

Article

Mapping Localization Preferences for Residential Buildings

Jacek Jabłoński , Łukasz Wielebski  and Beata Medyńska-Gulij * 

Department of Cartography and Geomatics, Adam Mickiewicz University, 61-712 Poznań, Poland;
jacob@st.amu.edu.pl (J.J.); lukwiel@amu.edu.pl (Ł.W.)

* Correspondence: bmg@amu.edu.pl

Abstract: In this study, we tried to gauge the trends of localization preferences for residential buildings among young adults. The pragmatic dimension of these studies is important in the process of real estate investment, where a location can be expressed using indicators and statistical data and then, using maps, indicate preferred areas for living in a small town. The aim of our research was to examine and visualize the preferences of young people for living locations in relation to access to services. We conducted an online survey using a Likert scale to determine which services and amenities are most important for young residents. Using multi-criteria evaluation (MCE) methods and their formulas, we calculated the attractiveness coefficient of the location of residential buildings, which we propose to call the RBLAF (Residential Building's Localization Attractiveness Factor). The results of this research are maps: qualitative–quantitative with point symbols for the structure of services and quantitative isochromatics showing the preferences of potential future investors in real estate.

Keywords: multi-criteria evaluation; residential building localization attractiveness factor; cartographic representation; symbol map; isochrome map; building's localization attractiveness; online survey



Citation: Jabłoński, J.; Wielebski, Ł.; Medyńska-Gulij, B. Mapping Localization Preferences for Residential Buildings. *ISPRS Int. J. Geo-Inf.* **2024**, *13*, 329. <https://doi.org/10.3390/ijgi13090329>

Academic Editors: Florian Hruby and Wolfgang Kainz

Received: 22 June 2024

Revised: 4 September 2024

Accepted: 13 September 2024

Published: 15 September 2024



Copyright: © 2024 by the authors. Published by MDPI on behalf of the International Society for Photogrammetry and Remote Sensing. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Real estate investors are part of a very dynamic area of business [1,2]. Thriving in this sector requires either much foresight or experience. Therefore, investors help themselves with statistical aids to minimize the risk of bad investments. They use financial calculators, such as Return of Investment calculators and comparative market analysis that shows data on historic sale rates and average prices of real estate in any chosen area [3,4]. In this study, we focus on factors related to the town's topography and, more specifically, the location of services in the subject town, which may also be important when choosing a suitable apartment [5].

An important part of the attractiveness of a property's location is its immediate surroundings [6,7]. The availability of specific types of services and amenities in the immediate vicinity of a property may influence the investor's final decision to purchase it [8]. Therefore, this ambient environment that a property and its surroundings create can be crucial in determining its potential value [9]. However, due to the subjective nature of the requirements and preferences of each possible investor, it is difficult to reduce this type of attractiveness to one factor and visualize it graphically [10].

One of the most suitable methods for studying subjective preferences is anonymous surveys. Surveys allow potential respondents to transform their subjective views into categorized, organized results [11]. Online surveys are also a frequently used method in cartography. The selection of a representative sample of respondents is crucial for the credibility of survey results [12]. In this case, it was important to select a possibly homogeneous group of people of similar age and at a similar stage of life. As people age, their expectations related to the availability of certain types of services and amenities near their place of residence may change [13]. An evaluation of online surveys in cartography

concerns not only the choice of mapping technique but also the graphical representation of statistical data [14].

For the representation of each geographical phenomenon, an adequate mapping method is selected so that the reader can easily draw unambiguous conclusions [15]. In the case of city service maps, the typical qualitative method of point symbols can be used, as well as grouping these symbols according to the geometric shape of the sign [16] or several colors to distinguish the type of service [17]. With the point symbol method, a problem occurs when the topographical arrangement of the symbols causes them to overlap.

Isochromatic maps are used to represent a continuous phenomenon in a space related to numerical values or calculated coefficients [18]. Isochromatic maps are created based on source point data with specific, measured numerical values and points, with intermediate values found on their basis in the interpolation process. They show isolines connecting points with the same values, allowing for the obtaining of a continuous spatial distribution of the intensity of a quantitative phenomenon. Isochromes, i.e., colored spaces between isolines, to which a gradually changing color scale is assigned that intuitively indicates the intensity of the phenomenon, can be helpful in the interpretation of this type of map [19].

A separate problem related to cartographic visualization is the dilemma of creating a map with one mapping method or with two or more. Using two or more mapping methods shows the phenomenon more comprehensively, but it also increases the level of difficulty of interpretation. In the case of a large accumulation of information, it may also negatively affect the information transmission efficiency [20].

Therefore, in this study we touch upon the problem of creating separate maps for a complex phenomenon, i.e., a map of point symbols on the topographic content of the town and simple isochromatic maps with minimalistic background content.

In the preparation of data for visualization, geoinformation operations play a key role, which in this case involves the multi-criteria evaluation (MCE) process that enhances the GIS system visualization potential [21]. The basis for our further calculations was a set of methods related to this process that allowed us to compare possible residential building localizations throughout the town and judge their attractiveness.

2. Aim and Questions

The main objective of this study was the examination and cartographic visualization of the preferences of young people for living locations in relation to services, using an attractiveness factor and data from an online survey.

The objective of this research raised the following questions:

- How to standardize subjective data from an online survey to combine this data with spatial information;
- How to calculate the attractiveness index for each residential building in the city under study;
- How to visualize the structure and layout of services and amenities throughout the city using the point symbol method;
- How to design an isochromatic map for the attractiveness index.

3. Methodology

To meet the objective of this research and answer the questions above, five main stages of study work were adopted:

- Picking the subject town for further analysis (Section 3.1.);
- Finding the mathematical basis for further visualization work (Section 3.2.);
- Preparing and conducting an online survey (Section 3.3.);
- Making calculations connected with computing the standardized survey data and measurement of Residential Building's Localization Attractiveness Factor (RBLAF) (Section 3.4.);
- Visualization of resulting data (Section 3.5).

3.1. Picking the Subject City for Further Analysis

For the purposes of this research, we had to select a subject city for this analysis. It had to have a diverse network of services and amenities. We chose a small town named Lwówek, which has close to 120 services and amenities present within its borders and also spans only roughly 3 km² of area. The location of Lwówek within Poland, the spatial arrangement of the city on the orthophotomap, and a photograph of the city center (market square with clock tower) are visible in Figure 1.

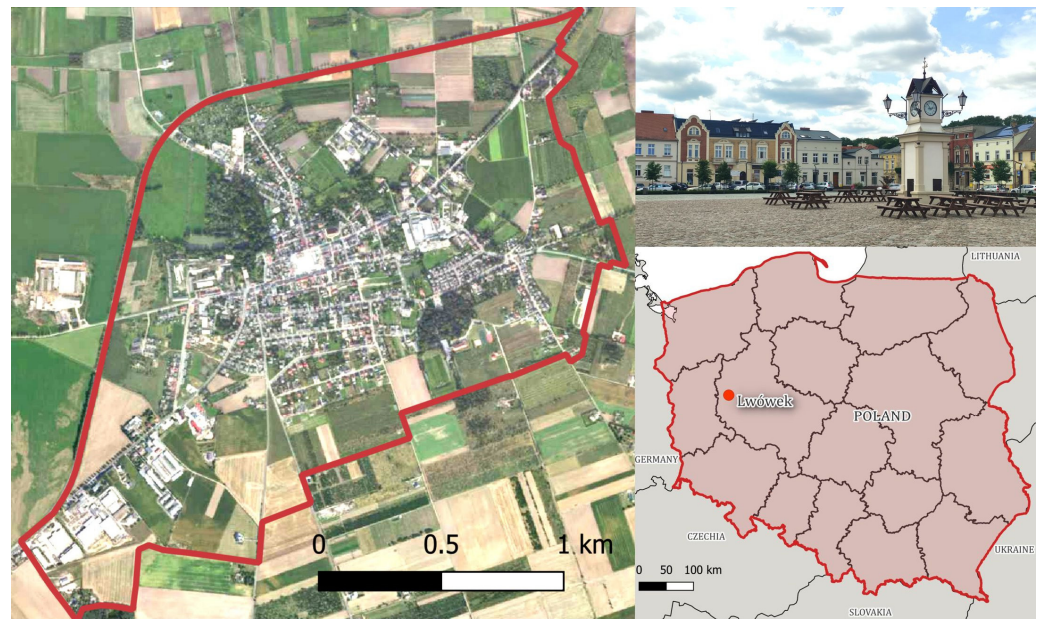


Figure 1. Layout of buildings, streets, and area coverage of the town of Lwówek against the background of an orthophotomap (orthophotographic background sourced from www.geoportal.gov.pl, accessed on 14 May 2024, location of the town Lwówek within Poland (OSM data), and photo of its main service hub—town square with clock tower (photography author: Jacek Jabłoński).

3.2. Finding the Mathematical Basis for Further Visualization Work

There are many ways of conducting calculations oriented toward the standardization of different types of data [22,23]. To properly calculate and standardize data in the next steps of our work, we decided to follow the multi-criteria evaluation model. It allowed us to integrate the data regarding distances from services and amenities to every residential building in the town with their subjective attributes appointed to them through the online survey. It also enabled the possibility of considering the negative impact of close proximity to some of the services and amenities disliked by the survey's respondents.

The main formulas used in this research consist of the following:

$$S = \sum_k^n w_i * x_i \wedge c_j \quad (1)$$

This is a formula for calculating the usefulness of possible options [22,24,25], that in this research was adapted as a formula calculating the indicator, which we propose to call the Residential Building's Location Attractiveness Factor (RBLAF). S means degree of usefulness (in original equation; here: attractiveness); w —weight of the criterion (here: weight assigned to the type of service based on respondents' answers); x —standardized value of the distance from the service; i —selected criterion; c_j — j th maximum and minimum

thresholds of calculated values; k —starting index (first value of i); and n —final index (last value of i);

$$x_{ij} = \frac{\max S_{ij} - S_{ij}}{\max S_{ij} - \min S_{ij}} \quad (2)$$

This formula was used to standardize the distance from a set target into a range of 0–1 values [22,24,25]. The symbols used in it mean the following: x_{ij} —standardized value of the distance from the service; S_{ij} —distance of the service from a given place of residence; $\min S_{ij}$ —minimum threshold of the calculated distance; and $\max S_{ij}$ —maximum threshold of the calculated distance. It was adapted as a formula to standardize the values of the distances of services and amenities from residential buildings throughout the town. This specific variation was used because it is based on an assumption that the bigger the value that is being standardized, the worse the overall scoring of it is [22].

These formulas require value boundaries, specifically maximum and minimum values which are to be considered during the calculations of distance. Without them, the RBLAF could become highly inflated in cases of the unnecessarily close proximity of a specific service or amenity to residential buildings. In order to determine this range, the authors added appropriate questions to the online survey.

3.3. Preparation and Conducting of an Online Survey

To prepare an up-to-date online survey, we had to acquire accurate data concerning the localizations of services and amenities in the subject town of Lwówek. We started by collecting the data from OpenStreetMap (OSM). After obtaining the necessary vector files, we compiled them into a project in an application called QField, which is an open-source application that allows users to survey land by creating vector layers of POI using the navigation systems of a mobile phone [26,27]. It allowed us to pinpoint the locations of all the services and amenities in the town and correct the OSM data within the scope of the attribute table.

After verifying what types of services and amenities there are in the subject town, we started the process of classifying them to simplify the further calculations. They were separated, based on their nature, into three groups:

- Public services and amenities;
- Commercial services and amenities;
- Recreational services and amenities.

A total of 42 types of services were identified, of which 10 were classified as public services, 26 as commercial services, and 6 as recreational services. The public grouping consisted of services and amenities that were state-controlled and subsidized by the government, like public transport stops and libraries. The commercial services were connected to a private owner, who profited from selling goods through them. Recreational services were the ones that were tied to physical activity and nature. In further research work, we established the main colors of these groups—red colors to represent public services and amenities, blue for commercial services and amenities, and green for recreational ones.

After that classification, we started to prepare the survey. Its purpose was to determine how much a typical young adult cares about easy access to specific services and amenities. For the purpose of this research, we set the target group of respondents as young adults between 18 and 35 years of age. This group was chosen mainly because people at that age start trying to find their own living place. In some cases, changes in residence during this life stage may occur several times. In contrast, older age groups tend to change their place of living less frequently, mainly because of already having a well-established home. This is not always reflected in the age of property buyers, as many view purchasing an apartment as an investment, such as earning rental income.

We decided to make an online survey. That method choice was based on the fact that people of our selected age group are the ones most active in the sphere of online surveying [28,29]. Also, with it we were able to gather many more respondents in a much

shorter amount of time, which typical methods of conducting a survey, like a paper survey or an interview, could not provide [28,29]. The general scheme of the survey used in this study is visible in Figure 2.

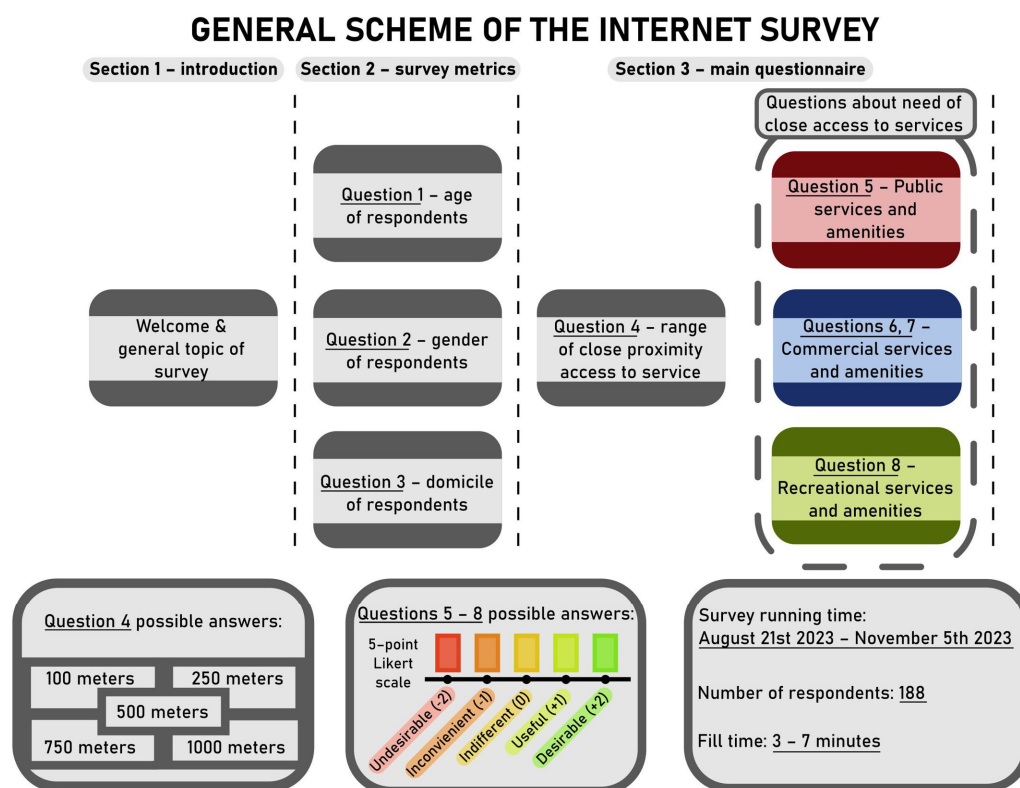


Figure 2. General scheme of the survey used in this study.

To evaluate the attractiveness of close-proximity access to services and amenities from residential buildings in the subject town, we picked a closed questions system, which would establish the following:

- Metric attributes of respondents (age, size of place of living, gender);
- Range of close-proximity access to services and amenities from place of living (minimum and maximum values the distance could take in our further calculations);
- Evaluation of what services and amenities the respondents would and would not like to be located in close proximity to their place of living.

When indicating their place of residence, respondents could specify either a village or a city according to four size categories: over 500,000 inhabitants; 150,000–500,000 inhabitants; 50,000–150,000 inhabitants; or up to 50,000 inhabitants. In the survey, we decided to suggest possible ranges of close proximity by choosing 5 options for the respondents to pick from, based on the literature [30,31]. These options were 100 m, 250 m, 500 m, 750 m, and 1000 m. For the evaluation of what services and amenities the respondents would and would not like to be located in close proximity to their place of living, we decided to use the 5-point Likert scale [32]. The possible responses indicating respondents' attitudes towards specific types of services in close proximity were categorized as follows: undesirable, inconvenient, indifferent, useful, or desirable.

The survey was prepared and conducted using the *Google Forms* application within a timespan of 2.5 months, and it gained a lot of traction. It was propagated by sending out questionnaires to students at different universities throughout the city of Poznań, using the internet. One of the channels for distributing the survey was social media. To ensure greater representativeness of the sample, we established a criterion that there should be at least one respondent from each birth year within the age group covered by the study.

Respondents were asked to complete the survey accurately, according to their subjective perceptions. The Likert scale questions concerning services were organized in a tabular format and divided into four sections, to prevent respondents from being discouraged by the number of ratings required and to facilitate convenient survey completion when using mobile devices.

3.4. Calculations Connected with Computing the Standardized Survey Data and Measurement of the Residential Building's Localization Attractiveness Factor (RBLAF)

After the survey data collection phase was completed, the process of data analysis began. Figure 3 shows the distribution of age and gender among respondents, the variation in the size of their place of current residence, and the results of the question regarding the range of proximity that respondents consider to be close access.

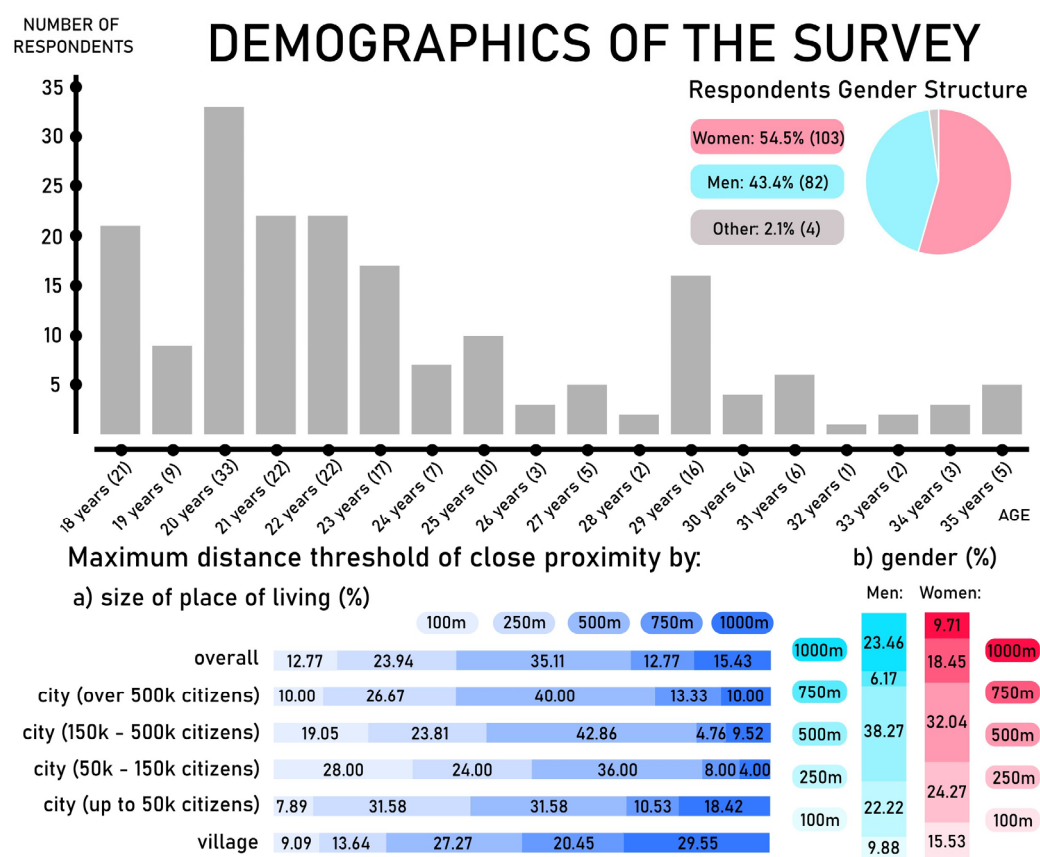


Figure 3. Age, gender, and size of place of living structure of the respondents and detailed results of close-proximity access question.

The survey collected responses from 188 young adults aged 18–35 years, including 103 women (54.5%) and 82 men (43.4%), with 4 individuals (2.1%) opting not to answer this question. The largest group consisted of individuals aged 20 years (33 respondents, accounting for 17.6% of the sample), while the smallest group consisted of individuals aged 32 years (1 respondent, less than 0.5% of the sample). The average age of respondents was 23 years, due to the higher number of respondents in younger age groups. Among the distance ranges indicated by respondents, the most frequent choice was 500 m (66 votes, 35.11%), which was considered the upper distance limit for proximity in subsequent calculations. The next most common range was 250 m (23.94%), followed by 1000 m (15.43%), and then 100 m and 750 m (12.77% each). A distinction was observed between residents of cities and those from rural areas. Residents of rural areas showed a higher tolerance for greater distances, considering 1000 m as close access (29.55% of rural respondents), compared to 18.42% of urban respondents. Results for large cities (with populations over 500,000)

differed somewhat from smaller cities, showing greater tolerance for longer distances. This could be attributed to the more developed transportation and communication networks in large urban centers. An analysis of distance preferences by gender indicates that men generally accept larger distances.

The detailed results of the respondents' answers to the question about their attitude toward close-proximity access to specific types of services according to service groups are presented in Figure 4. The background colors of the sections correspond to different service groups (public—red, commercial—blue, and recreational—green). The white fields (boxes) list the types of services, with the total number of responses on the Likert scale shown below. The strip diagram depicts the percentage distribution of responses. In the charts, undesirable services are marked in red, inconvenient services in orange, indifferent services in yellow, useful services in light green, and desirable services in dark green. The degree of agreement among respondents regarding their opinions is expressed using the standard deviation in percentage terms (SD%). Higher standard deviation values indicate a greater concentration of specific opinions, while lower values reflect a greater diversity of responses.

After analyzing questionnaires filled by respondents regarding the group of public services (Figure 4.), it was discovered that close-proximity access to a health service and a bus stop were most important to them. A total of 151 and 167 respondents considered them useful or desirable, respectively. The most indifferent attitude was expressed toward access to the library and community center (102 votes) and the police station and fire brigade headquarters (92 votes). The opinions of young adults regarding close-proximity access to the church are striking in comparison with the rest of the results (64 considered it indifferent, 33 found it inconvenient, and 66 considered it undesirable). It was the only service or amenity that respondents showed a greater negative view on.

After reviewing the respondents' votes regarding the close-proximity access to commercial services (Figure 4.), the largest number of "undesirable" (−2) and "inconvenient" (−1) votes were cast for pubs, discos, and cafes. These are places that may generate a lot of noise, which could be the reason for this scoring (just like the ringing of church bells or the sound of the alarm sirens of emergency services). However, at the same time, these negative votes were balanced by "useful" votes, which moved these services higher in the converted point value and which may be understandable considering that these are young people who statistically use such forms of entertainment more often. Ultimately, close-proximity access to a construction or furniture store turned out to be the least necessary. The most indifferent attitude was related to the close proximity of an English language school, while the most important was the close access to a grocery store, pharmacy, post office/parcel locker, and bakery.

Among recreational services (Figure 4), close-proximity access to parks, allotment gardens, and bicycle paths was the most important. The respondents considered the availability of a playground to be the least important, and they were most ambivalent toward the availability of a bicycle service.

Based on the respondents' answers, weights were calculated for each type of service, indicating their importance to the survey participants. To do this, each response variant was assigned a numerical value: undesirable (−2), inconvenient (−1), indifferent (0), useful (1), and desirable (2). These values were then multiplied by the frequency of the corresponding responses. A formula based on the weighted average was applied using the following notations (the assigned values are given in brackets): w_i —weight of a given criterion (service); V_{un} —number of votes for undesirable; V_{in} —number of votes for inconvenient; V_{us} —number of votes for useful; V_{de} —number of votes for desirable; and L_r —total number of respondents.

$$w_i = \frac{V_{un} * (-2) + V_{in} * (-1) + V_{us} * (1) + V_{de} * (2)}{L_r} \quad (3)$$

Detailed weights calculated using this formula for each service are shown in Figure 4.

SURVEY RESULTS

"Close proximity access to a service is..."

Undesirable Inconvenient Indifferent Useful Desirable



Figure 4. Preferences of young adults regarding close-proximity access to particular types of services in three groups based on results of the survey by total number and percentage of answers with standard deviation (in percent) and weights assigned to each service according to respondents' opinions.

The next step was to calculate the distance values between all residential buildings and urban services within the town of Lwówek. To achieve this, the network analysis algorithm in the QGIS application (Network analysis/shortest path/point to layer) was used, summing up the values of the distances between points calculated along the urban road network. To make the distance values as accurate as possible, a layer of point centroids was generated, created from the residential building's vector layer adapted for this purpose, acquired from the national geospatial data bank (BDOT10k data—Polish topographic objects database) via the Geoportal service (www.geoportal.gov.pl, accessed on 21 June 2024). In the case of area-based services, represented with polygon geometries (parks, allotment gardens, markets), the distance only to their nearest entrance was measured.

Then we began work on calculating the value of the Residential Building Localization's Attractiveness Factor (RBLAF) of all residential buildings in the town. The value of the RBLAF was a parameter calculated from the standardized value of the distances from all the services and amenities in the subject town to residential buildings, multiplied by the average weight of these services resulting from the survey. The values of the distances from all the urban services and amenities in the subject town to residential buildings were standardized using the previously shown Formula (2) [22]. The minimum and maximum thresholds were determined based on the survey results. The maximum close-proximity access distance was set as 500 m, and the minimum was set as equal to 0.1 of the maximum distance. The minimum threshold was set as 50 m because of a sharp increase in the standardized values of distances in cases of proximity of 50 m and less while using MCE formulas. Standardized values of distances for services situated 500 m or more from a specific residential building would be set as a value of 0 (lowest value) and services at a distance of 50 m or less, as a constant 1 (highest value). The RBLAF values of residential building centroids were calculated, and the vector layers were supplemented with the calculated data according to Formula (1) [22,24,25].

3.5. Visualization of Resulting Data

After collecting and computing all necessary data, we had to decide which specific form of data visualization to use to show the results and nuances of this research. To present the localizations and layout of services and amenities network throughout the town, we used the quantitative—qualitative sign map method. To show the most important aspect of this research, i.e., the attractiveness of a residential building's localization, we used the quantitative isochrome map method. The cartographic visualization process we conducted in the QGIS program due to its accessibility and the number of available geodata processing tools and algorithms [33]. First, we decided which vector layers of BDOT10k that were acquired from the national Geoportal would be used in our work. We started with collecting data for the service and amenity localization map. For its base layers, we chose vector layers that show the road network, buildings and squares, administrative boundaries, water areas, and green areas. This data was used to help users identify key topographic features in the town and provide proper and faster spatial orientation. These layers were limited and cut to the borders of the town of Lwówek. The thematic layer of this map was a point layer, visualizing the locations of services and amenities and their types by using unique symbolic signs created by the authors.

We needed to choose the color scheme for the selected layers. We decided to base our color scheme off the colors used in the BDOT10k data visualization, which is a graphical presentation of the thematic layers included in the Polish topographic objects database [34]. The colors were vibrant and could lead to unnecessary problems with the readability of our maps, so we decided to tone them down by lowering their saturation. This way, the base layer data would interfere less in the process of communicating our data to the users [35].

After the initial selection of colors for individual service groups and all the layers of the map, we began the process of preparing map signs for the services and amenities in digital form, based on hand-drawn concepts. This work was performed using a vector graphics application called *Inkscape*, which allows the fast and intuitive creation of vector graphics

in .SVG format [36]. We chose a symbolic sign method using circular signs (diameter set to 7 mm in the program) to minimize problems with visibility in the situation when there would be a major congestion of services in a specific place. Then, it would be easier to lay them out in a readable manner. This would be especially important in visualizing the structure of the services located in the town square, for which we planned to use an inset map. The view of signs for the point map was set as a vertical view. Due to map scale constraints, many of the signs were adjusted so that they could be recognized on a smaller scale. For this study, a rule was set that no vector object could be narrower than 0.2 mm, in order to maintain its readability. Signs that were too vague and could be confused with other services were adapted. All signs were colored using the main colors of their respective service groups, which were established in the earlier steps of our work. To keep the visual harmony of the whole service localization map, we made the main sign colors less intense but kept them saturated enough to contrast nicely with the base layers. The set of prepared cartographic signs is visible in Figure 5.

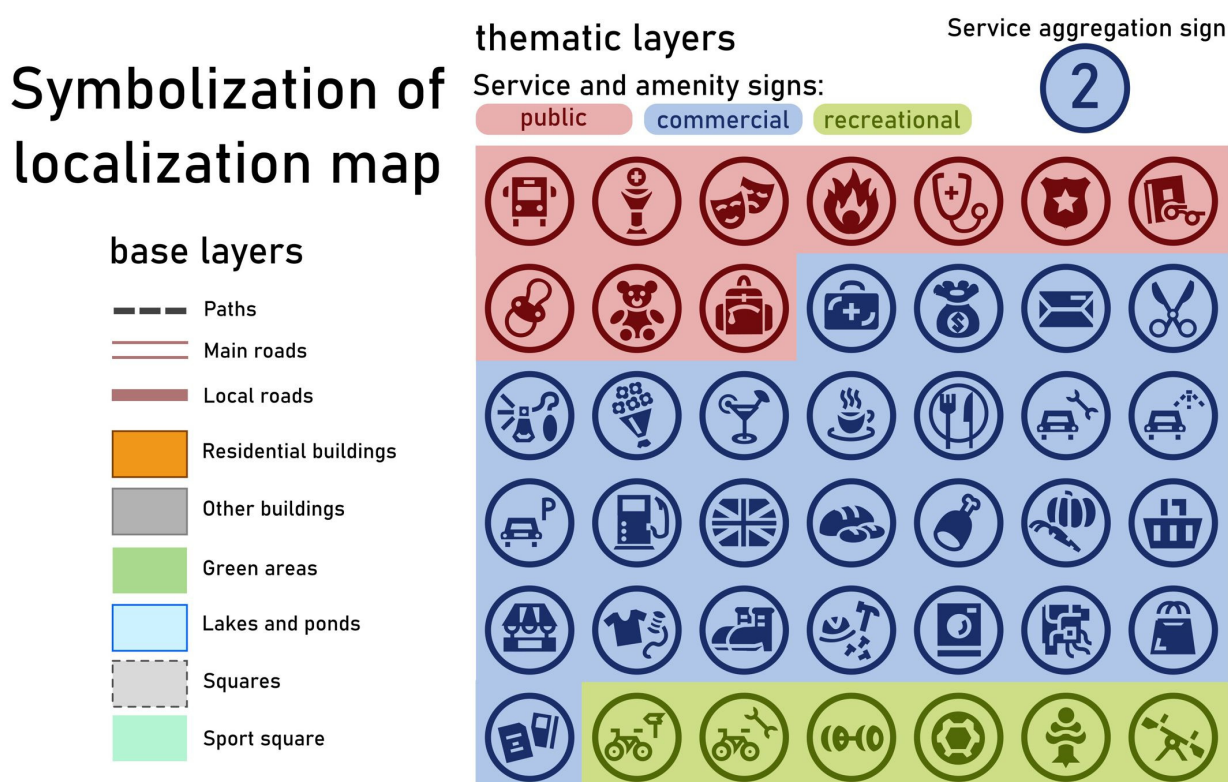


Figure 5. Symbolization of service and amenity localization map (size of signs enlarged by 200%).

After finalizing the preparation of the vector layers data and setting their style to match our color scheme, we started the process of preparing a map layout of the service and amenity localization map, consisting of a map title, a main map with the scale 1:15,000, and an inset map that was set to visualize the services located in the town square and used the same layers as the main map (both with a linear scale), as well as a legend with our original service signs. In that legend, we separated the signs into their groups and made sure to space them out evenly. We also organized them by similarity to other services in their groups, and within these groups, we organized them alphabetically. To ensure proper visual hierarchy of the map, the base layers were added first, and then we added thematic point layers with locations and types of services to the layout.

Despite the larger scale of the inset map, it was not possible to showcase the localization of services in the town square without either allowing partial coverage of signs or generalization. The rules of cartography suggest that signs should not overlap [37], but in our case, the accuracy of their placement was crucial. We decided to try both methods

and see which one would yield better results (Figure 6). The conventional method of no sign coverage allowed us to clearly differentiate between signs, but at the cost of service location accuracy. The method allowing partial coverage of signs ensured the accuracy of the locations of services but at the cost of partial visibility and harder identification of services. We decided to use the method allowing partial coverage of signs because the basis of our research was distance from services and localization accuracy. Then we had to decide how much of a sign we can overlap to keep it identifiable. After comparing the 50% and 70% sign overlap layouts, visible in Figure 6, we came to the conclusion that the 50% coverage option allowed us to accurately visualize the locations of services and made the overlapping signs identifiable enough.

Differences in localization of services based on the rule of no sign coverage and 50% coverage

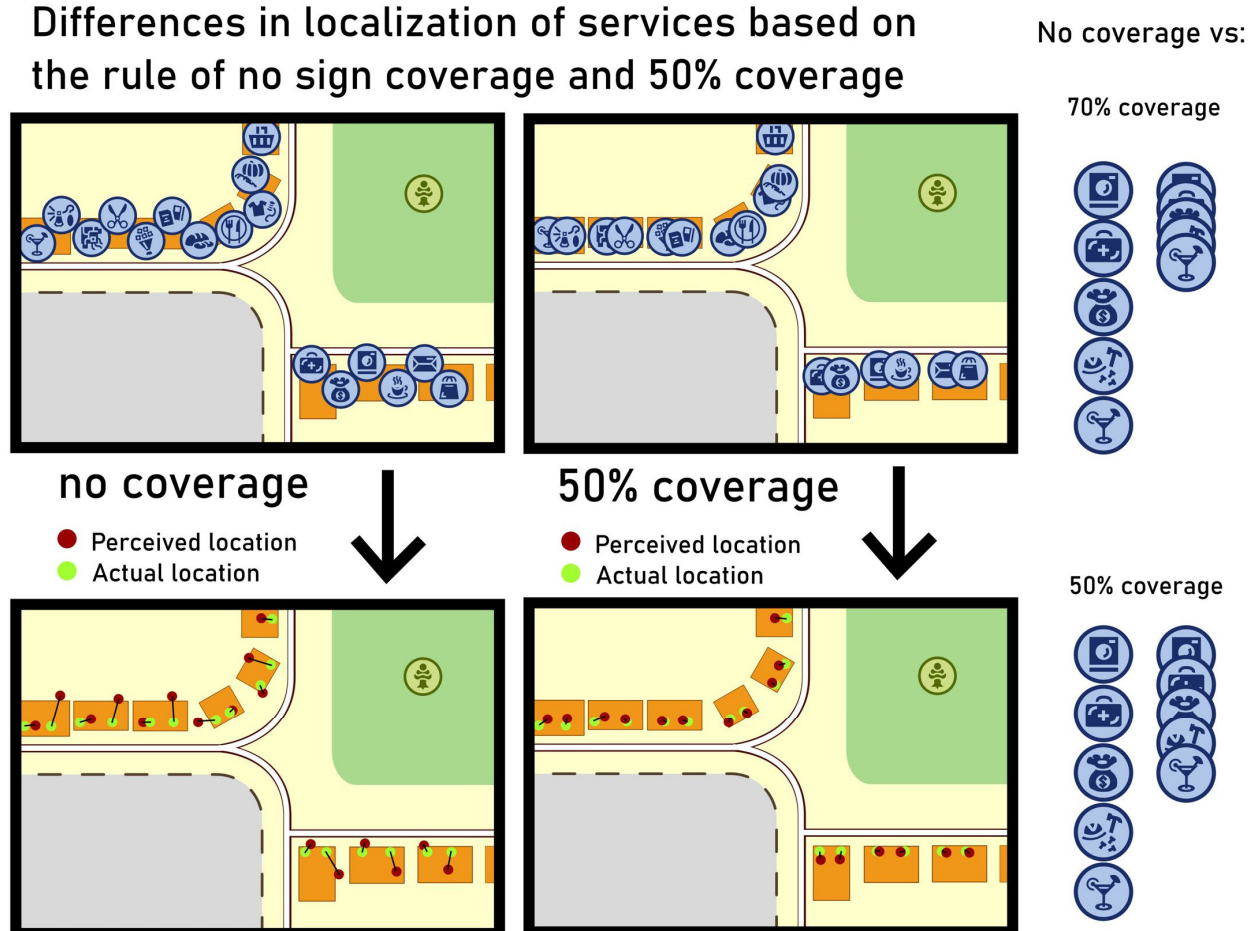


Figure 6. Comparison of generalizing localization of services and allowing partial overlap of signs.

Another possible solution would be leader lines (connector lines), used when a label or diagram does not fit within the area of the object it refers to on the map, but they also were not applicable here. In the case of places with the highest density of services, a sign combining several services belonging to the same group was used. After determining the method to visualize congested signs, we finished the layout of the first map by adding a linear scale and box A in the corner of our inset map.

The second map, ie., isochrone map, showing localization preferences for residential buildings among young adults, would only use road network data as its base layer. In this way, it would show the calculated value of a location's attractiveness level for the entirety of the town, which would be the main focus of the map without losing readability of the end product. Road network data would also enable the user to compare both maps, connecting them geographically by the similar road layout.

In a step connected with the second map layout, we utilized the residential buildings' centroid points layer to create an isoline representation of RBLAF values for the entire town, using a QGIS plugin named *QGIS Contour*. We generated one isoline layer for the overall RBLAF value and three separate isoline layers for the partial RBLAF value based on the accessibility of a specified group of services only (public, commercial, or recreational). For the main map of the second map layout, we divided the values into 12 2-point intervals and used a sequential color scheme, ranging between pink and saturated purple, to best show the intensity of the phenomenon and accommodate the number of intervals.

For these three layers with partial RBLAF values, we used the main colors of their respective service groups, each with four classes showing partial points for each service group according to the total number of points represented by the RBLAF value in an indicated spatial location on the main map. The class described as "very high" means that from 75% up to 100% of the points of the RBLAF value are connected with a certain service group. The class "high" covers the range of 50 to 75% of all points, whereas the "medium" class is connected with values from 25% up to 50% of the total points sum. The category "low" means the number of points is from 0 to 25% of the total RBLAF value.

We set the scale of the main isochrome map on the second map layout showing the summed-up RBLAF values of public, commercial, and recreational services as 1:15,000, to best accommodate for comparisons with the service localization map. To this map, we also added a simplified road to make it easier to connect it geographically with the service localization map. Under the main map, we added the additional maps on a scale of 1:55,000, showing the attractiveness of residential buildings based on the specific type of service. We added linear scales to all the maps and their respective legends. The main map showed precise values, while additional ones indicated which regions of the town were most attractive by specific service group standards.

4. Results

Our work culminated in two separate maps showing the localization of services and amenities in the vicinity of the town of Lwówek (Figure 7) and localization preferences for residential buildings in Lwówek, expressed through the RBLAF value (Figure 8). The former shows that the town square is greatly oversaturated with services in comparison to the rest of the town. The latter confirms that the town square is the area with the highest concentration and diversity of service types, but it also visualizes few service centers that could prove to be an attractive localization to settle in. The maps show that different parts of town could be attractive for different reasons. The eastern part of the town may be crucial for individuals who care the most about close-proximity access to public and recreational services. In the city center, commercial services play a particularly important role in making the location attractive.

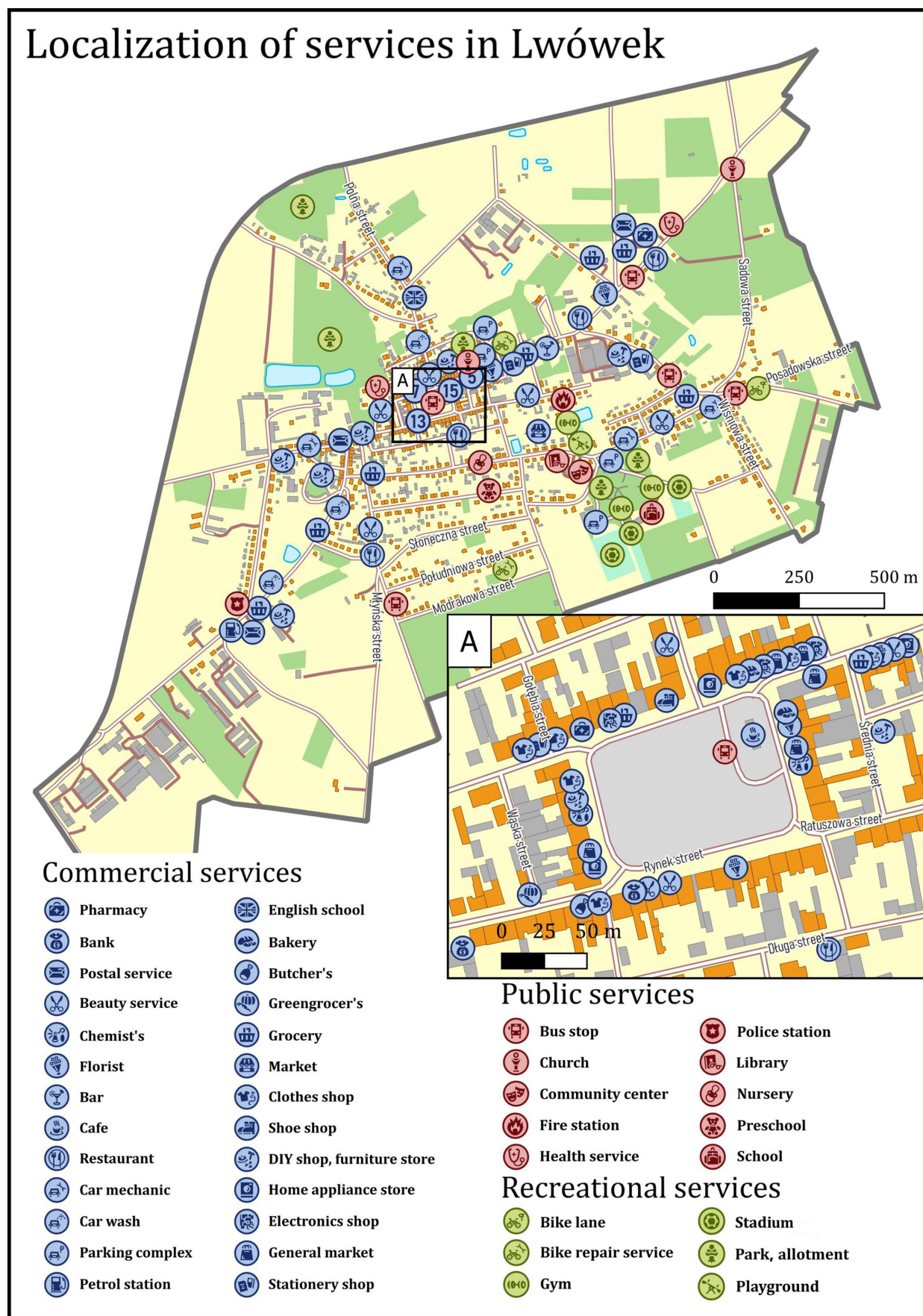


Figure 7. Map of localization of services in the town of Lwówek.

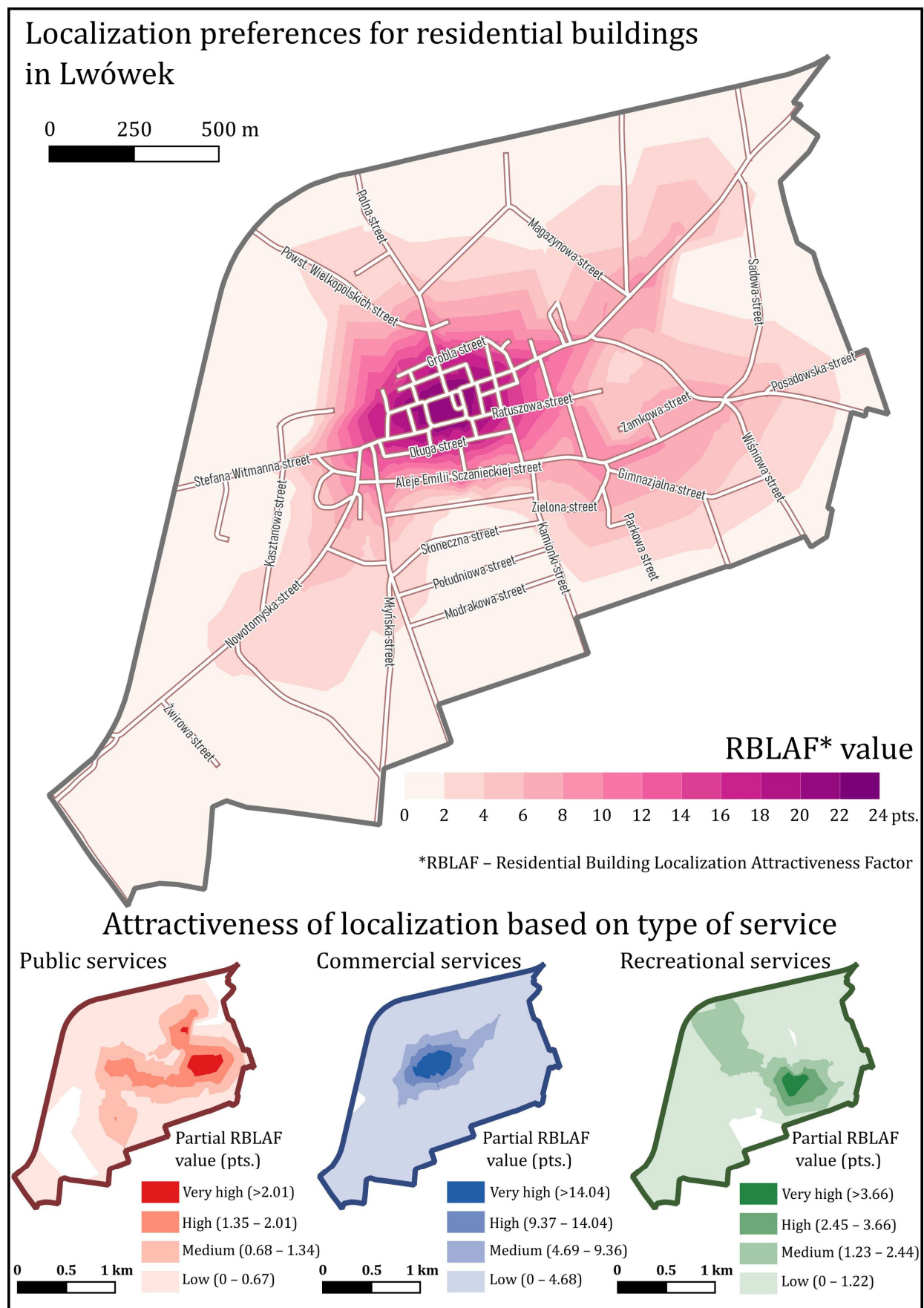


Figure 8. Map of localization preferences for residential buildings in Lwówek by RBLAF.

5. Discussion

Throughout our work, we demonstrated a way of incorporating information about close-proximity access to services and amenities into the investment decision-making process. We accomplished that using proper models and formulas, connected with determining the most suitable course of action using a multi-criteria analysis. However, this research did not come without some limitations.

The first limitation was connected with the nature of measured preferences. The generalization of such phenomenon is typically difficult because for a person interested in choosing an attractive apartment location, what is important is their own opinion, not the opinions of other people. However, sample research is important for people involved in the housing business. In this work, we tried our best to find solutions that would allow for the usage of this data in further GIS calculations. Naturally, it will never perfectly apply to the whole population, but setting the methodological basis for further research work was important. Additionally, respondents had slightly differing views regarding what distance was an acceptable maximum close-proximity threshold, depending on their place of living. For people living in villages, particularly, this distance is much greater than in any other group. Because we averaged their opinions, the limit for our calculations was still 500 m, but it potentially could wrongly reflect the opinions of people living in villages.

The list of services analyzed in our study is limited and tailored to the town that was the subject of our research. The actual catalog of services may be much broader, particularly in large cities.

We did not take into account other factors that, in practice, often determine the choice of a place for residence and its attractiveness, such as the level of noise, air pollution and safety at location, the existence of movement impairment adaptations in regards to services, the surroundings' aesthetic and landscape qualities, or issues related to the standard of the building, price, or even proximity to the workplace. Some of these factors can be used to create an average housing value map [38], or residential property value maps can be created using clustering and geostatistics [39,40].

The next problem was the method of the placement of cartographic signs in the cases of areas congested with services. We decided to use the overlapping method, even though, according to applicable cartographic rules, the signs should not overlap. Similar solutions are used in cartography in the case of map diagrams related to areas, where the problem is often that the area of the circle showing the value of the phenomenon is larger than the area of the small administrative unit to which it refers. A good example of such situations and solutions with a detailed description of the rules that should be applied in such cases can be found in the publication of the Polish central statistical office (Statistics Poland; GUS, Warsaw) [19].

The problem of readability and overlapping does not only apply to static maps. Similar problems occur in interactive maps, especially when the user changes the map display scale. Interactive maps using the proportional point symbols technique can use various strategies to prevent or reduce visual clutter [41]. The aggregation of location point data with a display of the number of objects occurring in clusters in specific areas while displaying the map on a smaller scale has become a popular way of presenting information on interactive internet maps, and it is called clustering [42,43]. The very use of numbers as a simple way of presenting data on maps attracts the attention of researchers as an alternative possibility that could "replace or complement well-established quantitative cartographic methods of presentation" [44].

Although we simplified and toned down the vibrance of the base layers of the service localization map, it could still be too vibrant and cause focus problems for some users. The base layer of the road network in the second map could also block out the view of specific values in some regions, but it was necessary so both maps could be easily interpreted in conjunction.

It is debatable whether the first map with the point signs is sufficient in terms of intuitive reading by a public user. However, reading an isochromatic map with a minimalist

topographic reference may not be so easy. Our intention is to be able to read and draw conclusions separately from these two visualizations or complementarily.

6. Conclusions

The goal of this study was to evaluate and visualize trends regarding potential future property buyers' needs and desires connected to the close-proximity access of urban services to their new potential place of living. We also wanted to provide some methodological tips in terms of the calculations of a numerical indicator that allows for a measurable determination of the attractiveness of the location of residential buildings and a visualization showing these values graphically in an easy form in a wider spatial context. The adaptation of the formulas for MCE and weighted average allowed for the calculation of an indicator that we propose to call the RBLAF.

The combination of survey techniques with computational methods, GIS tools, and a set of methods and principles for map design allowed the creation of a useful cartographic visualization [45] and led to the conclusion that two types of maps can be used to represent the locations of residential buildings: a map of point symbols of services with an appropriate reference for the city's topography and an isochromatic map with a representation of the attractiveness index. A great advantage of such a methodology is the possibility given to the user, who can draw conclusions by reading these two visualizations complementarily.

There are numerous possible ways to use the results and graphical analyses obtained in this study. First, they can be used in conjunction with cadastral data on property values to better analyze and optimize the value of residential properties. Second, the preference analysis method we proposed can help expedite the process of determining property offers for discerning clients, as it provides insights into the services they desire. Third, such analyses can benefit not only the housing industry but also the service market. Using it, investors can make more rational decisions about site selection for new projects and reduce the risk of investment unprofitability.

The methodology developed through this research could be utilized as a basis for the creation of an interactive mapping application, which could adhere more to the specific needs of a singular user. It could, as it launches, ask the user to fill out a questionnaire similar to ours and, based on their answers, calculate an RBLAF factor specifically catered toward that singular user. By collecting anonymous user data, the application could build a database providing valuable insights into the preferences of potential home buyers.

The RBLAF values could be used in these possible applications to enrich and better specify which locations of residential buildings or possible new services are the most attractive.

Author Contributions: Conceptualization, Jacek Jabłoński and Łukasz Wielebski; methodology, Jacek Jabłoński; software, Jacek Jabłoński; validation, Jacek Jabłoński, Łukasz Wielebski and Beata Medyńska-Gulij; formal analysis, Łukasz Wielebski, Beata Medyńska-Gulij; investigation, Jacek Jabłoński; data curation, Jacek Jabłoński; writing—original draft preparation, Jacek Jabłoński; writing—review and editing, Łukasz Wielebski, Beata Medyńska-Gulij; visualization, Jacek Jabłoński; supervision, Łukasz Wielebski, Beata Medyńska-Gulij; project administration, Beata Medyńska-Gulij. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Dataset available on request from the authors.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Case, B.; Goetzmann, W.N.; Rouwenhorst, K.G. Global Real Estate Markets: Cycles and Fundamentals. *SSRN J.* **1999**, *2*, 107. [\[CrossRef\]](#)
2. Toivonen, S.; Viitanen, K. Forces of change shaping the future commercial real estate market in the Helsinki Metropolitan Area in Finland. *Land Use Policy* **2015**, *42*, 471–478. [\[CrossRef\]](#)

3. Tuluca, S.A.; Myer, F.C.N.; Webb, J.R. Dynamics of private and public real estate markets. *J. Real Estate Financ. Econ.* **2000**, *21*, 279–296. [\[CrossRef\]](#)
4. Hudson-Wilson, S.; Gordon, J.N.; Fabozzi, F.J.; Anson, M.J.P.; Giliberto, S.M. Why Real Estate? *JPM* **2005**, *31*, 12–21. [\[CrossRef\]](#)
5. Konowalczyk, J. The Corporate Real Estate Market in Public Statistics in Poland. *Real Estate Manag. Valuat.* **2014**, *22*, 41–51. [\[CrossRef\]](#)
6. Barreca, A.; Curto, R.; Rolando, D. Urban Vibrancy: An Emerging Factor that Spatially Influences the Real Estate Market. *Sustainability* **2020**, *12*, 346. [\[CrossRef\]](#)
7. Wilhelmsson, M.; Ismail, M.; Warsame, A. Gentrification effects on housing prices in neighbouring areas. *IJHMA* **2021**, *15*, 910–929. [\[CrossRef\]](#)
8. Jæger, M.M. “A Thing of Beauty is a Joy Forever”?: Returns to Physical Attractiveness over the Life Course. *Soc. Forces* **2011**, *89*, 983–1003. [\[CrossRef\]](#)
9. Karanikolas, N.; Vagiona, D.; Xifilidou, A. Real estate values and environment: A case study on the effect of the environment on residential real estate values. *Int. J. Acad. Res.* **2011**, *3*, 861–868.
10. Zoderer, B.M.; Tasser, E.; Carver, S.; Tappeiner, U. An integrated method for the mapping of landscape preferences at the regional scale. *Ecol. Indic.* **2019**, *106*, 105430. [\[CrossRef\]](#)
11. Tourangeau, R.; Plewes, T.J.; Division on Behavioral and Social Sciences and Education; National Research Council. *Nonresponse in Social Science Surveys: A Research Agenda*; The National Academies Press: Washington, DC, USA, 2013. [\[CrossRef\]](#)
12. Groves, R.M.; Peytcheva, E. The Impact of Nonresponse Rates on Nonresponse Bias: A Meta-Analysis. *Public Opin. Q.* **2008**, *72*, 167–189. [\[CrossRef\]](#)
13. Victor, C.R. *Ageing, Health and Care*; Policy Press: Southampton, UK, 2010; ISBN 97818470879.
14. Wielebski, Ł.; Medyńska-Gulij, B. Graphically supported evaluation of mapping techniques used in presenting spatial accessibility. *Cartogr. Geogr. Inf. Sci.* **2019**, *46*, 311–333. [\[CrossRef\]](#)
15. Forrest, D. Thematic Maps in Geography. In *International Encyclopedia of the Social & Behavioral Sciences*, 2nd ed.; Wright, J.D., Ed.; Elsevier: Oxford, UK, 2015; pp. 260–267, ISBN 978-0-08-097087-5.
16. Ratajski, L. The methodical basis of the standardization of sign on economic maps. *Int. Yearb. Cartogr.* **1971**, *11*, 137–159.
17. Medyńska-Gulij, B. The Effect of Cartographic Content on Tourist Map Users. *Cartography* **2003**, *32*, 49–54. [\[CrossRef\]](#)
18. Slocum, T.A.; McMaster, R.B.; Kessler, F.; Howard, H.H. *Thematic Cartography and Geovisualization*, 4th ed.; CRC Press, Taylor & Francis Group: Boca Raton, FL, USA, 2023; ISBN 0367713705.
19. Pieniążek, M.; Zych, M. *Statistical Maps: Data Visualisation Methods*; Extended and Updated Edition; Główny Urząd Statystyczny: Warszawa, Poland, 2020; ISBN 8366466094.
20. Medyńska-Gulij, B.; Cybulski, P. Spatio-temporal dependencies between hospital beds, physicians and health expenditure using visual variables and data classification in statistical table. *Geod. Cartogr.* **2016**, *65*, 67–80. [\[CrossRef\]](#)
21. Chakhar, S.; Martel, J.-M. Enhancing geographical information systems capabilities with multi-criteria evaluation functions. *J. Geogr. Inf. Decis. Anal.* **2003**, *7*, 47–71.
22. Carver, S.J. Integrating multi-criteria evaluation with geographical information systems. *Int. J. Geogr. Inf. Syst.* **1991**, *5*, 321–339. [\[CrossRef\]](#)
23. Voogd, H. *Multicriteria Evaluation for Urban and Regional Planning*; Pion: London, UK, 1983; ISBN 9780850861068.
24. Hejmanowska, B.; Hnat, E. Wielokryterialna analiza lokalizacji zabudowy na przykładzie gminy Podegrodzie. *Arch. Fotogram. Kartogr. Teledetekcji* **2009**, *20*, 109–121.
25. Eastman, J.R. *IDRISI Kilimanjaro: Guide to GIS and Image Processing*; Clark Labs, Clark University: Worcester, MA, USA, 2003.
26. Kupach, T.; Gryniuk, O.; Demianenko, S. Software for Field Research: Qfield. In Proceedings of the 17th International Conference Monitoring of Geological Processes and Ecological Condition of the Environment, Kyiv, Ukraine, 7–10 November 2023; EAGE Publications BV: Bunnik, The Netherlands, 2023; pp. 1–5.
27. Medyńska-Gulij, B. *Kartografia Geomatycznie i Geomedialnie*; PWN: Warszawa, Poland, 2024; ISBN 8301235888.
28. Tuten, T.L.; Urban, D.J.; Bosnjak, M. Internet Surveys and Data Quality: A Review. In *Online Social Sciences*; Batinic, B., Ed.; Hogrefe & Huber: Seattle, WA, USA, 2002; pp. 7–26.
29. Coomber, R. Using the Internet for Survey Research. *Sociol. Res. Online* **1997**, *2*, 49–58. [\[CrossRef\]](#)
30. Pozoukidou, G.; Angelidou, M. Urban Planning in the 15-Minute City: Revisited under Sustainable and Smart City Developments until 2030. *Smart Cities* **2022**, *5*, 1356–1375. [\[CrossRef\]](#)
31. Shatu, F.; Kamruzzaman, M. Determining Optimum Design Density for 20-minute Neighbourhoods. *Findings* **2021**, *26*, 66. [\[CrossRef\]](#)
32. Joshi, A.; Kale, S.; Chandel, S.; Pal, D. Likert Scale: Explored and Explained. *BJAST* **2015**, *7*, 396–403. [\[CrossRef\]](#)
33. Kurt, M.; Richard, S.J.; Pirelli, L. *Mastering QGIS*; Packt Publishing: Birmingham, UK, 2016; ISBN 1786460378.
34. Ślusarski, M.; Siejka, M. Model of quality of data collected in the topographic database. In *17th International Multidisciplinary Scientific GeoConference SGEM2017, Proceedings of the Informatics, Geoinformatics and Remote Sensing, Issue 23: Photogrammetry and Remote Sensing, Cartography and GIS*; STEF92 Technology: Sofia, Bulgaria, 2017; pp. 595–603.
35. MacEachren, A.M. *How Maps Work: Representation, Visualization, and Design*, 2nd ed.; Guilford Press: New York, USA, 2004; ISBN 9781572300408.

36. Kirsanov, D. *The Book of Inkscape: The Definitive Guide to the Graphics Editor*, 2nd ed.; No Starch Press: San Francisco, CA, USA, 2022; ISBN 1718501757.
37. MacEachren, A.; Kraak, J.A. Research challenges in geovisualization. *Cartography Geograph. Inf. Sci.* **2001**, *28*, 3–12.
38. Bielecka, E.M.; Całka, B. Mapa wartości mieszkań: Studium przypadku pierwotnego rynku nieruchomości w Siedlcach. *Rocz. Geomatyki [Ann. Geomat.]* **2014**, *12*, 379–388.
39. Knura, M.; Schiewe, J. Analysis of User Behaviour While Interpreting Spatial Patterns in Point Data Sets. *KN J. Cartogr. Geogr. Inf.* **2022**, *72*, 229–242. [[CrossRef](#)]
40. Całka, B. Estimating Residential Property Values on the Basis of Clustering and Geostatistics. *Geosciences* **2019**, *9*, 143. [[CrossRef](#)]
41. Opach, T.; Korycka-Skorupa, J.; Karsznia, I.; Nowacki, T.; Gołębiowska, I.; Rød, J.K. Visual clutter reduction in zoomable proportional point symbol maps. *Cartogr. Geogr. Inf. Sci.* **2019**, *46*, 347–367. [[CrossRef](#)]
42. Fürhoff, L. Rethinking the Usage and Experience of Clustering Markers in Web Mapping. *PeerJ* **2019**, *7*, e27858v3.
43. Meert, W.; Janssens, G.; Tronçon, R. Clustering Maps. Master's Thesis, Katholieke Universiteit Leuven, Leuven, Belgium, 2006.
44. Korycka-Skorupa, J.; Gołębiowska, I. Numbers on Thematic Maps: Helpful Simplicity or too Raw to Be Useful for Map Reading? *IJGI* **2020**, *9*, 415. [[CrossRef](#)]
45. Schiewe, J. Empirical Studies on the Visual Perception of Spatial Patterns in Choropleth Maps. *KN J. Cartogr. Geogr. Inf.* **2019**, *69*, 217–228. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.