Identification of priority objects for the implementation of projects to restore the transport infrastructure of settlements in the post-war period

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Abstract
The paper presents an approach to determining the priority objects of transport infrastructure of individual settlements in the postwar period. It is the basis for initiating projects to restore the transport infrastructure of individual settlements in the postwar period. The proposed approach involves the use of the Overpass Turbo service with queries to the OpenStreetMap (OSM) database and the use of the Overpass QL query language. The main management operation is to quickly and accurately collect information about the transport infrastructure. For this purpose, it is proposed to obtain spatial data on transport infrastructure objects from the OpenStreetMap (OSM) open service with queries to the OpenStreetMap (OSM) database and using the Overpass QL query language. The results of using the Overpass Turbo service to display priority transport infrastructure facilities for restoration in the example of the city of Kramatorsk, Donetsk region, show that they can be used to identify projects for the restoration of transport infrastructure in the post-war period. In particular, the obtained data on transport infrastructure facilities form the basis for assessing the current state of the transport infrastructure of a given city. This will make it possible, with a limited budget, to understand which facilities require priority restoration and which can be restored at the following stages of financing transport infrastructure development projects.

Keywords
Approach, initiation, projects, restoration, transport infrastructure, settlements, post-war situation.

1. Introduction

Identification of priority objects is one of the tasks of project managers when implementing projects to restore the transport infrastructure of settlements in the post-war period. Russia's military aggression in Ukraine has caused significant damage to the transport

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infrastructure of settlements in the combat zone [1-3]. Many bridges, roads, railroad tracks, and other infrastructure facilities have been destroyed or damaged. This complicates the movement of people and goods, as well as the economic recovery of individual regions and the country. After the war ends, it will be important to rebuild the transportation infrastructure as quickly as possible. However, resources will be scarce, so it will be important to prioritize objects for reconstruction projects. Thus, there is a need to implement projects to restore the transport infrastructure of settlements in the postwar period. An important stage is the initiation of these projects, which requires the identification of priority objects of the transport infrastructure of settlements for restoration in the postwar period [4-6].

Thus, the restoration of transport infrastructure is an important task for Ukraine. Identification of priority transport infrastructure facilities when initiating their restoration projects will allow for the most efficient use of limited resources [36-38]. There is a need to substantiate the approach to determining the priority objects that underlie the initiation of projects to restore the transport infrastructure of individual settlements in the postwar period.

2. Analysis of the state of the art and research objectives

The post-war reconstruction of the destroyed transport infrastructure of settlements requires the identification of priority objects, which is the basis for the implementation of relevant projects in the post-war period. It is known that the development of urban infrastructure, including transport infrastructure, in the postwar period was crucial for the restoration of economic and social well-being [7-10]. Collecting data on the characteristics of the project environment, such as the state of the existing transport infrastructure, is a critical process for the successful initiation of transport infrastructure development projects [11-15].

The authors of many scientific papers confirm the impact of the specifics of data collection on the effectiveness of project implementation in various fields [16-19]. At the same time, some scientists are working on the development of project management methods and tools that involve the development of models for managing individual processes [20-22, 24]. However, it is not possible to use them to the fullest extent to determine the priority objects that underlie the initiation of projects to restore the transport infrastructure of individual settlements in the postwar period. In particular, they do not take into account the peculiarities of generating real data and using it to initiate projects to develop the transport infrastructure of settlements in the combat zone.

We have analyzed the available research papers related to data collection tools for project implementation and their use in various application areas. Some studies suggest using the SMART model [23]. The SCAT model used in [25] is based on an assessment system that collects data on the state of existing infrastructure, and it deserves special attention. Geographic Information Systems (GIS) [26] are used to visualize and analyze spatial data that can be used for planning transportation projects. However, they are of limited use for initiating projects to restore the transport infrastructure of individual settlements in the postwar period. Thus, existing research papers propose various models for collecting information about the project environment for the implementation of transport infrastructure development projects [27-35]. However, this process of identifying priority objects during the initiation of projects to restore the transport infrastructure of individual settlements in the postwar period requires the use of an approach involving modern information technologies and the development of appropriate models [39-43].

In our study, we propose to use the OpenStreetMap (OSM) framework and the open-source Overpass API server software. To do this, we wrote the program code in Python using the Jupyter Notebook interactive development environment. The main source of information was the Overpass Turbo service, which provides access to the OpenStreetMap (OSM) database. The Overpass QL query language was used to search and analyze the geodata needed to determine the state and needs of the transport infrastructure.

3. Objectives of the study

The purpose of our research was to substantiate the approach to identifying priority objects that underlie the initiation of projects to restore the transport infrastructure of individual settlements after the war based on the use of the Overpass Turbo service with queries to the OpenStreetMap (OSM) database and the use of the Overpass QL query language. The study collected information on the transport infrastructure of Kramatorsk, Donetsk region (Ukraine), whose transport infrastructure was damaged due to Russia's military aggression. To do this, we used the OpenStreetMap (OSM) framework and the open-source Overpass API server software. To do this, we wrote the program code in Python using the Jupyter Notebook interactive development environment.

To achieve the goal, the following tasks were solved

– to substantiate the approach to determining the priority objects that underlie the initiation of projects for the restoration of the transport infrastructure of individual settlements in the post-war period;

– using the developed approach, to determine the priority objects for initiating projects to restore the transport infrastructure of a given settlement in the post-war period.

4. Approach to identifying priority objects that underlie the initiation of projects to restore the transport infrastructure of individual settlements in the postwar period

Identification of priority transport infrastructure facilities for the implementation of projects to restore certain settlements after the war is one of the main tasks of project managers. In particular, it is proposed to use the OpenStreetMap (OSM) framework to perform this management operation. This framework provides for the creation and editing of geospatial data with k types of transport infrastructure objects O_{ki} in a given locality. OSM provides access to detailed information about transport infrastructure objects O_{ki} of k types in a given locality (roads, bridges, railways, bicycle routes, etc.).

The proposed approach for identifying such objects, based on the use of modern information technologies, is presented in the diagram shown in Fig. 1 To collect information about the transportation infrastructure of a locality, the open-source Overpass API server software is used. The Overpass API is a powerful tool for extracting data from the OSM database at the request of users. This tool is optimized for tasks of any complexity. In particular, it can retrieve data from the database about several transport infrastructure objects O_{ki} of k-th types in a given locality, as well as retrieve data about hundreds of millions of such objects. They are selected by the user's request in the form of XML or Overpass QL (a modernized version of Overpass XML).

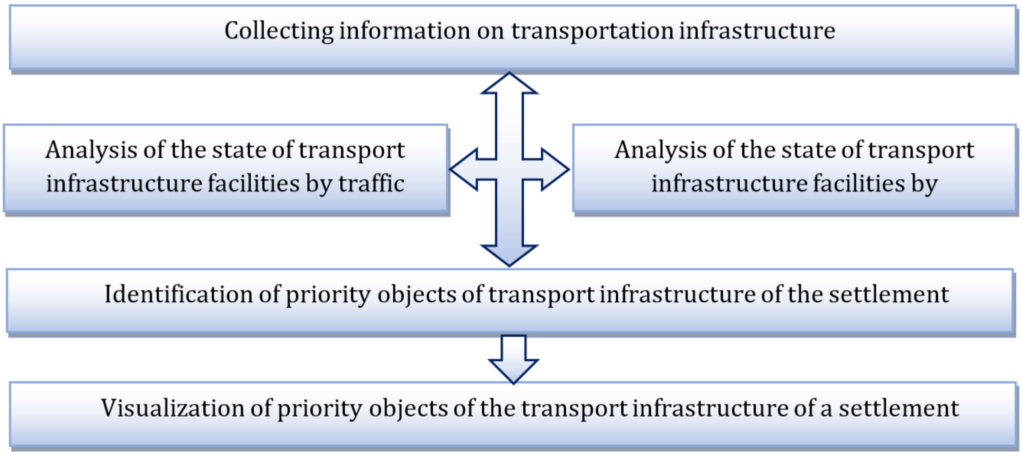

Figure 1: Scheme of the approach to determining the priority objects of transport infrastructure of a given settlement for restoration in the post-war period

First of all, a request to the Overpass API is executed, which makes it possible to obtain geographic data on transport infrastructure objects O_{ki} of k-th types in a given settlement. The query provides data on roads, bridges, complex interchanges, etc.

To determine the priority objects of the transport infrastructure of the settlement by traffic, the analysis of the road condition is performed (R_c):

$$R_c = f\left(T_r, T_c, S_c\right), \quad (1)$$

where R_c – condition of roads in the settlement; T_r – types of roads in the settlement; T_c – type of road surface in the settlement; S_c – condition of the road surface in the settlement.

The type of roads T_r in a settlement has the following categories: 1) main roads; 2) primary roads; 3) secondary roads; 4) urban (rural) roads; 5) streets; 6) bicycle paths; and 7) unclassified roads. The analysis of road type makes it possible to identify strategically important roads. These include trunk and main roads. Trunk roads are designed for high-speed traffic. They have divided traffic, separate exits, bridges, and tunnels. They also have a high capacity and pass outside settlements. Consequently, such important transport infrastructure facilities as highways are not available in some settlements. They are subsequently not taken into account when initiating projects for the development of the transport infrastructure of settlements.

The main focus of the prioritization of transport infrastructure in individual settlements is on primary and secondary roads. Such roads are important in the transportation network of a given settlement. They are smaller than main roads but can have a lot of traffic. This is because they connect important industrial facilities and administrative areas.

After that, the most congested roads are identified (R_{mc}), those with the highest traffic, taking into account the type of road and the number of pedestrian crossings:

$$R_{mc} = f\left(T_h \Leftrightarrow T_r\right), \quad (2)$$

where R_{mc} – the most congested roads in the settlement; T_h – indicators of traffic flows on the roads of the settlement; T_r – types of roads in the settlement.

In post-war settlements, it is impossible to determine the real quantitative value of traffic flows T_h on individual roads using known methods and approaches. This is because fully or partially damaged roads do not allow for freight and passenger transportation. Therefore, we propose to determine the indicator of traffic flows T_h on individual roads by road type.

To determine the indicator of traffic flows on individual roads of a settlement, it is proposed to use the Overpass API. In this case, executing a query through the Overpass API provides access to OpenStreetMap geographic data. In particular, executing a GET request to the Overpass API server makes it possible to obtain geographic data on the transport infrastructure of a given settlement. In OpenStreetMap, the "highway" tag indicates the type of road or highway. We used this tag to assess the condition of roads (R_c) according to the indicators presented in expression (1). This makes it possible to determine the types of roads, the type of pavement, and the condition of the road surface.

Provided that a particular road (street) in a settlement is characterized by primary or secondary road types, the traffic flow indicator T_h is increased by one for the corresponding street. This makes it possible to record the number of traffic flows on each of the streets of primary or secondary roads. Therefore, to determine the traffic flow indicator T_h, it is necessary to sum the number of primary N_{rpj} and secondary N_{rsj} roads that pass through the j-th street of the settlement:

$$T_{hi} = N_{rpj} + N_{rsj}, \quad (3)$$

where T_{hi} – indicator of traffic flows on the *i*-th street of the settlement; N_{rpj} – number of primary roads passing through the j-th street of the settlement ту; N_{rsj} – number of secondary roads passing through the j-th street of the settlement.

Based on the quantitative value of the traffic flow indicator T_{hi} on the *i*-th street of the settlement, its priority for repair or modernization is established. The higher the value of the traffic flow indicator T_{hi} on the *i*-th street, the higher the priority for repair or modernization.

The analysis of the state of transport infrastructure facilities by complexity involves determining the complexity indicator (I_{ci}):

$$I_{ci} = f\left(T_c, S_c, N_b, N_{ti}, N_{pc}\right), \quad (4)$$

where T_c – is the type of road surface in the settlement; S_c – is the condition of the road surface in the settlement; N_b – is the number of bridges on the settlement's roads; N_{ti} – is the number of complex traffic junctions on the settlement's roads; N_{pc} – is the number of pedestrian crossings on the settlement's roads.

Determining the priority objects of the transport infrastructure of a given settlement requires a preliminary determination of such indicators as: 1) the total number of streets in the settlement (N); 2) the number of traffic flows (N_{T_i}) on the *i*-th street; 3) the type of pavement (S_i) on the *i*-th street; 4) the number of bridges N_{bi} on the *i*-th street; 3) the number of complex traffic junctions N_{ti} on the *i*-th street; 4) the number of pedestrian crossings N_{pci} on the *i*-th street.

Using these indicators, you can calculate the priority indicator (P_{str}) of the i-th street in a given settlement:

$$P_{str} = \alpha \cdot N_{T_i} + \beta \cdot N_{S_i} + \gamma \cdot N_{bi} + \delta \cdot N_{ti} + \varepsilon \cdot N_{pci}, \qquad (5)$$

where $\alpha, \beta, \gamma, \delta, \varepsilon$ – respectively, the coefficients of traffic flows, street pavement type, bridges, complex traffic junctions and pedestrian crossings, which determine the importance of each of the priority criteria for the *i*-th street in a given settlement; N_{T_i} – normalized number of traffic flows on the *i*-th street; N_{S_i} – normalized pavement type on the *i*-th street; N_{bi} – normalized number of bridges on the *i*-th street; N_{ti} – normalized number of complex traffic junctions on the *i*-th street; N_{pci} – normalized number of pedestrian crossings on the *i*-th street.

To normalize the indicators presented $N_{нор}$ in formula (5), we use the minimum-maximum method. It ensures that the values of the relevant indicators range from 0 to 1. The following formula is used for this purpose:

$$N_{нор} = \frac{N_i - N_{\min}}{N_{\max} - N_{\min}}, \qquad (6)$$

where $N_{нор}$ – normalized indicator; N_i – current value of the indicator; $N_{\min}, N_{\max}$ – minimum and maximum values of the indicator.

The presented expression (5) makes it possible to take into account the main criteria for evaluating streets when determining their priority. This expression is adapted to the conditions of the given transport infrastructure of the settlement. After determining the priority indicators (P_{str}) for each *i*-th street in a given settlement, they are ranked in descending order:

$$P_{str1} \geq P_{str2} \geq \ldots \geq P_{strn}, \qquad (7)$$

where $1, 2, \ldots, n$ – respectively, the index of the first, second, and fifth streets of a given settlement in the ordered list; $P_{str1}, P_{str2}, \ldots, P_{strn}$ – respectively, the value of the priority indicator for the first, second, and fifth streets of a given settlement in the ordered list.

The last step in identifying priority transport infrastructure objects is to visualize priority streets and represent objects in a given settlement on them. In this process, graphs of changes in the priority indicators of transport infrastructure objects are built and the indicated objects are displayed on the map of the settlement.

5. The results of identifying priority objects for initiating projects to restore the transport infrastructure of a given settlement in the postwar period

To justify the priority transport infrastructure facilities that need to be restored or developed, we used the proposed approach. We selected one of the settlements located near the combat zone and having damaged transport infrastructure facilities. The city of Kramatorsk, Donetsk region, was chosen as such a settlement. To collect information about the transport infrastructure of Kramatorsk, we used the OpenStreetMap (OSM) framework and the open-source Overpass API server software. Their use led to the writing of Python code using the Jupyter Notebook interactive development environment.

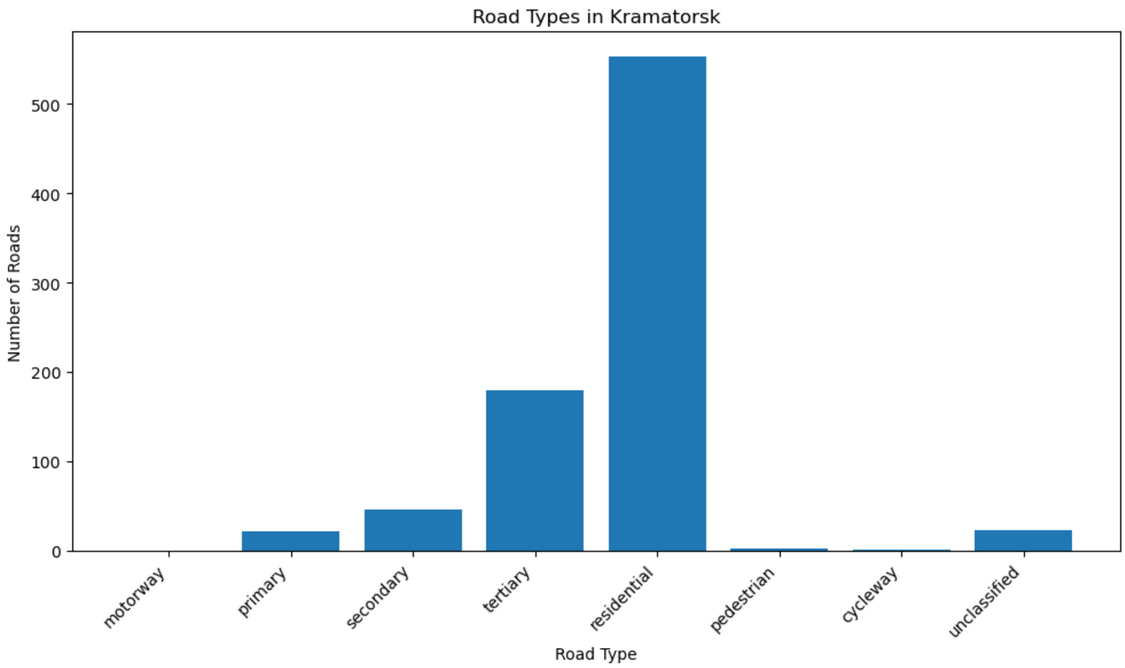

Figure 2: Diagram of road types in Kramatorsk, Donetsk region.

Based on the written code, we requested the Overpass API, which made it possible to obtain geographic data on transport infrastructure objects of k types in Kramatorsk. In particular, we obtained data on existing roads, bridges, complex interchanges, pedestrian crossings, etc. This made it possible to build diagrams of road types (Fig. 2) in the city of Kramatorsk, Donetsk region.

The data obtained made it possible to identify that there are 826 roads in Kramatorsk, Donetsk region. The analysis of roads by their types indicates that the largest share of them falls on city streets, which is 553 units or 66.95% of the total number of roads in the city. Urban roads make up 179 units or 21.66%, primary roads - 21 units or 2.54%, and secondary roads - 46 units or 5.57%. There are unclassified roads, which amount to 23 units or 2.78% of the total in a given settlement. In addition, there are no such types of roads as main roads, pedestrian roads, and bicycle paths in Kramatorsk.

Based on the use of formula (3), the quantitative value of traffic flow indicators T_h for individual streets in Kramatorsk was determined. This made it possible to build a diagram of priority streets for repair or modernization according to the indicator of traffic flows T_h in the city of Kramatorsk, Donetsk region (Fig. 3).

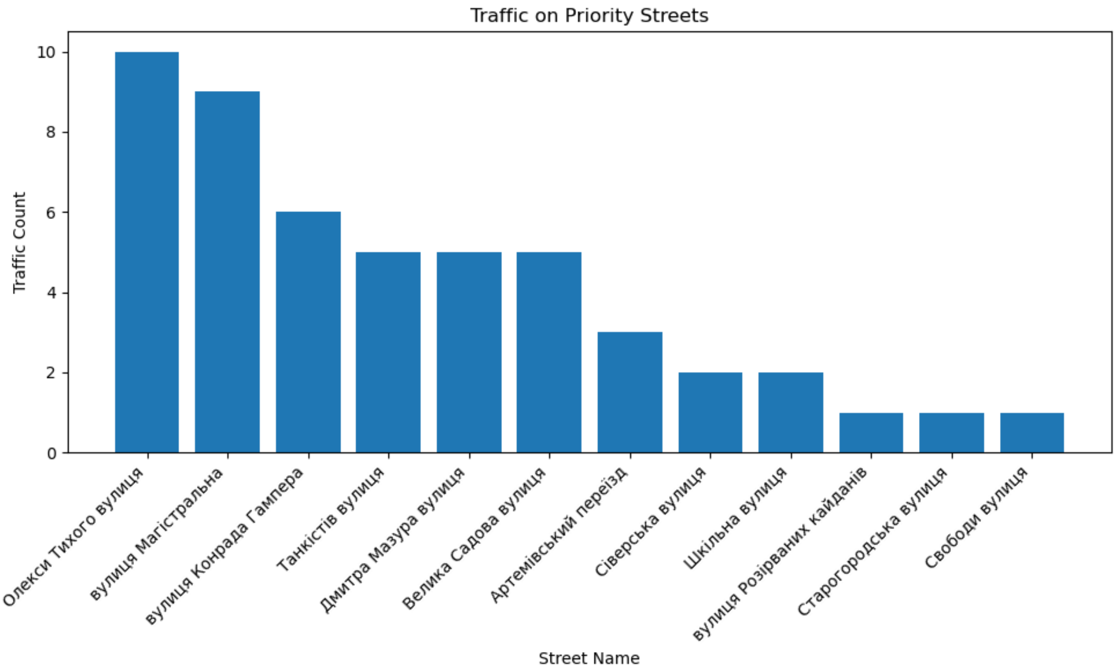

Figure 3: Diagram of priority streets for repair or modernization according to traffic flow T_h in the city of Kramatorsk, Donetsk region.

Based on the analysis of the results presented in Fig. 3 to determine the priority streets for repair or modernization in Kramatorsk, Donetsk region, the following is established. Rozryvanykh Kaidaniv, Starohorodska, and Svobody streets have the lowest traffic flows ($T_{hi} = 1$), which indicates a low intensity of vehicle traffic. At the same time, Rozryvanykh Kaidaniv and Starohorodska streets have the highest number of pedestrian crossings ($N_{pc} = 28$ units and $N_{pc} = 35$ units, respectively). This requires additional costs in the budget of their modernization projects to ensure pedestrian safety. At the same time, these streets require priority repair or modernization of the road surface and infrastructure to ensure pedestrian safety.

The Overpass Turbo service was used to display the priority roads for restoration (Fig. 4) in the city of Kramatorsk, Donetsk Oblast. It is a web-based interface that enables queries to the OpenStreetMap (OSM) database using the Overpass QL query language. Using this tool, project managers can create complex queries to obtain geographic data on priority transport infrastructure objects from OSM and visualize them on maps directly in a web browser.

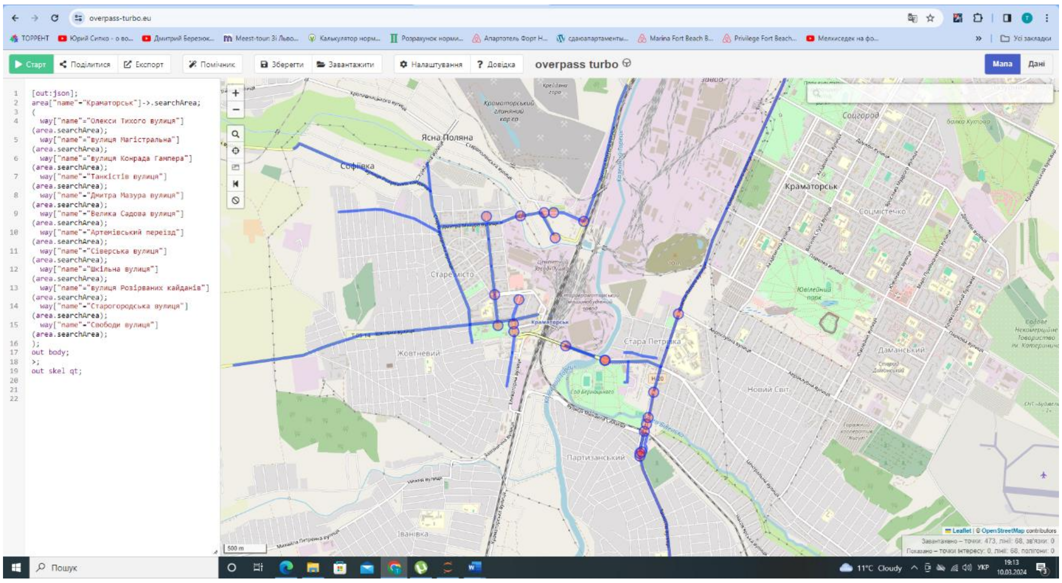

Figure 4: The results of using the Overpass Turbo service to display the priority roads for restoration in Kramatorsk, Donetsk region.

Based on the results obtained, we can see that the use of Overpass Turbo provides an interactive workspace with priority transport infrastructure facilities for restoration. In this case, project managers can edit and run new queries, view the results with the priority transport infrastructure facilities for restoration in the form of a map layer, and export the data obtained in various formats.

The results of using the Overpass Turbo service to display priority transport infrastructure facilities for restoration on the example of the city of Kramatorsk, Donetsk region, indicate that they can be used to manage projects to restore transport infrastructure after the war. In particular, the obtained data on transport infrastructure facilities form the basis for assessing the current state of the transport infrastructure of a given city. This will make it possible, with a limited budget, to understand which facilities require priority restoration and which can be restored in the next stages of financing transport infrastructure development projects.

6. Conclusions

1. An approach to identifying priority objects underlying the initiation of projects to restore the transport infrastructure of individual settlements in the post-war period is proposed. It is based on the use of the Overpass Turbo service with queries to the OpenStreetMap (OSM) database and the application of the Overpass QL query language. In this case, the main management operation is the fast and accurate collection of information about the transport infrastructure. For this purpose, it is proposed to obtain spatial data on transport infrastructure objects from the OpenStreetMap (OSM) service with queries to the OpenStreetMap (OSM) database and using the Overpass QL query language. They provide

fast and accurate detection and visualization of priority objects, which is the basis for initiating projects to restore the transport infrastructure of individual settlements in the post-war period.

2. Based on the proposed approach to identifying priority objects that underlie the initiation of transport infrastructure restoration projects, we collected data on the state of the transport infrastructure of Kramatorsk, Donetsk region (Ukraine), whose transport infrastructure was damaged due to Russian military aggression. To do this, we used the OpenStreetMap (OSM) framework and the open-source Overpass API server software. For this purpose, we wrote the program code in Python using the interactive development environment Jupyter Notebook. It has been established that Rozirvanykh Kaidaniv, Starohorodska, and Svobody streets have the lowest traffic flow rate ($T_{hi} = 1$), which indicates a low intensity of vehicle traffic. At the same time, Rozryvanykh Kaidaniv and Starohorodska streets have the highest number of pedestrian crossings ($N_{pc} = 28$ units and $N_{pc} = 35$ units, respectively). This requires additional costs in the budget of their modernization projects to ensure pedestrian safety. At the same time, these streets require priority repair or modernization of the road surface and infrastructure to ensure pedestrian safety.

3. The results of using the Overpass Turbo service to display priority transport infrastructure facilities for restoration on the example of the city of Kramatorsk, Donetsk region, indicate the possibility of its use for managing projects to restore transport infrastructure after the war. In particular, the obtained data on transport infrastructure facilities form the basis for assessing the current state of the transport infrastructure of a given city. This will make it possible, with a limited budget, to understand which facilities require priority restoration and which can be restored in the next stages of financing transport infrastructure development projects.

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