

Original scientific article

SPATIAL ANALYSIS OF SCHOOL AREAS AND SELECTION OF POTENTIAL LOCATIONS FOR PUBLIC SECTOR FACILITIES USING THE EXAMPLE OF THE CITY OF NOVI SAD (SERBIA)

Tina Klevernić^A

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ABSTRACT

It is essential to prioritise the protection of children and employees in primary and secondary schools in the City of Novi Sad is essential to ensure the sustainability of a healthy society. This study employs Network Analysis methodology in ArcGISPro to explore spatial connectivity and analyse service accessibility in the City of Novi Sad, focusing on emergency medical services, police, and fire departments. By utilizing tools such as Service Area and Location-Allocation, the study assesses the coverage and response times of these vital services. Data from ArcGISOnline, geofabrik.de, and geosrbija.rs are processed to identify optimal service locations and address spatial challenges. The results reveal spatial disparities in service coverage, particularly in outlying settlements, necessitating the establishment of new facilities to improve accessibility. The proposed locations for emergency services and police stations aim to enhance response times and coverage, addressing critical gaps identified through spatial analysis. The study underscores the importance of spatial planning and data-driven decision-making in providing optimal public services while acknowledging the need for comprehensive data collection and ongoing analysis to adapt to evolving spatial dynamics and service demands. The findings of the study indicate the need for emergency medical services in settlements including Kać, Čenej, Budisava, Begeč, Futog, Kisač, and Stepanovićevo, while fire stations are required in settlements of Ledinci and Bukovac. Additionally, a police station is required only in the settlement of Kovilj.

Keywords: network analysis; service area; location-allocation; ArcGISPro; services.

INTRODUCTION

Protecting children and employees in primary and secondary schools is a high-priority factor for the development of society. Public services (emergency medical service, fire service, police) in the city of Novi Sad should be able to adequately and quickly resolve potential problems in educational institutions. The biggest obstacles to solving the problem are the distribution of traffic infrastructure, speed limits on roads, and increased motorisation in cities, which slow down the resolution of this socio-geographical issue (Yu et al., 2020). By analyzing the accessibility area in the ArcGISPro tool, we can address the issue of potential new public sector facilities in settlements where they are necessary (Noon, Hankins, 2001). The result of the analysis aims to find suitable locations for a new public services that could effectively and promptly respond to social problems re-

^A Department of Geography, Tourism and Hotel Management, Faculty of Sciences, University of Novi Sad, Trg Dositeja Obradovića, 3, Novi Sad, Serbia

* Correspondence: klevernictina@gmail.com

quiring emergency medical services, police, and fire services. The subject of the research is the protection of employees as well as the protection of children in primary and secondary schools in the municipality of Novi Sad, where the focus is on opening new public sector facilities (police stations, fire stations, emergency medical services) in settlements where they are necessary. The term “necessary” refers to situations where settlements on the outskirts of the municipality of Novi Sad do not have health centres, emergency medical services, or police stations that could solve problems as soon as possible. The response time limit should not be longer than 5 to 10 minutes. As for the objectives of the work, there are more of them. It is necessary to point out the tragic situation that happened in the city of Belgrade on May 3, 2023, as well as the great need for urbanisation of settlements on the outskirts of the municipality, to avoid the overloading of services which can sometimes lead to delayed response in critical situations and suffering of people.

The research questions are:

1. Which schools require the support of (which) services?
2. In what time frame is it possible for the public service to adequately respond to an urgent request in primary and secondary schools in the City of Novi Sad?
3. What are the socio-geographical factors that influence the slower response of public service?
4. What is the solution? How many buildings (which services) need to be built?

The main assumption of the hypothesis is that the process of urbanisation in settlements with the largest population has contributed to better availability of services for their residents compared to those settlements with a smaller population, which are mostly located on the outskirts of the municipality (Noon, Hankins, 2001).

The focus of the hypothesis would be four variables that are correlated: the population of the settlement (young population aged 7-18), the degree of urbanisation of the settlement in the given municipality, the availability of public service provision in all settlements of the municipality, and the transportation infrastructure.

One of the first studies that dealt with a similar topic and applied GIS as a solution and tool was published in the *Journal of Agricultural Economics*. The essence of the work was to study and measure the profitability of travel from the aspect of the economy (Bateman et al., 1996).

In certain papers, the examination of Euclidean distance and Manhattan distance is common. However, this approach can sometimes lead to inaccurate results. For precise results, it is essential to consider only network distance, which represents the shortest path, or shortest network time. The accuracy of the shortest network time hinges upon the traffic infrastructure and congestion levels on the roads (Apparicio et al., 2008).

In this research, the economic aspect is not primary. Priority is given to the time that emergencies can be dealt with. This text summarises previous research on the given topic. It states that there have been several scientific research publications, but there have been no extensive publications on the subject like these. Typically, these papers have focused only on one public service, often comparing factors such as population size and road layout. Research is often based on the type of patients (pregnant women and mothers in labour) who use certain types of services such as emergency medical assistance (Noon, Hankins, 2001).

Radaković M. explored a related topic by focusing on the application of the location-allocation method to identify optimal locations for establishing new postal services. This example comes from the territory of the Republic of Serbia (Novi Sad), which was found in a literature review that utilised the location-allocation function within GIS (Radaković, 2017).

In the 21st century, research has contributed to addressing this socio-geographical problem, particularly through the development of Geographic Information Systems (GIS) (Church, 2002).

Without GIS and the support it provides through various software solutions, and the availability of input data, the analysis of public service accessibility would not be possible (Tali et al., 2017).

A good example of a study where the population expresses preferences for using healthcare services and where GIS determines spatially which branch of healthcare services they should belong to is the work by Bullen et al. Such studies often result in deviations from the expressed preferences of the surveyed population, which is perfectly fine. This type of work shows us that GIS, without field research and inquiries with the local population, would not have a clear and concise claim to accurate Geospatial analysis (Bullen et al., 1996).

The evidence that straight-line distance (which can be calculated even without GIS) can be equally well calculated and utilized for spatial analysis as Network analysis is demonstrated in the paper “Comparison of perceived and modelled geographical access to accident and emergency departments: A cross-sectional analysis from the Caerphilly Health and Social Needs Study.” However, in this study, ArcGIS Pro was not used; instead, the software MapInfo with the Drive-time function was employed (Fone et al., 2006).

The World Health Organisation (WHO) has recently introduced HealthMapper and the Service Availability Mapping (SAM) Program, both aimed at enhancing the visualization and monitoring of healthcare service spatial coverage. Particularly critical is the assessment of methadone clinic distribution within defined spatial units. Conducting such analyses through Geographic Information Systems (GIS) holds promise for improving urban coverage and ensuring convenient access to methadone for individuals undergoing treatment (Pang, Lee, 2008).

GIS serves as a tool that complements the theory of location by providing visualisation of spatial data, often supplementing geostatistics, which typically have a descriptive nature. For GIS analysts, research findings often appear familiar and understandable. Such experts are already immersed in the field. The challenge for every analyst processing geospatial data is to bring them closer to their readers. With the advancement of software, achieving this task is increasingly easier and aesthetically pleasing (Church, 2002).

METHODOLOGY AND DATA

Network Analysis - The methodology of network analysis in ArcGisPro enables us to explore and analyse the connectivity between objects (entities) in space. Various tools such as route analysis, flow analysis, and distance analysis are used. The data being analysed is located in the ArcGisOnline Cloud database, so it is not necessary to input data on traffic infrastructure. The results include the estimation of the best routes, finding the shortest distances, as well as the analysis of markets, traffic, and other socio-geographical disciplines. The most common application of Network Analysis methodology is in planning and decision-making. Within this methodology, two geospatial analysis tools are used - Service Area and Location-Allocation.

Service Area - The service availability area in ArcGisPro allows us to determine the area that is accessible to a location within a certain time limit. This type of analysis can be suitable in various scenarios such as researching the availability of public services, planning emergency interventions where response time is a crucial factor, and traffic infrastructure. In our case, we used the Service Area method to visualise the areas covered by a specific service/resource within time limits of 5, 10, and 15 minutes, which is crucial for future planning, decision-making on locations, and implementation.

Location-allocation analysis - Involves a detailed analysis of spatial data to identify the most favourable locations for specific purposes. Within this method, there are certain parameters based on which the best location is chosen. Specifically, the Maximum Coverage method is applied. This method answers the question of how many other locations a certain number of new facilities could serve within an adequate period if they were to be built.

During the analysis of the Service Area and Location-allocation functions within the Network Analysis methodology, hosted data from ArcGIS Online (Internet1) were used. This data contains information related to the complete road network, as well as the positions of traffic lights, objects, road obstacles, and other barriers that slow down the active flow of traffic. Among other geographical data, data on the location of primary and secondary schools (<https://www.geofabrik.de/>) were used. The data from the Geofabrik site are used in various geospatial analyses, providing data as well as tools related to OpenStreetMap (OSM). Data on the boundary of the analysed area (City of Novi Sad) were obtained from the website <https://geosrbija.rs/>

During data processing, GIS software developed by ESRI (Environmental Systems Research Institute) was used. This tool enables users to analyse, visualise, edit, and share spatial data. ArcGIS Pro stands out with a modernly designed interface and advanced features, including support for 2D and 3D views. It supports work-

ing with various types of geospatial data, allowing us to analyse routes, terrain, geoprocessing operations, and much more. Its frequent applications include urban planning, ecology, business planning, and more. (Internet2)

RESEARCH AREA

Novi Sad is located in the northern part of the Republic of Serbia, in the Autonomous territory of Vojvodina. Geographically, the city lies on the banks of the Danube River, one of the most important rivers in Europe, which gives it a significant strategic position in the European context. Additionally, Novi Sad is situated near the border with Hungary, contributing to its position as an important trade and cultural hub in this part of Europe. The City Municipalities of Novi Sad and Petrovaradin were formed to manage certain tasks in the City. The areas of these municipalities include settlements that are administrative division units, that is, parts of cadastral municipalities (Bubalo Živković, 2003). The city municipalities of Novi Sad include Novi Sad, Futog, Veternik, Begeč, Kisač, Rumenka, Stepanovićevo, Kač, Čenej, Budisava and Kovilj. The settlements of the City Municipality of Petrovaradin include Petrovaradin and other settlements such as Sremska Kamenica, Bukovac and Ledinci. These municipalities have their specific responsibilities and functions within the management and maintenance of life in those areas. Novi Sad is the second largest city in Serbia, right after Belgrade. It is located on the left bank of the Danube River in Vojvodina. Part of the city is built on the flat alluvial plain of the Danube, while the rest is positioned on slightly higher ground. Initially, due to the proximity of the river and marshy terrain, construction along the Danube banks was not feasible. Urbanisation and drainage of marshy areas were necessary to provide access to the river. Novi Sad is a relatively young city. Its construction began in the late 17th century, coinciding with the construction of the Petrovaradin Fortress on the right bank of the Danube. However, archaeological research has shown that the territory of Novi Sad

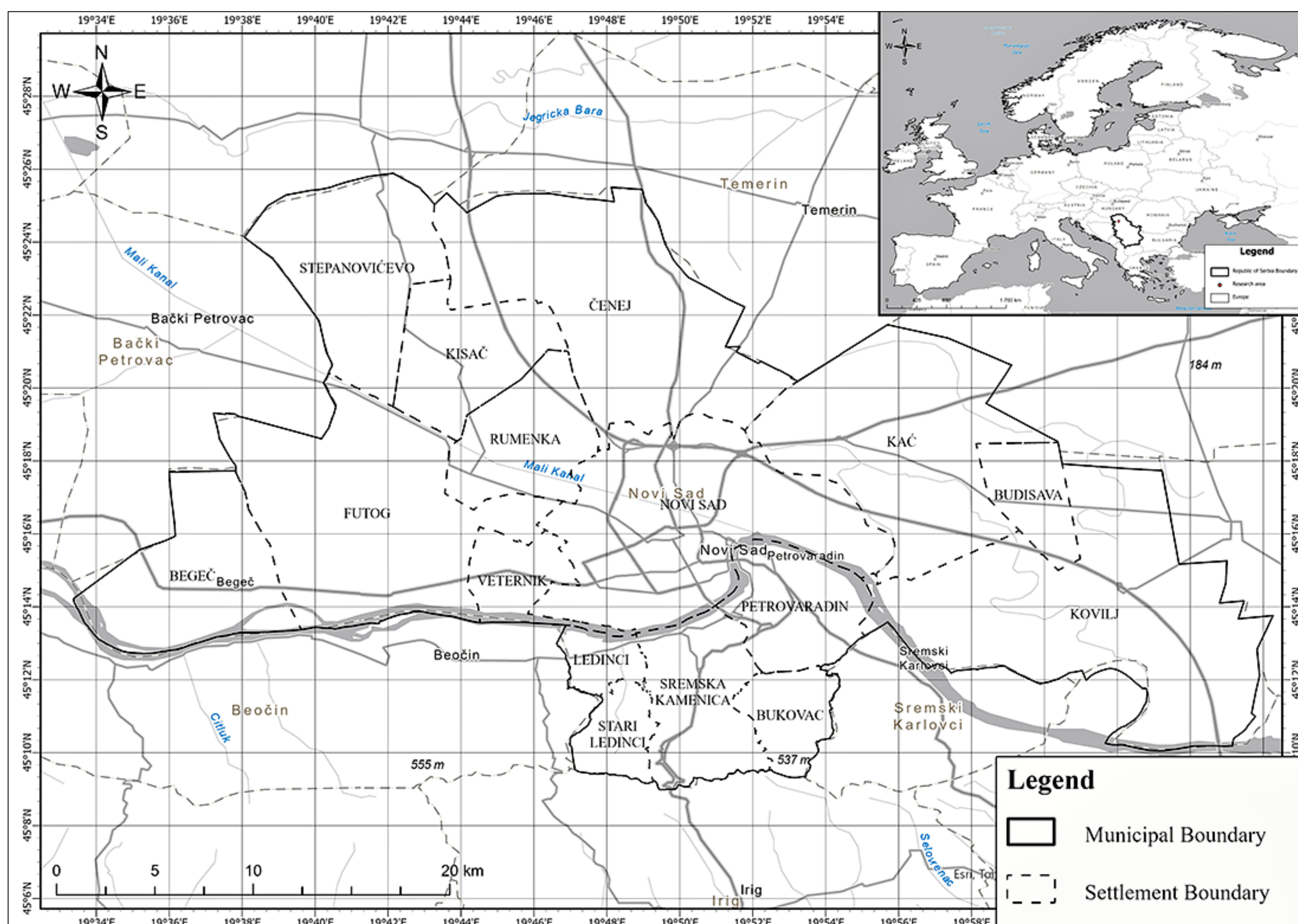


Figure 1. Geographical position of Novi Sad

was inhabited long before the construction of the Petrovaradin Fortress began. After World War I and especially World War II, Novi Sad experienced intensive development. The city grew, new boulevards and residential blocks were built, embankments were constructed in the Liman area, new parts of the city were formed, industrial facilities were built, and industrial zones were established. The population grew rapidly, especially during the 1960s and 1970s, as well as in the first decade of the 21st century. This development attracted a large number of migrants (Bubalo Živković et al., 2020).

Urbanisation is the process of growth and development of cities, involving increased population density, economic development, changes in lifestyle, and infrastructure transformations. For Novi Sad, as for other cities, urbanisation has had a significant impact on its development and transformation (Bubalo Živković et al., 2020).

- Demographic Growth: Urbanisation has led to a significant increase in the population of Novi Sad, both due to internal migration from rural to urban areas and because of the city's attractiveness as a centre of education, culture, and economy.
- Economic Development: Urbanisation has enabled economic development in Novi Sad through the growth of industry, commerce, services, and other sectors. The city has become a centre of business activities, attracting investments, and creating new job opportunities for the population.
- Infrastructure Changes: Urbanisation has brought significant changes to the infrastructure of Novi Sad. New roads, bridges, public transportation, educational institutions, hospitals, shopping centres, and other facilities have been built, improving the quality of life for citizens and enabling more efficient city functioning.
- Cultural Development: As a centre of culture and education, Novi Sad has become an important cultural hub through the process of urbanisation. The development of cultural institutions, festivals, artistic events, and other events has contributed to the richness of the city's cultural life.
- Social Aspects: Urbanisation has also brought social changes, such as changes in lifestyle, social interactions, and community identity. Novi Sad has become a multicultural centre, bringing together people of different cultures, languages, and traditions (Kostreš, Atanacković-Jeličić, 2011).

The municipality of Novi Sad has 16 settlements, with the largest urban settlement being Novi Sad itself. Since the beginning of the 20th century, the municipality has experienced continuous population growth. Until the beginning of the 21st century, population growth was contributed to by both natural increase and population migrations. In the early years of the 21st century, natural increase showed negative values, despite being positive in the city itself and some suburban settlements. Therefore, the recent population growth can be attributed to mechanical population movements, i.e., migrations (Bubalo Živković et al., 2020).

The largest number of migrants settled in Novi Sad, which could be expected given that Novi Sad is the economic, university, and administrative centre of Vojvodina. Besides Novi Sad, other settlements in the municipality also experienced population growth, but in the first decade of the 21st century, natural population growth in most settlements was low and negative. If this trend continues in the coming years, it will inevitably lead to stagnation and, in some settlements, a decrease in the number of inhabitants. (Arsenović, Đurđev, 2012)

In the census in October 2022, it was determined that 368,967 inhabitants live on the territory of the municipality. Of that number, the city's population is 306,702, while the surrounding settlements have only 62,265. (Stanovništvo prema starosti i polu, po naseljima. (2022) Beograd: Republički zavod za statistiku) This was an increase of 27,342 inhabitants compared to the 2011 census for the region of the entire municipality of Novi Sad. (Stanovništvo prema starosti i polu, po naseljima. (2011) Beograd: Republički zavod za statistiku) Such figures indicate the potential possibility of developing urbanisation from the aspect of increasing the number of inhabitants in the settlement of Novi Sad.

In summary, the urbanisation of Novi Sad reflects the processes and changes that characterise the development of modern cities. Through this process, Novi Sad becomes a dynamic urban centre with diverse opportunities for living, working, and cultural development.

RESULTS AND DISCUSSION

ArcGIS Pro as a tool for spatial visualisation and analysis of geographical data in this specific case adequately met all the analysis requirements. (Internet2) During the processing of data obtained from the website www.geofabrik.de, obstacles were identified in the attribute tables. The specific issue was the lack of names for the entities in the area, whereas in some locations the name of the public service object was not entered. The problem was resolved by entering the missing data manually. Additionally, some objects were provided in the form of point data type and some in the form of polygon data type. To solve the problem, it was necessary to convert all polygon data to point data. This type of problem was observed only in the case of the city of Novi Sad for now.

The non-governmental organisation OpenStreetMap aims to make data accessible to everyone. However, while this goal has been achieved, the validity of the provided data is not always ensured. Consequently, this can lead to potential errors in analyses (Fredriksson, 2017).

Travel time estimated electronically in GIS can only aim to represent the average scenario. Nonetheless, for most applications, the average scenario suffices as an appropriate measure. Large-scale studies regarding service equality across regions, the influence of accessibility on service utilisation, and the effects of poor service access on health often lack direct information on actual travel times and must rely on estimations (Haynes et al., 2006).

Public services of the city of Novi Sad

In this section, it is important to emphasise the crucial role of emergency medical services, fire departments, and police services in supporting the safety and health of citizens. Emergency medical services provide essential first aid and medical support in critical moments, saving lives and reducing the consequences of injuries and illnesses. The fire department is vital in extinguishing fires, evacuating endangered people, and protecting property, often used in dangerous and unpredictable conditions. The police service ensures law and order, protecting citizens from criminal activities and providing a sense of security within the community. The collaborative work of these services is essential for a rapid response to emergencies and keeping stability and safety in society (Varano, Schafer, 2012).

Emergency medical service

Figure 2 highlights the locations of all Emergency Medical Services in the municipality of Novi Sad. Table 1 lists the exact names of the institutions.

At first sight, the map offers a comprehensive overview of the status of emergency medical services and the extent of coverage concerning primary and secondary schools. Emergency medical services are deficient on the municipality's periphery.

Table 1. Emergency medical service in Novi Sad

ID	Settlement	Name
1	Novi Sad	Klinički centar Vojvodine
2	Novi Sad	Hitna-Patrijaha Pavla
3	Petrovaradin	Vojnomedicinski centar Novi Sad
4	Novi Sad	Kovid bolnica Novi Sad
5	Sremska Kamenica	Institut za kardiovaskularne bolesti Vojvodine-Srem

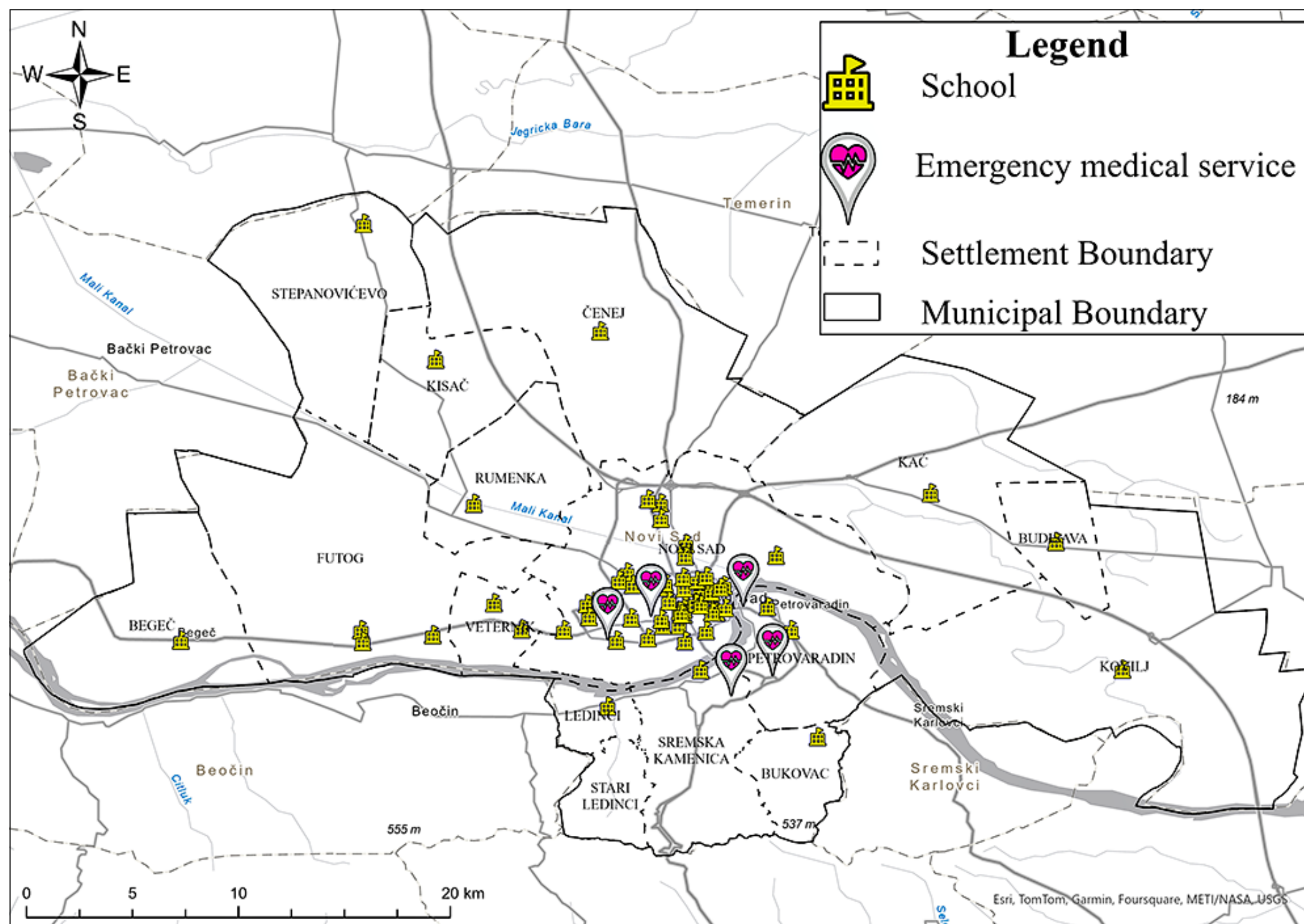


Figure 2. Geographical position of emergency medical services and schools

Police

Figure 3 highlights the locations of all police stations in the municipality of Novi Sad. Table 2 lists the exact names of the institutions.

The police coverage in the municipality of Novi Sad has more effectively met the service's task. In Figure 3, it is observed that all primary and secondary schools in the municipality have at least one police station capable of responding to an incident within an almost ideal period.

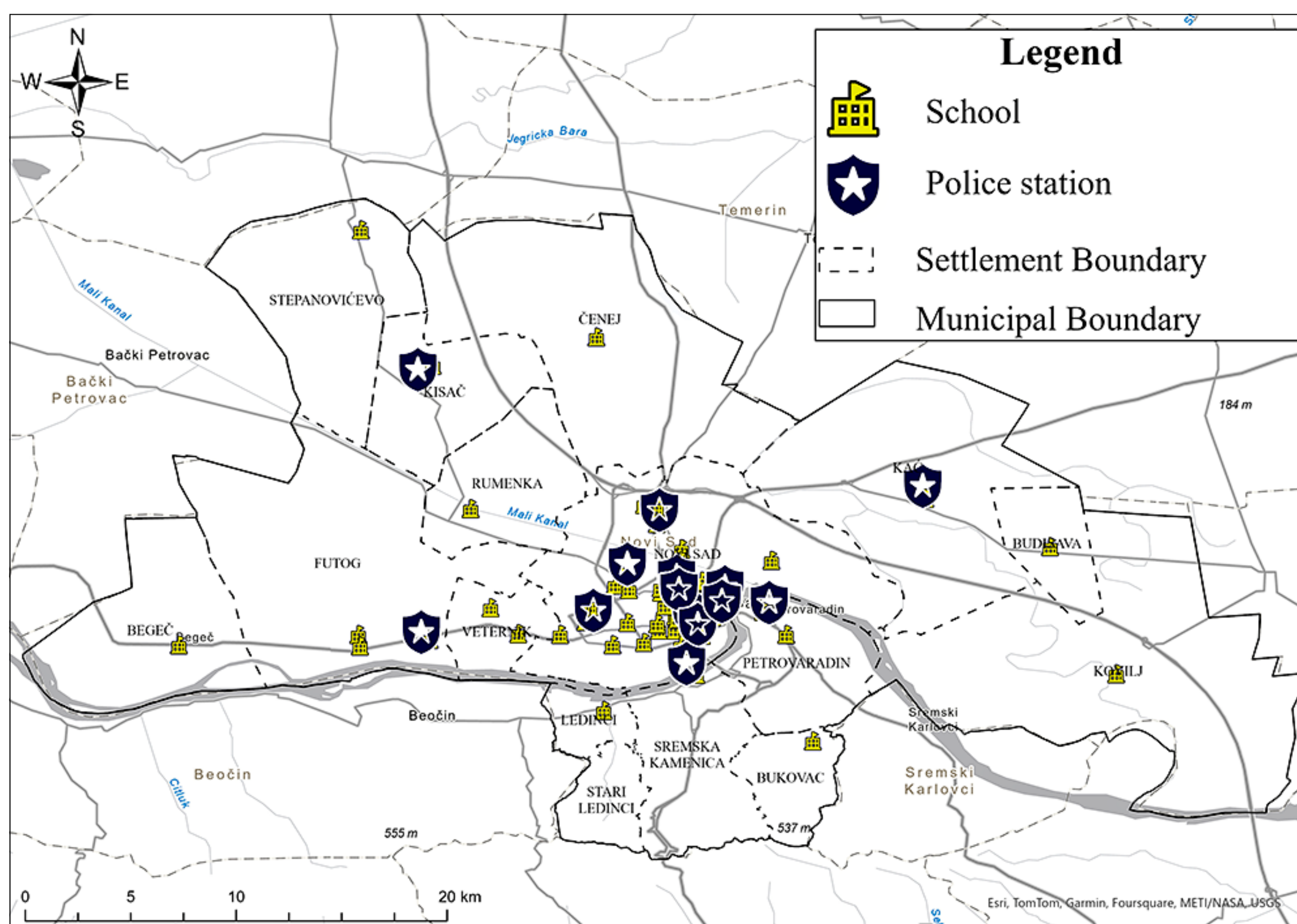


Figure 3. Geographical position of police station and schools

Table 2. Police in Novi Sad

ID	Settlement	Name
1	Novi Sad	Komunalna policija- Novi Sad
2	Novi Sad	PU- Novi Sad
3	Novi Sad	PU- Novi Sad
4	Novi Sad	MUP, šalter sala za izdavanje dokumenata
5	Kisač	PU- Kisač
6	Kač	PU- Kač
7	Novi Sad	Policajska ispostava- Bate Brkić
8	Novi Sad	Policajska stanica - Detelinara
9	Petrovaradin	Policajska stanica - Petrovaradin
10	Novi Sad	SUP "Slana Bara"
11	Novi Sad	Granična policija Novi Sad
12	Futog	Policajska stanica - Futog
13	Novi Sad	Policajska ispostava Stari Grad
14	Sremska Kamenica	Policajska ispostava Sremska Kamenica

Fire service

Figure 4 highlights the locations of all fire stations in the municipality of Novi Sad. Table 3 lists the exact names of the institutions.

In Figure 4, an insufficient number of fire services is observed. Although the spatial network appears to be well-equipped and each primary and secondary school seems to have its fire service, this is not the practice case. Schools in the Sremska Kamenica area specifically require at least one dedicated fire service.

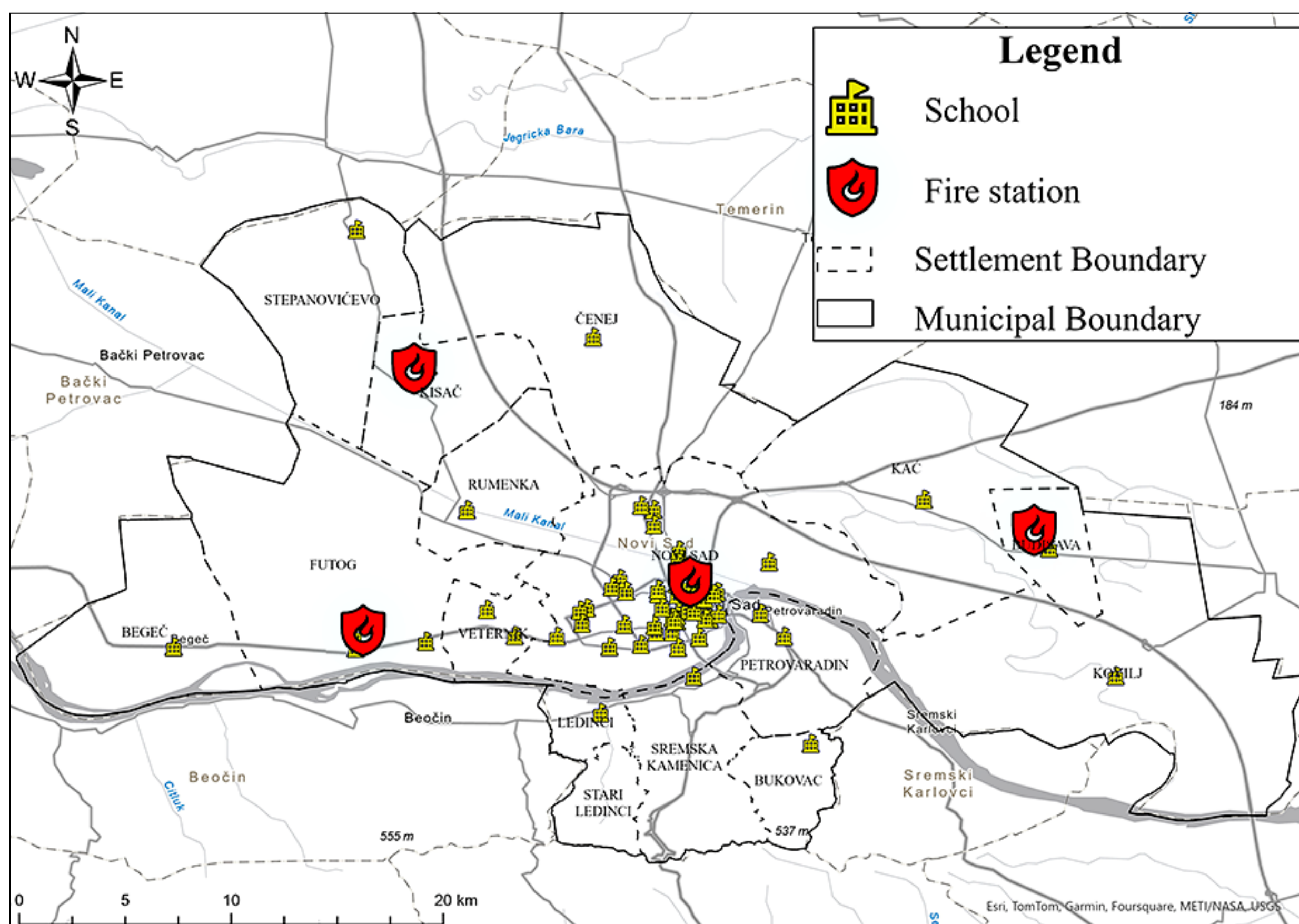


Figure 4. Geographical position of fire services and schools

Table 3. Fire service in Novi Sad

ID	Settlement	Name
1	Budisava	Vatrogasni dom
2	Kisač	Dobrovoljno vatrogasno društvo
3	Futog	Vatrogasni dom Futog
4	Novi Sad	Vatrogasna brigada Novi Sad

Emergency medical service

The transportation system is crucial for urban development, economic conditions, and the functionality of a city. GIS technology facilitates route planning and access, supporting sustainable development. GIS integrates spatial and attribute data to better understand infrastructure and plan transportation networks. Roads are vital for urban functionality, and urban growth depends on efficient transportation infrastructure. In situations requiring emergency response from medical services, the shortest route and time of arrival from school to emergency medical services and back play a crucial role. This aspect further emphasises the importance of transportation system efficiency in urban environments (Rai et al., 2013).

Some case studies for assessing the availability of medical services often take into consideration postal codes (geographic units of areas) as input data, as exemplified in the case of the northeastern part of New York. Through such analyses, the potentials, supplies, demands for medical services, and limitations are explored (Wing, Reynolds, 1988).

In Figure 5, a clear spatial problem is observed with primary and secondary schools in the settlements of Kisač, Stepanovićevo, Begeč, Kovilj, and Budisava. Reading the legend, it is evident that the emergency medical service needs to travel for more than 20 minutes to reach these settlements. This time distance is not crucial for drivers who migrate daily from these settlements to the settlement of Novi Sad for work. However, in the case of a medical emergency, the key solution to the problem is the construction of new emergency medical services. This would achieve better coverage and supply of certain public services in the city of Novi Sad.

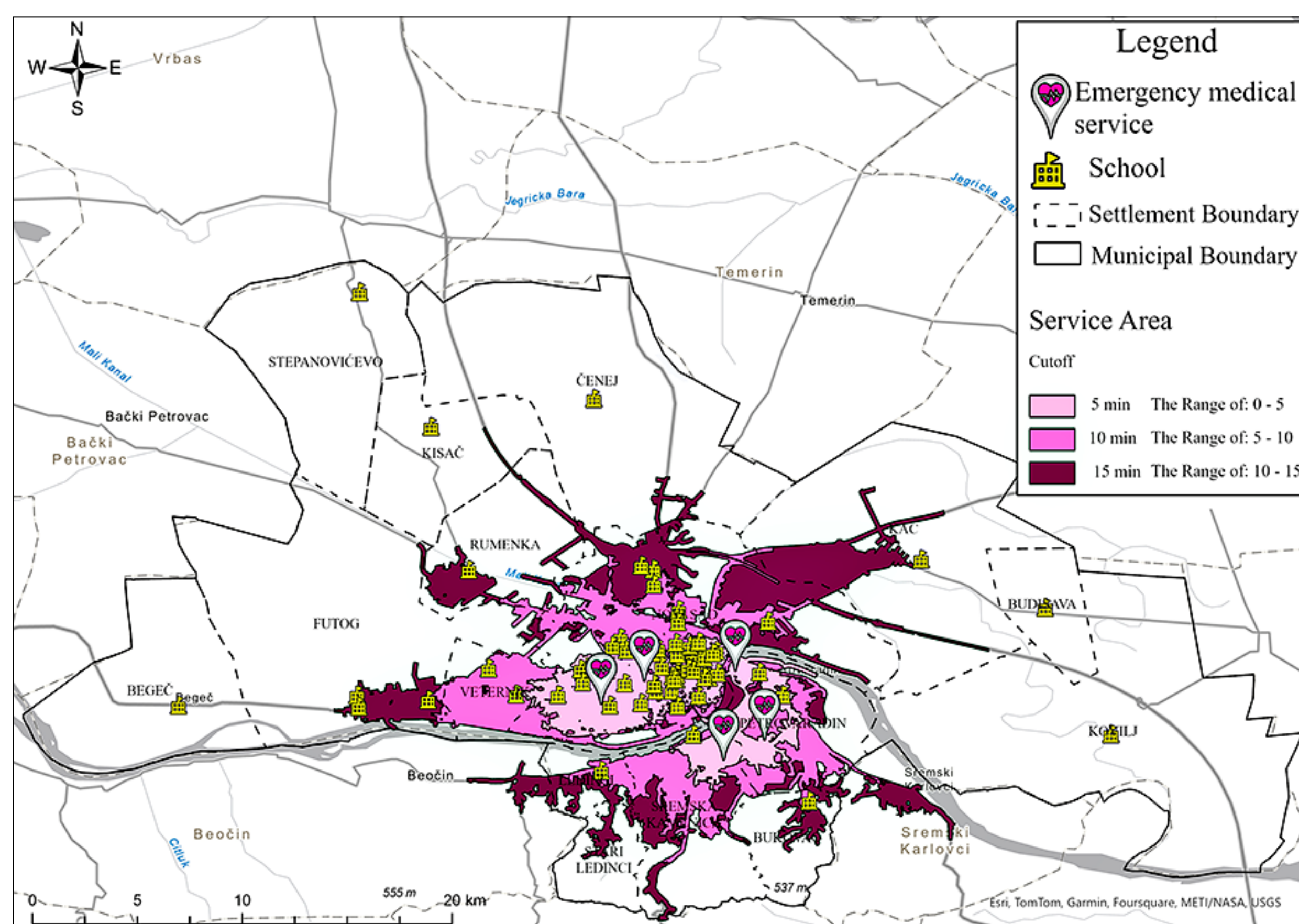


Figure 5. Service Area of emergency medical services

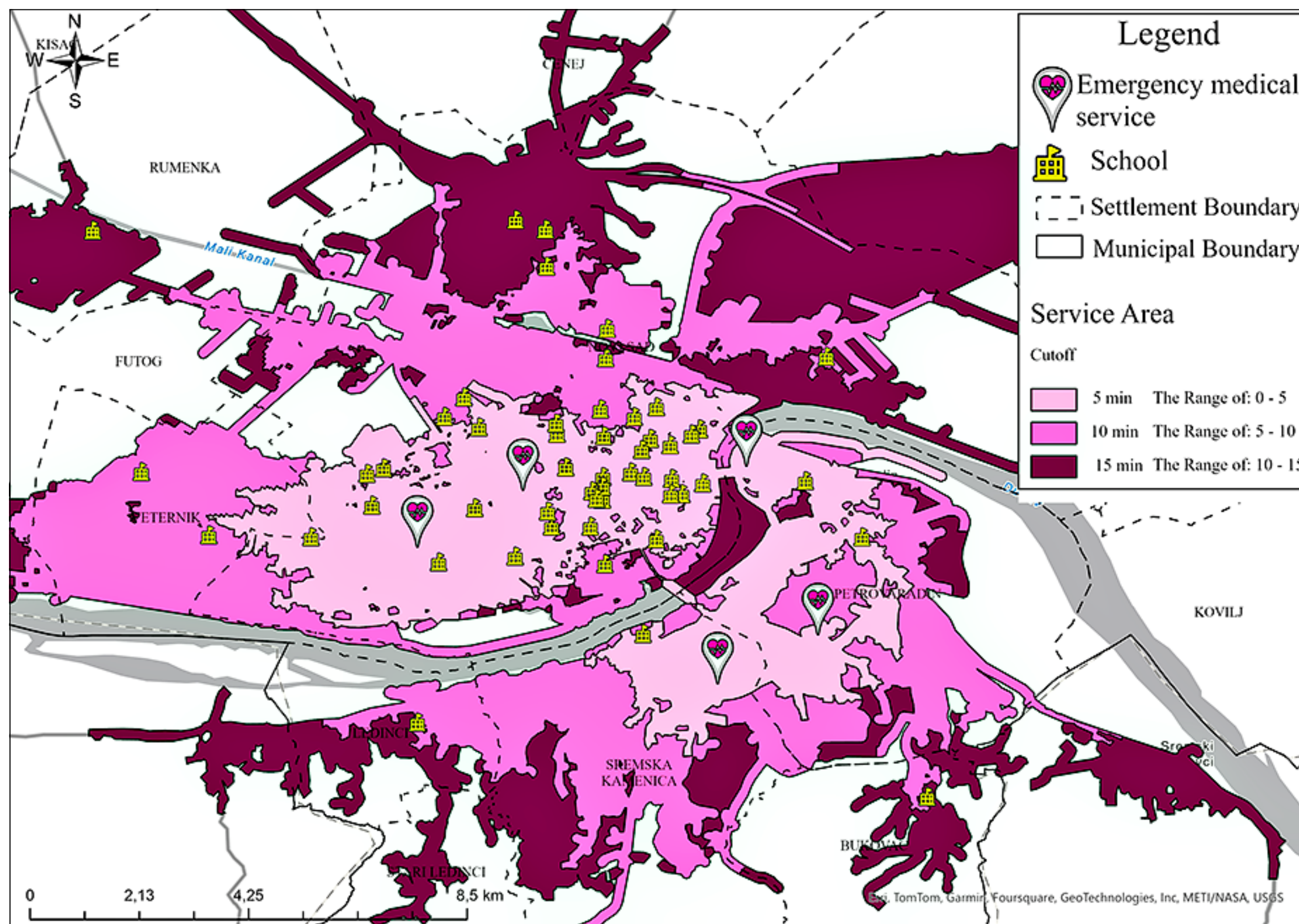


Figure 6. Enlarged Figure 5

In Figure 6, it is clear that the settlement of Novi Sad is adequately covered by emergency medical services and that within a time range of 5 to 10 minutes, every primary and secondary school in the settlement of Novi Sad would be adequately taken care of. Only the schools in the settlements of Bukovac and Rumenska would require a longer response time, approximately 15 minutes.

In Figure 7, potential locations for the opening of new emergency medical services are presented. The line connecting the emergency services with primary and secondary schools at risk actually indicates which schools would be covered by that particular emergency service. In the event that an emergency medical ser-

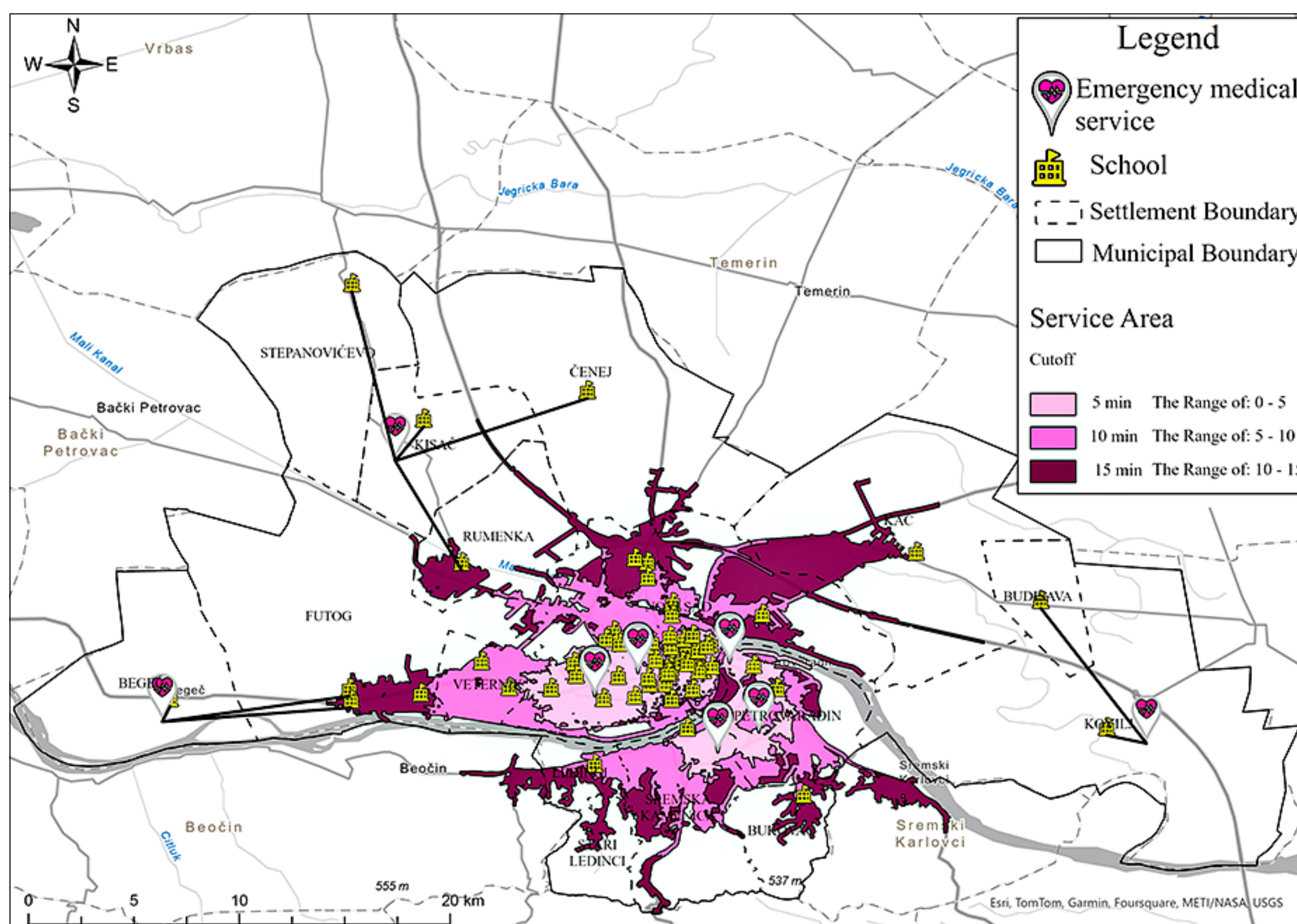


Figure 7. Location-allocation of emergency medical service

vice is established in the settlement of Begeč, it would territorially cover the school in Begeč and two schools in Futog. If a new emergency medical service is established in the settlement of Kisač, it could adequately respond to cases in the settlements of Kisač, Čenej, Rumenka, and Stepanovićevo. A potential emergency service in the settlement of Kovilj could adequately supply schools in the settlements of Budisava and Kovilj. A travel time of 5 to 10 minutes from the emergency service to the school has been considered. It is important to note that this time also includes the return time from the school to the emergency medical service in case of more urgent cases, hence considerations of 5 to 10 minutes of travel have been taken into account.

When analyzing healthcare, we often look at several key aspects, such as geographic accessibility, general accessibility, financial accessibility, and acceptability. Geographic accessibility assesses how physically available healthcare resources are to the local population, while general accessibility reflects the availability of resources and to what extent they are accessible to the local population. By considering all four aspects, we can obtain an index that evaluates the coverage of the healthcare network. When examining a specific area, it is often assumed that it is closed meaning that healthcare services from other towns or municipalities cannot provide services to it (Ray, Ebener, 2008).

Police

In the study of police coverage of the city and the application of appropriate network analysis methods, it is also important to examine the number of cases in specific neighbourhoods within the research area. Analysing the number and type of cases would further enrich the analysis (Curtin, et al., 2010).

In police planning, territories are often divided into several patrol districts with balanced coverage to combat crime and provide better police service. However, conventionally, the impact of the street network is often insufficiently considered in this districting problem (Huanfa et al., 2019).

In Figure 8, a relatively good spatial distribution of police stations is clearly evident, which could adequately respond to sociological demands within 10 to 15 minutes. In order to achieve better spatial coverage and reduce the travel time between settlements, specific locations for potential police stations are proposed in the following attached pictures.

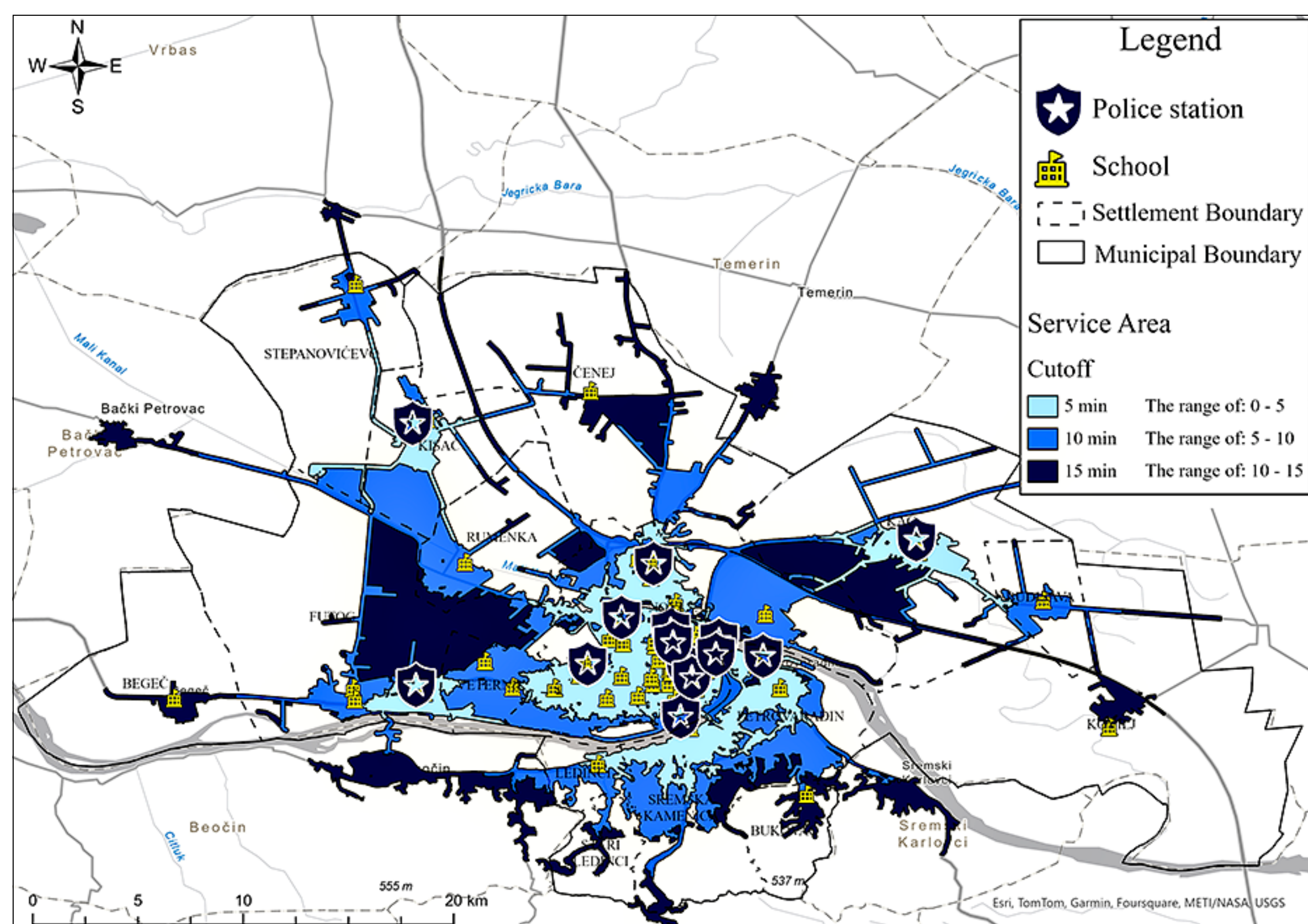


Figure 8. Service Area of the Police Station

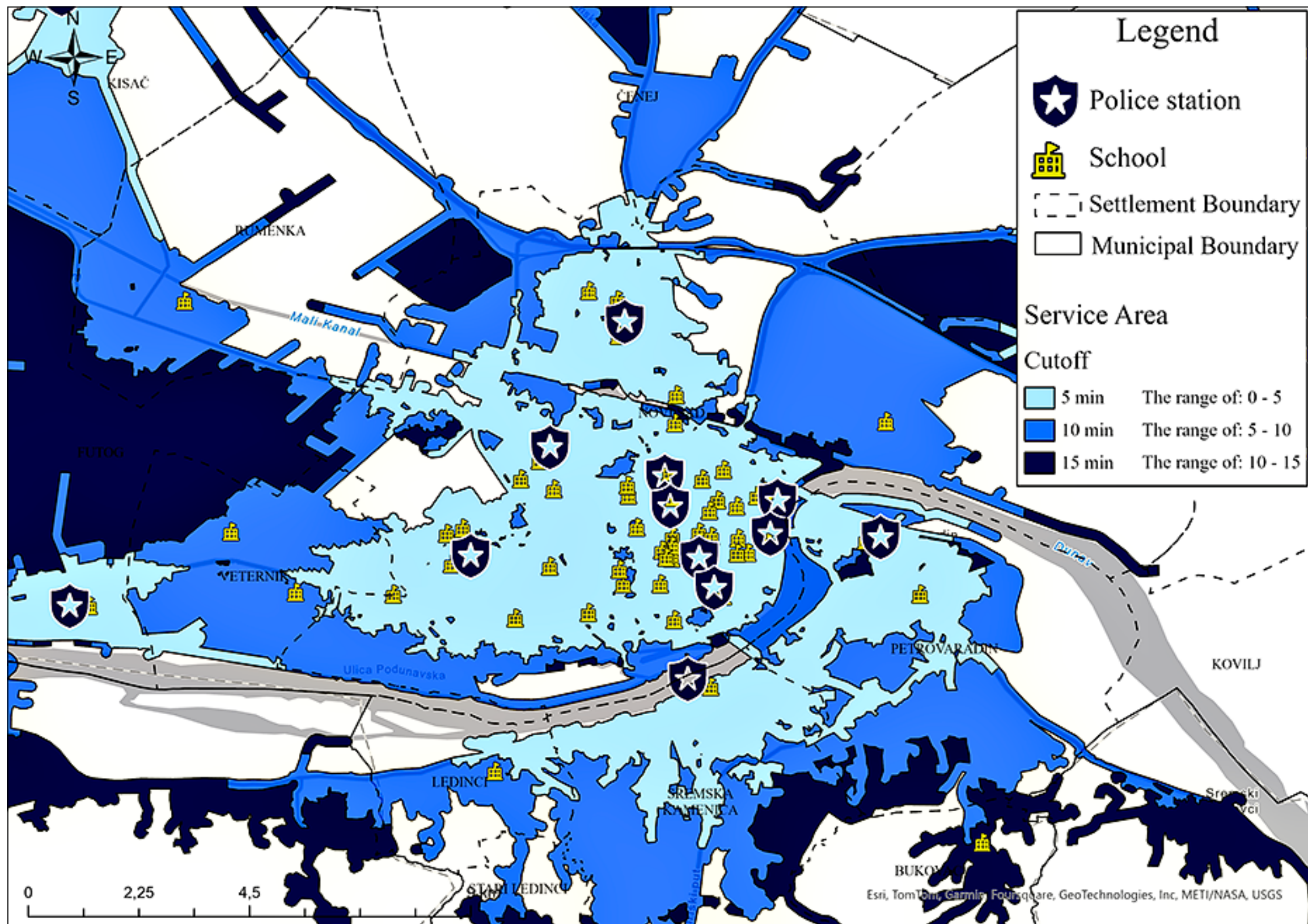


Figure 9. Enlarged Figure 8

The settlement of Novi Sad has a solid distribution of police facilities that even cover the surrounding settlements of the City of Novi Sad. A potential proposal for the construction of new facilities would be in the settlements of Veternik, Rumenka, and Bukovac.

In Figure 10, we notice new potential stations that would reach school locations within 5 to 10 minutes. Three new stations are proposed in the Kovilj settlement, covering schools in the Kovilj and Budisava settlements. The location of the second police station is proposed in the Begeč settlement, covering cases from schools in the Begeč and Futog settlements, including 2 schools. This would relieve the Futog police station of

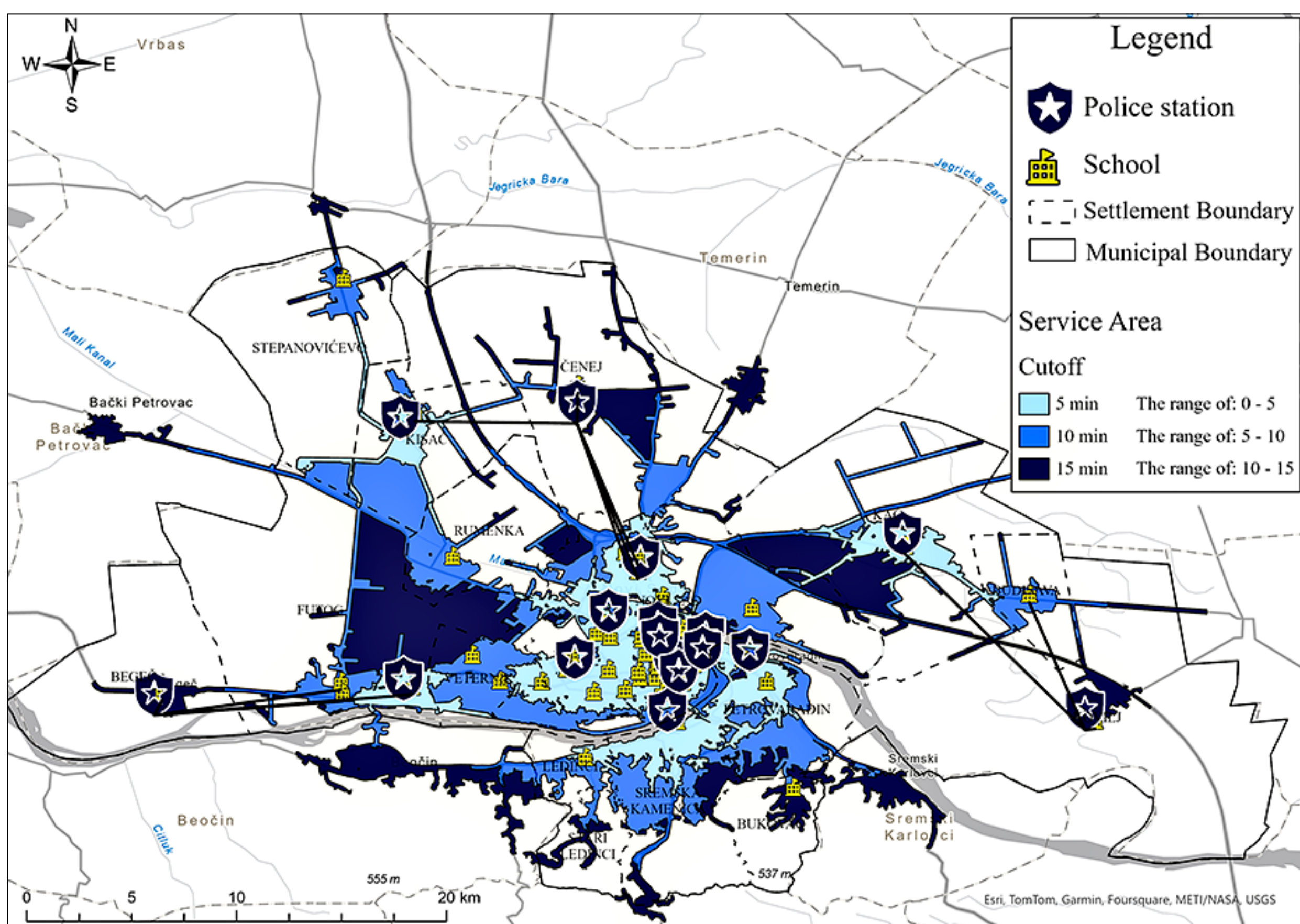


Figure 10. Location-allocation of the Police Station

cases for 3 settlements, as is the current situation where it covers cases in the Futog, Begeč, and Veternik settlements. The third police station would be planned in the Čenej settlement, with coverage extending to the Kisač settlement, significantly reducing the number of cases for the settlement in the city of Novi Sad – Klisa.

Fire service

Inadequate infrastructure for emergencies in the event of fires and the lack of defined service coverage remain key obstacles to timely response in case of fires. This study is applied research that used geospatial techniques and aimed to investigate the demand and supply relationship in emergencies related to fires in order to delineate service coverage and locate more facilities for optimal coverage in the municipality of Novi Sad (Sulaiman et al., 2023). In contrast to the case study conducted by Sulaiman, Y., Julius, A. F., Ibrahim, M. J. (2023), this case study focuses on protecting schools from potential fires. It aims to alleviate the burden on the Novi Sad Fire Department and to highlight the need for the inclusion of voluntary fire brigades in the public sector.

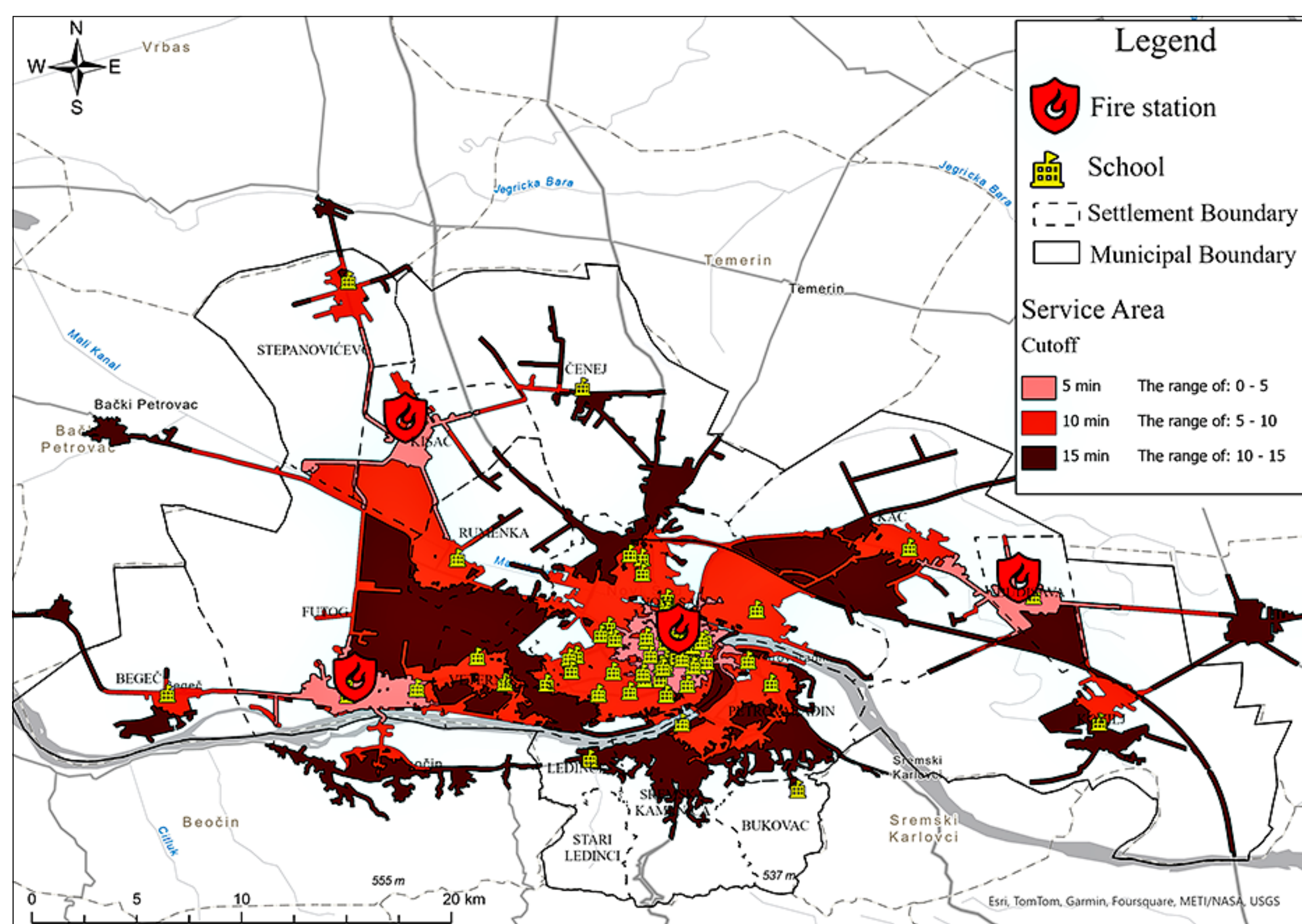


Figure 11. Service Area of Fire Sfire station

In Figure 11, the locations of the fire services of the City of Novi Sad are observed, and when analysing the Service Area, we notice a lack of time coverage for certain settlements. Fruška Gora, as a National Park and an area of great natural importance, should be adequately covered by fire services. Unfortunately, there has been a problem with the data on the locations of the voluntary fire services of the City of Novi Sad, so certain known locations have been entered. Further attachments will explain why new fire services should be built.

Upon reviewing Figure 12, it was observed that the entire settlement of Novi Sad has only one fire department. In this case, this service should supply all the schools in the settlement of Novi Sad, as well as the surrounding nearby settlements. During the analysis, a lack of coverage of at least 15 minutes for the school in the Bukovac settlement was noted. Using a random selection method, new potential locations for fire departments were identified by the analysts.

In Figure 13, newly selected locations of fire services are clearly visible, which would adequately cover a large number of schools on the Srem side of the city of Novi Sad, as well as relieve the fire service in the Novi Sad settlement.

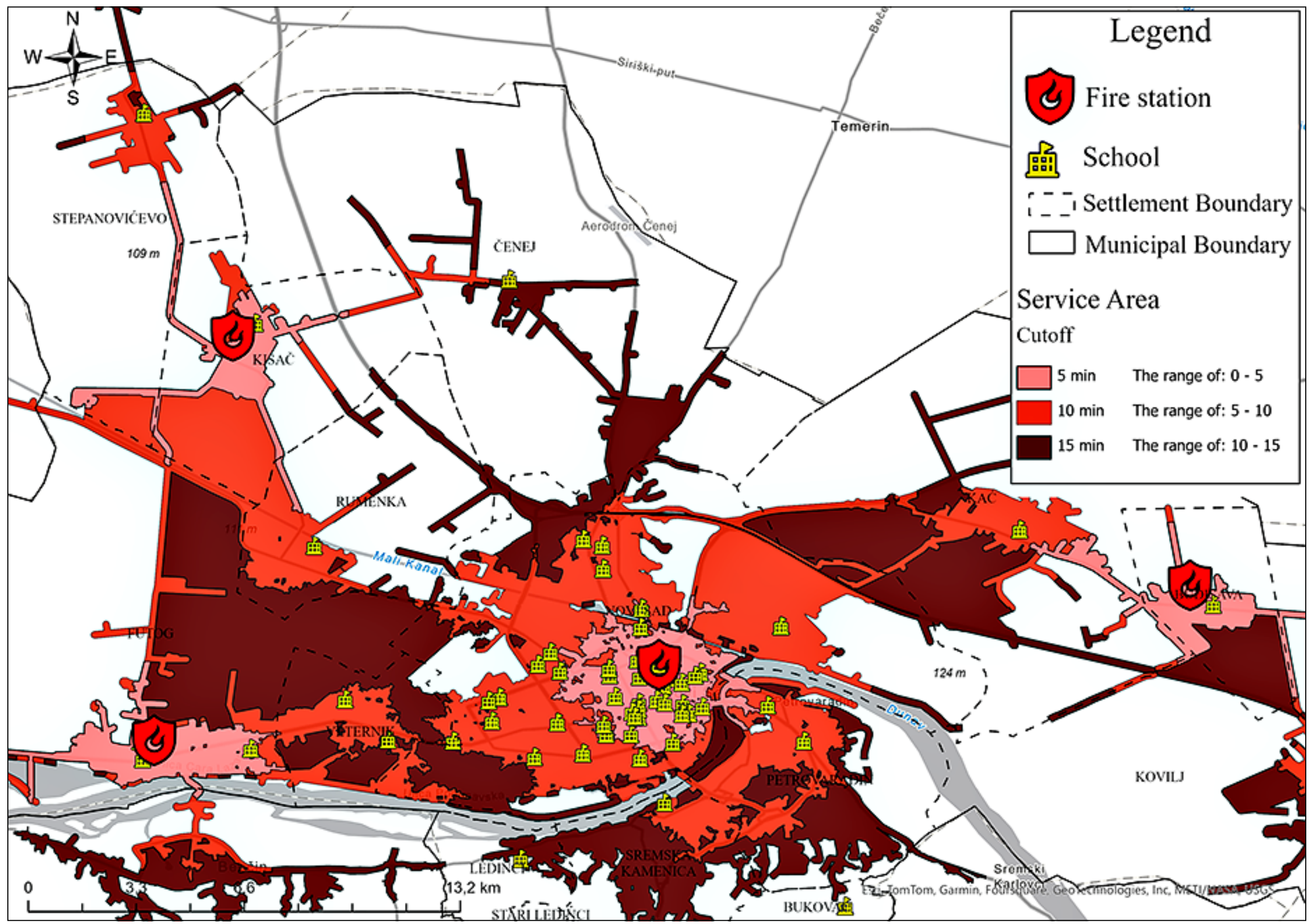


Figure 12. Enlarged Figure 11

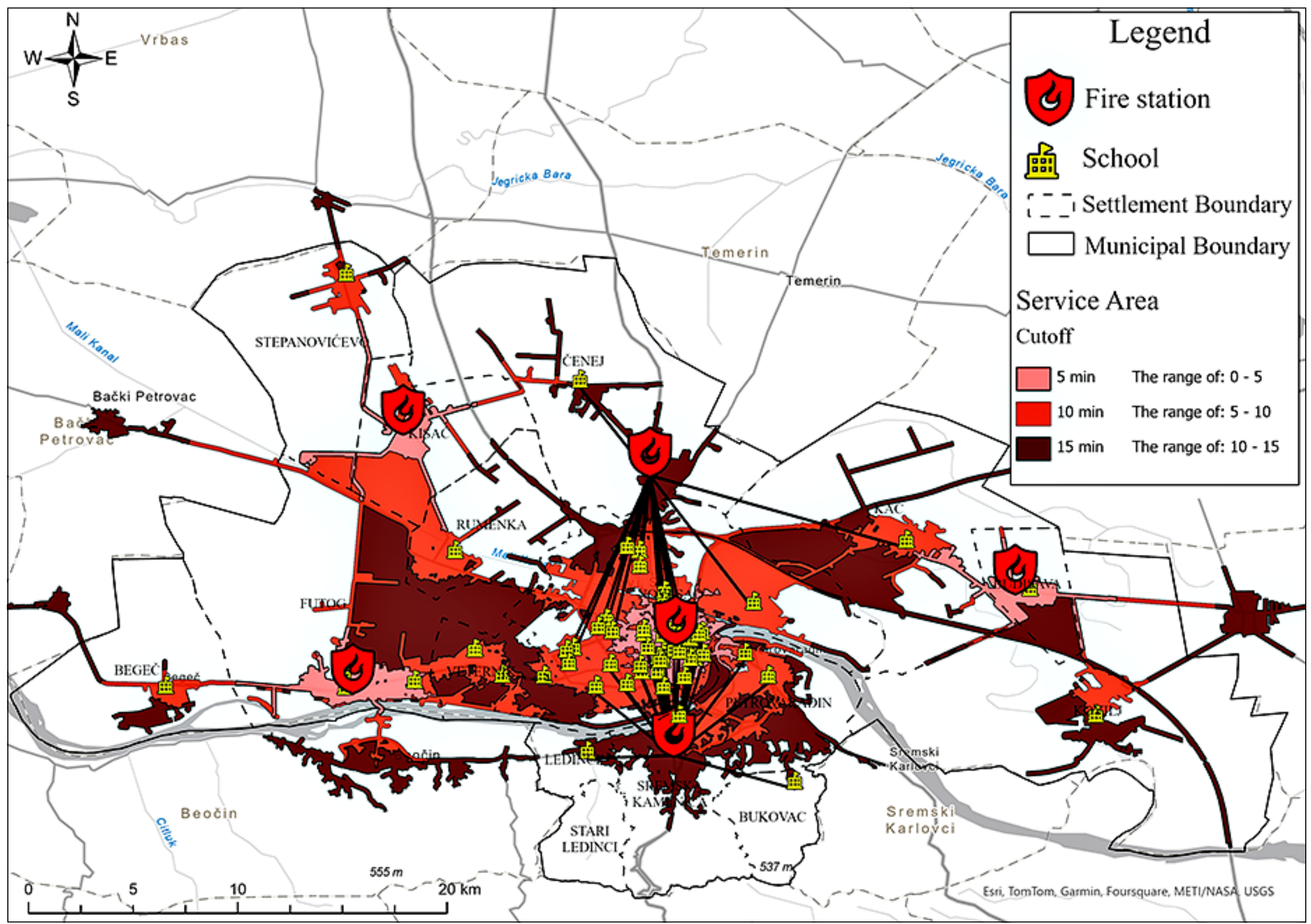


Figure 13. Location-allocation of the Fire Station

Table 4. Tabular representation of obtained results

ID	Education level	Name	Settlement	Emergency medical assistance (min)	Police (min)	Fire service (min)
1	Primary	Primary School "Jovan Popovic"	Novi Sad	5	5	10
2	Secondary	Secondary Mechanical School Novi Sad	Novi Sad	5	5	5
3	Secondary	Technical School "Mileva Marić"	Novi Sad	5	5	5
4	Primary	Primary School "Aleksa Šantić"	Stepanovićevo	20	10	10
5	Primary	Primary School "Sveti Sava"	Novi Sad	5	5	5
6	Secondary	Gymnasium "Isidora Sekulić"	Novi Sad	5	5	5
7	Secondary	"E-Gimnazija"	Novi Sad	5	5	5
8	Secondary	Gymnasium "Laza Kostić"	Novi Sad	5	5	10
9	Primary	Primary School "Jožef Atila"	Novi Sad	5	5	10
10	Primary	Primary School "Miroslav Antić"	Futog	15	5	10
11	Primary	Primary School "Sonja Marinković"	Novi Sad	5	5	10
12	Primary	Primary School "Žarko Zrenjanin"	Novi Sad	10	5	10
13	Primary	Primary School "Dositej Obradović"	Novi Sad	10	5	10
14	Primary	Primary School "Svetozar Marković Toza"	Novi Sad	5	5	10
15	Secondary	Secondary agricultural School with Students Dormitory	Futog	20	10	5
16	Secondary	Secondary catering School "Svetozar Miletić"	Novi Sad	5	5	5
17	Secondary	Gymnasium "Svetozar Marković"	Novi Sad	5	5	5
18	Primary	Primary School "Dr Milan Petrović"	Novi Sad	5	5	5
19	Primary	Primary School "Branko Radičević"	Novi Sad	5	5	5
20	Primary	Primary School "Đorđe Natošević"	Novi Sad	5	5	5
21	Primary	Music School "Josip Slavenski"	Novi Sad	5	5	5
22	Secondary	Ballet School	Novi Sad	5	5	5
23	Secondary	Secondary economic School "Svetozar Miletić"	Novi Sad	5	5	5
24	Secondary	Electrical engineering School "Mihajlo Pupin"	Novi Sad	5	5	5
25	Secondary	Secondary Medical School "7. April"	Novi Sad	5	5	10
26	Primary	Primary School "Vasa Stajić"	Novi Sad	5	5	5
27	Primary	Primary School "22. Avgust"	Bukovac	10	15	20
28	Secondary	Gymnasium "Jovan Jovanović Zmaj"	Novi Sad	5	5	5
29	Primary	Primary School "Jovan Dučić" (Malinova)	Petrovaradin	5	5	10
30	Primary	Primary School "Ivo Lola Ribar"	Novi Sad	5	5	5
31	Primary	Private School "Miroslav Mika Antić"	Novi Sad	10	5	5
32	Primary	Primary School "Marija Trandafil"	Veternik	10	10	15
33	Primary	Primary School "Dušan Radović"	Novi Sad	10	5	10
34	Primary	Primary School Ľudovíta Štúra	Kisač	20	5	5
35	Secondary	Secondary medical School "Dositej Obradović"	Veternik	5	5	10
36	Primary	Primary School "Mihajlo Pupin"	Veternik	10	10	10
37	Primary	Primary School "Veljko Vlahović"	Šangaj	10	10	10

ID	Education level	Name	Settlement	Emergency medical assistance (min)	Police (min)	Fire service (min)
38	Primary	Primary School "Dušan Radović"	Novi Sad	15	5	10
39	Primary	Primary School "Prva Vojvođanska Brigada"	Novi Sad	5	5	10
40	Secondary	Secondary School "Mileva Marić Ajnštajn"	Novi Sad	5	5	5
41	Primary	Primary School "Petefi Šandor"	Novi Sad	5	5	5
42	Primary	Primary School "Jovan Jovanović Zmaj"	Ledinci	15	10	20
43	Secondary	Secondary Art School "Bogdan Šuput"	Novi Sad	5	5	10
44	Primary	Primary School "Nikola Tesla"	Novi Sad	5	5	10
45	Primary	Primary School "Dušan Radović"	Novi Sad	15	5	10
46	Secondary	School with Primary and Secondary education "Milan Petrović"	Novi Sad	5	5	10
47	Primary	Primary School "Kosta Trifković"	Novi Sad	10	5	5
48	Primary	Primary School "Jovan Dučić"	Petrovaradin	5	5	10
49	Primary	Primary School "Miloš Crnjanski"	Novi Sad	5	5	10
50	Primary	Primary School "Ivan Gundulić"	Novi Sad	5	5	5
51	Primary	Primary School "Đura Daničić"	Novi Sad	5	5	5
52	Secondary	Secondary traffic School "Pinki"	Novi Sad	5	5	5
53	Secondary	Secondary technical School "Pavle Savić"	Novi Sad	10	5	5
54	Primary	Primary School "Desanka Maksimović"	Futog	15	10	5
55	Primary	Primary School "Ivo Andrić"	Budisava	20	10	5
56	Primary	Primary School "Laza Kostić"	Kovilj	20	20	15
57	Primary	Primary School "Jovan Jovanović Zmaj"	Sremska Kamenica	5	5	10
58	Primary	Primary School "Đura Jakšić"	Kač	20	5	10
59	Primary	Primary School "Veljko Petrović"	Begeč	20	15	10
60	Primary	Primary School "Sveti Sava"	Rumenka	15	10	10
61	Primary	Primary School "Ivan Gundulić"	Čenej	20	15	15

Source: ArcGISPro – Service Area Attribute table

The tabular display provides an answer to the question of which school requires a specific response time from public services. It clearly highlights the issue of the Fire Department's arrival time at the "22. Avgust" Primary School in Bukovac settlement, and the "Jovan Jovanović Zmaj" Primary School in Ledinci settlement, where the service arrival time ranges from 15 to 20 minutes. The issue of the police service arrival time is highlighted at the "Laza Kostić" Primary School in Kovilj settlement. The Emergency Medical Service has a greater distance from schools, as seen in the examples of the "Đura Jakšić" Primary School in Kač settlement, "Ivan Gundulić" Primary School in the Čenej settlement, "Ivo Andrić" Primary School in the Budisava settlement, "Laza Kostić" Primary School in Kovilj settlement, "Veljko Petrović" Primary School in Begeč settlement, "Aleksa Šantić" Primary School in Stepanovićevo settlement, the Secondary Agricultural School with a student dormitory in Futog settlement, as well as the Ludovít Štúr Primary School in Kisač settlement. It is important to note that some locations were not gathered during data collection, and this type of spatial analysis is subject to changes depending on the collected data (whether from the field or from specific services). Specifically, for the data on the fire stations of the City of Novi Sad, it can be said that the data is quite scarce and that certain locations of voluntary fire services are missing. Nevertheless, the analysis of the available data would not significantly differ from the analysis of the actual locations of fire and voluntary fire departments in the City of Novi Sad.

CONCLUSION

Observing the obtained spatial results, it was concluded that elementary schools in certain neighbourhoods of the City of Novi Sad do not have adequate time coverage of emergency public services. This is not the case with high schools because they are mostly located in the Novi Sad settlement area. The settlement of Novi Sad has an ideal spatial coverage and public services would always be able to respond to urgent requests in the shortest possible time. Unfortunately, we are witnessing an increasing number of cases where emergency response is a key factor in solving social problems. The key factor also refers to the response time, which depends on the traffic infrastructure and the connectivity of settlements within a municipality. An adequate solution for reducing the spatial problem would be the construction of new emergency public services in the settlements that need them. Most often, these are settlements in the suburbs of the City of Novi Sad. By using GIS tools for spatial analysis, we would remove a certain degree of risk related to the safety of children in primary and secondary schools. By using GIS in socio-geographical problems, we would achieve optimal territorial development of the City of Novi Sad, as well as greater social protection of children in primary and secondary schools. This type of methodology and spatial analysis can be applied in other spheres of public spatial planning. The problem of analysis in the future would only be the lack of spatial data, which is a solvable problem. This type of analysis could also be applied to market analysis. Because of such social problems, every public service (emergency medical, police, fire department) today requires professional staff to solve spatial problems. In addition to professional staff, adequate databases of an extended type are necessary. The main drawback of the study would be the need for adequately georeferenced data that would support and refine this type of geoinformatic analysis. Specifically, data on the location of certain public services were either unavailable or their full names were incorrectly entered. Due to such a situation regarding the data, the analysis required a good understanding of the researched area by the author/analyst. It is assumed that if there were no control over the input data, as well as their supplementation/reconstruction, the results of the analysis would be quite different, thus not providing a complete answer to the main questions of the study. Roughly speaking, the input data would be the main weakness of the study. The advantage of the study is observed in the fact that in the future (with much improvement of the input data), this type of study could contribute to various geospatial research as well as urban planning as a good example of the need for certain services in settlements and municipalities. The situation where the shortcomings and deficiencies of the study could be eliminated is that efforts should be made to achieve perfect accuracy of the input data where they would be assigned the correct name, and precise location (without duplication). The most ideal situation would be to have a geoportal of the Republic of Serbia that includes all the locations of public services of the Republic of Serbia. This geoportal would allow spatial analysts to download data in both the native and English languages for educational, research, civil, and political purposes, and manipulate the data for various research purposes. For future research to improve the analysis, it would be necessary to survey the population. The result of the survey would provide a supplementary analysis or one more of the variables that would be taken into account when making a decision. Some of the surveys to be conducted may require individuals to indicate their need for any of the services even outside of the school year. This could impact the working hours of employees in newly opened departments.

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