

URBAN DESIGN AND SPATIAL PLANNING

**URBANISTYKA
I PLANOWANIE
PRZESTRZENNE**

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ACCESSIBILITY OF PUBLIC-USE GREEN AREAS IN LVIV

DOSTĘPNOŚĆ PUBLICZNYCH TERENÓW ZIELENI WE LWOWIE

ABSTRACT

Along with the growth of the population of a city, the need for the availability and accessibility of green areas for all population categories, regardless of age, financial capabilities, legal requirements, time, physical barriers, and most importantly — distance, increases, as green areas are important for maintaining physical and mental health of city residents. In Lviv, the area of public green areas per inhabitant significantly exceeds state norms. However, due to the uneven distribution of these areas in the city's structure, some of the residents have problems with accessing them. Proposals of the development of the city's green areas do not account for accessibility, which makes it impossible to improve it in the future due to the impossibility of reserving land for the development of such greened zones. In order to equalize the anthropogenic load and ensure that all residents have access to natural areas, an assessment of the territory of the city of Lviv was carried out in accordance with the green area pedestrian accessibility standard. Zones with an urgent need for the development of public-use green areas use were identified and methods of solving of this problem were proposed.

Keywords: accessibility, Lviv, city's green areas, urban standards, the structure of the city, use of public green areas

STRESZCZENIE

Wraz ze wzrostem liczby ludności miasta wzrasta potrzeba dostępności terenów zielonych dla wszystkich kategorii użytkowników, niezależnie od wieku, możliwości finansowych, wymogów prawnych, czasu na dostęp, barier fizycznych, a co najważniejsze — odległości, ponieważ tereny zieleni są ważne dla zachowania zdrowia fizycznego i psychicznego mieszkańców miasta. We Lwowie powierzchnia terenów zieleni publicznej na mieszkańca znacznie przekracza normy państwowe. Jednak ze względu na nierównomierne rozmieszczenie tych obszarów w strukturze miasta część mieszkańców ma problemy z dojazdem do nich. Propozycje zagospodarowania miejskich terenów zieleni nie uwzględniają dostępności, co uniemożliwia poprawę tego współczynnika w przyszłości ze względu na niemożliwość zarezerwowania gruntów dla urządzenia terenów zielonych. W celu zrównoważenia zagospodarowania antropogenicznego i zapewnienia wszystkim mieszkańcom dostępu do obszarów przyrodniczych przeprowadzono ocenę terytorium miasta Lwowa zgodnie ze standardem dostępności pieszych terenów zielonych. Zidentyfikowano strefy o pilnej potrzebie rozwoju użytkowania terenów zieleni publicznej oraz zaproponowano sposoby rozwiązania tego problemu.

Słowa kluczowe: Lwów, dostępność, tereny zieleni miejskiej, standardy urbanistyczne, struktura miasta, użytkowanie terenów zieleni publicznej

1. INTRODUCTION

In Ukraine, urban population growth dynamics reflect a tendency towards the concentration of residents in large cities, especially in the central and western regions (International Bank for Reconstruction and Development / The World Bank, 2015, p. 15). The growth of the urban population stimulates an increase of built-up areas and their density. At the same time, there is an increasing need for public-use greened areas, which, due to the growth of urban pressure, require utmost control so that the existing green spaces can be preserved due to a significant number of visitors. In this regard, it is necessary to plan the development of green areas and reserve of valuable areas for their development in the future to ensure a proper urban microclimate and meet the needs of residents (Rohovsky, 2019, p. 14). The direct and indirect influence of green areas on the well-being of residents was confirmed by a number of studies. In particular, the presence of green spaces in nearby areas indicates a decrease in the number of deaths among the population (Gascon et al., 2016, p. 65), an improvement in the work of the cardiovascular system (Tamosiunas et al., 2014, p. 9), a positive impact on mental health (stress reduction, attention span improvement) (World Health Organization, 2016, p. 4), and was tied with overall well-being and aesthetic impressions (Zachariasz, 2019). The lack of green spaces near one's place of residence was especially noticeable during the COVID-19 pandemic (Burnett, Olsen and Mitchell, 2022, p. 12).

Lviv is one of the first cities in Ukraine to adopt a green development strategy, which it did in 2020 (Pressluzhba L'vivs'koyi mis'koyi rady, 2020). One of the key elements in this strategy is the development and quality of green spaces. Statistical data for 2000 showed that ratio of green spaces per citizen was 54 m²/person (L'vivska mis'ka rada, Upravlinnya ekolohiyi ta pryrodnykh resursiv, n.d.). At the same time, in recent years, the number of green areas has continued to increase, as evidenced by the projects for the development of Bolotyanyy Park in the Riasne-2 district, the creation of the Bilohorshcha Reserve Park, Kulparkiv Park (Staniewska et al., 2021, p. 22) etc. At the same time, one can list a number of residential areas within Lviv's city limits where green areas are either significantly distant (Sholok, 2014, p. 421) or considerable barriers must be overcome to reach them (Petryshyn and Sosnova, 2017, p. 123). Accordingly, the city-wide provision of regulatory indicators is not sufficient to ensure citizens have high-quality access to green areas.

The accessibility to green spaces as defined by distance and travel time, as components of the city's infrastructure, is a key idea featured in the proposal of developing Lviv as a city of short distances (L'vivs'ka mis'ka rada, Departament mistobuduvannya, Upravlinnya arkhitektury ta urbanistyky, 2021, p. 5). From the perspective of the 'Sustainable Urban Mobility Plan of Lviv', implementing the concept of short distances will reduce the load on the public transport system and contribute to popularizing an active lifestyle (Instytut mista, 2020). The results of a study by the Department of Ecology of the Lviv City Council showed that 31.3% of residents visit parks every day, and 38.3% do so several times a week. It is important to note that, according to the answers of the respondents, this percentage depended on the proximity of the park to their place of residence (44.6% reported that a park was at a distance of up to 5 minutes' walking distance from their home; 35.4% — responded it took them 5 to 15 minutes to reach a park) (L'vivska mis'ka rada, Upravlinnya ekolohiyi ta pryrodnykh resursiv, 2020, p. 9).

Aim of the paper, methods and scope

The purpose of this study was to investigate the accessibility of public green areas to the residents of Lviv and develop proposals for its provision. The boundaries of the study covered the residential and recreational areas of the city of Lviv.

The methodology was based on a complex of general academic research methods — a review of the literature and sources, legislative and urban planning documentation, survey results, comparative analysis, and synthesis. Special research methods were also used: the layering method and point assessment, based on GIS, aimed at performing of quantitative analysis and research cartograms (for details, see sections 3–5).

2. PREREQUISITES OF STUDYING OF THE ACCESSIBILITY OF GREEN SPACES IN CITIES

The accessibility of green spaces has a significant impact on a number of problems of urban development and everyday difficulties faced by resident in particular. Potential health benefits include increased physical activity and improvement of mental health (Hartig et al., 2014, p. 224; Cohen et al., 2014, p. 16). This was found based on a survey of urban residents in the USA, who claim that green spaces were important for maintaining physical and mental health. Research showed a 26% increase in the number of people who exercise at least three times a week after

new green spaces had been created in their area (National Recreation and Park Association, 2012, p. 3). In instances where green spaces were within walking distance, 24% more people were physically active (Stone, 2009, p. 2). Increased physical activity among city residents saves money on healthcare by contributing to disease prevention and enhanced immunity (Warburton, Nicol and Bredin, 2006, p. 805). Also, daily walks in green areas contribute to a 15% reduction in the number of overweight or obese people (Butland et al., 2007, p. 126). There is also an improvement in social connections through new casual interactions during walks (Roo, 2011, p. 32; Vreke, Salverda and Langers, 2010, p. 11).

In an urban structure, green spaces are islands of coolness, and their rhythmical distribution throughout the urban structure lowers air temperature, improves air exchange and increases the amount of biodiversity, especially if they are combined with each other. Also, it was found that small greened areas cool the city better than one large green zone, while the cooling is felt at a distance of 300 m from the park boundary (Roo, 2011, p. 30).

3. THE MULTIPLICITY OF THE ACCESSIBILITY OF GREEN AREAS AS A CONCEPT

Green area accessibility is studied in different countries. The British Standard defines 'accessible green spaces' as places that are *open to the general public free of charge and without time restrictions* (Natural England, 2010, p. 41). In Germany, the term 'accessible urban green space' has been proposed as *the amount of green spaces at a certain distance relative to a person's place of residence*¹ (Kabisch et al., 2016, p. 587). When describing the components of accessibility, the following aspects should be taken into account:

- social: age, income, race or ethnicity, population density in the area of residence;
- economic: involves free use not limited by an entrance fee (Grunewald et al., 2017, p. 27);
- physical: indicates the possibility of getting to the destination for all population groups without additional effort and time;
- safety: consists in providing psychologically comfortable conditions for visitors at different times of day (World Health Organization, 2016, p. 45);
- spatio-temporal: the optimal time required to cover the path's distance, taking into account the char-

acteristics of human behaviour, factoring in the covering on the path, shading, noise indicators.

The full definition of the term 'accessible urban green space' implies openness for all categories of the population, the absence of physical barriers along the way, the preservation of natural conditions through controlling the recreational load on the natural system and the fixation of the geometric parameters of the territory.

The distance and time to get to a green space is often the main indicator when calculating the provision of greened areas. This indicator also depends on the quality of the surface, pedestrian density, weather conditions, route configuration, etc. The concept of an acceptable walking distance is conditional and depends on a person's age, state of health and type of mobility. On average, a pedestrian covers a distance of 450 m in 5 minutes, and 900 m in 10 minutes, provided that there are *few people on the streets and they move without stopping or obstacles* (Gehl, 2010, p. 43). In Ukraine, the average walking distance for most people is considered to be 500 m (Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, 2019, p. 32). However, if a route is poorly covered or uninteresting, a distance of 300 m also seems long (Bosselmann, 1998, p. 152). The maximum distance a person is willing to travel to a place depends upon the nature, quality and cost of what they want to visit (Kit Campbell Associates, 2001, p. 11). On the other hand, *it is possible to ensure the functional use of objects in the city only if they are within walking distance* (Senatsverwaltung für Stadtentwicklung und Umwelt, 2015, p. 22).

In currently applicable Ukrainian normative documents, the issue of planning green spaces and their accessibility is considered at different levels of the organization of an agricultural territory, the structural elements of which are the block, the microdistrict, the residential district, and the planning district. The purpose of green space planning is to ensure two aspects: the area of landscaped spaces per inhabitant and the availability of landscaped facilities. When designing structural elements of landscaped areas, only the microdistrict is standardized. In a microdistrict, it is necessary to provide a public-use recreational area within walking distance, parks are added at the level of the residential district, and forest parks are added at the level of the planning district (Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, 2019, p. 43). When designing structural elements of green areas, only the minimum area is standardized, which is 2 ha for parks; 0.05 ha for and 1.5 ha for gardens (Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, 2019, p. 44).

¹ Here and further in the text — the authors' own translation.

Recreational landscaped areas should be located no further than:

- 10 minutes on foot for squares;
- 15 minutes on foot for district parks;
- 20 minutes by public transport to city parks;
- in towns — 30 minutes, in medium-sized cities — 60 minutes, in large cities — 90 minutes by public transport for forest parks and forests (Pro zatverdzhennya Derzhavnykh sanitarnykh pravyl planuvannya ta zabudovy naselenykh punktiv, 1996, § 6.4).

According to these documents, the demand for landscape and recreation areas is calculated based on green space area per person, which is determined depending on the size of the settlement, its location within Ukraine, as well as the type of landscape and recreation area. For example, Lviv, which is a city with a population of over 250,000 people and is located in the second zone of mixed and broad-leaved forests, has a norm of 10 m² of public greenery per person.

When planning new residential units, there is a requirement to provide limited-use landscaped areas (Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, p. 25), therefore, when developing a detailed plan of a territory, architects mostly do not make calculations, but list existing green areas nearby.

To date, normative greening has been corrected by the concept of the city of short distances, which has become popular among urban planners and politicians. According to this idea, the focus is time, not space, which emphasizes how proximity and ease of access can improve quality of life (Moreno, 2019). With the growing popularity of sustainable urban development, the concept of a compact green city has become a global reference (Szumacher and Pabjanek, 2017), and green spaces are its main component (Zibtseva, 2020).

The principle of short distances became key in the creation of the Integrated Development Concept of Lviv 2030. It supports the development of the city by rethinking post-industrial areas, as well as the development of existing districts as self-sufficient units (L'vivs'ka mis'ka rada, Departament mistobuduvannya, Upravlinnya arkhitektury ta urbanistyky, 2021, p. 7).

4. METHODOLOGY

Green areas in Ukraine are divided by use into three types: general use, limited use and special-purpose areas (Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, 2019, p. 44). For our study in Lviv, we selected public areas. Components of the

structural elements of public-use green areas are parks, gardens, squares, boulevards, botanical gardens, embankments, forest parks, meadow parks, water parks and urban forests (Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, 2019, p. 46).

Nature reserve resource assets were included in this study only partially, as they mostly had limited access. For example, the Ivan Franko park-monument of garden and park design was included, since it offered free access to visitors, while botanical gardens with closed hours were not. Sites with access limited by entrance fees, which is an economic barrier (such as the Klymentiy Sheptytsky Museum of Folk Architecture and Life) were also not included in the study.

These locations in the city structure and their geometric parameters are based on existing urban planning documents and resources — the Urban Cadastre of the City of Lviv (*Mistobudivnyy kadastr*; Lvivs'ka mis'ka rada, 2017), the Geoportal of the Urban Cadastre of the City of Lviv (*Heoportala mista L'vova*; L'vivs'ka mis'ka rada, 2022b), the Open Data of Lviv web portal (*Portal vidkrytykh danykh Lvova*; L'vivs'ka mis'ka rada and LKP 'Mis'kyy centr informatsiynykh tekhnolohiy', n.d.), the Public Cadastral Map (*Publichna kadastrova karta Ukrayiny*, 2021), OpenStreetMap (*OpenStreetMap*, 2021), resolutions of the Lviv City Council (*Dokumenty L'vivs'koyi mis'koyi rady*; L'vivska mis'ka rada, 2022a) and other urban planning documents.

Green spaces, depending on area, can provide different levels of recreational characteristics. A study of the relationship between the size of a green area and human mental health found that parks with an area of more than 5 ha create more opportunities for walking, and meet the needs of users in regards to space, shade and water to a greater degree (Wood et al., 2017, p. 68) Accordingly, in the study, the elements public landscaping were divided by area **into three types**: areas up to 2 ha (squares), areas between 2 and 5 ha, and those with an area of 5 ha or more.

The definition of the threshold of accessibility values for Lviv is based on knowledge about human behaviour (Gehl, 2010), the accessibility of different types of green areas to housing (Senatsverwaltung für Stadtentwicklung, Bauen und Wohnen, 2013; Handley et al., 2006, p. 25; Stadt Leipzig, 2018; Roo, 2011; Kit Campbell Associates, 2001). For example, the European Environmental Protection Agency recommends ensuring access to green space within a 10 minutes' walking distance (European Environment Agency, 2020), or organize a network of green spaces within a radius

of 300 m (Kochel and Zieliński, 2021). Based on them, a comparative analysis of the specified recommendations was performed and recommended accessibility values for Lviv were formulated (Table 1). These figures are for straight-line distances, and distance travelled, including routes and barriers, may be longer.

Green space area (ha)	Straight-line distance to the green area (m)
< 2	300
2–5	500
> 5	750

Tab. 1. Threshold distance values proposed for Lviv. By the authors.

Tab. 1. Odległości od terenów zielonych proponowane dla Lwowa. Opracowanie własne.

5. COMPREHENSIVE RESEARCH METHODOLOGY FOR INVESTIGATING THE ACCESSIBILITY OF GREEN SPACES

For the purposes of our study, the territory of the city was divided into squares measuring 150×150 m, which were assigned data from the results of the study on the accessibility of local green spaces to residents, according to pedestrian accessibility radii (300, 500 and 750 m). The ability of a green space to accommodate and withstand anthropogenic load was also taken into account through the calculation of the normative indicator.

The result of the analysis of the availability of green areas is the division of the city into three zones. For this, the entire population living within the radius of accessibility to each green zone was taken into account. The calculated number of people was multiplied by the ratio of green area per inhabitant, which is equal to 10 m^2 (according to Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, 2019, p. 44) and received the required landscaped area. To identify the level of provision (the Provision Level, hereinafter referred to as **LP**), it is necessary to subtract the calculated required area from the actual area of a green space.

The indicators obtained were graded and marked on the diagrams according to the following principle:

- **LP** > 0 — pedestrian accessibility is ensured and there is access to the required area (marked in green);
- **LP** < 0 — pedestrian accessibility is ensured, but the required space is not provided (marked in yellow);
- **LP** — empty — there is no accessibility (marked in orange);
- non-residential areas are marked in grey.

To calculate anthropogenic load, it was necessary to calculate the population density of the city. Given the lack of quality data on the number of people in each individual building, additional calculations were made. For this purpose, polygons of residential buildings were selected, and the built-up area (calculated using GIS) and the number of floors (visual inspection) were determined for each building. Next, the living area was calculated, which was equal to 70% of the total building area. We obtained the population figure by dividing the living space by the indicator of housing provision per inhabitant, which as of 2019 was equal to $23.8 \text{ m}^2/\text{person}$ (Derzhavna sluzhba statystyky Ukrainy, Holovne upravlinnya statystyky u L'vivs'kiy oblasti, 2019). In this way, a population density map of Lviv was plotted.

Based on the obtained indicators, an analysis of the priority of the implementation of the City Council proposals regarding the creation of new parks and their accessibility was carried out. Priority was given to parks that served larger living areas with a higher population density, because addressing them would provide greenery to the largest number of people.

In addition to the analysis of existing problem areas, a number of future-oriented solutions for the entire territory of the city was proposed, based on the analysis of the possible further development of housing. Data on the location of the territories of future housing development was taken from urban planning documentation and the Integrated Concept of Development: Lviv 2030 (L'vivs'ka mis'ka rada, Department mistobuduvannya, Upravlinnya arkhitektury ta urbanistyky, 2021).

It is proposed to reserve the necessary parts of the territory for each problem areas and thereby protect them from development or other functional use. The formed network should cover areas of residential development.

As solutions for problem areas, the territories defined in the available urban planning documentation as **public-use recreational green zones** (hereinafter R-3) were considered in the first place. The concept includes all territories corresponding to the above zone's definition, regardless of their area. Next, the territories of the nature reserve stock, which are currently not freely accessible to residents, were worked out. Large green areas that were not labelled as an R-3 zone in urban planning documents, but

have the potential to become such, were analysed as well. The concept includes territories with a required minimum area of 0.05 ha.

In the case of the absence or lack of the necessary area after the application of the above-mentioned decisions, territories that can potentially be subjected to natural and ecological revitalization were considered, such as: post-industrial territories (also warehouse and transport areas), garage cooperatives, unbuilt residential and public building projects, utility structures, etc. Proposals with an area of more than 2 ha were included in the concept.

6. SPATIAL POLICY OF THE CITY

The basis for the planning of the landscaped area network was the existing natural framework and its features. From the point of view of the spatial structure, three concentric rings form the green areas of the city of Lviv. The first ring was formed at the beginning of the 19th century on the site of the fortifications of the medieval city and consists of boulevards and squares around the city centre. The second ring consists of parks laid out in the 19th and early 20th centuries on the slopes of the Lviv basin. The third ring is located on the borders of the city and is formed by suburban forest parks: Vynnykivskyy, Bryukhovyt'skyy, Basivskyy, Lypnykivskyy forests and is being transformed into a recreational zone of the agglomeration (Pohrebennyk et al., 2018, p. 582). From the northwest to the southeast, two pronounced green wedges cut into the city on the hills of Roztochchia and Holohory. Therefore, the system of green areas of Lviv can be described as a radial-ring system, which is highlighted in the General Plan of the City of Lviv (Kryvoruchko et al, 2008) (ill. 1). *The Integrated Concept of Development: Lviv 2030* envisages the development of a natural framework in the spatial development of Lviv (ill. 2) (L'vivs'ka mis'ka rada, Departament mistobuduvannya, Upravlinnya arkhitektury ta urbanistyky, 2021, p. 20).

The scope of the study were public-use green spaces: a total of 103 public squares (39.1 ha), 26 parks (699.7 ha) and 5 forest parks (3106 ha) were taken into account, each with legally defined boundaries or in the process of such boundaries being defined. Their total area was 3844.8 ha (ill. 3). The existing system of green spaces in Lviv was formed on the basis of natural potential and did not always take into account the location of residential areas and the need for green sites. Therefore, there is a need to develop a concept for the development of a public-use greenery network, which will help

bring recreation closer to residents, stimulate physical activity, and improve the quality of life in the city in general.

7. ACCESSIBILITY OF PUBLIC-USE GREEN SPACES IN LVIV

To carry out our study, the areas of public green spaces were identified using the cadastre, and the density was calculated according to the method above (ill. 4). Afterwards, an analysis of whether residents were provided with a normative area of green spaces was carried out.

Illustration 5 will present how many square meters of greenery were found to be available for each resident from a certain point in the city, regardless of population density. According to the results, the situation was the best in the peripheral areas of the city, located close to city forest parks. Here, the residents had more than 60 m² of green areas within walking distance. The worst situation in terms of ensuring the standard area within walking distance was found in the areas from the Soviet period, where there was no coverage within walking distance and the necessary landscaped space area. In the central part of the city, a significant number of parks were found to provide residents with green spaces within walking distance, but their total area was determined to be too small to meet the recreational needs of all residents.

The map presented in illustration 6 will show the results of the analysis of the access to public-use green spaces in Lviv, taking into account the population density.

In general, the ratio of green area per capita in the city was 52.7 m²/person. (taking into account the area of forest parks, which are poorly adapted for recreation) at 10 m²/person. Despite the significant excess, according to the conducted research, 46.7% of city residents had access to high-quality green areas within walking distance, 21.3% of residents are within walking distance to green space with a large anthropogenic load, and 32% of residents lived in areas without access to greenery (ill. 6).

Problem areas were identified and assigned priority status for overcoming of existing deficits:

- A — area outlined by Kulparkivska, Naukova, Knyahyni Ol'hy and Volodymyra Velykoho streets;
- B — area outlined by Zaliznychna, Horodotska, and Shevchenko streets;
- C — area outlined by Pekarska and Zelena streets;
- D — the Sykhiv district;
- E — area outlined by V. Chornovola, Zamarstynivska, Promyslova streets and the railway line;

F — area outlined by Hashek and Maksymovych streets;

G — area outlined by Hrinchenko, B. Khmelnytsky and Lypynskyy streets;

H — Riasne-1 district.

A number of measures to improve landscaping are planned by the Lviv City Council. In 2020–2024, it is planned to approve the boundaries of 10 more parks with a total area of 200 ha: a park on the Citadel, a park on the territory of the SKA, a park near the Medical University (Pekarska street), the Industrial Park (between Lincoln and Lypynskyy streets), Metropolitan Gardens, the park near Stosika Lake and around the lake at the intersection of Stryiska and Naukova streets, the Bilohorshcha peatland (three of them already have approved boundaries, Bolytanyy Park in Riasne, Kulparkiv Park) (Sadovy and Obyednannya Samopomich, 2021). If these plans are implemented, 53.1% of the city's residents will have access to greenery. Access is provided for 23.2% of residents, but there is a lack of green areas. In general, this proposal will improve the situation in the city by 6.4% and 1.9%, respectively. However, 23.7% of the population will still not have access to public-use landscaped areas within walking distance from their house (ill. 7).

8. MAIN MEANS OF ENSURING ACCESS TO PUBLIC-USE GREEN AREAS

Access to public green spaces was found to vary widely across the city and even within the same district. The concept of forming a public greening network is aimed at solving this problem.

Proposal of ensuring access to green areas

As a result of the analysis, the eight most problematic areas of the city with limited access to public green spaces were identified. Most of them were districts planned during the Soviet era: Volodymyra Velykoho–Naukova, Sykhiv, Riasne-1, Hrinchenko–Mazepa, which is due to the incorrect approach to providing of recreational functions in the district during the Soviet period. The lack of greening in the Pidzamche area was probably caused by the historical industrial specialization of the area.

The following types of solutions are proposed to address issues in the problem areas:

1. Approve the boundaries of the green areas defined in the existing urban planning documentation as R-3 zones.
2. Develop usage models that will improve access to nature reserve resource asset sites (e.g., botanical gardens, dendrological parks of closed institutions).

3. Reserve land for public-use landscaped areas in the process of transformation of the grounds of industrial plants or technology parks.

4. Transform garage cooperatives into public green areas.

5. Change the functional use of areas (intended for the construction or transport infrastructure).

6. Clarify regulatory requirements for the design of new residential blocks.

Among the R-3 zones defined in the urban planning documentation, most of them have an area of less than 2 ha, that is, they are public squares that do not fully meet the basic needs of residents. Only 147 ha of land (16 sites) out of the 337.2 ha provided for in the urban planning documentation can be considered parks with an area greater than 2 ha. These territories are mostly located in districts that are equipped with necessary areas and have proper access radii (Pidholosko Hills and the area north of the Zboishcha district), some are located near the city limits or in undeveloped areas (to the south of Arena Lviv and northwards of the Bilohorshcha district). It is important to preserve both the first and second groups in the documentation for the perspective of expanding residential development. Other such areas are located near the already existing large green areas in the zone of low-density single-family development (to the south of Sykhiv Forest and between the two strands of Vynnyky Forest), the Professor's Colony (loose development), on Yaneva street (it is crucial for the prospect of further development around).

Among areas that greatly contribute to providing the relevant access is the lake near Symonenko Street. All the sites described above are important as part of the general natural framework, but due to their location relative to residential development, they are not decisive in terms of providing access to greenery to the population.

As the last item in the list of proposed types of solutions, it is recommended to clarify the regulatory requirement for the design of new residential blocks, which only provides for the standardization of the total landscaped area (Derzhavni budivel'ni normy. Planuvannya i zabudova terytoriy, 2019, p. 47), which designers usually count as the area of lawns around a building. Instead, it is proposed to create public greenery facilities (parks, squares) with an area proportional to the number of apartments.

Applying the above list of solution types, we will formulate a proposal to solve key problem areas with specific territories, which will complement the existing situation and the proposals of the Lviv City Council and form a network of public-use greenery, i.e., equitable coverage of the city's territory.

The proposed areas will increase the available area of public green spaces by 155.2 hectares. In general, it is proposed to reserve additional land in the city and increase the available area of public-use green areas by 553.5 ha (taking into account the proposal of the Lviv City Council) for the perspective of development (ill. 8).

Proposed types of solutions:

- 337.2 ha — approval of the borders of green areas, which are defined in the existing urban planning documentation as the R-3 zone;
- 49.2 ha — improving access to nature reserve resource assets (botanical gardens);
- 56.5 ha — reservation of land for public-use landscaped areas in the process of the transformation of post-industrial areas or technology parks;
- 25 ha — transformation of garage cooperatives into public landscaping areas;
- 85.6 ha — change of functional use of territories (intended for construction or transport infrastructure).

Implementing the proposed areas will ensure access to green spaces for 61.2% of the city's residents. Access will be provided to 31.6% of residents, but there will be a lack of space, and 7.2% will not have such access. As we can see from the results, this list is not definitive and requires more detailed elaboration by specialists and strategic planning by the city to ensure 100% access to green spaces.

9. CONCLUSIONS

Green areas have a significant impact on the well-being of residents, the development of the economy and the ecology of the entire city. It is a determining factor in the formation of a comfortable city environment.

The green area accessibility proposal includes a number of characteristics — social, economic, spatio-temporal, physical, etc. When analysing or planning the availability of green spaces in the city, it is necessary to take into account both the ratio of green area per capita and its physical accessibility relative to residential areas.

This study was built on several stages of verification: accessibility as measured by distance, accessibility as measured by normative indicators, problem

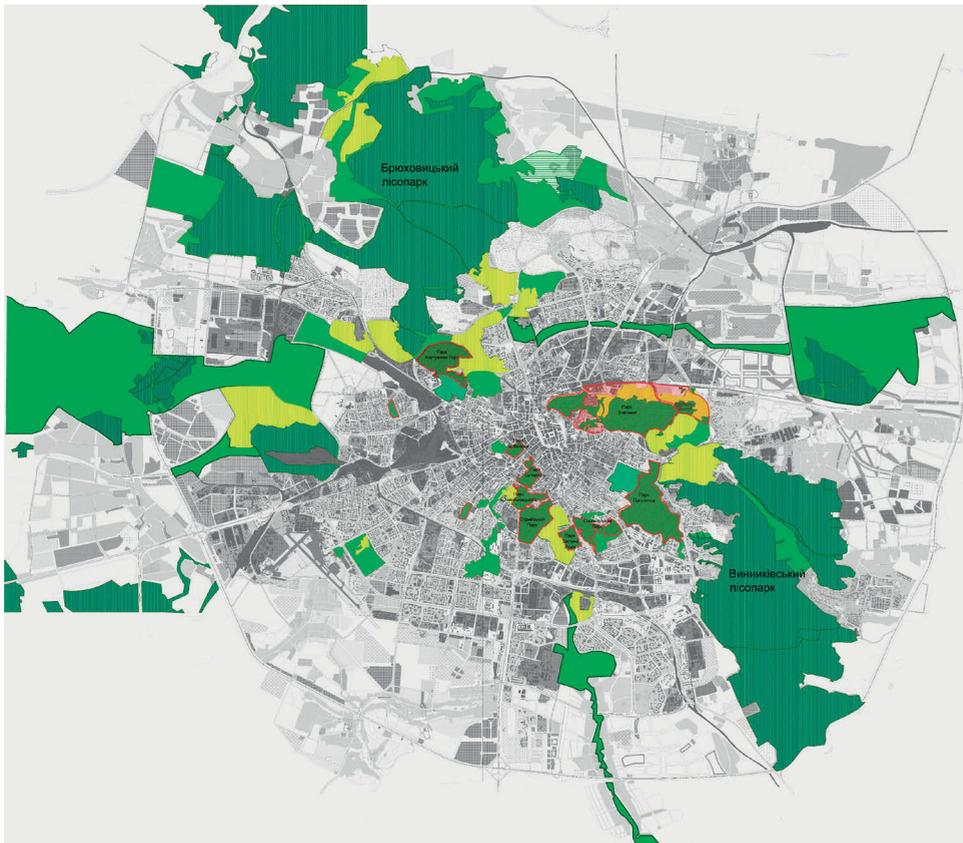
area identification, implementation of existing project proposals. All decisions are correlated with population density, which determines the priority of intervention. The results of the analysis of the accessibility of green areas were graded by the level of provision for zones: pedestrian accessibility and the required area were provided; pedestrian accessibility was ensured, but there was a lack of space; accessibility was not guaranteed.

It is proposed to divide all public-use green areas in Lviv into three types by area in accordance with their capacity to serve specific uses: up to 2 ha, between 2 and 5 ha, more than 5 ha. Threshold values of pedestrian accessibility are a straight-line distance (radius) and are determined basing on the analysed experience for each type: up to 2 ha — 300 m; from 2 to 5 ha — 500 m; more than 5 ha — 750 m.

As a result of the research, it was found that today 32% of residents have no access to green areas, provided that project-related decisions of the Lviv City Council are implemented, this figure will decrease to 23.7%. At the same time, the number of residents with good access, for whom regulatory indicators are met was found to be 46.7% (it will be 53.1%).

The understanding of the problem of the access to green spaces is offered in planning purposes and can be traced in strategic documents, but neither they nor the existing natural framework contributes to improving the situation. This analysis found eight significant problem areas in the city without access to green areas. The most problematic zones are Soviet-planned areas, as well as former industrial areas that are currently being transformed. By 2024, the city council plans to create new parks, to a greater extent approving the boundaries of existing green areas, but the proposed solutions will not solve the situation as a whole.

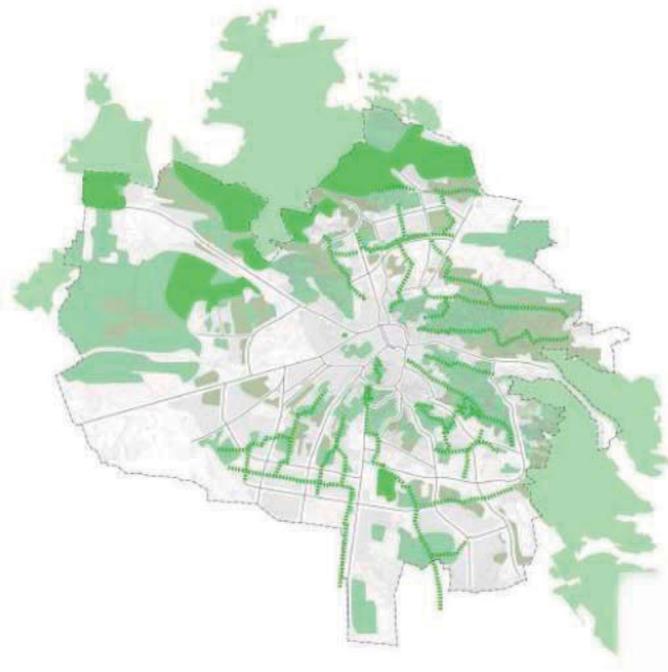
It is proposed to implement the concept of development of public-use green spaces, evenly distributed within the structure of the city, by such means as: approval of the boundaries of existing public-use green spaces, transformation of areas (technoparks; garage cooperatives; former industrial enterprises; land intended for development or transport infrastructure of the city) into green spaces. In addition, it is recommended to define the provisions of regulatory documents regarding the design of new residential blocks in terms of ensuring green space access to the population.



Ill. 1. Scheme of the framework of Lviv's green spaces according to the General Plan until 2025.

Il. 1. Schemat systemu przestrzeni zielonych Lwowa według Generalnego Planu miasta Lwowa do roku 2025.

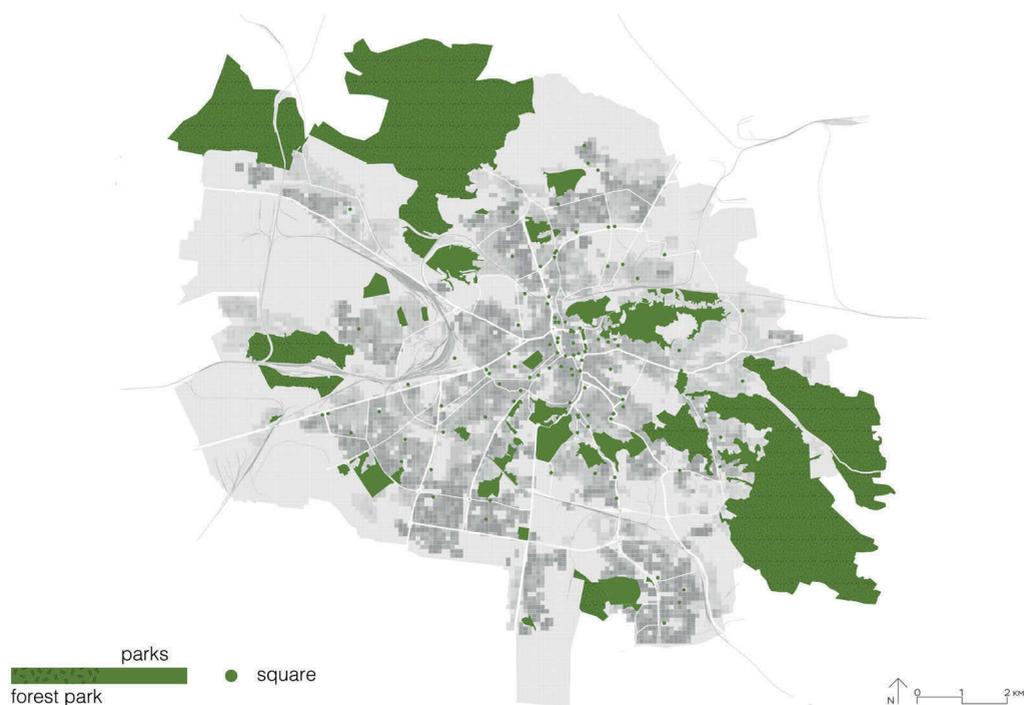
Source/źródło: (Kryvoruchko et al., 2008, scheme 10).



Ill. 2. Development of the natural framework in the spatial development of Lviv according to the Integrated Concept of Development: Lviv 2030 (marked in bright green).

Il. 2. Rozwój systemu przyrodniczego w rozwoju przestrzennym Lwowa według Zintegrowanej Koncepcji Rozwoju: Lwów 2030 (oznaczone na jasnozielono)

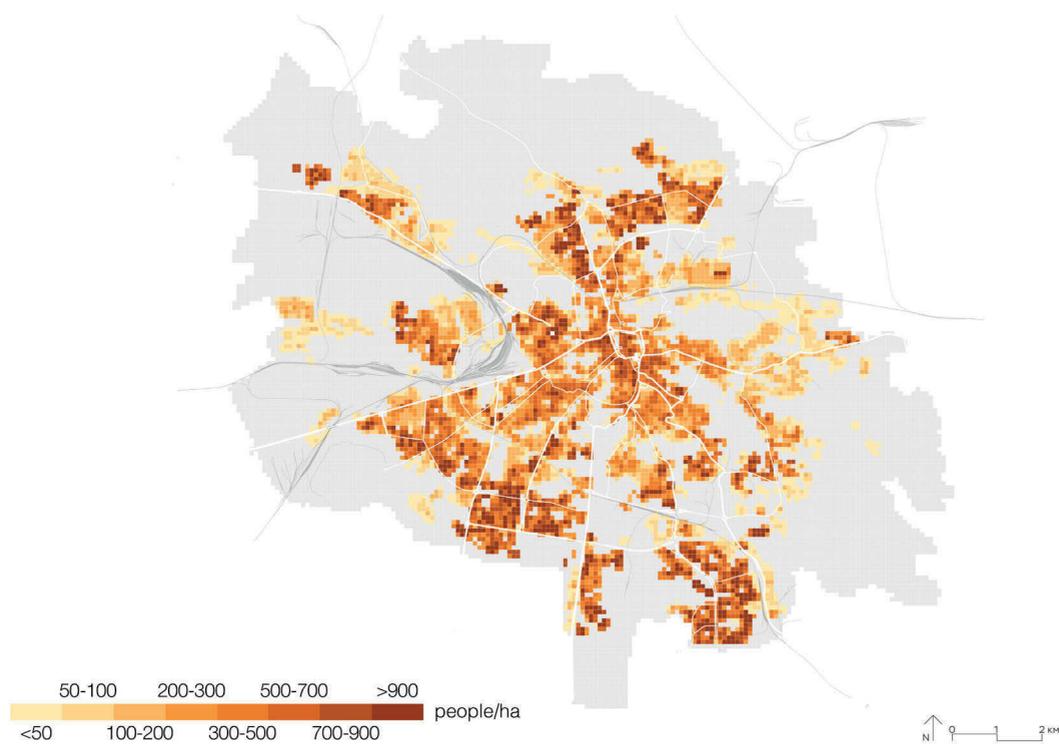
Source/źródło: (L'vivs'ka mis'ka rada, Departament mistobuduvannya, Upravlinnya arkhitektury ta urbanistyky, 2021, p. 20).



III. 3. The system of public-use green spaces in Lviv as of 2021.

II. 3. System przestrzeni zielonych użytku publicznego we Lwowie w 2021 roku

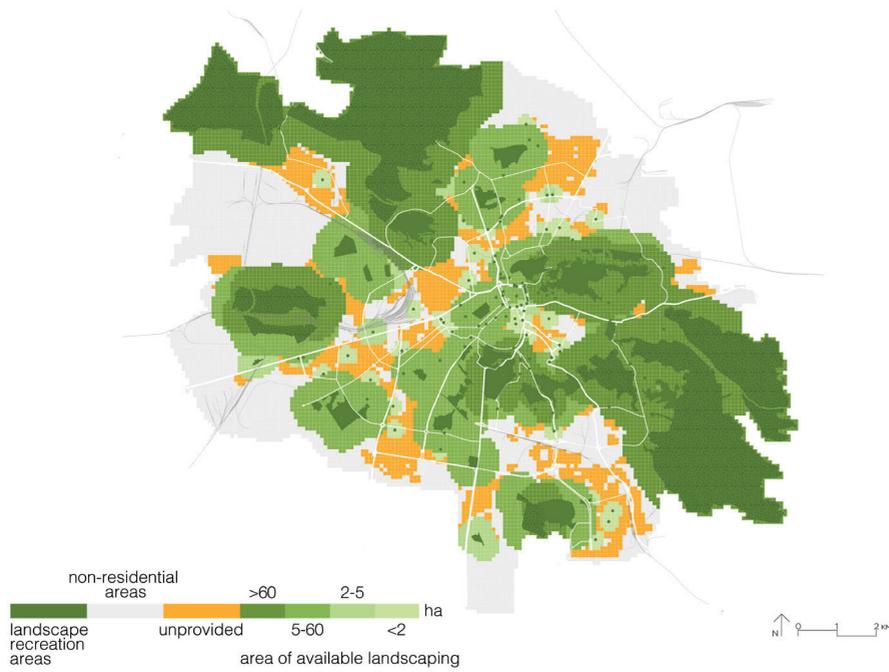
Source/źródło: (Peleshchak, 2021, p. 44).



III. 4. Analysis of population density of Lviv.

II. 4. Analiza gęstości zaludnienia Lwowa.

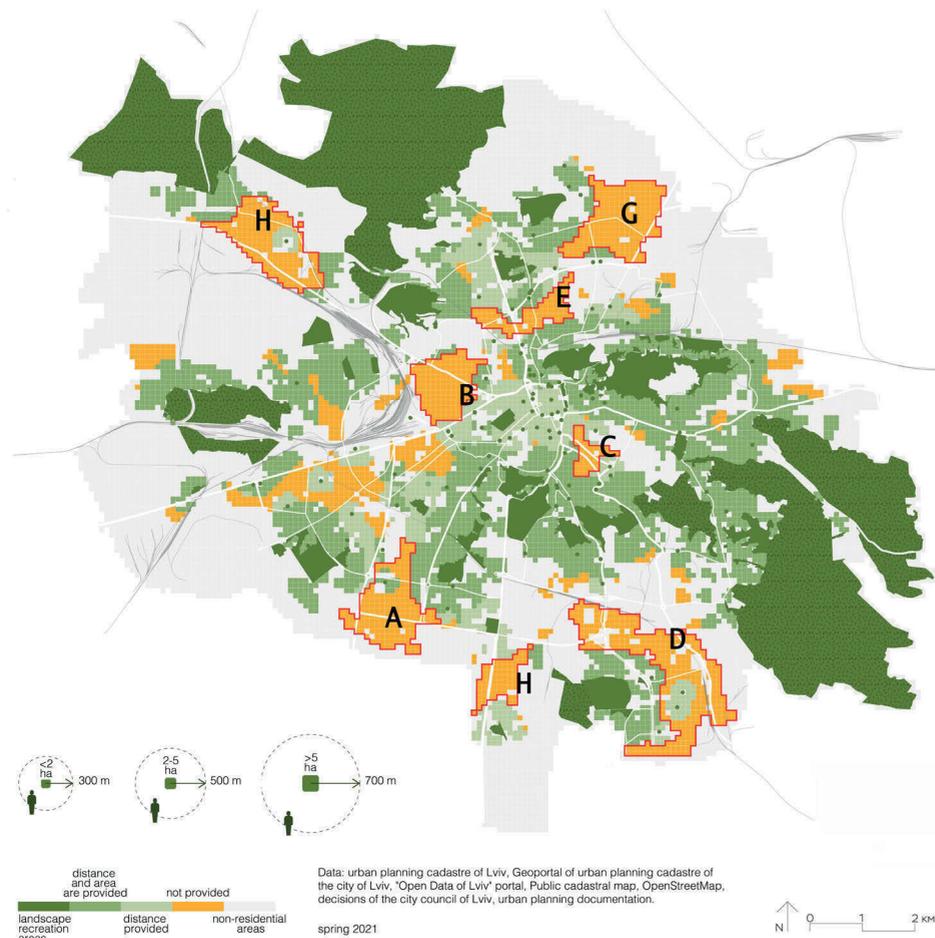
Źródło/source: (Peleshchak, 2021, p. 47).



Ill. 5. Analysis of the provision of public-use green areas in Lviv.

Il. 5. Analiza zapewnienia przestrzeni zielonych użytku publicznego we Lwowie.

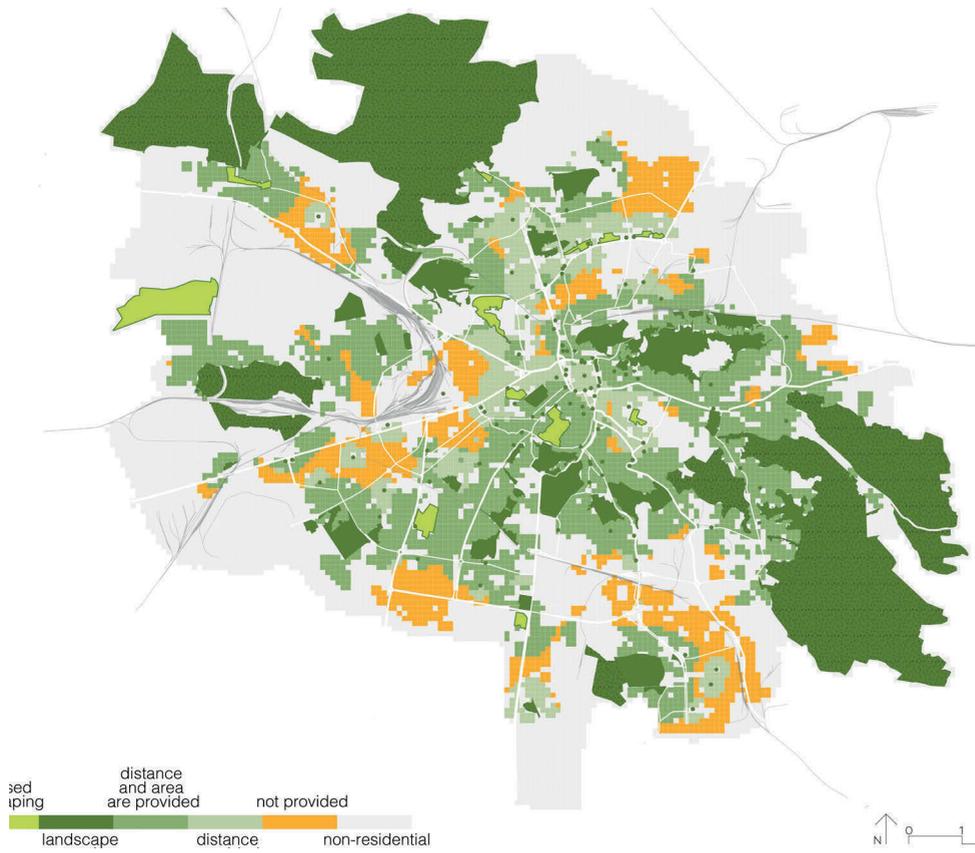
Source/źródło: (Peleshchak, 2021, p. 48).



Ill. 6. Analysis of access to public-use green spaces in Lviv. Letters were used to mark the areas with deficits.

Il. 6. Analiza dostępności publicznych przestrzeni zielonych we Lwowie. Literami oznaczono obszary z deficytami.

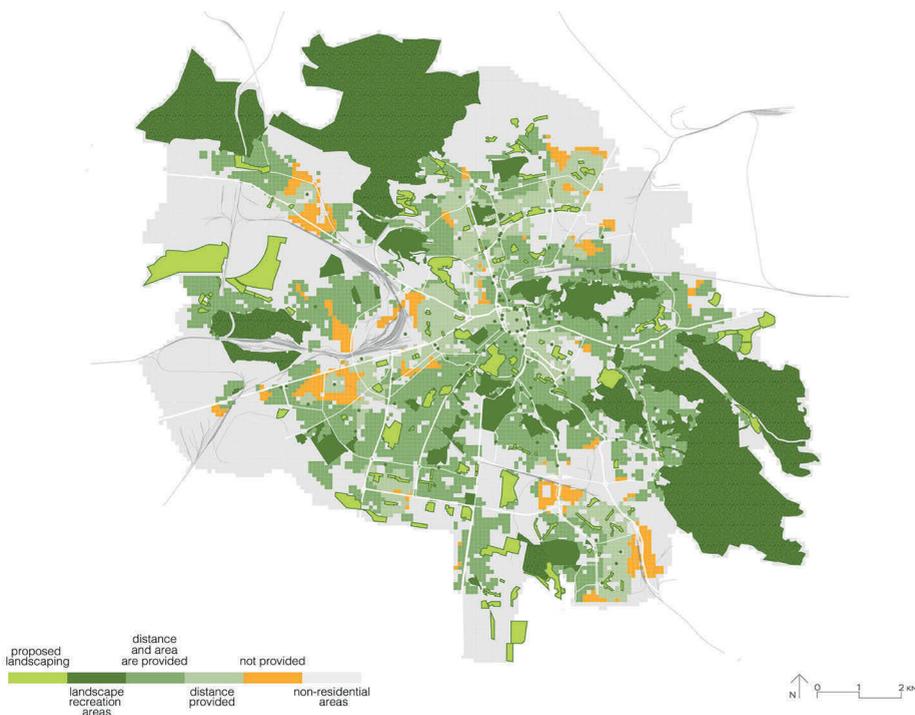
Source/źródło: (Peleshchak, 2021, p. 49).



Ill. 7. Analysis of the accessibility of public-use green spaces in Lviv, taking into account the proposals of the Lviv City Council 2020–2024.

Il. 7. Analiza dostępności publicznych przestrzeni zielonych we Lwowie, po uwzględnieniu koncepcji Rady Miasta Lwowa na lata 2020–2024.

Source/źródło: (Peleshchak, 2021, p. 53).



Ill. 8. Green area accessibility proposal.

Il. 8. Koncepcja kształtowania dostępności terenów zielonych.

Source/źródło: (Peleshchak, 2021, p. 60).

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