high school.

| Distance Interval (km) | No. of High School-Aged Individuals | | | % of the High School-Aged Population | | |
|---|---|---|---|---|---|---|
| | Total | Urban | Rural | Total | Urban | Rural |
| <5 | 445,878 | 392,733 | 53,145 | 49.5 | 85.5 | 12.0 |
| 5–10 | 162,219 | 49,598 | 112,621 | 18.0 | 10.8 | 25.5 |
| 10–15 | 152,817 | 15,064 | 137,753 | 17.0 | 3.3 | 31.2 |
| 15–30 | 131,904 | 1451 | 130,453 | 14.6 | 0.3 | 29.5 |
| >30 | 7484 | 0 | 7484 | 0.8 | 0 | 1.7 |
| No data * | 344 | 0 | 344 | 0.04 | 0 | 0.08 |

* LAU2 from the Danube Delta.

Only 27.2% of students are less than 5 km away from three different types of educational units. Meanwhile, 29.7% of the high school-aged population has to travel between 10 and 20 km. Also, 22.7% of the high school-aged population has to travel a distance of 20–30 km, while 10.3% faces distances further than 30 km. In this category, the urban–rural divide deepens. While 53.2% of the urban population aged 15–18 can find three options in less than 5 km, only 0.1% of the corresponding rural population has this option (Table 4).

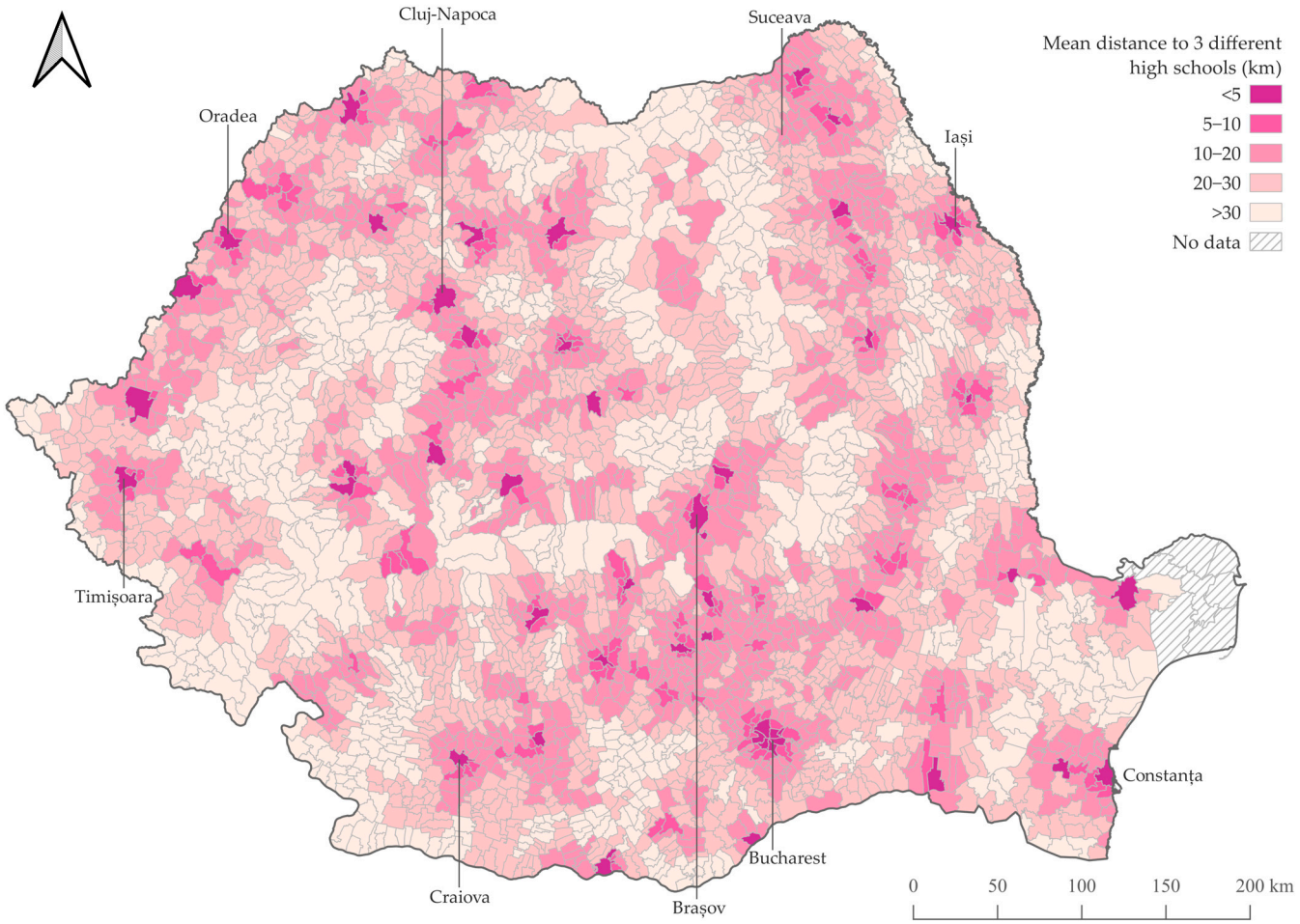



**Figure 4.** Diversity map of the spatial accessibility of the high school network in Romania.

**Table 4.** Population distribution by mean distance to three different high schools.

| Distance Interval (km) | No. of High School-Aged Individuals | | | % of the High School-Aged Population | | |
|---|---|---|---|---|---|---|
| | Total | Urban | Rural | Total | Urban | Rural |
| <5 | 244,754 | 244,214 | 540 | 27.2 | 53.2 | 0.1 |
| 5–10 | 90,660 | 56,007 | 34,653 | 10.1 | 12.2 | 7.8 |
| 10–20 | 267,493 | 112,835 | 154,658 | 29.7 | 24.6 | 35.0 |
| 20–30 | 204,666 | 34,753 | 169,913 | 22.7 | 7.6 | 38.5 |
| >30 | 92,590 | 10,918 | 81,672 | 10.3 | 2.4 | 18.5 |
| No data * | 463 | 119 | 344 | 0.1 | 0.03 | 0.08 |

* LAU2 from the Danube Delta.

### *3.5. Education Accessibility Index*

The Education Accessibility Index ($I_{EA}$) varies between 0 and 32.5. The highest values are registered in Bucharest, followed by the largest cities such as Cluj-Napoca, Iași, Brașov, and Timișoara. Accessibility is also high in the metropolitan areas of these cities. The lowest values are found in isolated rural areas which overlap with mountainous landforms, making accessibility even more difficult. Low values can also be found in eastern Romania, as well as in the southern plains areas. However, the general distribution of the $I_{EA}$ shows a clear concentric distribution decreasing from large urban centres to remote rural settlements (Figure 5).

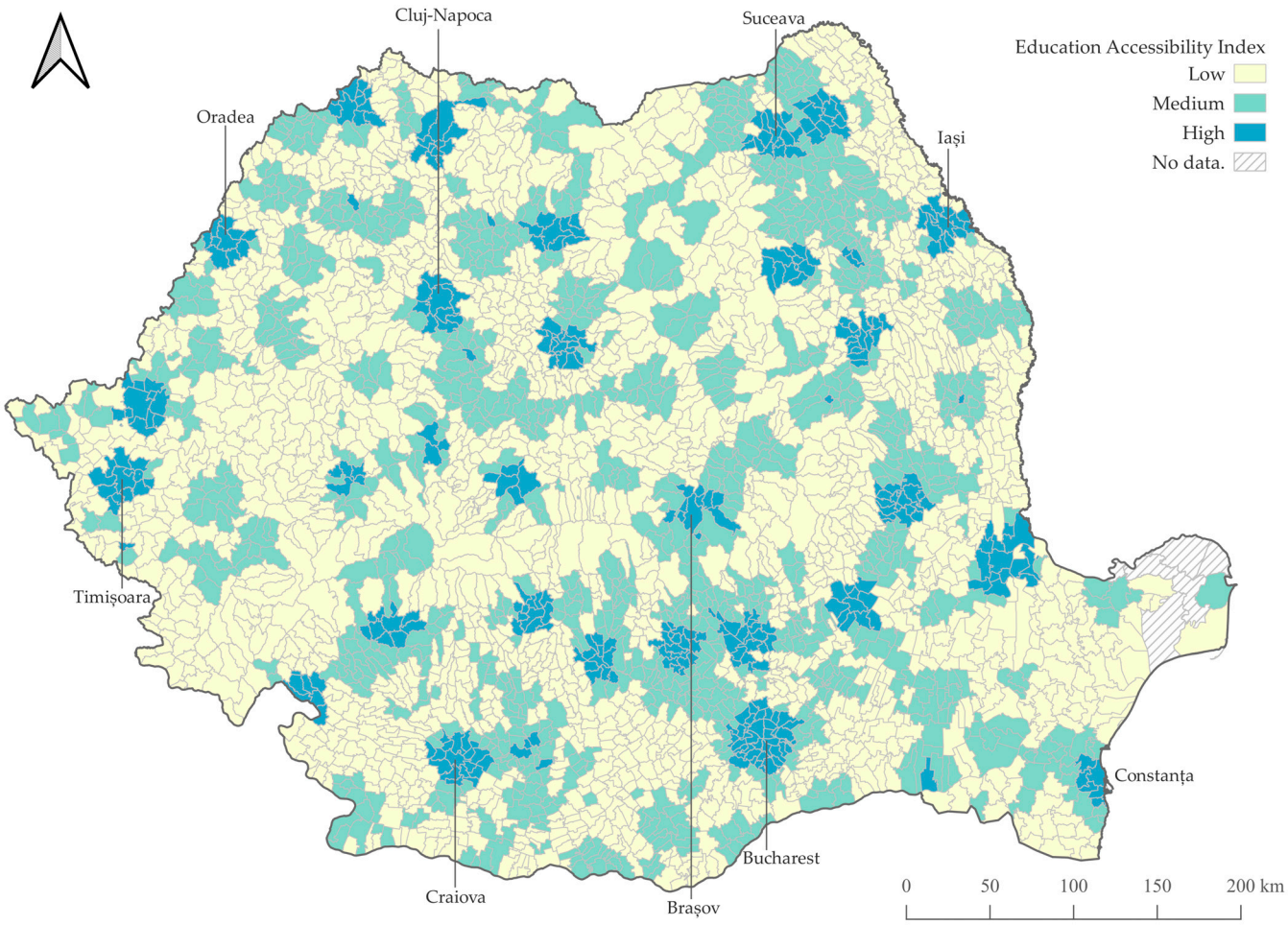



**Figure 5.** The spatial distribution of the Education Accessibility Index ($I_{EA}$) in Romania.

The spatial distribution of the $I_{EA}$ shows that 40.4% of the high school-aged population lives in areas with high accessibility of the high school network, 32.5% faces medium accessibility, and 27.1% faces low accessibility. However, differences become significant when comparing rural and urban areas. Thus, over 46% of the high school-aged population lives in rural areas with low access to the high school network, while only 18.5% has high accessibility. In contrast, a significant proportion of the high school-aged population in urban areas benefits from high accessibility (61.5%), and less than 9% faces low accessibility scores (Table 5).

**Table 5.** Population by education accessibility index values.

| EAI | No. of High School-Aged Individuals | | | % of the High School-Aged Population | | |
|---|---|---|---|---|---|---|
| | Total | Urban | Rural | Total | Urban | Rural |
| Low | 244,090 | 40,263 | 203,827 | 27.1 | 8.8 | 46.1 |
| Medium | 292,507 | 136,535 | 155,972 | 32.5 | 29.8 | 35.3 |
| High | 363,685 | 282,048 | 81,637 | 40.4 | 61.5 | 18.5 |
| No data * | 344 | 0 | 344 | 0.04 | 0 | 0.08 |

* LAU2 from the Danube Delta.

## 4. Discussion

The results of this study conclusively reveal the urban–rural education divide. The disparities between the two areas in terms of availability show huge gaps. The rural high

school-aged population is deprived of high school education units in near proximity, which endangers these individuals' economic prospects. The availability indicator shows that the allocation of high school units is uneven across Romania, with students in urban areas being offered significantly more options than those in rural areas. As students choose high schools based on their results on the National Evaluation, having various categories of high schools in near proximity increases their access to secondary education and their chances to attain a tertiary education. Figure 2 identifies the most serious voids in terms of availability, where some overlap natural barriers such as the Carpathians, and the southern and south-eastern parts of the country contain many LAU2 without even one high school unit in a radius of 20 km. While these deserts might be the result of the influence of stronger urban centres such as Bucharest, local authorities should support the strengthening of the high school network in these communities, as the lack of a high school unit is often a reason for the younger sector of the population to move away, sometimes permanently.

The proximity indicator shows relatively good accessibility scores for some rural settlements: <5 km for 12% of the rural high school-aged population. These values exist because these areas have at least one high school (15.9%). While proximity is a good indicator of accessibility, when it comes to high school choice, it is important to reiterate that in Romania, high school admission is not made based on proximity of residence but rather on the results of the National Evaluation [90,91]. Admission threshold scores are generally higher for national colleges and lower for technological high schools. Thus, considering the distance to only the closest high school can bias the results. In some cases, there are rural settlements where the distance to the nearest high school is short, but this is not enough to conclude that the students residing there have a good accessibility score, as a lack of diversity and the admission requirements could interfere with the proximity indicator.

In this case, the Education Accessibility Index ($I_{EA}$) offers a more comprehensive method of measuring accessibility because it considers the availability and diversity of high schools as well as the distances to each category of high school. The $I_{EA}$ better proves the strong divide between urban and rural areas. $I_{EA}$ scores are high in urban centres that contain prestigious high schools with long histories because they are perceived as providing higher-quality educational services. High accessibility scores were also identified in the localities immediately surrounding large cities. Due to the quality of the transport network, education units in these areas can be reached easily.

However, this might result in inconsistencies between high school units within the same area. Prestigious high schools attract very large numbers of students, becoming overcrowded, while other high schools can barely achieve their enrolment plans. These issues constitute opportunities to discuss spatial accessibility from a local perspective. In Bucharest, which contains the best high schools in the country, travel distances are not very long, but due to traffic congestion, travel time increases significantly, thus creating new barriers to accessibility, which are worth exploring in future studies.

Another important issue arising from the concentration of the best-performing high schools within large cities is school commuting or even migration. In Romania, many students choose to commute daily over long distances to access a specific high school or move to a city where numerous options exist, deepening the burden on the family budget [92]. The particular case of the Danube Delta is generated by the lack of road transportation infrastructure, which is why accessibility was found to be null. Transportation in the region is performed by boat, meaning that the journey to school is long, expensive, and often tedious in bad weather conditions. Thus, the most viable option for students living in these rural communities who want to attend a high school is to move to a city where such units exist, and that usually puts more pressure on the family budget [92]. Alternatively, in order

to complete their secondary education, these students have to rely on private tutoring, again increasing their financial burden.

The $I_{EA}$ scores were low for a series of medium and small towns experiencing depopulation. A decreased number of school-aged individuals, in turn, leads to the closure of many high schools and reduces the number of options for remaining students. In fact, in many rural areas of Romania, population decline is a process that affects the number of students [74]. As such, many schools have closed. The school is a central institution around which a community is formed, and in its absence, the community will not be able to revitalise itself demographically or, in many cases, economically [93,94]. Living in rural areas with low accessibility makes following the educational pathway more difficult. Besides the limited number of options, the high school-aged population also faces problems related to the quality of education, as many rural high schools experience a lack of qualified personnel, again creating the need for additional tutoring [95].

The Romanian authorities have stated their focus on evaluating and finding strategies for coping with the negative effects of this issue. Even though the strategies exist, such as the 2015 *Strategy of reducing early leaving from school in Romania*, adopted by the Ministry of Education, they lack detailed educational data at the LAU2 level, such as actual travel distance or the identification of underserved areas [15]. Distance implies additional costs for transportation; as such, these two factors are actually interconnected. In fact, as distance from school increases, students are more likely to exhibit absenteeism, early leaving from school, or dropping out [16,96].

The present study stands as an example of integrating geospatial measurements in the decision-making process for educational public policies on the subject of optimising the spatial accessibility of the high school network. Maintaining a high school with a small number of students in each settlement in Romania would not be a viable or cost-effective solution. As such, we consider that increasing the quality of educational services in all types of high schools in order to standardise the quality of the educational process and reduce the discrepancies between high schools' perceived quality would be a better course of action. This would also prevent the overcrowding of some educational units.

The need for education is equal between urban and rural spaces. The need for adapted policies can help make the journey to school easier. Many rural settlements with no high schools in close proximity can benefit from free accommodation in urban centres where many options are available. By increasing the capacity and improving the conditions of the public school accommodation infrastructure, such as the so-called dormitories for students, accessibility could be increased. For students living at medium distances (Figure 3), full public transportation reimbursement between the place of residence and the high school may motivate more young people to continue their studies and improve the school commuting experience. Thus, improvements in the spatial accessibility of the high school network can be made by policymakers while considering science-based results, allowing them to make decisions and prioritise vulnerable regions more easily and improve functionality.

## 5. Conclusions

The present study aimed to evaluate the urban–rural divide in education provision in Romania based on the spatial accessibility of the high school network. We used geospatial analysis to examine the spatial distribution of the high school network and measure the spatial accessibility of educational units. Travel distance was used to measure the spatial accessibility of high schools, considering three dimensions that cover the principles of proximity and possibility of choice specific to educational services. The dimensions of availability, proximity, and diversity were integrated into the Education Accessibility Index ($I_{EA}$).

The results of this analysis show that even though the high school-aged populations living in rural and urban areas are comparable, the allocation of educational infrastructure is uneven. Thus, the $I_{EA}$ values are low for 41.6% of the rural high school-aged population and high for 61.5% of the urban high school-aged population. Large urban centres, with their high diversity of high schools in near proximity and short travel distances, exhibit the highest values of $I_{EA}$, while the lowest values of $I_{EA}$ prevail in many rural areas, with long distances to travel and very few options for potential students.

This study provides insights into the educational landscape in Romania, pointing out the areas with limited access to high schools (southern and south-eastern areas as well as those where geographical landforms constitute natural barriers). The mapping of the $I_{EA}$ can constitute a framework for pointing out inequalities in educational attainment. The present findings can serve as a basis for developing policies and practices to bridge the urban–rural divide in educational opportunities and foster a more equitable and inclusive education system.

Additional work is needed to better understand the spatial accessibility of the high school network. Future studies will explore high school accessibility by measuring travel time and travel distance using public transport. This can provide a more granular perspective on spatial accessibility, as commuting is most often performed using public transport (bus, train, tram, metro, etc.) or even active modes of travel such as walking and cycling. The type of school environment and the willingness of students to travel long distances to pursue their studies are important issues that should also be addressed.

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