CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Environmental Sciences

Department of Landscape and Urban Planning

The role of neighborhood green space in urban green space provision: a case study in Brest, Belarus

Diploma Thesis

Thesis Supervisor: doc. Peter Kumble, Ph.D.
Author: Petr Pushkarou

Prague
2022

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Environmental Sciences

DIPLOMA THESIS ASSIGNMENT

Petr Pushkarou

Landscape Engineering
Landscape Planning

Thesis title

The role of neighborhood green space in urban green space provision: a case study in Brest, Belarus

---

Objectives of thesis

The thesis aims to define the role of neighborhood green spaces, which in this thesis are understood as semi-public urban green spaces of neighborhood significance located in high- and low-density residential development and are mainly used by local residents of adjacent housing units (community gardens, public courtyards, playgrounds, green buffers, etc.), on the basis of analysis of the spatial distribution of urban green spaces in Brest, Belarus. Through the spatial distribution, the residential districts with the richest and the poorest quality of urban green space provision within walking proximity can be identified, and through the analysis of the survey results, the perceived role of neighborhood green spaces for the residents throughout the city can be defined.
The goal is to assess residents’ perception and current use of neighborhood green spaces in their residential districts in the city of Brest, Belarus to identify what possible changes may be implemented to make these spaces more suitable and attractive for people’s use.
This study raises a set of questions. (1) Are residents of Brest equitably provided with urban green spaces of city and district significance? (2) Can neighborhood green spaces be perceived as an important element for meeting recreational and nature needs among residents, and if so, (3) what possible changes in legislation, management, and design approaches regarding neighborhood green spaces need to be achieved to meet public needs?

Methodology

The thesis is based on the analysis of both theoretical and empirical literature as well as original analysis. The first part of the work consists of geospatial analysis represented by GIS open data visualization of the urban green infrastructure of the city of Brest, Belarus, along with qualitative and quantitative methods. Geospatial analysis has been performed in QGIS software. In order to differentiate residential districts according to the degree of urban green space provision, the following steps have been taken:

- Identifying urban green spaces and their qualities (green cover, area, ownership, etc.)

- Defining a walking distance that represents an accessibility radius of a service area of urban green spaces

- Estimating a population living within urban green spaces’ service area

- Finding an urban green space provision per capita (sq.m. of green cover per capita)

- Differentiating residential districts according to urban green spaces provision for further analysis

Based on that, the author identifies the poorest and richest residential districts in the city in terms of urban green space provision. Defining critical areas across the city with the lowest numbers may help to prioritize future actions for city planners in renovating neighborhood green spaces within the poorest districts, considering these green spaces as a possible compensatory element filling gaps in urban green spaces in walking proximity.

In the second part, a perception and current use of neighborhood green spaces in Brest's residential districts is assessed by holding a questionnaire to find its actual potential as recreational areas in immediate surroundings and possible ways of its renovation. The research addresses issues concerning residents' demand for renovating their neighborhood green spaces which nowadays is manifested in Do-It-Yourself urban green space interventions. Also, it emphasizes the actual potential of neighborhood green spaces in meeting people's demand in recreation and nature contact in their immediate surroundings, which becomes crucial in the light of the densification process as one of the contemporary trends in urban policy worldwide.

The proposed extent of the thesis

70 pages

Keywords

green infrastructure, urban green space, neighborhood green space, green space change, urban green space intervention, renovation, urban green space provision, residential density, sustainable urban development, social cohesion, geospatial analysis, GIS, questionnaire

---

Recommended information sources

Haaland C., van den Bosch C.K. (2015). Challenges and strategies for urban green-space planning in cities undergoing densification: A review. Urban Forestry & Urban Greening 14 (2015) 760–771.

Rupprecht C. D.D., Byrne J. A. (2014). Informal urban greenspace: A typology and trilingual systematic review of its role for urban residents and trends in the literature. Urban Forestry & Urban Greening 13 (2014) 597–611.

Sikorska D., Łaszkiewicz E., Krauze K., Sikorski P. (2020). The role of informal green spaces in reducing inequalities in urban green space availability to children and seniors. Environmental Science and Policy 108 (2020) 144–154.

Taylor L., Hochuli D.F. (2016). Defining green space: Multiple uses across multiple disciplines. Landscape and Urban Planning 158 (2017) 25–38.

WHO Regional Office for Europe (2016). Urban green spaces and health: a review of evidence. Copenhagen: WHO Regional Office for Europe (http://www.euro.who.int/ en/health-topics/environment-and-health/urbanhealth/publications/2016/urban-green-spaces-andhealth-a-review-of-evidence-2016, accessed 23 March 2017).

WHO Regional Office for Europe (2017). Urban green space interventions and health: a review of impacts and effectiveness. Copenhagen: WHO Regional Office for Europe (http://www.euro.who.int/__data/assets/ pdf_file/0010/ 337690/FULL-REPORT-for-LLP.pdf?ua=1, accessed 15 May 2017).

Expected date of thesis defence

2021/22 SS – FES

The Diploma Thesis Supervisor

doc. Peter Kumble, Ph.D.

Supervising department

Department of Landscape and Urban Planning

Electronic approval: 21. 2. 2022

prof. Ing. Petr Sklenička, CSc.

Head of department

Electronic approval: 22. 2. 2022

prof. RNDr. Vladimír Bejček, CSc.

Dean

Prague on 23. 03. 2022

Author’s Declaration:

I hereby declare that the work presented in this thesis entitled ‘The role of neighborhood green space in urban green space provision: a case study in Brest, Belarus’ is original and done by me independently, under the direction of doc. Peter Kumble. I have listed all literature and publications from which I acquired information in the attached list of references at the end of the thesis.

In Prague on 27.03.2022

Acknowledgements

Thank you to my supervisor, doc. Peter Kumble, for supporting and encouraging me throughout my studies and particularly during writing this work.

I am deeply obliged for support of my family who has been always inspiring me and believing in my capacities. This work would also not be achievable if not my friends from the Czech Republic, Italy, and Belarus, who have been constantly boosting morale and motivating me over the past three years.

Abstract

The thesis aims to define the role of neighborhood green spaces based on analysis of the spatial distribution of urban green spaces in Brest, Belarus. The goal is to assess provision of urban green spaces in the city and evaluate the residents' perception and current use of neighborhood green spaces located in residential blocks. A GIS analysis performed in the work identifies the city's residential blocks with the highest and lowest numbers of urban green space provision per capita. The research classifies green spaces into two groups (of city and district significance) with the respect to their size, location, and recreational value. UGSs' accessibility radius which represents a service area is chosen based on a type of significance (5 km – for city, 1 km – for district significance). Critically small numbers on the provision of green spaces of district significance throughout the city (67.2% of inhabitants have <1 m² of green spaces with a recommended value of 7 m²/capita) raise an issue of their accessibility in walking proximity for residents. The questionnaire results show that the respondents acknowledge unexplored potential of their neighborhood green spaces and express demand for their renovation to use them in the future. Low level of maintenance and lack of amenities is the key factor limiting more frequent use of green spaces in the city.

Key words: urban green space intervention, green space change, residential development, spatial analysis, questionnaire

Abstrakt

Cílem práce je definovat roli zeleně v sousedních městských částech města Brest v Bělorusku na základě analýzy prostorového rozmístění městské zeleně. Cílem je posoudit dostupnost městské zeleně a zhodnotit, jak obyvatelé vnímají a aktuálně využívají sousedské zelené plochy nacházející se v rezidenčních oblastech města. Analýza GIS provedená v práci identifikuje rezidenční oblasti města s nejvyšším a nejnižším zastoupením městské zeleně v přepočtu na obyvatele. Výzkum klasifikuje zelené plochy do dvou skupin (město a čtvrtě) s ohledem na jejich velikost, umístění a rekreační hodnotu. Poloměr dostupnosti městských zelených ploch, který představuje obslužnou oblast, je zvolen na základě typu významu (5 km - pro město, 1 km - pro čtvrť). Vysledky ukazují kriticky malé zastoupení zeleně na urovni čtvrtí a to v rámci celého města (67.2 % obyvatel má < 1m² zeleně s doporučenou hodnotou 7m²/obyvatele) a poukazují na otázku jejich dostupnosti v pěší vzdálenosti pro obyvatele. Z výsledků dotazníku vyplývá, že respondenti vnímají nevyužitý potenciál zelených ploch ve své čtvrti a vyjadřují poptávku po jejich obnově, tak aby mohli tyto plochy v budoucnu využívat. Nízká úroveň údržby a nedostatečná vybavenost je klíčovým faktorem omezujícím častější návštěvnost zelených ploch ve městě.

Klíčová slova: údržba městské zeleně, změna distribuce městské zeleně, obytná zástavba, prostorová analýza, dotazník

Table of Contents

1. Introduction

Urban green spaces (UGSs) have become a key component in shaping cities providing various social, ecological, and economic benefits for urban inhabitants. UGSs include gardens, parks, zoos, suburban natural areas, and forests, etc. (EEA, 2012), and provide an important common space and zone for social cohesion for people and nature within a highly urbanized landscape. Urban green spaces in cities provide a wide range of ecosystem services for people, improving human health and well-being, mitigating climate change effects and extreme weather events, and reducing maintenance costs (Schipperijn, 2010).

A population trend for recent generations has remained unchanged and grown exponentially. Worldwide people have continued to inhabit urban areas as a result of rapid population growth and as transformations of the world's economy by a combination of rapid technological and political change. By 2050, 68% of the world's population is estimated to live in urban areas, which are characterized by a high population density and infrastructure of the built environment with paved surfaces and impervious (non-vegetated) surfaces (Weeks, 2010). Nowadays, this figure comprises about 55% (UN WPP Highlights, 2018). Being centers of both production and consumption, capacity of urban areas across the globe to provide services for their inhabitants is not keeping pace with rapid urban growth (Cohen, 2006).

There is a growing body of studies showing a strong connection between urban vegetation in residents' immediate surroundings and positive health outcomes, especially among the elderly and children (Amoly et al., 2014; Ekkel & de Vries, 2017; Grazuleviciene et al., 2015; etc.), due to regular direct and indirect exposure to their closest UGSs. To provide all residents with available UGSs in their immediate surroundings, urban planners ought to thoroughly plan its spatial distribution within an urban area. However, constantly growing cities nowadays lack green spaces throughout their urban environment. More dramatically, dense urban areas end up being unable to create new green spaces (such as parks) to fulfill requirements on green space provision (Baycan-Levent & Nijkamp, 2009).

While residential blocks are provided with formally designed and regularly maintained green spaces in surroundings, others might be deprived of them. A walking distance for UGSs is defined differently across studies. It has been noted that a 300-400 m distance is a threshold value after which the use of UGS plummets significantly (Hogendorf et al., 2020; Grahn & Stigsdotter, 2003). Nevertheless, researchers and urban planners often set their own acceptable figures according to local context. For instance, a study in California (U.S.) used a 500-meter buffer as a suitable walking distance from the residential blocks to the nearest parks to find correlations between the childhood obesity rate and proximity to green spaces (Wolch et al., 2011). In this work, UGSs of the city of Brest (Belarus) are classified into two groups (city and district significance) with the respect to such qualities as UGS' size, location, and recreational value. This allows to apply different distances of UGSs' service areas for each group. One kilometer distance is taken for UGSs of district significance, while five kilometers for UGSs of city significance.

Unequal distribution of UGSs (Kabisch & Haase, 2014) may also cause exclusion of certain population groups in their level of exposure to green spaces (visit frequency), depending on their age, race, income, and immigrant status (Wolch et al., 2014; Sister et al., 2010; Pham et al., 2012).

The role of neighborhood green spaces (NGS) in this regard may be reconsidered to increase urban green space provision (per capita) for vulnerable strata of society, especially for the elderly and children (Sikorska et al., 2020). NGSs may take various forms ranging from informal 'green' gaps (buffers) between residential buildings and brownfields (Rupprecht & Byrne, 2014) to more regularly maintained types like courtyards and community gardens. Being broadly spread across the urban area, NGS has an unexplored potential in terms of enhancing UGS supply for residents in their walking proximity. However, NGSs in Brest are usually poorly designed and are not regularly maintained, which make them less attractive for people's use.

The research presented in this thesis aims to explore three main themes: (1) a definition of the spatial distribution of the UGS-system in the city of Brest, the 6th most populated city in Belarus (around 352,300 inhabitants) with a constantly growing population to identify the most disadvantaged residential districts in terms of formal urban green space provision, and (2) assessment of the residents' perception of NGSs and their potential role in residential areas. After defining its aspects and unexplored potential, the research then (3) discusses potential ways of renovating and adding functionality to NGSs based on residents' preferences derived from survey results to turn them into viable and full-functional spaces for recreation.

2. Objectives of study

The thesis aims to define the role of neighborhood green spaces based on analysis of the spatial distribution of urban green spaces in Brest, Belarus.

The primary objective of the thesis is evaluating current perception of neighborhood green spaces among respondents as a potential space for recreation and finding their readiness in renovation of these spaces for further use. The work also identifies factors limiting more frequent use of UGSs and NGSs and finds ways of addressing the issue.

The study detects critical areas with low UGS provision (per capita) across the city by calculating this indicator for each residential block. Ranging UGSs according to a type of significance may help evaluating a provision of green spaces with the respect to their qualities (size, location, recreational value). Identifying areas with the lowest provision of green spaces in a walking proximity may allow urban planners to prioritize their further actions on renovation of NGSs within disadvantaged blocks to provide an equitable UGS provision in the whole city.

3. Literature review

3.1. Defining urban green space (UGS)

Despite a relatively well-established understanding of the importance of green spaces for the quality of urban life among researchers (Sadler et al., 2011; Bolund and Hunhammar, 1999; Hickman, 2013, etc.) there still does not exist a universally agreed-upon definition for it. This is mainly due to the abundance of disciplines across different fields of sciences in which the term is applied.

The basic term ‘green space’ is usually complemented with an adjective ‘urban’, referring to a concrete type of human-dominated ecosystem called ‘urban ecosystem’ (McIntyre et al., 2000). Spatially, a study subject (vegetation) in the term ‘urban green space’ is strictly defined, which makes it more coherent. At the same time, the term ‘open space’ (without specifying a presence of vegetation) is more associated with rural and suburban environment where vegetation is presented to a much bigger extent. In these terms, it is important to rigorously define the common term and adhere solely to it throughout the paper to avoid possible ambiguities (Taylor & Hochuli, 2016).

Even more holistic term that encompasses the term ‘green space’ is ‘green infrastructure’ (GI). It also has no single recognized definition due to its multifunctional character. GI incorporates a broad range of different elements (green space is one of them). A spatial application of the term is no less ambiguous and sometimes may include both urban and rural settings because no well-defined spatial limits have been established for GI distribution. At a regional scale of application, for example, GI uses the Natura 2000 network as its backbone. The Natura 2000 is a coordinated network of protected areas covering Europe's most valuable and threatened species and habitats (European Commission, 2019).

Moreover, green infrastructure may be considered variously, according to actual needs of study. The following table represents some examples of GI definitions across the studies.

Table 3.1.1 Examples of green infrastructure interpretation (Credits: author)

GI as:	Definition	Reference
Approach and tech-nology	GI ‘is management approaches and technologies (to wet weather management) that uses soils and vegetation to utilize, enhance and/or mimic the natural hydrological cycle processes of infiltration, evapotranspiration, and reuse.’	US EPA (2008)
	GI ‘as the set of planning approaches that maintain ecological functions at the landscape scale in combination with multi-functional land uses.’	IEEP (2011)
Concept	GI ‘is a concept that is principally structured by a hybrid hydrological/drainage network, complementing, and linking relic green areas with built infrastructure that provides ecological functions. It is the principles of landscape ecology applied to urban environments.’	Ahern et al. (2007)
Actions	GI ‘is the actions to build connectivity nature protection networks as well as the actions to incorporate multifunctional green spaces in urban environment.’	EEAC (2009)

Network	GI 'is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services; it incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings.'	European Commission (2019)
	GI 'is an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife.'	Benedict & McMahon (2006)

Wide range of scales and diverse interpretations of the term 'GI' create an abundance of its definitions. GI can be manifested in different elements at every scale of planning: build, street, neighborhood, and regional (or, strategic) scales (Simić & Bajić, 2013; The Scottish Government, 2011). GI is often complemented with blue infrastructure (BI) elements setting together a strategically planned blue-green infrastructure (BGI) network (European Commission, 2019). The following figure adapted from the Scottish Government' (2011) handbook on green infrastructure provides a series of examples of BGI elements depending on a scale. Being mutually connected, elements form a BGI network which can benefit the area at a strategic (regional) level.

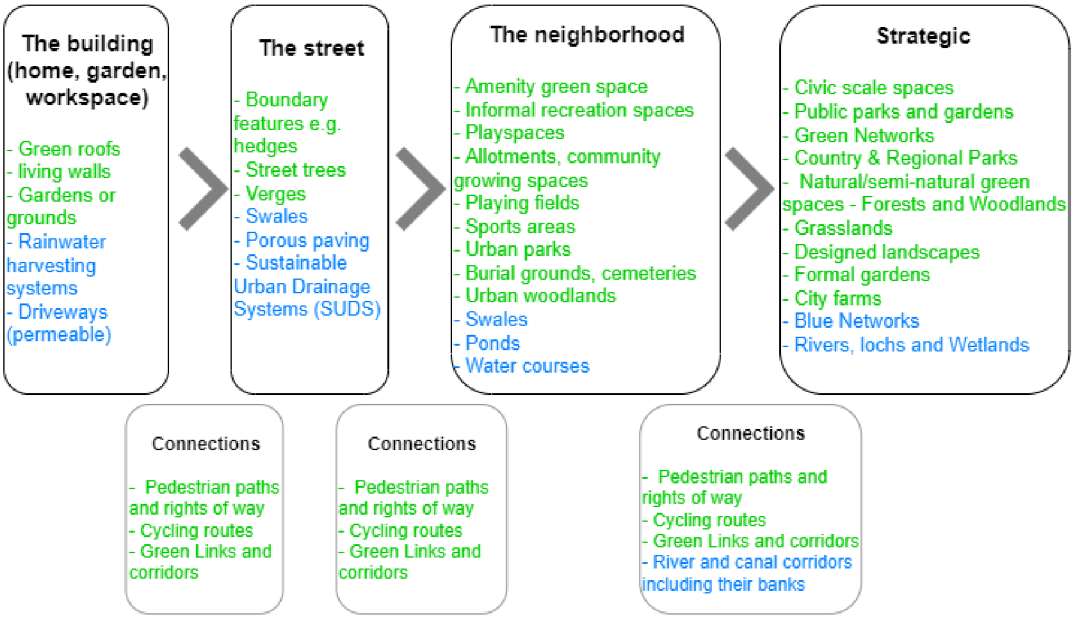

Figure 3.1.1 Green and blue infrastructure elements (defined by color) in different scales of application
(Adapted from the Scottish Government' handbook, 2011)

The ensemble of various GI elements can be generally grouped into four categories, the Bartesaghi Koc et al.' (2017) multi-study analysis claims: (a) tree canopy; (b) green open spaces; (c) green roofs; and (d) vertical greenery systems (green walls/facades). First two categories where specified as the most of researchers' attention due to their complexity, variability, and important role in GI planning. Despite overlaps in the terminology across studies, most of green assets can be grouped into four categories. The categories together with different terminology is illustrated in Table 3.1.2.

It is noteworthy that some studies consider green roofs (GR) together with green open spaces since they can provide the same set of ecosystem services benefiting residents. The importance of GR can also be explained in replacement of lost terrestrial green space in cities, especially the ones undergoing densification process (Rogers, 2013; Molloy & Albert, 2008).

Table 3.1.2 Different terminology associated with main categories of green infrastructure (GI) (Credits: Bartesaghi Koc et al., 2017)

Tree canopy (TC)	Green open spaces (GOS)	Green roofs (GR)	Vertical greenery systems (VGS)
- Green canopy - Green streets - Green alleys - (Street) Trees - Shrubs, shrubbery - Tree cover - Urban forestry - Urban tree canopy - Woodland - (Forest) land	- Green belts - Green corridors - Green covers - Green spaces - Greenways - (Vegetated) ground covers - Ground surfaces - Land covers - (Public) (Urban) open spaces - Urban land - (Urban) vegetation structures - Vegetative covers	- Eco-roofs - Green rooftops - Living roofs - Rooftop gardens	- Bio-walls - Green facades - Green walls - Living walls - Vertical landscaping - Vertical vegetation

The present work mainly deals with the GOS-category of GI. The subject (green spaces) and locality (urban area of the city of Brest) of the present work determine use of one particular element of green infrastructure more than others. To avoid ambiguity, the author modifies the term for GOS according to the subject (green spaces) and locality (Brest urban area). The term ‘urban green space’ (UGS) is considered more accurate, since it refers directly to an urban area and thus meets the research objectives the most. This term is used throughout the paper if other GI elements are not intentionally specified. In generic terms, UGS is defined by the author as *vegetated, formally designed publicly accessible open space in an urban area with a certain level of maintenance and amenities (e.g., city park, residential park, boulevard)*.

As stated above, there are a myriad of overlapping definitions that might confuse both researchers and readers. Rakhshandehroo et al. (2017) identify the most common terms similar to ‘green space’ that are used in studies: urban space, public space, open space, open space reserve, green open space, urban greenery, green space, urban green space, and green infrastructure.

Sometimes, researchers give direct examples to provide an explicit definition of the term ‘green space’ suitable for research. This approach may be acceptable in single discipline studies and/or limited scope in their object of research (Taylor & Hochuli, 2016). For instance, Tavernia & Reed’ (2009) research on the evaluation of the influence of landscape extent and habitat context on correlations between urban metrics at 1105 sites in Massachusetts (the U.S.) identify the term ‘green space’ as ‘combined areas of open land, cropland, urban open land, pasture, forest, and woody perennial’.

With this diversity and abundance of interpretations and interchangeable terms, it is crucial to settle the key elements and contributing factors to thoroughly clarify what is an urban green space. The author specifies four of them:

- Study field of application;
- Factor of vegetation;
- Spatial context;
- Human perception of services and benefits.

I) Scientific disputes on choosing the most coherent definition appear due to a **wide range of study fields** the term ‘green space’ can be applied in, whether it is urban planning and design, medical sciences, ecology, agricultural sciences, etc. For example, papers from environmental studies describe green space as parks (Ikin et al., 2013), undeveloped land (Dallimer et al., 2011), and vegetation and water (Lindemann-Matthies & Marty, 2013). Meanwhile, papers related to urban planning define green space in terms of its function and potential benefit provision for humans like ecosystem services (Yokohari & Bolthouse, 2011), and open land or forest (Tavernia & Reed, 2009). Every field of study prefers to define a green space in its own manner adding similar terms to reach better clarity.

Taylor & Hochuli (2016) conclude that researchers do not have the same understanding of green space and the term limits the ability of researchers to draw meaning from multiple contexts or create syntheses. It is also compounded by a different understanding of green space quality according to the field of study. An absence of a coherent, explicit definition of green space is due to various applications of the term according to a researcher’s field of study, its scope, etc. All these factors utilize both qualitative and quantitative aspects of the definition according to the context of research. Given that, it becomes evident that the term ‘green space’ is cited more frequently in papers with multidisciplinary studies rather than in papers related to some specific study field.

II) A broad application of the term in various fields is determined by the perception of what constitutes a green space. An important, but non-binding part of green spaces is **vegetation**. They form permeable (mainly non-paved) surfaces**.** Vegetated areas can be presented in various forms ranging from public lawns and graveyards to allotment gardens, parks, and green roofs. A type of future vegetation needs to correlate with the existing conditions of the place in terms of its local vegetation, climate, topography, function, activities, development (within urban areas), and so on. It is rather common among researchers to list explicit examples of what is a green space in their understanding, based on specific objectives of the research.

For instance, green spaces as defined by the Urban Atlas database, which is considered one of the most common definitions of green space that has been used in European studies include: ‘*public green areas used predominantly for recreation such as gardens, zoos, parks, and suburban natural areas and forests, or green areas bordered by urban areas that are managed or used for recreational purposes’* (Copernicus, 2018). The above-mentioned way of listing green spaces’ common types may help readers to form a clear picture of the definition meaning presented in an article. In the meantime, however, it can also eliminate their perception only by the listed forms of green spaces excluding others. For this reason, a generic description of the definition with its core aspects together with explicit examples based on research objectives may help to form a coherent view on the term 'green space'. Taylor & Hochuli's (2016) review of 125 papers that defined a meaning of the term 'green space', which helps to identify the six most common types of green space definition (in descending order, with examples provided):

Table 3.1.3 Examples of green space interpretation (Adapted from Taylor & Hochuli, 2016)

Types of definition:	Explanation	Reference
1. Vegetated areas	'green in the sense of being predominantly covered with vegetation'	Heckert (2013)
2. Explicit examples of the term as the definition	'combined areas of open land, cropland, urban open land, pasture, forest, and woody perennial'	Tavernia & Reed (2009)
3. Land uses	'recreational or undeveloped land'	Boone-Heinonen et al. (2010)
4. Range of vegetative complexity	'greenness describes a level of vegetation, ranging from sparsely-landscaped streets to tree-lined walk-ways to playfields and forested parks'	Almanza et al. (2012)
5. A generic explanation of greenness or nature without example or description	'the area investigated included substantial green elements'	Gentin (2011)
6. Ecosystem services	'a type of land use which has notable contributions to urban environments in terms of ecology, aesthetics, or public health, but which serves human needs and uses'	Aydin & Cukur, 2012

Together with green natural elements and associated terms, another integral part can be involved in the definition - *blue space* that represents such blue infrastructure (BI) elements as lakes, ponds, coastal zones, swales, and other rainwater harvesting systems, etc. (The Scottish Government, 2011). Despite being a fully independent term, it has affiliation to green spaces (and vice versa) since their natural elements are mutually connected e.g., riparian vegetation & water edge. Although the functions may vary from one term to another, both of them serve the same people's needs in recreation and well-being and thus are treated together in multiple types of research. The European Atlas (Copernicus, 2018) definition of green space presented above deliberately excludes blue spaces from it due to different functions and entities in land use. Defining these differences in green and blue spaces, in turn, meet one of the core objectives in mapping which is required for establishing the European Atlas. This only proves the importance of the field of study as the first contributing factor for shaping the definition.

In these terms, every definition of green space is nuanced, determined by its context, and reflects certain features concerning a specific field of study and its objectives.

III) Another apparent feature that runs throughout various definitions of green space in scientific articles is its **spatial context**. In scientific papers, the term is widely considered within an urban environment, mainly because of a primary need for green spaces, particularly in these areas. At the same time, people perceive a non-urban (rural) environment as one that does not lack vegetation; thus, the term 'green space' is applied much more rarely to it. The term 'open space' is more commonly used for rural and suburban areas, meanwhile 'green space' is more referred to urban areas. In some articles, though, the term can be applied to both urban and rural environments describing specific types of green spaces that are not necessarily attached to some particular environment e.g., marine parks within a coastal environment (Pittman et al., 2019; McPhee, 2011) and public forests (Doick et al., 2013). To be more precise in defining a green space in terms of spatial context without excluding some of the types that are not located in urban fabric but affiliated to it, the Urban Atlas specifies it as 'green areas extending from the surroundings into urban areas' (Copernicus, 2018).

IV) **Human perception of services and benefits** provided by green spaces may vary. While services and benefits provided by some green spaces are intuitively evident, others may fail to reach the same level of understanding among users. Considering a human-oriented origin of the term 'green space' that is broadly applied particularly to an urban environment (where most people live), it can be interpreted in terms of direct and indirect levels of human-environment interaction. This in turn results in people's perception of 'directness' and 'indirectness' of benefits provided by different types of green spaces.

For instance, human benefits like shading provided by tree canopies in parks may contribute to multiple positive health and psychological outcomes that can be experienced immediately (to some extent) due to direct physical and visual exposure to vegetation (Shanahan et al., 2015; Lafortezza et al., 2009). At the same time, less evident benefits such as temperature regulation, air, and water quality, noise reduction do contribute to users' well-being indirectly and can be perceived by them minorly or not perceived at all.

People tend to interact with ground-level landscapes (green spaces such as parks, urban forests, etc.) more frequently rather than with any others mainly because they are more easily visible from the surface, meanwhile visual access to other non-ground level forms of green spaces such as green roofs can be considerably limited (Sutton, 2014). The difference in people's perception of and further interaction with ground level and non-ground level landscapes - parks and green roofs - is presented below.

A relatively low level of human-environment interaction with green roofs is also compounded by other limitations: highly restricted physical access, generally small sizes of roofs constraining an engagement of users on physical activities, weight-bearing capacity precluding tree and shrubs plantings, etc. (Yuen & Hien, 2005; Weiler & Scholz-Barth, 2009). In contrast to green roof limitations, direct human-environment interaction with ground-level landscapes (e.g., parks) promotes human perception towards these types of green spaces as beneficial for humans, whilst at the same time, other non-evident types of green spaces (such as green roofs, green facades) appear to be much less important.

Even despite being restricted from direct human use, less conventional green spaces such as green roofs provide various environmental and economic benefits, which in turn indirectly contribute to people's well-being and prosperity: climate regulation (stormwater management, temperature regulations, enhancing air and water quality), wildlife habitat provision, building energy savings, etc. (Berardi et al., 2014).

In addition, there is a myriad of less evident (indirect) human benefits of green roofs, perception of which are entirely dependent on the level of its visual and physical accessibilities for people: reducing noise pollution, increasing attention control, elevating mood, and improving work performance, aesthetic enjoyment provision and psychological restoration support, possibilities for social cohesion (Van Renterghem, 2018; Lee et al., 2015; Lee et al., 2018; Lee et al., 2014; White & Gatersleben, 2011; Langemeyer et al., 2020).

It is important to mention that almost every green space contains both evident and non-evident benefits, and the ratio between the different types of benefits depends on multiple factors: target group of users and their actual needs, their biological knowledge, availability, physical and visual accessibility of a particular green space, etc. For instance, parents with toddlers would appreciate paved pathways and proper lighting around playgrounds in parks (Lachowycz et al., 2012), whereas dog owners are more focused on off-leashed large open spaces (Matisoff & Noonan, 2012).

It may become even more ambiguous when the subject of the study lies outside of the human-oriented perspective on green space. Birds, for example, prefer unmowed landscapes (Vallejo et al., 2009), which is hardly correlated with people's conventional understanding of green spaces. However, there are multiple cases of human-environment 'trade-offs', where certain traits of green spaces eventually end up beneficial both for visitors and nature. Species richness and ecological integrity are some of them: being crucial for reaching healthy ecosystems and providing habitats, these features are found to be aesthetically pleasing for people (Sadler et al., 2011; Rupprecht & Byrne, 2014).

Speaking of the terms 'green space' and 'urban green space' (UGS), it is important to emphasize *their interdependence*. It is a common practice when researchers tend to assign the term 'green space' to an urban environment. Being a broader term, 'green space' can be interpreted equally to 'UGS' unless there is no doubt about spatial context defined in a paper. At the same time, *the terms are not interchangeable*: while the term 'green space' can be applied both for urban and rural environments, 'urban green space' is restricted in terms of spatial application and can be applied only to an urban context. Thus, it becomes highly important for a researcher to decide the right term according to chosen scale and spatial context and use it coherently throughout the research.

To conclude, no uniform patterns that would fully cover the term 'green space' have been found. This is due to vast areas of its application in different fields of study that may be proved by its high citation rate specifically in multidisciplinary studies. It makes the actual meaning of the same term extremely variable. Also, there is no need to uniform and agglomerate all the aspects of green spaces into one term. This would make the term less meaningful for a researcher and more ambiguous for a reader.

Instead of trying to put every characteristic in one term, it is more appropriate to provide both qualitative and quantitative aspects of it considering a research's aims and field of study. In many cases, photographs of actual types of green spaces as visual examples may also be useful in clarifying the term. The term is mainly applied to an urban environment where there is a direct need for green spaces. Among the key aspects forming the term 'green space' are field of study, natural vegetation included, spatial context, people's perception of the green spaces' viability.

3.2. The role of green spaces in urban areas

Spatially, the main scope of application of the term 'green space' is an urban environment, which formed by gray structures and paved surfaces. Among such a built environment, green infrastructure (GI), which includes urban green spaces (UGSs), becomes an indispensable unit in urban planning, benefiting an urban environment and its residents socially, physically, and environmentally. This is due to the essential role of natural features for human life that cannot exist on the earth without a sufficient level of the natural environment around. People derive services directly or indirectly from local ecosystem functions as ecosystem services within urban ecosystems they inhabit (Bolund & Hunhammar, 1999).

Compared to a rural environment, the natural areas within an urban environment are significantly limited in their size, function, ecosystem services provision, again because of available space and context. In many cases, they are distributed inequitably and have no mutual connectivity within an urban unit. Also, within an urban context, they are exposed to a far greater population pressure than natural areas in a rural environment. Some types of UGSs are subjected to potential dynamics of built-up development (Sikorska et al., 2020).

It is notable that a level of the below-mentioned benefits derived from UGS depends on such quantitative and qualitative factors as its accessibility, proximity to residences, size, vegetation content, etc. Keeping in mind a range of factors in urban planning would bring various benefits from these 'nature-like' spaces to a greater extent. This, in turn, will form a more resilient urban environment and provide benefits to residents more equitably.

3.2.1 Benefits derived from urban green spaces

I) Improved human health and well-being. It has been proven by many researchers that UGS variously benefits human health and well-being by increasing the general level of physical activity. Twohig-Bennett & Jones (2018) systematize and quantify the impact of green space on a wide range of health outcomes in their meta-analysis of more than 160 studies and show the association between increased green space exposure and a wide range of positive physical health outcomes: decreased salivary cortisol and heart rate, normalization of diastolic blood pressure, decreased risk of preterm birth, reduced obesity and decreased risk of type II diabetes, stroke, hypertension, dyslipidemia, asthma, and coronary heart disease. The authors emphasize that analyzed data should encourage urban planners and decision-makers to give due regard to how they can design, maintain, and improve existing UGSs in urban areas.

The psycho-evolutionary theory called 'Aesthetic Affective Theory' (AAT) suggests that the natural environment (that humans have always been a part of) formed human's affection for nature through evolution. Throughout centuries, humans have developed the ability to define safe natural environments for restoration. AAT states that people's preference for more natural environments as a place for mental restoration is an intuitive choice and not a conscious one (Ulrich, 1983). Exposure to green space mitigates depression symptoms (Bratman et al., 2015), reduces traceable chronic stress and attentional fatigue (Hartig et al., 2014), provides psychological health benefits improving human mood, enhancing a sense of wellness (Kaplan et al., 1998), and promotes healthy sleep (Astell-Burt et al., 2013).

These findings are proven by the increasing role of UGSs during the COVID-19 outbreak and period of pandemic-related restrictions. The case study in Brisbane, Australia (Berdejo-Espinola et al., 2021) shows the growing use of green spaces in urban settings for coping with stress-related disorders and mental fatigue (that have been increased during the time of lockdowns in 2020) among residents, regardless of whether the resident was considered nature-related before the pandemic outbreak or not.

A distance to green spaces is mentioned as an important factor in association with risk reduction of several diseases. The review of Gascon et al. (2016) of 12 studies worldwide show that high presence of residential green spaces in residential blocks is associated with reduction of the risk of cardiovascular disease mortality, however, evidence of a reduction of all-cause mortality is more limited.

II) Positive social outcomes. Sullivan et al.'s (2004) research indicates that green spaces contained on average 90% more visitors than barren spaces, the most significant differences are observed for adults - 125% on average. In addition, green spaces stimulate visitors of both genders with physical activities and attract solo visitors more than barren spaces - on average 91% and 125% respectively. Taken together, these findings state that the level of tree and grass cover in an outdoor space is directly associated with the extent of social activity that takes place there. The authors conclude that shared spaces in surroundings with sufficient green cover (tree canopy and grass) serve as stimuli for informal face-to-face connections between neighbors and thus form more social interaction and shape a sense of community, which is also proven by Coley et al. (1997), Kim & Kaplan (2004) findings.

Forming social capital, a feeling of social cohesion among residents involves mutually accepted norms and values that are manifested in trust, belonging, urge for collective efforts, social support, and empowerment. Social cohesion also shapes positive health and behavioral responses that are evident in benefits to physical and psychological health e.g., reduced stress, increased physical activity, enhanced immune system. Features related to shaping a social cohesion are described in detail in the subchapter 3.3 of the Literature review.

At the same time, various factors, such as noise exposure (Cohen & Lezak, 1977), crowding (McCarthy & Saegert, 1978), and poor quality and quantity of greenery (de Vries et al., 2013) may encourage social withdrawal, reduce the probability of social interaction between individuals and lower perceived social cohesion at the neighborhood scale.

The cohort review of 45 articles summarized by Shepley et al. (2019) states that the presence of green spaces in neighborhoods reduces the level of urban violent crime, such as murders, assaults, and thefts. Among the mechanisms that may account for the impact of green space on crime are social interaction and recreation, community perception, stress reduction, and climate modulation. Scientists conclude that evidence of mitigation impact of nature on violence in urban environments should encourage city governments and communities to support urban green space interventions.

Other features and actions related to green space design, such as lighting, sufficient level of maintenance, comfortable sitting places, paved walking trails, access to water, local business involvement, etc., in turn, may shape a safer and more accessible environment and thus provide better conditions for further social cohesion.

III) Environmental benefits of UGS. Urban green spaces play a vital role in the mitigation of the urban heat island (UHI) effect – the phenomenon that the urban air temperature is higher than that of the rural environment nearby (Kleerekoper et al., 2012). In the U.S., the UHI effect results in daytime temperatures 0.5°-4.0°C higher and night-time temperatures 1.0°-2.5°C higher in urban areas than in rural areas, and it continues to strengthen as the structure and spatial extent as well as population density of urban areas change and grow (USGCRP, 2017).

Formed mainly by heat-absorbing materials (such as concrete and asphalt), an urban environment is a subject of UHI effect exposure. Any significant replacement of green vegetation leads to an increase of air temperature in the area by heating the surrounding surface, which may cause various diseases, such as heat-related morbidity, heat stress, fatigue, etc., especially among elderly individuals (Smargiassi et al., 2009). Also, territories lacking proper shading (e.g., streets) provided by UGS types (e.g., street trees) are subjected to higher costs for air-conditioning in the warm period and heating demand in the cold period (Aram et al., 2019).

Such factors as the type, size, level of maintenance (watering as a key activity) of vegetation in the city contribute to the establishment of the opposite effect called 'the urban green space cooling effect' (Schmidt, 2009; Aram et al., 2019). It has an average cooling effect of 1-4.7°C that spreads 100-1000 m across an urban area; together with UGSs, the implication of different processes and elements, like façade greening system, artificial rainwater pond, and other types of water bodies, exhaust air cooling units, may contribute to greater cooling effects (Schmidt, 2009).

UGSs normalize a city's hydrologic regime by infiltrating surface water runoff and thus reducing the load on a city's sewer infrastructure and preventing flooding hazards. Also, it limits the occurrence of poor airflows with a high concentration of particulate matter (PM) (Guo & Maghirang, 2012), improve the air quality by capturing air pollutants and directly sequestering CO_2 (Nowak et al., 2006), decrease noise pollution by vegetation buffering (vegetation belts, street trees, etc.) (Pathak et al., 2008), serve as habitats for the biodiversity of plants and animals in urban ecosystems (Savard et al., 2000; Nielsen et al., 2014).

There is a group of indirect human-environment co-benefits provided by green spaces in the cityscape related to human behavior. UGSs offer opportunities for environmental education shaping environmental consciousness and eco-friendly behavior among visitors (Alcock et al., 2020). Also, the UGSs' areas serve as commuting routes for non-motorized mobility (e.g., walking, cycling) encouraging dwellers to choose low-carbon (or, zero-carbon) solutions and thus not contributing to greenhouse gas emissions (e.g., ICF Report, 2008).

IV) Economic benefits of UGS. Close proximity to UGSs makes buildings and urban infrastructure more energy-efficient by decreasing costs on air conditioning during a warm period and heating demand in a cold period, as mentioned above.

Elmqvist et al. (2015) calculate estimates of monetary values of benefits from UGSs using various monetary valuation methods derived from 25 case studies in the U.S., Canada, and China. Values are based on quantification in biophysical terms (amounts of carbon stored/sequestered by trees per hectare per year; pollution removal in kg/ha/y; stormwater reduction in m^3/ha/y; energy savings in kWh/ha/y) for green spaces in the urban areas. The data from the studies analyzed by the authors state that the chosen services, conservatively estimated, provide on average 9.701 US$/ha/y of benefits, mainly in the form of savings.

The study conducted in Warsaw, Poland, states that, on average, the presence of a green area within 100 meters from an apartment increases the price of a dwelling by 2.8% to 3.1% (Trojanek et al., 2018). Another Polish case study in Lodz demonstrates that the size and proximity of UGS in a 500 meters radius positively influence apartment prices (Czembrowski & Kronenberg, 2016).

Additionally, improved public health as a positive outcome from UGS can be also linked to the cost reduction of healthcare (Natural Capital Committee, 2015).

V) Negative sides of UGS. Increased exposure to UGSs, despite the various health benefits listed above, may cause negative outcomes. Being generally perceived as a safe environment, some types of UGSs such as enclosed green spaces in large urban areas are associated with a reduced feeling of social safety among city dwellers, the Dutch study concluded (Maas et al., 2009).

Feeling of insecurity might be enhanced with poor levels of maintenance of UGSs in such urban areas that can be manifested in graffiti, garbage, vandalism, lack of lighting, as well as the availability of obstructive trees and shrubs that may attract assailants. The research conducted in Leicester, UK (Madge, 1997) found fear as a major limiting factor structuring the use of parks, especially for women, the elderly, and Asian and African-Caribbean people.

In relation to human health, increased use of UGSs and their inappropriate maintenance are linked to higher levels of unintentional injuries (MMWR, 2012), burns and skin cancer in countries with a non-trivial level of UV radiation (Astell-Burt et al., 2013), pollen allergies and asthma (Aerts et al., 2021), 'unintended' biodiversity (e.g. urban rats, city weeds) that cause several infectious diseases, as well as exposure to pesticides, herbicides (Meftaul et al., 2020) and left pet waste (urine and feces) causing respiratory diseases (Penakalapati et al., 2017) and negative impacts on local soil chemistry (Allen et al., 2020).

The overall conclusion that has been deduced throughout the researchers mentioned above is as follows: landscape and urban planners should acknowledge negative sides of UGSs in decision-making on every project stage (as well as post-project stage, such as maintenance), providing safe environments for urban dwellers and urban ecosystems.

It is important to emphasize the synergy trend among the above-mentioned types of benefits derived from UGSs. Many potential interventions within one type of benefit (e.g., environmental benefits) enhance the positive outcomes from benefits of another type (e.g., economic benefits). Mutual linkage of different types of benefits from UGSs should be considered in the planning process.

3.2.2 Features of urban green space shaping its classification

There is a set of measures identifying the level of exposure to urban green space among residents such as its availability, accessibility and usage which may have various indicators across the studies. Using certain indicators helps urban planners to identify problematic aspects in city policy to then accomplish the equitable provision of green infrastructure to residents throughout an urban area.

The following table contains a set of measures adapted from the WHO report (WHO Regional Office for Europe, 2016) unless other studies are specified. It is noteworthy that a measure of accessibility may be applied to evaluation on various scales, ranging from single UGS to a system of UGSs within an urban area. Also, it can be identified in different ways e.g., according to walking distance to the nearest UGS, type of ownership, physical and visual access. Only distance-based accessibility among them, though, is considered a measure in the report, while others are identified as characteristics that are supplementary elements.

Table 3.2.1 Measures representing the level of exposure to urban green space among residential neighborhoods, with types of survey and features provided (Adapted from WHO Regional Office for Europe, 2016)

Measure	Description	Survey type	Features
1. Availability	'...measures quantify neighborhood green space without distinguishing between that which is publicly accessible and that which is not, and without any consideration of the proximity of specific areas of green space to individual residences or communities.'	Geospatial Analysis	Number of green spaces within a specific area
2. Accessibility (distance-based)	'the proximity of specific green spaces to residences or communities'		Linear distance or walking distance based on a particular spatial planning pattern

3. Usage	The indicator reflects 'actual use of greenspace by individuals or communities.'	On-site self-report study (survey, observation), post, telephone, online	Observed use, location tracking, subjective measures e.g., travel diary (Stewart et al., 2016), etc.

One measure can be expressed with the help of various indicators. Indicators may be chosen by researchers depending on the subject of study, its scale, data available, etc. The key indicators by each measure are adapted from the WHO report (WHO Regional Office for Europe, 2016) and described below.

Availability:

- *Normalized Difference Vegetation Index (NDVI).* Average 'greenness' of ground cover derived from aerial imagery through estimation of the proportion of wavelengths of light absorbed by chlorophyll in plants. Calculated for statistical areas (e.g., census output areas). It ranges from '-1' to '1'.
- *Density (or %) of UGS by area*. The proportion of green area within the statistical boundaries, postal code locations or buffer zones based on aerial imagery that is classified by land use or land cover. Calculated for statistical areas or within buffers around a residential location. It is expressed in % of the total residential area.

Accessibility:

- *Proximity to UGS*. A distance from a residential neighborhood to the nearest UGS. It may take a form of 1) a straight (linear) distance (in meters) from a residential location to the nearest UGS, 2) travel distance (in meters) considering existing development and road network, or 3) may be converted into estimated travel time (in minutes). No universally accepted figure on threshold distance has been indicated across the city policies. It is important to define the points of measurement of the distance. It can be measured between the nearest possible boundaries of residential location and UGS, or it may consider a position of UGS' entrances and trailheads, as well as the central point of a residential neighborhood.
- *Proportion of UGS within a certain distance from a residence*. The indicator helps to define UGS' acreage in a specified radius of the study' residential location. Expressed in % of the total radius area.
- *Perception-based accessibility*. The indicator represents differences between objectively measured proximity to the nearest UGS and perceived proximity across population subgroups. The differences may also be linked to a measure of walkability representing how friendly an area is to walk to and from particular destinations (Lwin & Murayama, 2011) of a study area and its level of development. Estimated in % agreement between measured network distance and a distance reported by residents.

Usage:

- *Population-based usage*. The indicator assesses the frequency of visits of the nearest UGS among residents, attractiveness of its characteristics, etc. Data is collected on a self-reported basis.

- *Individual-based usage.* It defines preferred UGSs and certain areas within them, duration of visit, etc. by location tracking via Global Positional System (GPS) technology.
- *UGS-based usage assessment.* Assessment of specific UGS' characteristics such as usage frequency, number of visits, activities by on-site data collection (gate count, observation, survey data, etc.). This indicator may be helpful for assessing the effects of policy measures and/or certain interventions aimed at improving use of a certain UGS.

Along with that, indicators may incorporate some additional characteristics (quantitative and/or qualitative) that are chosen based on the research aims (WHO Regional Office for Europe, 2016). The characteristics may vary, but in general terms, they refer to a quality of UGS, its type, size, and possible functions. Incorporating them in indicators' definitions can be helpful in defining key UGSs in the area that benefit residents the most. For example, characteristics such as the size and physical accessibility of UGS (relatively big space with facilities, public toilets, lighting, etc.) as well as its vegetation cover (dense and diverse vegetation), have been linked to an increasing likelihood of visits (Giles-Corti et al., 2005).

Other characteristics may consider an availability of blue spaces within UGS (Well & Ludwig, 2020), recreational type (Lachowycz et al., 2012; Matisoff & Noonan, 2012), etc. As a result, an indicator may be composed of both measures and characteristics, e.g., research aiming to identify proximity of public (qualitative) green spaces of at least 1 ha size (quantitative) to residential blocks within a 300 m radius.

Adhering to the measures within an elaborated urban planning policy helps to establish equitable access to urban green spaces for residents. In practice, however, it often becomes unreachable for urban planners to fit into their own recommendations and norms on UGS provision and walking accessibility. The study conducted in Sheffield states that 72% of households fail to meet the recommendation of the English Nature (EN) regulatory agency, that residents should live within 300 m from their nearest green space (Barbosa et al., 2007). Usually, this number comes together with other indicators representing a size and population living within an indicated radius, which normally represents a service area of UGS. For example, in the U.K. in the 1950s an acceptable walking distance to the nearest UGS was considered 800 meters with a UGS size of 1,6 ha per 1000 residents (Byrne & Sipe, 2010).

Multiple European entities (EEA, ISTAT, etc.) use a concept called 'within 15 minutes' walk' to define accessibility of UGS to residents, which may reasonably be translated into around 600-900 m walking linear distance e.g., a sidewalk along the road (AIRI, 2003) without considerable obstacles on the way. Being applicable for green spaces in a neighborhood, the '15 minutes' concept is broadly used on a city scale as well which became more relevant during the COVID-19 pandemic. Urban planners worldwide try to reach this number by providing essential infrastructure (e.g., public health service, food retail, transportation, etc.) for each neighborhood within walking proximity of 15 minutes (Moreno et al., 2021).

Yet another concept called ‘the 3-30-300 rule’ proposed by NBSI (van den Bosch, 2021) aims to provide residents with green infrastructure referring to three scales of application:

- *Site-scale.* Every resident should be exposed to at least 3 trees from the place of their residence.
- *Neighborhood-scale*. Every neighborhood should contain at least 30 percent tree canopy cover).
- *City-scale.* An urban area should comprise a system of green spaces forming its accessibility within a walking distance of 300 meters from a place of residence.

Apart from considering a distance-based indicator of accessibility, the concept also deals with visual accessibility, encouraging urban planners to provide residents with vegetation that can be seen directly from the house or apartment. A scale of application of green infrastructure elements (such as UGS) and thus its size predetermines capacities for functions and recreational value that an element can accommodate (Byrne & Sipe, 2010; Simić & Bajić, 2013). Nonetheless, every element should be treated respectfully in the UGS planning process.

While one study states that 300-400 meters to the nearest UGS is a threshold after which its use drops down significantly (Hogendorf et al., 2020; Grahn & Stigsdotter, 2003), the others conclude that the factor of distance is not necessarily a primary one. The Danish survey conducted by Nielsen & Hansen (2007) indicates, for example, that lack of time and bad weather are mentioned most frequently as key limiting factors for non-regular use of UGS, whereas distance is not seen as critical by most respondents. The authors conclude that the character of the neighborhood and its predisposition to outdoor activities and “healthy” modes of transportation (walking and cycling) predetermine the significance of the factor of distance to green spaces. In other words, the more walkable a residential neighborhood is, the more willingly (and more frequently) residents would visit their nearest park, no matter how far from a residence it is.

Along with that, there are other features proving that a solely long walking distance to the nearest UGS cannot be considered a factor limiting the frequency of its use. Among them, the presence of public toilets and other facilities, lights, walking and cycling routes, and overall level of maintenance of UGS, its design, size, and availability of additional green spaces around (Kaczynski et al., 2009; Giles-Corti et al., 2005). The characteristics specified above should be also considered in urban planning and green space design to reach required UGS provision, as well as walkability (Lwin & Murayama, 2011) within urban areas.

A far wider scientific consensus, though, has been reached on the links between a walking distance to the nearest UGS and the potential exclusion of certain demographics from regular use of urban green spaces. Primarily the children and elderly are subjected to exclusion from regular UGS use if they do not have it in their immediate surroundings (Sikorska et al., 2020; Wolch et al., 2014). In these terms, the indicator of accessibility based on walking distance will play a crucial role in identifying residential neighborhoods that lack UGSs in walking proximity the most. It goes alongside the census data representing the number of populations (primarily, elderly and children) that might be excluded from UGS's regular use more than any other strata of society.

The factor of the residential density (RD) plays an important role in defining to what extent UGSs are subjected to the population pressure in a particular area, especially for higher density built-up areas undergoing densification process. The results of Wolff & Haase's (2019) review of UGS supply (within 300 m from residential area) in 905 European cities that are covered in the Urban Atlas database (Copernicus, 2018) show that UGS supply is sensitive to population size. To determine this, the researchers define relations between several indicators using correlation analysis and trend curve calculations for two UGS types: UG type (urban green spaces representing parks, public gardens, cemeteries; class 141 in the Urban Atlas) and TG type (total green spaces representing a merge of UG type with forests; class 310 in the Urban Atlas).

Table 3.2.2 Indicators used to define a relation between population density and UGS (Adapted from Wolff & Haase, 2019)

Indicator	Description	Measured in	Examples of relation with other indicators
1. Residential density (RD)	The ratio between residents and area of their residential block	residents per hectare (residents/ha)	- The more RD is within a residential area, the less UGS supply would be, and the more it would be a subject of PP, and vice versa - 'The denser a city is, the lower is its UGS provision of TG, but the larger is its UGS provision of UG'
2. UGS provision	UGS' share of total residential area	area (ha) available for 1 ha of residential area	- With increasing UGS provision and RD, UGS supply increases until it reaches a turning point where PP bottoms out - The less UGS supply, and the more PP are, the less UGS provision would be (for UG), and vice versa
3. UGS supply	The supply of UGSs per resident	m^2 UGS/resident	- The low UGS supply for UG in low density cities is a result of low UGS provision and is compensated by TG
4. Population pressure (PP)	Number of residents per 100 m^2 of UGS	residents/100 m^2 UGS	- The more PP is, the less UGS supply would be, and vice versa

The UGS provision indicator is similar to the indicator of availability called 'Density of UGS by area', which is specified in the WHO report and expressed in % UGS of the total residential area.

WHO estimated a minimum standard for UGS supply in Europe, which is 9 m^2 per person within 300 meters from a residential area (WHO, 2012). In European cities, UGS supply reaches 14 m^2/resident (numeric median), with considerable difference between regions: Northern European cities have much more UGS supply per capita (21 m^2/resident) than Southern European cities, especially cities in the Balkans (6 m^2/resident) (Wolff & Haase, 2019). These differences reveal a spatial pattern across countries in Europe, representing a gradient increase in UGS supply from the south and east to north and northwest (Wolff & Haase, 2019; Fuller & Gaston, 2009).

At the same time, Wolff & Haase (2019) do not detract from the necessity of residential density, highlighting its importance for infrastructure networks and facilities to run more efficiently, for residential areas to be walkable and accessible, for urban environments to lower fuel emissions and city's maintenance costs, etc. No single optimal residential density to reach optimal UGS supply has been identified across the cities, however, each city does have its own threshold for this indicator. With further increase in RD the population pressure (PP) exceeds the UGS supply as a consequence of the increasing population demand and a decreasing UGS provision.

Exceeding this number leads to decreasing UGS supply. And on the contrary, UGS supply may reach the highest numbers at a certain population density (this concept is called by the authors as 'turning point', which indicates an optimal compromise between high and low population densities) that should be specified for each city individually. By defining acceptable numbers for residential density, cities have a high potential to optimize the balance between people's liveability and UGS supply.

Fuller & Gaston (2009) in their review of 386 European cities' UGS networks also document a dramatic drop in per capita UGS provision (which is similar to 'UGS supply' indicator in Wolff & Haase (2019) study) in cities with greater population densities ('RD' indicator). However, authors emphasize that UGS coverage ('UGS provision' indicator) in the cities undergoing a densification process does not lose in its quantity. Moreover, UGS coverage increases more rapidly than city area which is related to a 'space-filling' effect, which proves that a UGS network can be robust in compact cities. Researchers conclude that, as cities will continue to grow, the role of quality and quantity of vegetation outside formal UGS networks (such as street plantings) will increase.

Byrne & Sipe (2010) review various works on UGS use in dense built-up areas undergoing consolidation process (that is taking place together with a densification process) and identify three important factors to consider:

- *Different UGS needs.* Different groups of residents who live in highly dense urban environments will have different UGS needs.
- *Integration of existing UGS.* Many UGSs have historical features in their planning and design reflecting a designer's philosophy (which has been mainly based on different understanding of UGS benefits in different periods throughout history, as well as new types of UGSs that are emerging) and a clientele that has been used a particular UGS for a long time. Consolidation and densification processes bring new residents to a neighborhood. It alters preferences towards use of closest UGS, which is as broadly differentiated as the populations who rely upon it.
- *Character of built environment.* A built environment should encourage people to easily reach local UGS on foot. It should also be safe and have high levels of environmental quality.

Review shows that the development design should consider future residents' preferences and needs on UGS with the regard to the capacity of the built environment to meet those needs. It is stated that residents living in high-density built environments are broadly varied, differing by age, race/ethnicity, income, household composition, family status and so on. Different groups of residents use UGSs for a variety of reasons according to their actual needs and preferences, available time, and physical capabilities, etc. Any proposal to increase residential densities in inner city areas should first consider the availability and characteristics of UGS, which should be reflected in UGS typology for its further classification (Byrne & Sipe, 2010).

Urban green spaces may differ according to their size, location and spatial scale, purpose and function, level of maintenance and type of ownership, ecological value, and type of vegetation, etc. (WHO Regional Office for Europe, 2016; Byrne & Sipe, 2010; Simić & Bajić, 2013; Bartesaghi Koc et al., 2017, etc.). To clearly develop a classification system of UGS, it is important to establish its criteria that represent differences in types of UGS within a particular area and reveal their potential and downsides for possible changes in UGS planning and management approaches to improve their quality and quantity in the future.

Nor & Abdullah (2019) in their study emphasize that various countries have a set of regulatory and administrative measures and recommendations for UGS provision in cities, however, definitions of types of UGS and their characteristics, as well as UGS' classification in general lack consistency, which is reflected in the subchapter 3.1. The researchers provide a classification system of UGS according to seven criteria processed after landscape pattern (via satellite image) analysis, field observation and census data analysis in Kuala Lumpur City, Malaysia.

The authors' review of several studies on UGS classification show that criteria can be grouped into two aspects: structure (size, location, shape, etc.) and function (purpose, infrastructure, and facilities, etc.). Each criterion has its own scale and unit, which has been identified and recorded by conducting a field survey at each UGS within the city. The locations of UGSs have been recorded using a global positioning system (GPS). After that, classification of UGSs has been conducted by cluster analysis based on specified criteria, identifying five categories of UGSs for further assessment of their distribution and proportion in the city and its strategic zones.

It is noted that conventional UGS analysis of its size and vegetation greenness (processed by NDVI) through remote sensing and GIS techniques with further classification of UGS based on a current legislation framework may not represent a set of differences and/or similarities among spaces, especially when it comes to their structures and functions.

In this regard, it is assumed that consistent UGS categorization via a multi-criteria approach can be the first milestone for cities to adhere to a sustainable development of these spaces and the whole urban environment in general. A set of criteria may vary (hence, classification as an output, too) depending on different city's characteristics and features, however, the researchers in the study aim to present the most universal ones that can be applicable for other urban areas as well (to some extent). The scheme of specified UGS aspects, criteria and categorization adjusted by the author is presented below.

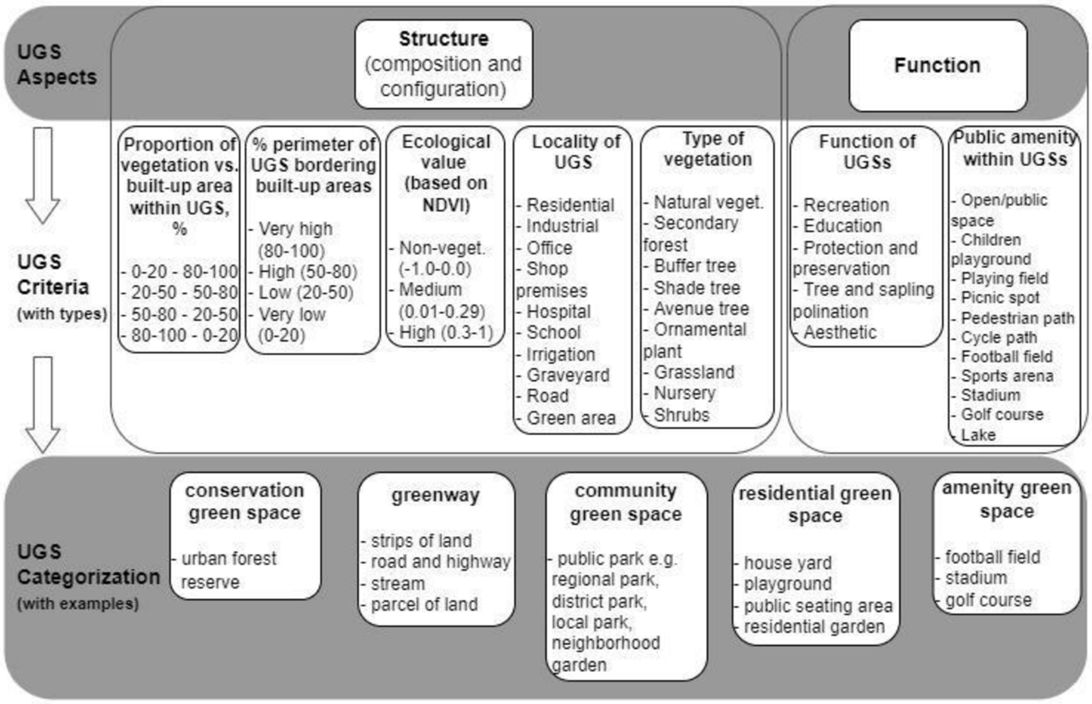

Figure 3.2.1 Categorization of UGS based on a multi-criteria approach (Adapted from Nor & Abdullah, 2019)

Nor & Abdullah (2019) come to one of the conclusions that the socio-economic characteristics of residents and development process in the city are among the prevailing factors that determine the type and distribution of UGSs. Several strategic zones in Kuala Lumpur City have the lowest residential green space because they are designated mainly for commercial and trade development. At the same time, the proportion of conservation green space is low in other zones because many residential developments have been designated there.

Bartesaghi Koc et al. (2017) in their analysis of 85 studies related to GI elements' classification specify four the most common criteria for classifying green spaces: **a) the spatial scale (hierarchy), dimension and location of spaces** (urban core versus periphery); **(b) their primary purposes** (land uses/land covers) and intensities of use; **(c) accessibility and ownership** (private versus public); and **(d) biophysical surface characteristics** (permeability, amount of vegetation cover, thermal attributes). The results show that proposed ternary approach in terms of the functional (purpose, use, services), structural (morphology) and configurational (spatial arrangements) attributes can be used to reach a more comprehensive classification, although this approximation of results is inherently generic. Coincidentally, the multi-criteria approach proposed by Nor & Abdullah (2019) is based on the same attributes (aspects): structural (configuration combined with composition) and functional ones.

Throughout the work, the authors use the term 'green open space', mentioning that rural-urban dichotomy has been seen as one of the most apparent criterion for distinguishing. Due to this, the key term 'urban green space' that is used in the present work may be equally compared to 'green open space' within urban cores. The following table shows the specified criteria with classification.

Table 3.2.3 Classification of green open spaces (GOS) according to most used criteria, with examples provided (Adapted from Bartesaghi Koc et al., 2017)

Criterion	Classification
Spatial scale (hierarchy) and location	1. Urban periphery a. National-regional • Patches, corridors, matrixes 2. Urban cores a. City-district b. Neighborhood c. Local / parcel
Purposes based on land uses/land covers	1. Parks and gardens: country, urban and local parks, public & private gardens, courtyards 2. Natural & semi-natural green spaces: woodlands, forests, reserves, heathlands, grassland, meadow, conservation land 3. Greenways, green corridors, ecological buffers, green streets/alleys, green wedges, cycle paths, pedestrian trails, routes 4. Wetlands: marshlands, intertidal mudflats 5. Brownfield land: quarries, wastelands, landfills, vacant and derelict land 6. Amenity green spaces: recreation grounds, sport fields/facilities, golf courses, playgrounds, racecourses 7. Community green spaces: allotments, community gardens, orchards 8. Water bodies and waterside areas: coasts, beaches, seafronts, rivers, canals, ponds, lakes, estuaries, swales, ditches 9. Green links, utility areas: roads, rails, power lines, drainage-ways, transport corridors 10. Agricultural land, farms, ranches 11. Landscaped and incidental areas 12. Churchyards, cemeteries, burial grounds 13. Institutional grounds 14. Civic spaces: squares, plazas, malls, foyers 15. Built-up areas: residential land, multistorey buildings, mixed uses, construction sites
Accessibility and ownership	1. Unrestricted 2. Limited 3. Not accessible
Biophysical surface characteristics	1. Pervious surfaces (permeable) a. Irrigated green space b. Non-irrigated green space c. Vegetated surfaces (grasslands, pasture, crops, forests, fields, greenspaces) d. Non-vegetated / bare soils / sands / snow e. Porous pavements f. Rain-gardens / biofilters / bioswales 2. Impervious surfaces (impermeable) a. Reflective pavements / hard surfaces b. Bare rocks 3. Water bodies a. Vegetated wetlands / wet grounds b. Open water / lakes / rivers

As mentioned in the subchapter 3.1, the present study is focused on ‘green open space’ type of green infrastructure. The other three types (green roofs, vertical greenery systems, and tree canopy) are considered by the author much less. In the present study, the term ‘green open space’ has been changed to ‘urban green space’ (UGS) according to the subject (green spaces) and settings (urban area of the city of Brest) of the work, since GOS can be applied for a green space outside of urban areas (in urban periphery), which is not applicable for the current work. The term ‘open space’ is more commonly used for rural and suburban areas, meanwhile ‘urban green space’ is directly referred to urban areas.

Byrne & Sipe (2010) in their work state that a size, naturalness, and facilities remain the standard characteristics shaping a classification of parks, which has been chosen as a key element comprising a large portion of UGS network in cities (characteristics and methods described below, though, are applicable for any type of UGS, the authors specify). Sometimes, these characteristics are complemented by additional non-quantitative characteristics such as park location and its deemed function.

Nonetheless, there are much more mutually related characteristics for classifying parks that can be variously combined with standardized method of classifying parks:

- Specific activities that occur within a park (skate-board park, bike park, etc.);
- Governance (national, state, city, district);
- Overall condition of a park (level of maintenance);
- The age and land use history of the area (newly built corner park in a dense district or vast Victorian-era nature park);
- Types of users (according to their age, preferences and needs, free time, physical capabilities, etc.);
- Landscaping and embellishments (zen garden, dog park, etc.);
- Scale and catchment area (national park, regional park, community park, local park).

These factors can be combined addressing the actual needs, which, in turn, will affect a UGS classification. This makes a standardized method of classifying UGSs less meaningful and rather impossible, the authors state.

Instead of trying to classify the variety of UGSs according to a set of characteristics, the authors suggest combining criteria into one assessment tool. This could help researchers to assess each UGS within a study area and score them according to chosen criteria, relying on individual characteristics of each UGS. Then, the scores would be summed to generate an overall rating for each criterion. A spider diagram (Figure 3.2.2) has been mentioned as an efficient tool to illustrate the differences in scores of chosen criteria for further differentiation of UGSs types within a study area. It also gives a much better overall assessment of the type and quality of each UGS.

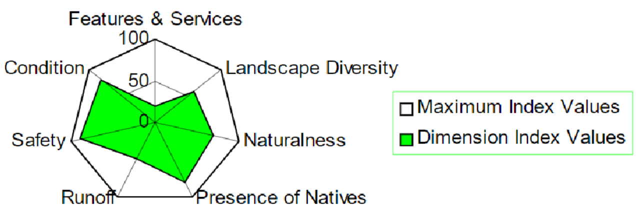

Figure 3.2.2 Spider diagram of potential park (or any UGS) indicators (Credits: Byrne & Sipe, 2010)

This approach has more practical application dealing with assessment of qualities for each UGS. It helps researchers to define types and then elaborate their own classification within a study area based on chosen criteria rather than trying to fit researched UGSs into existing standardized categories.

Measures, indicators, and characteristics of UGS presented in this subchapter represent the most common and scientifically accepted categories applied in urban planning to classify green spaces within a city and establish its equitable provision for residents. These features are found to be useful for the present study and may be incorporated in the research.

3.3 The role of neighborhood green space (NGS) in urban areas

The present work deals with green spaces in residential environments in the Brest urban area. Several comparable terms have been identified across the studies reviewed in the Literature review that represent green spaces in a residential area: nearby green space (Ekkel & de Vries, 2017), residential green space (Gascon et al, 2016), community green space (Nor & Abdullah, 2019), neighborhood green space (Sullivan et al., 2004). To choose the right term and use throughout the work, key aspects of green spaces in residential areas important for the research are specified:

- *Accessibility (distance-based)* - UGSs in the immediate surrounding of the residents' neighborhood that can be reached in walking proximity;
- *Accessibility (ownership)* - UGSs that are publicly accessible for people;
- *Clientele* - UGSs that are mainly used by residents of adjacent houses with their specific preferences and needs;
- *Use* - UGSs that meet residents' needs in recreation by providing infrastructure and amenities.

The term 'nearby green space' refers solely to distance-based accessibility, while the other term 'residential green space' is generic and fails to show potential differences between UGSs in different neighborhoods. In this regard, the adjective 'district' in relation to green spaces also cannot be considered a coherent characteristic, since it refers to an administrative division and not to qualities of a neighborhood.

The term 'community green space' represents *'a unique park with beauty landscape located near residential areas and offices, equipped with a playground for a local recreational facility, and provide aesthetic value'*, the Nor & Abdullah' (2019) study states. Although the definition has distinct features specifying the uniqueness of the green spaces, it can also be related to green spaces within commercial development (e.g., offices) which is not the case of the present study.

Despite the mutual relation of identified terms, the term 'neighborhood green space' seems to be the most explicit for the present study since it more clearly reflects possible differences in UGS use in a certain residential area (e.g., in a residential block). These differences between neighborhoods are based on the needs of residents that are shaped by a common place of living.

To support that, the author provides the definition of the word 'neighborhood' in the Merriam-Webster vocabulary (Merriam-Webster): *'a section lived in by neighbors and usually having distinguishing characteristics'*. These distinguishing characteristics of NGS refer to residents' needs and preferences and may be reflected in an environment in the form of various infrastructure and amenities for activities required for recreation (e.g., playgrounds for children, outdoor gym, dog park, community garden, etc.). In these terms, an adjective 'neighborhood' in relation to green spaces may reflect distinguishable features on a basis of social character within a certain area, meanwhile, two first terms fail to do so.

Yet another issue is what types of green spaces can be considered an NGS. For example, vegetation in gaps between multi-story houses and a community garden differ in their purpose and functional capacities, level of maintenance, recreational use, etc.

The term 'neighborhood green space' (NGS) is defined as '*semi-public urban green spaces of neighborhood significance located in high- and low-density residential development that are mainly used by residents of adjacent housing units (courtyards, playgrounds, green buffers, etc.)'.* The NGS definition comprises certain characteristics of green spaces in residential environments together with local features of the Belarusian legislation, which are explained in detail in the Methodology.

The present definition encompasses the main types of green spaces that can be found in the immediate surroundings of housing units. Gaps between residential buildings (in this work they are called 'green buffers') listed as an example are indirectly referred to vegetated setback distances for buildings and mainly serve for non-recreational purposes (URA Guidance, 2019).

This type of non-recreational green space within an urban area is related to a group of urban green spaces called 'informal green spaces' (IGS). According to Rupprecht & Byrne (2014), IGS may be '*any urban space with a history of strong anthropogenic disturbance that is covered at least partly with non-remnant, spontaneous vegetation*'. Apart from gaps (or green buffers), IGSs include such types as street and railroad verges, vacant lots and brownfields, waterways, and power line corridors, structural (vertical), and microsite spontaneous vegetations (Rupprecht & Byrne, 2014). Some studies consider roof gardens, or green roofs in general, to IGSs as well (Hunter et al., 2019).

Making up a bigger share of UGS area in a city, usually IGSs do not have formal recognition by a governmental body and may be maintained irregularly. Unlike formally designed green spaces (parks, gardens, etc.), IGSs are much less subjected to regular management and are mainly shaped by human origin and ecological factors (Rupprecht & Byrne, 2014). Access to certain types of IGSs may be restricted since some types such as railroad and highway verges are considered a part of the heavy infrastructure and are usually limited for public use for safety reasons. Private-owned types of IGSs may be fenced and cannot be accessed by residents, even if they are located close to their residences and are safe to use (Rupprecht & Byrne, 2017).

Nevertheless, multiple studies show the perceived importance of IGSs among residents for their close proximity to residencies and unmaintained, 'nature-like' character (Rupprecht & Byrne, 2017). In terms of high-density urban areas, these spaces may play a vital role in city UGS provision as a compensatory element meeting residents' needs in recreation. IGSs are becoming crucial for the Asian aging megacities (in China, Japan, South Korea), where a population aging trend goes along with rapid urban growth. IGSs are highly recognized by elderlies who use them as places for close-to-home recreation (Kim et al., 2018).

A similar conclusion is found in the Polish study conducted in two post-communist cities of Warsaw and Lodz (Sikorska et al, 2020): comprising a big share of UGSs in cities, unmanaged IGSs (vacant lots, protected green areas, green buffers, brownfields, etc.) may be used for recreation enabling direct contact with nature. In this regard, IGSs may be found as equally important as formal UGSs. Informal green spaces within residential districts (NGSs) are identified as ones with great potential in improving UGS provision for residents, which is particularly crucial for elderlies and children as the most vulnerable strata of society.

In terms of IGS use, it is noted by Mahmoudi Farahani & Maller's (2019) study that dog owners particularly stress the importance of informal greenery. This is explained by demand in close-to-home green spaces that are used for dog walking on a daily basis. Residents in Melbourne (Australia) living in walking proximity to publicly accessible IGSs (particularly, channel verges) find them more viable for daily dog walking rather than formal UGSs such as a residential park. However, perception of unsafety together with a lack of regular maintenance and littering are identified as main concerns regarding IGS use (Mahmoudi Farahani & Maller, 2019).

Last but not least, Rupprecht & Byrne (2017) argue that a key difference between IGS and formally designed UGS is in non-regulated management of IGS. It opens up possibilities for residents to affect the design of these spaces according to their actual needs, directly filling their *'right to the city'* proposed by a French sociologist Henri Lefebvre (Lefebvre, 1968). Several studies (Mahmoudi Farahani & Maller, 2019; Włodarczyk-Marciniak et al., 2020) state that even minor design interventions in IGSs together with regular management (that can be performed by residents themselves) may improve the attractiveness of spaces and fully capitalize on their potential as integral parts of neighborhoods that can contribute to neighborhood liveability.

According to Hunter et al.' (2019) cohort study on identifying linkages between UGS interventions and improved health and well-being of residents, UGS interventions are defined as physical changes to the built environment in a predominantly urban context including improvements and modifications to existing UGS or the development of new UGS. UGS interventions are manifested in development of new walking and cycling trails, creation of rain gardens and green roofs, greening of vacant lots and urban streets, provision of outdoor gyms in local parks, new bridges to improve physical access, modifications of a playground in a park. It also includes innovative approaches applied to non-traditional locations such as roof gardens, green walls, a greening of vacant lots, and urban agriculture. The authors specify the usefulness of a *dual approach*, in which UGS interventions consist of physical change together with awareness (marketing or promotion program) to encourage further use of UGS for residents.

The author of the present work deliberately defines gaps (green buffers) in the NGS definition due to their high presence in residential areas of Brest (and other Belarussian cities in general). Unlike in Rupprecht & Byrne's (2014) study, the gaps between buildings are much wider in Belarus. They are designed for sanitary purposes providing sufficient exposure to the sunlight and air ventilation to residences (URA Guidance, 2019). That is why the term 'green buffer' is being found more relevant. The width of buffers may be explained by the urban planning approach that had been applied in post-communist cities during the Soviet era. This approach had been shaped by government ownership of all land and industry, centrally controlled top-down management in residential development together with an urgent public demand for affordable housing. At that time, the land was not considered a valuable asset, and urban planners did not strive for densifying urban environments.

This eventually reflected in uniform strict design requirements (interior and exterior), small dwelling sizes together with considerably large residential units (5-, 9-story housing depending on the time of construction, with long facades), the material of buildings (usually, concrete structural insulated panels which could be massively produced in a short time), and configuration of residential blocks (wide green buffers between buildings) (Metspalu & Hess, 2018).

Figure 3.3.1 An example of typical post-communist residential development: a residential block is comprised of uniform 9-story panel housings with large unused front green buffers in between (Credits: author, Minsk, 2021)

According to Krier's classification of public spaces (Krier, 1998), green buffers correspond to public (side and front buffers) and semi-public spaces (rear buffers). Post-communist residential blocks have relatively large semi-public spaces. A good example of semi-public NGSs would be courtyards and rear buffers. These types of NGSs usually have a partly blocked configuration and are not directly exposed to streets, which are considered public spaces. Even though these NGSs are normally publicly accessible and do not have restrictions on use, local residents interact with them significantly more often and thus they feel more belonged to them.

As mentioned in the previous subchapter, a proper building density should be adhered to for running city infrastructure more efficiently (Wolff & Haase, 2019). Together with providing public infrastructure (educational, health care, commercial, recreational facilities, etc.) directly at the place of residence, high building density stimulates opening private businesses that would primarily serve local residents in their neighborhoods. This falls within concepts of walkability and '15 minutes city'. In general, balanced building density would make cities more resilient.

According to Krier's typology (Krier, 1998), a good proportion of public spaces in residential areas should be around 25-35% of the total area, which allows cities to balance between dense environments and a presence of public spaces like UGSs. However, current development requirements in Belarus do not encourage developers to adhere to an optimal density, and which is more dramatic, in many cases they do not fully provide residential units with sufficient public infrastructure and services that would meet the demand coming from a certain number of population. This issue is described in detail in the Discussion chapter.

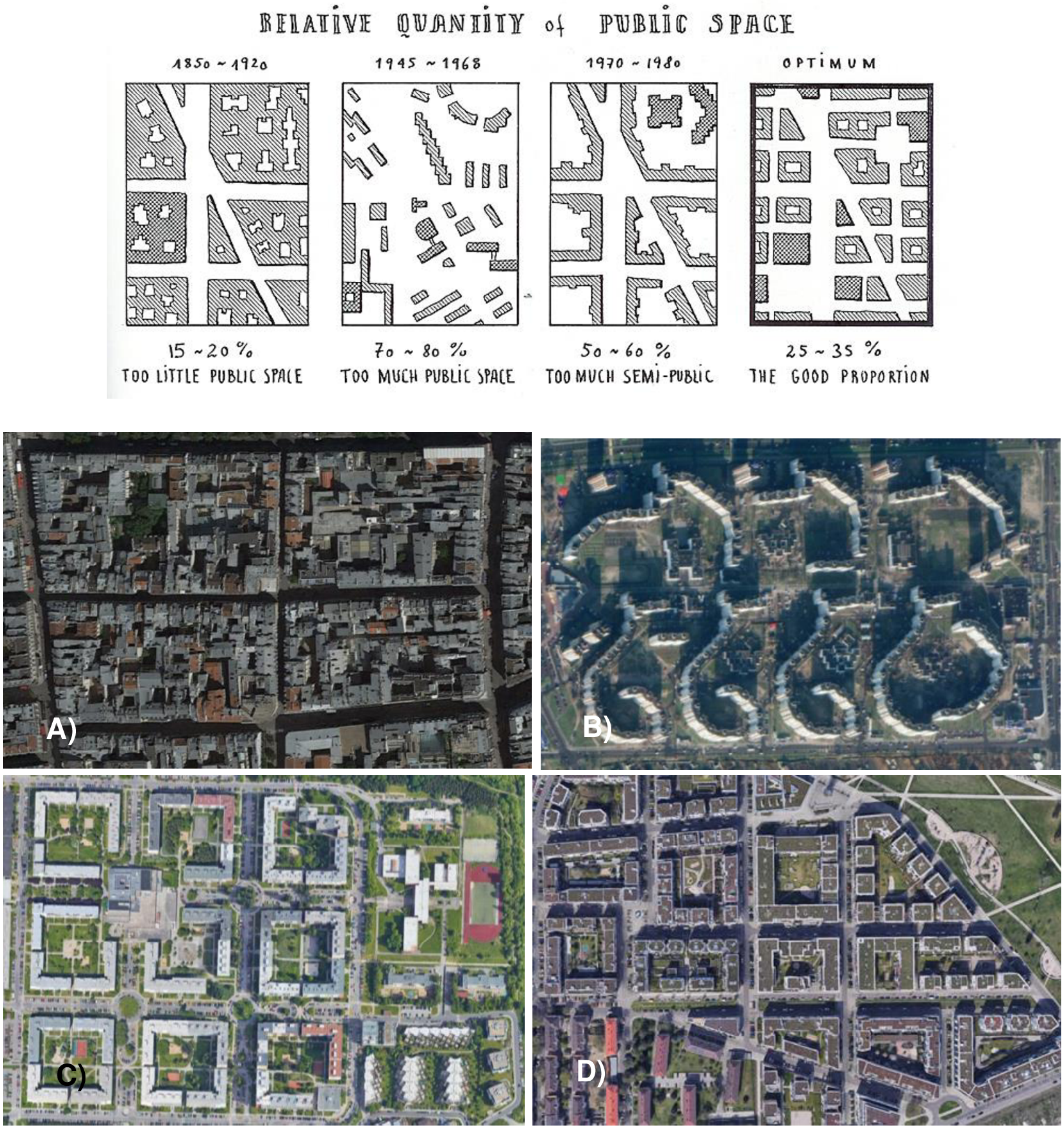

Figure 3.3.2 A typology of public space (PS) quantity ratio with examples: A) Paris, France - too little PSs; B) Brest, Belarus - too much PSs; C) Prague, Czech Republic - too much semi-PSs; D) Karlsruhe, Germany - an optimal proportion of PSs (Credits: Krier, 1998; images from Google Earth)

Apart from courtyards, blocked neighborhood parks, playgrounds, etc., vegetation in a multifamily residential environment is also located within rear, front, and side setback distances of buildings (which are called by the author ‘green buffers’). Compared to front and side green buffers, rear green buffers are maintained and embellished by local residents to more extent. They are usually maintained by local volunteers living nearby (Figure 3.3.3).

At the same time, front, and side green buffers of multifamily buildings in many cases can be considered public spaces since the level of exposure to streets and other public spaces is higher, which affects the decline of the level of residents’ interaction with these spaces.

Figure 3.3.3 DIY green space interventions within semi-public spaces (rear green buffer) in post-communist multifamily residential units in Vilnius, Lithuania (Credits: Neringa Utaraitė)

A configuration of buildings within a residential environment provides large unused front green buffers in between (Figure 3.3.1). Front green buffers are found to be NGSs of great potential and may serve as compensatory elements in formal UGS network to reach sufficient numbers in provision since these areas are comprised of vegetation, they are publicly accessible, and are located in residents' immediate surroundings. Their great potential and significance in reaching equitable UGS provision are also proved by the Sikorska et al. (2020) study mentioned above.

Besides public and semi-public spaces, there are two other types of spaces in residential development by Krier (1998): semi-private and private. Private spaces represent interiors of residences and cannot be considered objectives of the study.

Semi-private, though, is worthy of attention: they include facades together with extensions (balconies and other elements), entrances of a building, first-floor terraces, etc. Semi-private spaces can be variously modified by owners of a particular apartment (thus, owners may affect a surrounding environment itself to some extent), but at the same time, these spaces are visually accessible to others. Interventions within façade sections and/or adjacent green buffers is contrary to local legislation on building maintenance. In practice, though, residents with modified facades are rarely prosecuted due to an absence of formal complaints submitted against them by neighbors.

The present study considers public and semi-public spaces as an object. Inspired by Krier's (1998) typology of public spaces, this work provides a scheme of the hierarchy of public-private spaces in residential areas with regard to examples of spaces formed by post-communist approaches in residential development (Figure 3.3.4):

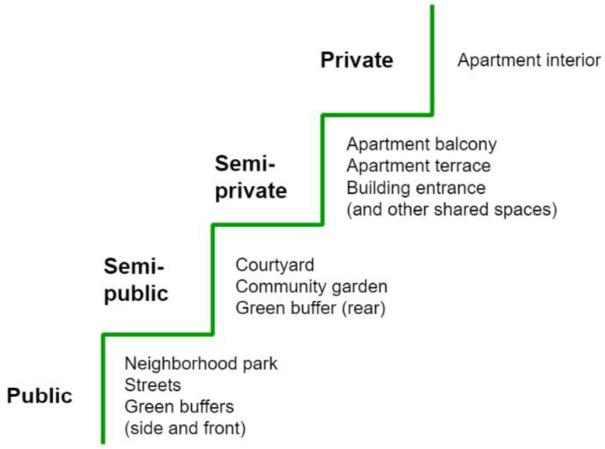

Figure 3.3.4 A hierarchy of public-private spaces in multifamily residential development, with examples provided (Adapted from Krier, 1998)

Sendi & Kerbler (2021), Bouzarovski et al. (2011) in their studies on the evolution of post-communist multifamily housing of different periods in cities of Slovenia, Georgia, and Macedonia (respectively) conclude that monotonous facades and unattractive, poorly, or overly modestly designed entrances to multifamily residential blocks are common features of post-communist housing estates.

The authors of two studies state that residents of post-communist residential development in specified countries (especially of post-World War II period of 1945-1965 years) feel an urge for alterations of their neighborhood environment which is manifested in various forms. Most of these alterations are uncoordinated, poorly designed, and partly illegal. This includes different modifications on façade sections of the multifamily building, usually done by individual apartment owners (Figure 3.3.5). It is manifested in erections of glass extensions on balconies, abundant vegetation on balconies; first-floor extensions with the aim to ‘expand’ the living space, installations of pergolas on the balconies and air-conditioning systems on the facades; painting window frames and balcony railings in various colors, etc. (Sendi & Kerbler, 2021; Bouzarovski et al., 2011).

It is summed up by the authors of the above-mentioned studies that residents’ interventions have usually resulted in the creation of non-aesthetic facades that are unpleasant to look at. Sendi & Kerbler (2021) find that post-socialist multifamily residential buildings (built mainly in 1965-1985 years) have better architectural designs and are generally more pleasant to view due to comparably low height and length. This scale of residential development helps to avoid the creation of monotonous facades, which, in turn, does not encourage residents for Do-It-Yourself (DIY) designed interventions with facades or surrounding areas that sometimes can be not aesthetically pleasing.

Figure 3.3.5 An example of combined intervention in semi-private space in a post-communist low-story residential area: first-floor glassed balcony extension and land occupation in a form of apartment terrace (Credits: author, Minsk, 2021)

Public and semi-public spaces are used primarily by a particular group of people, especially when it comes to courtyards and community gardens which can be met in rare green buffers of buildings. Well-planned and regularly maintained public spaces such as NGSs play a vital role in forming a good residential environment and may greatly contribute to the creation of a sense of a place or community cohesion among the residents (Mouratidis, 2021). Hartig et al. (2014) identify increased social cohesion as one of the four pathways of green spaces that are contributing to human well-being in urban environments, alongside improved air quality, stress reduction, and increased physical activity.

In another study conducted by de Vries et al. (2013) linkages of a quantity of streetscape greenery and perceived social interactions at the neighborhood scale are identified. Within the study, the term 'social cohesion' is defined as '*sense of community, with a focus on trust, shared norms and values, positive and friendly relationships, and feelings of being accepted and belonging*'.

Nevertheless, a place-belonging does not necessarily mean forming of social bonds. A case study conducted in a form of face-to-face questionnaires in 8 disadvantaged Soviet-designed neighborhoods in Berlin (Germany) shows that residents rather feel attached to an NGS than to people who they share it with (Säumel et al., 2021). The study shows that residents benefit daily from residential greenery compared to only once per week (on average) in formal UGS. Also, a passive use (enjoying the sun, getting fresh air) dominates active (meeting neighbors, exercising), which proves the importance of NGSs as green spaces for residents' recreation in immediate surroundings. It is concluded that a co-creative involvement of residents in the design and management of NGSs may be encouraging for creating social contacts which makes NGSs the social tissue of 'disadvantaged' neighborhoods who lack formally designed UGSs in walking proximity.

WHO states (WHO Regional Office for Europe, 2017) that through designing better social and physical infrastructure (which includes increasing and enhancing UGS provision, improving the mobility and social networks of the population) it is possible to achieve health and well-being by increased physical activity and social interaction at the neighborhood scale. Participation of residents in planning, designing, or renovation (interventions in existing UGSs) processes of UGSs improves the qualities of spaces by directly meeting the demands of a particular community involved in such processes. Interventions in UGSs are found beneficial on a neighborhood scale (enhanced social cohesion, reduction in crime, more equitable UGS provision, increased biodiversity, reduced illegal dumping, urban cooling) and individual scale (improved health and well-being). A participatory approach is also found cost-efficient and effective by researchers worldwide (WHO Regional Office for Europe, 2017; Hunter et al., 2019).

Residential areas of Brest, as well as many other residential areas in post-socialist countries, lack management, despite their great potential to serve residents as places for recreation in their immediate surroundings. People's desire to interact with NGSs in residential environments is manifested in various DIY interventions, which proves a certain level of demand among residents for renovation in order to have well-designed and organized green spaces that would meet their needs and preferences.

The present research is focused on estimating UGS provision in the Brest urban area for identifying the poorest residential blocks that need renovations of their NGSs the most. In this regard, renovated NGSs in such residential blocks may serve as a compensatory element that replaces an absence of formal UGSs in walking proximity. Residents' perception of the current state of their NGSs may be considered a starting point in the understanding of potential renovation processes of these spaces.

4. Methodology

This thesis considers the area of the city of Brest, Belarus. It is based on the assessment of the urban green space (UGS) network by defining its types and level of provision for residents. The evaluation of the city's UGS network is done with respect to the existing classification applied for regional cities with over 100 thousand residents in Belarus. Apart from the local standards and approaches on UGS provision, the methodology is being shaped by works considered in the Literature review chapter.

The sources of information used in within the research are census data (Belstat, 2021), local legislation on UGS provision (guidance from the Ministry of Architecture and Construction of Belarus (MAC, 2016); excerpts from the state laws), geospatial information derived by QGIS (version 3.20.2), Google Earth (version 7.1), and Yandex Maps Street view.

The photographs of UGSs presented in this chapter were made by the author during field visits to Brest in May and June 2020. They are complemented with screenshots from the Yandex Maps Street views and Google Earth aerial imagery.

The methodology consists of two parts: analysis of UGS provision and perception assessment of neighborhood green spaces (NGS) among residents.

An urban area of Brest was selected as the case study location due to several reasons. Firstly, the necessary GIS and site data on UGS locations was not publicly available for the capital city of Minsk. Initially, Minsk was considered as the focus for the case study location by the author as it is his place of residency. Secondly, the evaluation techniques for UGS proposed in the methodology is supposed to be applicable to the cities with various number of population densities, and, preferably, different population trends. Brest is a suitable alternative location because of the following two aspects: the data required for the research was publicly available, and the total population for the city is ranked sixth within Belarus with more than 352,000 inhabitants and an annual growth rate of approximately 1.3% (Belstat, 2021). This makes the research outputs more applicable for other Belarusian cities with various population numbers (bigger or lesser than Brest's numbers). The population data, as well as urban pattern and other characteristics of Brest are partly raised in the Methodology and are described in detail in the following chapters.

A questionnaire was conducted to determine an average resident's perception towards UGSs in Brest. The first part of the questionnaire aims to assess an overall residents' attitude towards green spaces in the city and raises issues regarding provision and other factors limiting their use. The second part deals with UGSs that are located in close proximity to residential blocks, which in the thesis are named as 'neighborhood green spaces' (NGSs). It is assumed that NGSs have a certain potential as a recreational space in residents' immediate surroundings. It raises issues related to the current state of these spaces and identifies demand among residents in their potential renovations.

The questionnaire was distributed among residents of the city of Brest online via Google Forms. The questions were asked in Russian language and were then translated into English for further analysis. The questionnaire timeline is approximately three weeks (from February 14th to March 6th, 2022).

The present methodology aims to provide urban planners with one of the potential ways of evaluating UGS provision and draws attention to the importance of neighborhood green spaces as a possible compensatory type of UGSs that may be used by residents for recreation.

4.1. Analysis of UGS provision

The present chapter proposes a coherent way for assessing UGS provisions with regard to the local legislation, approaches mentioned in the Literature review, available data, and the author's current understanding of this issue.

The first part of the methodology consists of two steps: (1) analyzing and arranging the local legislation on UGS in Belarus, and (2) identification of indicators needed for geospatial analysis of UGS provision.

4.1.1 Analyzing and arranging the local legislation on UGS in Belarus

To clearly define the subject of the research, the author aims to harmonize a local understanding of UGS and its existing classification in Belarus through the multi-criteria approach proposed by Bartesaghi Koc et al. (2017) and Nor & Abdullah (2019), which is described in the subchapter 3.2.2.

Currently, the term 'urban green space' may be found in two main Belarus legislation frameworks related to the field of study. The first one called 'The Life Plant Act' (2003) defines green spaces as '*parks, boulevards, urban forests, botanical gardens, arboretums, as well as recreational spaces located on public lands of urban areas, areas with water access, other green spaces (within the sanitary protection zones, areas of anti-erosion and street vegetation, green spaces in residential development) that are divided into city and district significance*' (article of Act 33, 2003). Through specifying distinct characteristics (location, ownership, significance, function) and listing different types of UGSs, the following definition provides an explicit understanding of what can be considered a green space in an urban area. UGSs are referred to recreational spaces, which represents its major function in urban areas: providing residents with a nature-based recreation and ecosystem services for their well-being. Other potential functions of UGSs may be understood by their application in various non-recreational zones listed in parentheses: sanitary, protective, engineering, aesthetic, etc.

Apart from that, the definition shows that UGSs are clustered into two groups depending on their significance: city and district. Significance, as it is written in the local legislation, represents a scale of a particular UGS. Green space' size, amenities, location, variety of function presented together with other aspects shapes UGS' level of significance. This, in turn, is translated into different distances of UGS service area (so-called accessibility radius), coefficient of recreational value and acceptable recreational pressure. These characteristics are described in detail within this chapter.

Apart from UGSs of city and district significance, urban planners in Belarus distinguish the third group of green spaces which represents green spaces within a residential development. In the present work, it is translated as 'UGSs of neighborhood significance'. According to the definition from the Life Plant Act (2003), this group of UGSs is listed together with green spaces with non-recreational function. However, it has its own requirements on provision per capita (10 m^2/capita), share of vegetation coverage within a residential block (25-58% of the area). and accessible walking distance (0.1 km), which emphasizes its significance in terms of recreation. Current legislation does not provide clear understanding of the legal status of this UGS group, specifying them as 'UGSs of restricted use.' This work aims to clarify this ambiguity about UGSs of neighborhood significance since green spaces of this group are considered the main subject of the research.

The second framework - the guidance 'The rules on urban green space provision' (MAC, 2016) - has a more practical character, defining measures, criteria, as well as normative and recommendations for UGS' planning and management. Criteria derived are distributed throughout the framework separately which may lead to their misinterpretations. The author tries to cluster some of the criteria based on mutual information between them to reach better visualization of potential ways of UGS classifications. Existing local classification and the Bartesaghi Koc et al.' (2017) work on green infrastructure (GI) classification were considered to reach this goal.

As a result, five criteria have been identified: primary purpose, type of ownership and level of access, size and significance, the proportion of vegetation versus built-up area, and recreational value. Several criteria (criteria 2, 4, 5) have been ranked by the author based on the approximation of types and their values. Explanation of terms presented in the classification is given in Appendix 5 of the study.

It is important to note that some categories within different criteria are overlapped e.g., UGSs of neighborhood significance (criterion 3) are identical to UGSs with restricted use (criterion 1). These two criteria have a common ground and are considered more than others within the research. Photographs taken by the author during visits to Brest are provided within the chapter to visually clarify some of the UGSs types that might be confusing for a reader.

There is no definition for private (non-state owned) UGSs that can be publicly accessible in Belarus' land use legislation framework. All the lands of public use such as '*streets, avenues, embankments, passages, boulevards, parks, and other public lands'* within an urban area are owned by the state (The State Code of Land, 2008).

Also, public beaches (along the lakes and rivers) are considered green spaces, since they are designed for recreational purposes and usually partly composed of vegetation, providing certain benefits to residents like other green spaces.

Figure 4.1.1 Examples of urban green spaces of city significance in Brest: A) the Central Park; B) public beach on the Mukhavets river; C) the Kasmanaŭtaŭ boulevard (city center); D) the Memorial park (Credits: author)

The term ‘green spaces with restricted use’ is considered ambiguous during analysis of the existing UGS classification in Belarus. This category represents green spaces within three different areas (zones): areas of industrial facilities, public facilities, and residential development. Green spaces within this category generally correlate with the UGSs of neighborhood significance which are located in a zone of residential development. However, a quality ‘restricted’ cannot be fully applied towards UGSs within residential blocks.

According to The State Code of Land (2008), green spaces within a living zone (such as courtyards, playgrounds, community gardens, unless they are not located in a private area) would be considered lands for public use. These spaces are not owned by residents, despite residents’ direct affiliation to them which is reflected in monthly payments for maintenance of these areas included in utilities. However, current legislation on UGS provision tends to attribute these spaces to restricted use. Using this term may be justified by a limited range of people who interact with these spaces, since residents of the adjacent houses are mainly the ones who use them. These areas correspond to semi-public spaces by Krier’s (1998) classification. Meanwhile, green spaces such as parks, gardens, boulevards are used by all the residents no matter how far they live from it. These spaces are considered public.

Restricted use does not imply any limitations on use of these green spaces for non-locals (e.g., residents of one condominium may use a courtyard that has been designed for another one) but rather specifies a unique character of each green space in a residential development that is shaped by the preferences of a certain clientele living in a certain neighborhood. Only two private forms of residential development are able to impose restrictions on public use of UGSs adjacent to their territories: homeowner associations (HOA) and private landowners. The owners of such land plots are obliged to comply with current requirements on vegetation coverage at their expense. This sub-type of UGSs of district significance within a residential development also falls within the research objectives. Despite being considered spaces of restricted use, they do provide residents with greenery and related services, even if the number of residents benefiting from these spaces is limited. This UGS sub-type is marked separately from publicly accessible UGSs within a residential development in the maps.

In practice, putting UGSs of restricted use in a separate group results in their irregular maintenance (if at all) and poor design. In many cases, local residents take initiative for improving the conditions of green spaces that are adjacent to their houses. This issue together with potential ways of its solution is described in the Discussion part.

The sub-categories of UGSs of restricted use refer to an urban zoning that is based on several types of activity within an urban area. UGSs of restricted use fall within industrial, public, and living urban functional zones. These zones are marked differently in the city's Master plan (DAB, 2019). Every zone has its own required area that needs to be covered with vegetation. At the same time, green spaces of public recreational use (city parks, residential parks, urban forests, etc.) are counted as green spaces and marked separately within the city's Master plan. These spaces should be composed of vegetation to a percentage specified by the proportion of vegetation versus built-up area within UGS for each UGS type (fifth criterion in Appendix 5).

The level of vegetation coverage may be equally converted into a UGS availability indicator that presents the area of green spaces (in %) available for 1 ha of a residential block (WHO Regional Office for Europe, 2016). Level of vegetation coverage required for each urban functional zone based on the local standards (MAC, 2016) and is comprised of 25-58% of vegetation coverage for living zone depending on residential density. For public zones (commercial, educational, tourist and other areas) this number is 25-60%, for industrial zones – over 15%, for sanitary-protection zones – 40-60%.

Neighborhood green space (NGS) as a main subject of the study may be estimated within each of the criteria mentioned in Appendix 5 for conceptualizing a definition. However, a type of usage is being deliberately changed from 'restricted' (MAC, 2016) to 'semi-public' (Krier, 1998) since the last quality better represents a real form of usage of these spaces. The author tries to incorporate NGS qualities linking them to the local legislation together with listing its types. In this regard, the definition of NGS is given as follows: *NGSs are semi-public urban green spaces of neighborhood significance located in high- and low-density residential development that are mainly used by local residents of adjacent housing units (community gardens, public courtyards, playgrounds, green buffers, etc.).*

Figure 4.1.2 Examples of neighborhood green spaces in Brest (Credits: author)

NGSs may drastically differ in the level of maintenance, presented infrastructure, vegetation content, etc., as may be noticed from the photographs (Figure 4.1.2). NGS may comprise multiple purposes e.g., serving as a green buffer and a playground. However, the main feature remains unchanged: NGSs are located in the immediate surroundings of people’s residence. These features and issues related to NGSs are raised in the Discussion part.

Green buffer is mentioned in the NGS definition, as well as within examples of UGSs of neighborhood significance. This UGS type is specified separately in order to highlight its non-recreational function. Green buffers are designed for sanitary reasons: they regulate the density of residential development allowing a building to be exposed to adequate natural light (this measure is called insolation) and not being shadowed by neighboring buildings. Also, they ensure sufficient ventilation and are used for noise and exhaust gas absorption, which is especially important for housing units that are adjacent to high-traffic roads. The parameters of green buffers (area, setback distance, vegetation content) may differ and are entirely dependent on the characteristics (primarily, height) of a particular building. For example, a 9-story condominium (a common in high-density residential development in post-socialist cities like Brest) is 32 meters in height on average, which requires a buffering for nine meters from front, side, and rear sides of a building (URA Guidance, 2019).

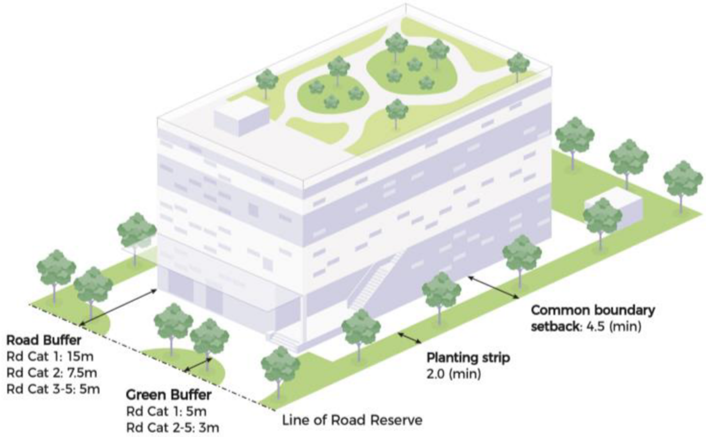

Figure 4.1.3 Examples of setbacks for non-industrial buildings, including a green buffer (Credits: URA Guideline, 2019)

Local residents normally interact with these spaces, indirectly or on purpose since they are located in people's immediate surroundings. The ways of current interaction and issues related to maintenance, as well as potential ways of redesigning these spaces are described in the Discussion chapter.

While analyzing several types of UGSs in the city, the author finds it difficult to distinguish between several types of UGSs of district significance (residential park in particular) and recreational types of NGSs (playground, courtyard). Sometimes, residential parks are located in close proximity to residential blocks and may be confused with NGSs. Visually, many of them are not regularly maintained (this issue is raised in the Discussion chapter), which is manifested in unmowed grass and spontaneous vegetation, for example. Lack of maintenance together with close location to residential blocks may lead to ambiguity between two types of UGSs.

Figure 4.1.4 Residential parks of district significance within a residential development in Maskoŭski district, Brest (Credits: author)

The author distinguishes between residential parks (RP) and NGSs by several features:

- *Size*. Usually, RP has a size around 1 ha, while NGSs are considerably less.
- *Location*. Despite being close to a residence, RPs are usually exposed to streets and/or centers of public demand, which are two different functional zones

according to the zoning plan (zone of streets and public zone, accordingly). NGSs are normally locked within a residential block (living zone).

- *Presence of nature features*. Vegetation content of RPs are usually more diverse and well-designed; they also may have a water body such a pond.
- *Amenities and infrastructure.* RPs usually have lighting, a network of paved pathways, benches, etc., while NGSs have few of it if at all.
- *Responsible body*. RP (just like the other UGS types of district significance) should always be managed by a local responsible body, however, it is not always visually apparent due to poor maintenance. On paper, NGSs are also managed by the responsible body, but this is poorly presented in reality.

This division between UGSs of district significance and NGSs (which are always of neighborhood significance) together with issues related to the management of green spaces in the city is explained in detail in the following chapters.

4.1.2 Indicators applied for geospatial analysis of UGS provision

Another part of the present legislation analysis deals with the identification of indicators that represent the research's steps in estimating UGS provision. Several indicators have been chosen with regard to the local legislation, the actual aims of the research, and the approaches studied during the Literature review chapter (such as WHO Report 'Urban green spaces and health' (WHO Regional Office for Europe, 2016) and the Wolff & Haase' (2019) paper). Necessary calculations are made in QGIS using various tools.

- *Residential density.* The ratio between the number of residents and the area of a residential block. It is measured in the number of residents per ha.
- *Accessibility radius (AR).* 'A distance from places of concentration of recreational demand (such as residential blocks) to UGSs' (MAC Guidance, 2016). It is measured in meters and may be translated into minutes of walking distance.
- *UGS provision.* The supply of UGSs' area per resident within a residential block. It is measured in square meters of green spaces per resident.

Residential density data have been derived from the database of the local Architect Department in the Brest Council in March 2021. It is based on the census data of the Belarusian Statistical Committee (Belstat, 2021). According to the Brest administrative division, the city is divided into two districts: Maskoŭski and Lieninski.

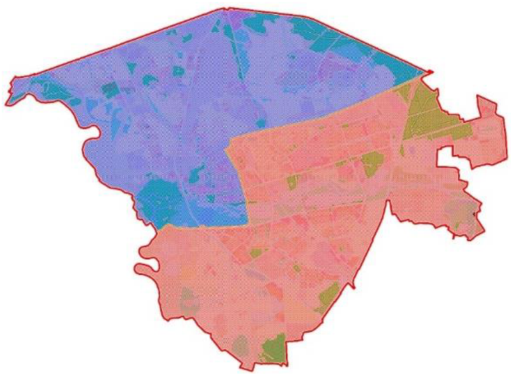

Figure 4.1.5 District division of Brest: blue – Lieninski, red – Maskoŭski (Credits: author)

These districts are comprised of ‘residential blocks’ (DAB, 2019). The residential density is calculated for each residential block in the city (106 in the Lieninski and 122 in the Maskoŭski district. 228 blocks in total). A simplified scheme of local administrative division is presented below.

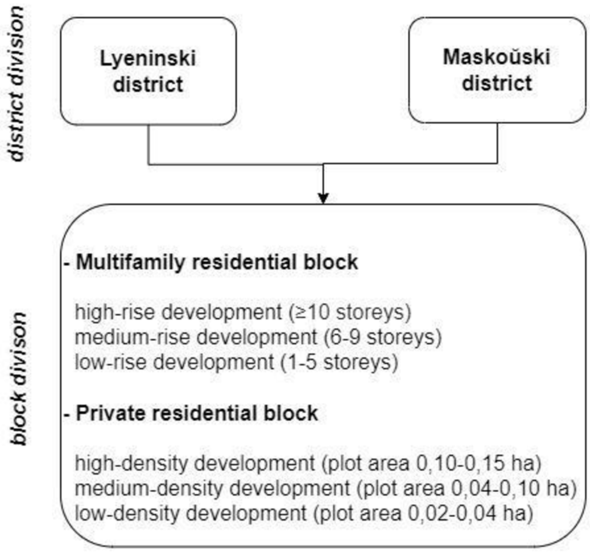

Figure 4.1.6 A simplified scheme of Brest administrative division (Adapted from DAB, 2019)

The blocks may vary in terms of the type of residential development. In general, types of residential development can be clustered into two groups: multifamily residential development (MFRD) and private residential development (PRD). The third group called ‘mixed development’ is not specified in the research due to the minor number of blocks in Brest falling within it. Instead of that, blocks with mixed development are distributed among two groups according to numbers of residential density.

All calculations and their outputs (Appendices 1, 2) regarding residential density, as well as other indicators, are described in the Results chapter.

Accessibility radius (AR) is measured for each UGS of the city (>5 ha size) and district significance (0.03-5 ha size). The radius represents a buffer zone around green spaces that can be done by performing a buffer analysis using selected attributes (size and significance) of UGSs as input data in QGIS (*Buffer* geoprocessing tool).

According to the Belarusian legislation on UGS provision, an acceptable distance to green spaces (measured as a walking distance and/or a ride on public means of transportation) may vary depending on the actual proximity of UGS to housing units, UGS level of significance (city, district, neighborhood), and size.

UGSs that have transport-related ARs are provided with public transport stops in close proximity to entrances and trailheads. In terms of the capital city Minsk (the only city in Belarus with a metro network), the transport-related radiuses may be doubled for those UGSs that are located in close proximity (up to 0,3 km) to the metro stations.

The distances for accessibility radiuses (ARs) chosen for the research are based on the local legislation, the existing urban layout of Brest, and recommendations on the UGS provision reviewed in the Literature review.

Table 4.1.1 Accessibility radius for UGS types in urban areas (Translated and adapted from MAC Guidance, 2016)

UGS type with approximate area	Accessibility radius (expressed in km and minutes) *	
	According to the local legislation	Vaues taken for the research
UGSs within a living zone (<5 ha)	0.1 km (5 minutes walking)	0.1 km (5 minutes walking)**
Residential park, garden, boulevard of a district significance (0.03-5 ha)	0.3-1 km (up to 15 minutes walking)	1 km (up to 15 minutes walking)
Multifunctional and specialized parks of a district significance (0.03-5 ha)	1 km (10 minutes ride on a public transport)	1 km (up to 15 minutes walking)
Multifunctional and specialized parks of a city significance (>5 ha)	2-5 km (up to 20 minutes ride on a public transport)	5 km (up to 20 minutes ride on a public transport)
Nature parks, urban forests, recreation area close to a water body (>5 ha)	2-5 km (up to 20 minutes ride on a public transport), or 2 km (30 minutes walking)	5 km (up to 20 minutes ride on a public transport)

* - The present research considers only the accessibility radiuses for UGSs of neighborhood and a city significance. Accessibility radius for UGSs within a living zone is provided in the normative but is not considered within the present research.
** - AR is not set for UGSs within a living zone in the research.

In terms of green spaces of district significance, it is assumed that residents taking a route through a living zone need to take minor detours on their way to green spaces. Normally, a pathway network within a residential block (especially, MFRD) is designed in a way to provide residents with the closest possible routes to the places of public demand (such as public transportation stops, commercial services, etc.). In practice, though, these pathways cannot be considered linear distances due to various physical barriers that may be encountered on a way (constructions, parking lots, fenced areas of engineering infrastructure, etc.). This may be justified by the observations of aerial footage of Brest's living zones and the author's personal experience living in a city with a similar urban pattern in living zones (which is Minsk, Belarus).

These facts are considered in choosing the radius for UGS of district significance. 1 km linear radius for UGSs of district significance represents an optimal distance and can be converted into 15 minutes of travel time, including time spent for possible minor deviations from a linear vector. Choosing the radius with a lower distance may lead to considerable dispersions between residential blocks regarding the UGS accessibility indicator and may not be representative of the present study.

Regarding UGSs of a city significance, preliminary visual observation of the city's present urban pattern allows assuming that a distance of 5 km may be considered representative for further research since most of the UGSs of a city significance (urban forest) with a size more than 5 ha are located on the urban fringes relatively far from central residential blocks. The distance for both radiuses is estimated from a border of a UGS.

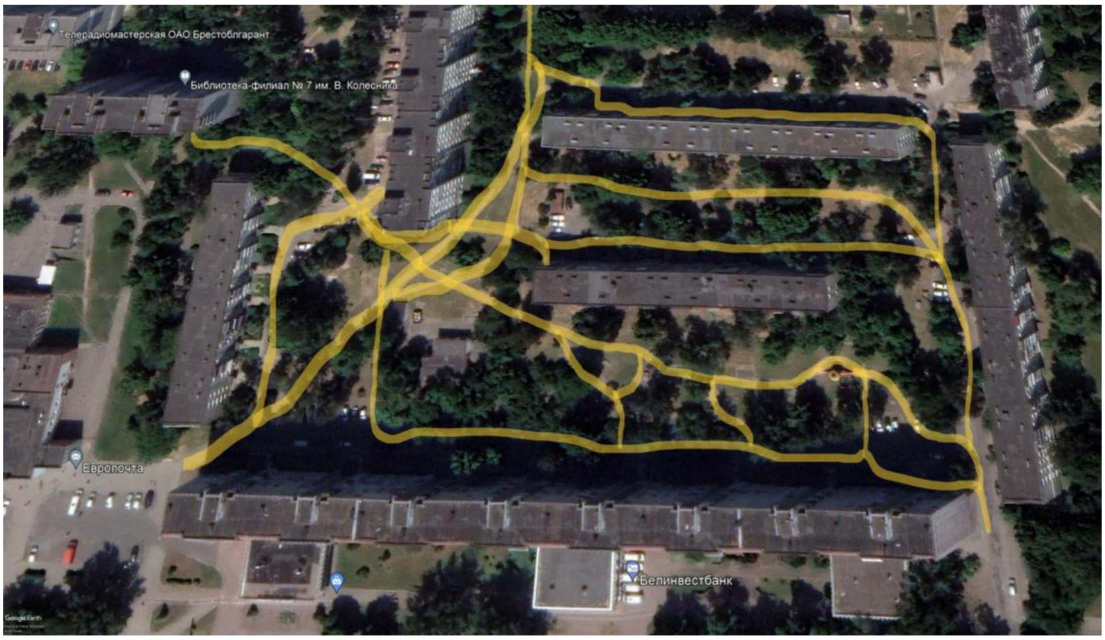

Figure 4.1.7 A fragment of a multifamily residential block in Maskoŭski district (Brest) with marked pathway network and public services (Image from Google Earth; Credits: author)

This distance-scale approach is found useful during the research. It shows that UGSs may have different supply areas according to their size. Bigger sizes of UGSs of city significance can be related to their capacities to accommodate more functions and amenities (Byrne & Sipe, 2010). UGSs of city significance are able to attract residents from around the city and even tourists outside of Brest. The accessibility radius (AR) which represents the UGS service area can be considerably bigger for these UGSs due to their bigger value for an urban area. The radius of 5 km is considered reachable primarily by the use of public transportation and has not been converted into estimated walking time.

The residential block is considered within the UGS service area even if a small part of the district is overlapped with its buffer zone. In this case, it is counted that the total population of the residential block is served by this UGS (Figure 4.1.9). The spatial selection of the population layer is performed in QGIS (*Select by Location* tool) and is based on the *Intersect* option. The author finds this option more applicable for the research than other alternatives (*Centroid* or *Completely within* options). Relatively small sizes of residential blocks (around 14 ha for multifamily and 19 ha for private residential blocks) do not affect a walking distance (thus, time) that may potentially be increased for those residents of the block who live outside of a UGS buffer zone (service area).

This may be proved by performing the tool using the *Centroid* option: the results do not differ between the two options, mainly because residential blocks are overlapped with UGS buffer zones to a considerable extent (around half of a block area). Meanwhile, potential increase in a walking distance within a residential block are being considered while identifying the AR (that is identified with a margin), which allows the author to consider any residential blocks intersected with a UGS service area.

UGS provision shows to what extent residents are supplied with green spaces. It is measured in m²/resident. According to MAC Guidance (2016), recommended numbers for UGS provision for Brest (large cities with a population over 100,000 inhabitants) are 7 m²/resident of UGSs of district importance, 8 m²/resident of UGSs of city importance, and 10 m²/resident of UGSs within a living zone.

This indicator is performed only for UGSs of district and city significance and is based on their ARs. General assessment of UGS provision in the city is based on a total area of UGSs regarding their type of significance. Calculations were made considering the total population of Brest together with population by each district. Also, UGS provision was calculated for the projected population for 2030 year. Following formula taken from MAC Guidance (2016) represents provision of green spaces for residents and is easily applicable in city or district scales.

$$UGS\ p.p.c. = Sc/d \times Cr \times 10{,}000\ /\ \sum Nr$$

Note: *UGSp.p.c.* - urban green space provision per capita (m²/resident);
Sc - an area of UGS of city significance (ha), *Sd* - an area of UGS of district significance (ha);
Cr - coefficient of recreational value, according to the fourth criterion in Appendix 5;
Nr - number of residents within a study area (city, district, residential block).

Apart from considering differentiations on UGS significance (Sc/d), the formula on UGS provision also includes a coefficient of recreational value (Cr) that differs for types of UGS. The research part considers an urban forest presented in Brest as UGS with the lowest recreational value (Cr=0,1) since these spaces are related to forest management and has other purpose which is usually manifested in lack of infrastructure and amenities presented in other types of UGSs for recreational use. Hence, urban forests cannot be evaluated equally with the rest types of UGSs.

Second part of the assessment is processed on a neighbor-scale using residential blocks as the research object. It is notable that one residential block may be located in multiple service areas of different UGSs. This is especially applied for UGSs of city significance since they have a 5 km service area which covers multiple blocks. This is applied for the private residential block 244 (Lieninski district) in the example below (Figure 4.1.8). It is intersected with multiple 5-km ARs (colored in gray dash and are marked with purple color), which represents a service area of UGS of a city significance (city parks and urban forests). Meanwhile, green spaces of district significance (residential parks, boulevards, etc.) with AR of 1 km (colored in red dash) are not intersected within the considered block. Most of UGSs of city significance cover residential blocks from both Lieninski and Maskoŭski districts. As a result, this residential block is provided with UGSs of city significance by 6.18 m²/capita, meanwhile a number on provision of UGSs of district significance is zero m²/capita. None of these values correspond to recommended numbers on UGS provision (MAC, 2016), which are 7 and 8 m²/capita, respectively.

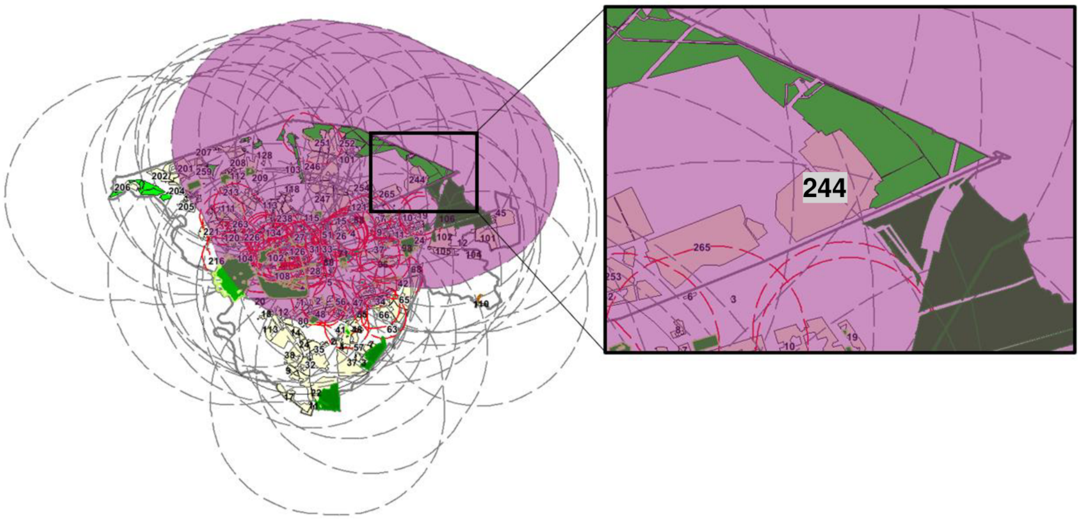

Figure 4.1.8 An example of evaluation of UGS provision for residential blocks with multiple overlays of accessibility radiuses (Credits: author)

The calculations of UGS provision per block were processed via SQL query. Equal shares of UGS' area (in ha) are equally divided between residential blocks that are located within accessibility radius (or radiuses). The sum of shares of green space' areas was then divided by the total population of a residential block. As a result, two maps were created representing the provision of green spaces of each significance (city and district) for residential blocks of the whole city (Appendices 3, 4). For illustrative purposes, a simplified scheme of the estimations is provided below (Figure 4.1.9):

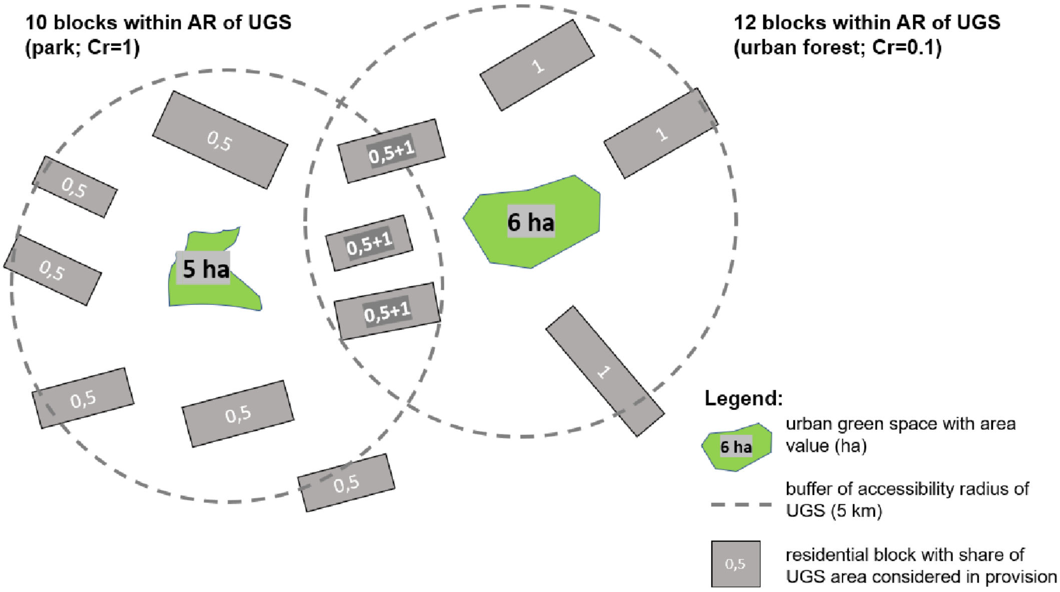

Figure 4.1.9 Visualized scheme of calculations on provision of UGS of city significance for each residential block (Credits: author)

The residential blocks that are overlapped with two ARs of green spaces are provided with equal shares of area from each UGS. These values (in ha) are then multiplied by a coefficient of recreational value (Cr) for each UGS and translated into square meters (by multiplying it to 10,000) and are divided by population of a particular residential block.

The example shows two UGSs types with different coefficients of recreational value (park: Cr=1; urban forest: Cr=0,1). This coefficient represents a level of maintenance and development of UGS (MAC, 2016). It is used to differentiate equipped green spaces with a sufficient level of maintenance and unmaintained UGSs (such as urban forest). Well-maintained UGSs are considered more valuable for residents' recreation and usually are subjected to bigger recreational pressure, while defining less-maintained green spaces helps preventing them from extensive development. Further estimations with recreational value are provided in the Results chapter.

In this case, a calculation formula for identifying UGS provision of city significance for residential blocks that are overlapped with two ARs of UGSs is as follows:

$$UGS\ p.p.c. = (5 \times 1 + 6 \times 0.1) \times 10{,}000\ /\ \sum Nr$$

The result of UGS provision per residential block is presented in a form of two separate maps: according to UGSs of city (Appendix 3) and district significance (Appendix 4).

This approach helps to identify the poorest and the richest residential blocks in terms of urban green space provision per capita while considering their significance. Finding residential blocks (and city areas) that lack UGSs in walking proximity the most may serve as for identifying areas of concern where NGSs need to be renovated first to serve residents as compensatory space for recreation.

4.2 Assessment of residents' perceptions for NGSs

The second part of the methodology is based on an assessment of residents' perception of NGSs by holding an online questionnaire using Google Forms. The questionnaire aims to assess residents' perception of the UGS network in general and detects potential demand on renovating NGSs to serve as a possible 'compensatory' element for recreational use.

An online questionnaire as a survey type is chosen in the second part of the research due to several reasons: ease of conducting it without a personal presence on a site and fastness of results collection for further analysis. This survey type is universally used in UGS-related studies and is mentioned in the Literature review (Nielsen & Hansen, 2006; Hogendorf et al., 2020, etc.).

Ideally, an online questionnaire should be complemented with an on-site survey based on personal observations and visitors' responses, especially when it comes to an assessment of UGS usage. While field visits in Brest's UGSs, it is noticed that many of UGSs, despite having the same characteristics, are full of their own distinct features. Residents' interaction with UGSs, in turn, may be different. These individual features shaping people's interactions with a particular UGS can be observed only personally, which makes a field survey so important, especially when a research deals with a specific UGS or a set of UGSs within one residential area.

The first part of the questionnaire aims to assess an overall residents' perception towards green spaces in the city, focusing on the UGSs of a city and district significance. This part also raises issues regarding provision among various categories of UGS. The second part deals with NGSs. It is assumed by the author that NGSs have a certain potential as a recreational space in residents' immediate surroundings. It raises issues related to the current state of these spaces and identifies demand among residents in their potential renovations.

The questionnaire was disseminated via VK social network, a Belarusian Green Network web-portal and local chats on Telegram messenger. Chats as a means of reaching the residents is worth noting. They may vary by scale (a chat for house, block, cluster of blocks) and usually are managed by the residents to inform them about upcoming maintenance works, potential interruptions in heating and water supply systems, planned public activities, and so on. Targeting directly a particular group of residents living in the same residential area is found to be a useful way for results collection. Small number of responses (n=58) may be explained by the unstable situation in the region (the war in Ukraine in February-March 2022) which caused an overall ignorance of non-essential issues as the research subject. It was also noted during the questionnaire that it is hard to reach elderly people since a few of them use the Internet.

The terms are being deliberately simplified for a respondent in the questionnaire to avoid confusion in their understanding. The term 'urban green space' is described within the questionnaire as 'green spaces for leisure' complementing it with several examples of UGSs of city and district significance together with pictures: city park, central boulevards, residential park, etc. (Figure 4.1.1). The term 'neighborhood green space' is described as 'green spaces that are adjacent to residence' listing among them public courtyards, playgrounds, green buffers, community gardens, etc. This term has been shortened to 'AS' (adjacent spaces).

The following tables represent groups of questions within the questionnaire. Most of the questions are obligatory (18 out of 20). Some of them may be skipped depending on the answer to the previous question. The questionnaire consists of several types of questions: one/multiple choice, rating scale, matrix, open-ended. Several types of questions help to keep respondents' attention span throughout the questionnaire. The type of each question is mentioned in brackets in the table. The first group consists of general information about the respondents. The name of a street as a residential location is considered representative for further understanding of what UGSs service areas may match with this location.

Table 4.2.1 Group 1 of the questionnaire: General information (Credits: author)

Question	Answers
Q1.1* Age [one choice q.]	- <18 - 18-30 - 31-45 - 46-65 - >65
Q1.2* Sex [one choice q.]	- Male - Female
Q1.3* Residence [open-ended q.]	*Please, type a street name*

* - Obligatory questions

Table 4.2.2 includes questions of the second group of the questionnaire that aims to assess UGS provision in Brest. Respondents are asked to assess particularly UGSs of city and district significance, the definition of which is provided at the beginning of the questionnaire form. The results of this part might detect residents' perception of poor and rich residential blocks in terms of UGS provision for further comparison with the GIS-based results. The author tries to exclude professional terms and definitions since it might seem overwhelming and unclear for respondents. For instance (Q2.1), most of the respondents may intuitively understand what type of city can be considered 'green' without additional explanations.

Table 4.2.2 Group 2 of the questionnaire: Assessment of UGS provision of city and district significance) (Credits: author)

<table>
<tr><th>Question</th><th>Answers</th></tr>
<tr><td>Q2.1* Do you find your city 'green'? [rating scale q.]</td><td>Please, choose from 1 to 5, where 1 - the city is not 'green' at all, 5 - the city is perfectly 'green'</td></tr>
<tr><td>Q2.2* How often do you use UGSs? [one choice q.]</td><td>- once per month or rarely
- 1-3 times per month
- 1-3 times per week
- almost every day
- I do not visit UGSs [to the Q2.8]</td></tr>
<tr><td>Q2.3* What is the purpose of the use of UGSs? [multiple choice q.]</td><td>- self-time (walking, sitting, contemplating)
- family time, playing with children
- physical activity (running, cycling, team sports, yoga, etc.)
- dog walking
- meeting with friends/colleagues
- celebrations/parties, picnics
- passing by
- other [type your own variant]</td></tr>
<tr><td>Q2.4* What are your favorite UGSs in the city that you visit the most? [multiple choice q.]</td><td>- City embankment
- City garden
- Central Park (1st of May Park)
- Warriors-Internationalists Park
- Mukhavets Eco-Trail
- Memorial Park Brest Hero-Fortress
- other [type a name/location of UGSs]</td></tr>
<tr><td>Q2.5* What time do you usually spend in these UGSs? [matrix q.]</td><td><table><tr><th></th><th><30 min</th><th>30-60 min</th><th>>60 min</th></tr><tr><td>weekend</td><td></td><td></td><td></td></tr><tr><td>weekday</td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Q2.6* What time does it take for you to reach UGSs from your residence? Choose the most common way of transportation [matrix q.]</td><td><table><tr><th></th><th>walking</th><th>cycling, etc.</th><th>public transport</th></tr><tr><td><15 min</td><td></td><td></td><td></td></tr><tr><td>15-30 min</td><td></td><td></td><td></td></tr><tr><td>>30 min</td><td></td><td></td><td></td></tr></table></td></tr>
<tr><td>Q2.7* Do you find travel time appropriate? [one choice q.]</td><td>- yes
- yes, but I would prefer getting to UGSs on foot
- no
- not sure
- other [type your answer]</td></tr>
<tr><td>Q2.8* What are the main obstacles in visiting UGSs more frequently? [multiple choice q.]</td><td>- they are located too far
- lack of free time
- weather factor
- poor maintenance (unmowed vegetation, presence of litter, faulty amenities, etc.)
- feeling of unsafety (due to traces of vandalism, graffiti,</td></tr>
</table>

	presence of drunk people, etc.) - fear of being hurt by (unleashed) dogs - lack of infrastructure (unpaved paths, no lighting, no resting areas, etc.) - non-inclusive environment (elevated curbs, too many stairs, no railings) - no playgrounds, sports grounds - all of the above - other [*type your own answer*]

* - Obligatory questions

The following table represents the third group of questions which aims to assess residents' perception to their neighborhood green spaces.

Table 4.2.3 Group 3 of the questionnaire: Perception of NGSs (Credits: author)

Question	Answers
Q3.1* Do you use your adjacent spaces (AS)? [one choice q.]	- yes, I use the AS of my house - yes, but I prefer to use another AS in the neighborhood - I live in a private house, but I use the AS in the neighborhood - I live in a private house and do not use the AS **[to the Q3.3]** - I live in an apartment building and do not use AS **[to the Q3.3]**
Q3.2* I visit the AS for (hereinafter - the AS of your residence. For those living in the private house, the AS that you visit the most): [multiple choice q.]	- get fresh air - play with the children in the yard - walk the dog - talk to neighbors/meet friends - sitting/walking/contemplating - exercising, workouting, etc. - doing team sports (football, basketball, etc.) - doing chores (beating the rugs, fixing the car, etc.) - enjoying nature and the sun - gardening (planting flowers, growing plants, etc.) - embellishing (any form of art and decoration) - other [*type your own answer*]
Q3.3* What elements does your AS have, and what elements do you lack? [matrix q.]	

	Presented in my AS and I am satisfied with it	**Presented in my AS, but I would prefer it to be fixed/ improved**	**Not presented in my AS, but nice to have it**	**Not presented in my AS do not need it**
benches				
trash bins				
paved paths				
playground				
diverse vegetation				
sports ground (incl. football, basketball)				
lighting				
dog park				
bike parking				

Q3.4 What other AS elements would you like to have? [open-ended q.] [*type your answer*]	
Q3.5* Rate the statements on a scale from 1 to 5, where 5 - strongly agree, 1 - strongly disagree: [rating scale q.]	- I consider my AS a place to relax - I feel safe in AS - my AS is a safe place for children - The AS is kept in good condition and always maintained (mowed grass, good infrastructure, etc.) - I like the vegetation of my AS

Q3.6* Check the statements with which you agree: [multiple choice q.]	- I started to use my ASs more often amid COVID-19 - my ASs could be used more diverse than they are used now - spending time in AS could help me get to know my neighbors better - I would like to be more involved in activities of my AS, if there will be some (maintain the area, plant seedlings, participate in activities, etc.) - AS can only be used by residents of the adjacent house/houses
Q3.7* Would you use the roof of your house as a resting area? **Q3.8*** Would you use ASs along with the houses as a resting area? [one choice q.]	- yes - no - I have access to it and I am already using this space (*if so, please, upload the photograph of this space by the end of the questionnaire*) - not sure

* - Obligatory questions

The questions Q3.7 and Q3.8 aim to provide a respondent with examples of possible green space interventions in residential blocks. Two potential spaces for interventions are chosen: a rooftop and a green buffer, respectively. In post-socialist residential development, these spaces are poorly exploited, despite their relatively big sizes. In many cases, residents of post-socialist cities are excluded from the use of their roofs, and green buffers have never been considered a place for recreation or other activities. The photographs are added to clarify what type of spaces are meant by the author. To ensure better visibility, they were derived from the renovation projects from residential developments with a similar to Belarus construction approaches. In the case of a green roof, the photograph from Moscow (Russia) is taken as a good example of potential green space interventions on rooftops (Moscow UPC, 2021). The second photograph is taken by the author in Minsk in October 2021 representing interventions within a front green buffer of a 5-story multifamily building.

Figure 4.2.1 Examples of green space interventions used in the questionnaire: A) green roof of the multifamily building, Moscow; B) resting area within the green buffer of the 5-story building, Minsk (Credits: Moscow UPC; author).

A combination of visual representation from spatial analysis and questionnaire results makes it possible to coherently evaluate UGS provision in Brest for identifying gaps in the city's UGS network. The questionnaire results give an understanding of residents' interaction with green spaces of city and district significance and help to identify the role of NGSs that may fill gaps in the UGS network providing people with recreational areas in their immediate surroundings. A residents' demand for renovations of their NGSs for their further use is also evaluated within the questionnaire.

5. Results

This chapter presents the results processed from different parts of the research: (1) analysis of the current characteristics of Brest on UGS network and population data, (2) assessment of UGS provision within the city based on spatial analysis, and (3) evaluation of residents' perception of the city's UGS network (and particularly neighborhood green spaces as a part of the network) by residents based on the questionnaire results.

5.1 Current characteristics of Brest

5.1.1 UGS network of Brest

The city of Brest is composed of UGSs of different scale, or significance (as it is named in the local legislation): city, district, and neighborhood. The UGS network of the city is based on green spaces of city and district scale, while UGSs of neighborhood significance are considered spaces of less importance. Within the work, six UGSs types were defined for further research: parks, residential parks, boulevards, community green spaces, recreation areas close to a water body, urban forests. These types were chosen among others due to their considerably greater share of the study area, high recreational value, and public accessibility. In this regard, they serve as a backbone of the UGS network. Other green spaces such as IGSs (green verges, buffers, vacant lots, etc.), with all due respect to their certain recreational potential and overall significance, cannot be considered as forming elements of the UGS network.

Definition for each UGS type specified in Table 5.1.1 is based on the data from the criteria described in Appendix 5. The criteria provided are needed for further analysis.

Table 5.1.1 Types of UGSs evaluated within the research

Type of UGS	Definition	Significance	Area, ha	Accessibility radius, km	Recreational value	Examples
Park	publicly accessible equipped green space within city borders	city	>5 ha	5 km	1	Multifunctional park, city park, nature park
Residential park	publicly accessible equipped green space located primarily near residential districts	district*	0.03 - 5 ha	1 km	1	Green spaces within residential districts and commercial zones, memorial park
Boulevard	publicly accessible equipped green space with one or several layers of plantings, located between transport lines of a street	district*	>0.03 ha	1 km	1	-
Community green space	publicly accessible equipped green space located within community centers	district*	<5 ha	0,1 km	1	-

	near residential districts					
Recreation area close to a water body	publicly accessible equipped green space of blue-green system	city	>0.03 ha	5 km	1	Beach, vegetated embankment
Urban forest	forest lands of forestry reserves located within city borders	city	-	5 km	0.1	-

* - Unless they are not located in the city center

The following table (Table 5.1.2) shows the amount and area of six of the most common types of green spaces described above. It also specifies a share of equipped UGSs among each type of green space, which is manifested in presence of lighting, network of pathways, benches, other amenities, playgrounds, and various sport grounds that may be used by residents for recreation and physical activity.

The idea of identifying the share of equipped UGSs came during the author's field visits to green spaces on the city's fringes. After visiting a few of them, it became evident that this issue has a generalized character since a lot of UGSs lack proper infrastructure or do not have it at all. It is relevant to urban forest, which are mainly located along the city's borders. Being considered an UGS of a city significance because of sizable areas, urban forests normally have a minimum of infrastructure, which may only be manifested in paved sidewalks and/or car roads with sporadic fireplaces and resting areas usually made by visitors. In order to mitigate an impact of area values for urban forests, a different coefficient of recreational value was taken (0.1 instead of 1 as for other UGS types) while estimating UGS provision for residents (Table 5.1.1).

A scale of the issue was identified by estimating the share of equipped green spaces in the total UGS area and described below the table. Field visits were complemented by visual analysis of UGSs' aerial imageries from Google Earth and Yandex Maps Street view, which in many cases was enough to define whether UGSs are equipped or not. The analysis of the structure of the UGS network and calculations of their area was conducted via QGIS. The issue of unequipped UGSs is also raised within the questionnaire, the results of which are presented in the next subchapter. The Discussion chapter provides the author's explanation of the issue and potential ways of addressing it.

The UGS network of Brest is comprised of 96 green spaces with public recreational use (Table 5.1.2), among them:

- **city parks** – 13 (city - 12 parks, district - 1);
- **residential parks** – 45 (city - 6; district - 39);
- **boulevards** – 8 (city - 6; district - 2);
- **recreation areas near the water** – 4 (city - 4);
- **community green spaces** – 7 (city - 2; district - 5);
- **urban forests** – 19 plots (all of them are considered UGSs of city significance).

Urban forests are considered as green spaces of city significance. The total area of green spaces of public use in the city of Brest considered in the research is about

1713.4 ha (11.73% of the total area of the city). The following table provides areas and amounts of UGSs for the whole city and does not specify it for each city district.

Table 5.1.2 The structure of the UGS network in Brest with share of area for each type

Types of UGS / *UGS significance*	**UGSs of public recreational use**			**Share of equipped UGSs**		
	Amount	**Total area, ha**	**%**	**Amount**	**Total area, ha**	**%**
City park	**13**	**582.65**	**34.01**	**7**	**363.27**	**85.10***
City	12	577.10	99.05	6	357.72	98.47
District	1	5.55	0.95	1	5.55	1.53
Residential park	**45**	**46.52**	**2,72**	**33**	**29,23**	**6.85***
City	6	8.41	18.08	2	1.50	5.13
District	39	38.11	81.92	31	27.73	94.87
Boulevard	**8**	**14.19**	**0.83**	**8**	**14.19**	**3.32***
City	6	12.20	0.00	6	12.20	85.98
District	2	1.99	100.00	2	1.99	14.02
Community green space	**7**	**11.28**	**0.66**	**4**	**9.40**	**2.20***
City	2	5.31	47.07	1	4.64	49.36
District	5	6.29	52.93	3	4.76	50.64
Recreational area close to a water body	**4**	**10.78**	**0.63**	**4**	**10.78**	**2.53***
City	4	10.78	100.00	4	10.78	100,00
District	0	0.00	0.00	0	0.00	0.00
Urban forest	**19**	**1047.98**	**61.16**	**0**	**0.00**	**0.00**
TOTAL	**96**	**1713.40**	**100.00**	**55**	**426.87**	**100.00***
City	48	1661.78	96.99	21	389.44	91.23
District	48	51.62	3.01	34	41.71	9.77

* - From the total area of UGSs of public recreational use

At first glance, the structure of the UGS network of Brest can be characterized by big shares of green spaces of city significance, particularly city parks and urban forests. These two types comprise 95.17% of the total area of UGSs in the city.

The total area of equipped UGSs is 426.87 hectares or 24.91% of the total area of urban green spaces of the city. These spaces (55 out of 96 UGSs in the city) are confined to the water system of the Mukhavets river, the main transport roads of the city and the established centers of public demand (squares, city center, community centers). The low-story (mainly with private development) residential blocks of the city lack green spaces of public use the most. Green spaces of city significance prevail

(96.99%), in particular, due to a vast area of urban forests and urban parks (Figure 5.1.1).

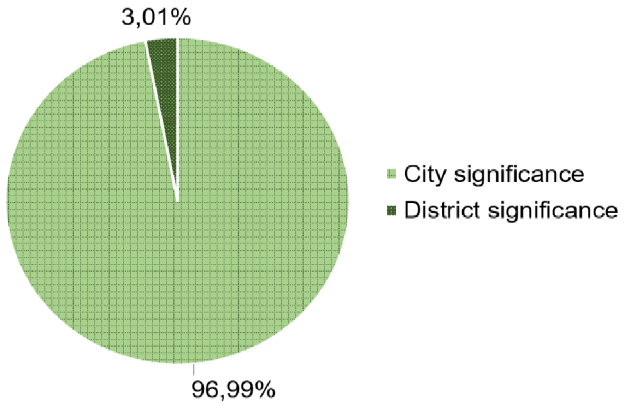

Figure 5.1.1 Proportion of UGSs within the UGS network of Brest according to their significance

Urban forests (61.16%) and parks (34.01%) predominate in the structure of green spaces of public recreational use in the city of Brest. Other types of spaces in the total structure account for only 4.83%. The green spaces of community centers have the smallest share (0.66%) (Figure 5.1.2).

Community green spaces are established in places of increased recreational demand and are designed to meet the need for short-term recreation of the residents in their walking proximity. Urban forests, despite the absence of infrastructure, are considered important UGS types that are used by residents of non-central neighborhoods and city' suburbs for recreation.

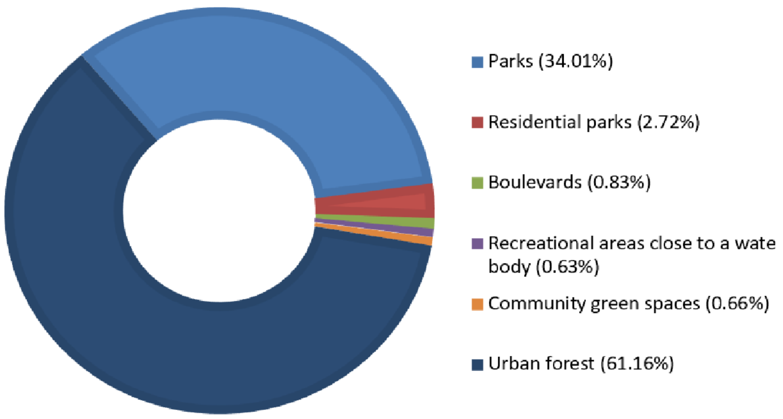

Figure 5.1.2 Structure of UGSs types within the UGS network of Brest

A distinctive feature of the Brest' UGS network is that UGSs of public use are mainly located within floodplain areas of the Mukhavets and Zakhodni Buh rivers. Green spaces within the city center are the most equipped and maintained ones since residents and tourists visit these spaces more than others.

Table 5.1.3 shows the structure of six specified types of UGSs by districts. The UGS structure by districts is as follows: Lieninski district - 1066.14 ha (15.43% of the total area of the district), Maskoŭski district - 647.26 ha (8.40% of the total area of the district).

Table 5.1.3 The structure of the UGS network by districts in Brest with share of area for each type

Types of UGS / *UGS significance*	**UGSs of public recreational use**					
	Lieninski district			**Maskoŭski district**		
	Amount	**Total area, ha**	**%**	**Amount**	**Total area, ha**	**%**
City park	**9**	**494.01**	**46.34**	**4**	**88,64**	**13,69**
City	9	494.01	100.00	3	83,09	93,74
District	0	0.00	0.00	1	5,55	6,26
Residential park	**21**	**18.21**	**1.71**	**24**	**28,31**	**4,37**
City	1	0.56	3.08	5	7,85	27,73
District	20	17.65	96.92	19	20,46	72,27
Boulevard	**6**	**11.19**	**1.05**	**2**	**3,00**	**0,46**
City	5	10.52	94.01	1	1,68	56,00
District	1	0.67	5.99	1	1,32	44,00
Community green space	**1**	**1.95**	**0.18**	**6**	**10,76**	**1,66**
City	1	1.95	100.00	2	5,31	49,35
District	0	0.00	0.00	4	5,45	50,65
Recreational area close to a water body	**1**	**0.52**	**1**	**3**	**8,83**	**1,36**
City	0	0.00	0	3	8,83	100,00
District	1	0.52	1	0	0,00	0,00
Urban forest	**12**	**540.26**	**50.67**	**7**	**507,72**	**78,44**
TOTAL	**50**	**1066.14**	**100.00**	**46**	**647,58**	**100,00**
City	28	1047.30	98.23	20	614,48	94,94
District	22	18.84	1.77	26	32,78	5,06

An analysis of the structure of **the Lieninski district'** UGS network showed that it is comprised of 9 parks (city significance), 21 residential parks (city - 1, district - 20), 6 boulevards (city - 5, district - 1), one community green space, one recreation area near a water body, as well as twelve plots of urban forests. The total area of green spaces in the Lieninski district is 1066.14 ha, or 15.40% of the total area of the district. The total area of equipped UGSs is about 313.88 ha, or 29.40% of the total area of UGS of public recreational use in the district. The overall structure of UGSs is dominated by green spaces of city significance (98.23%), in particular, due to the large area of urban forests (50.67%) and city parks (46.34%). The smallest share is among community green spaces (0.05%), as well as recreation areas near the water (0.18%).

An analysis of the structure of the **Maskoŭski district'** UGS network showed that it is comprised of four city parks (city significance - 3, district - 1), five residential parks of city and 19 of district significance, one boulevard of city and one of urban significance, six community green spaces (city - 2, district - 4), three green spaces adjacent to a water body, as well as seven plots of urban forest. The total area of UGSs in the Maskoŭski district is 647.26 ha, or 8.40% of the total area of the district. The total area of equipped UGSs is 112.99 hectares, or 17.44% of the total area of UGS of public recreational use in the district. UGSs of city significance prevails (94.94%), due to a significant area of urban forests (78.44%) and parks (13.69%). Boulevards (0.46%), green spaces of public centers (1.66%) and recreation areas near the water (1.36%) have the smallest share. The results of UGS composition by each district is presented below (Figure 5.1.3).

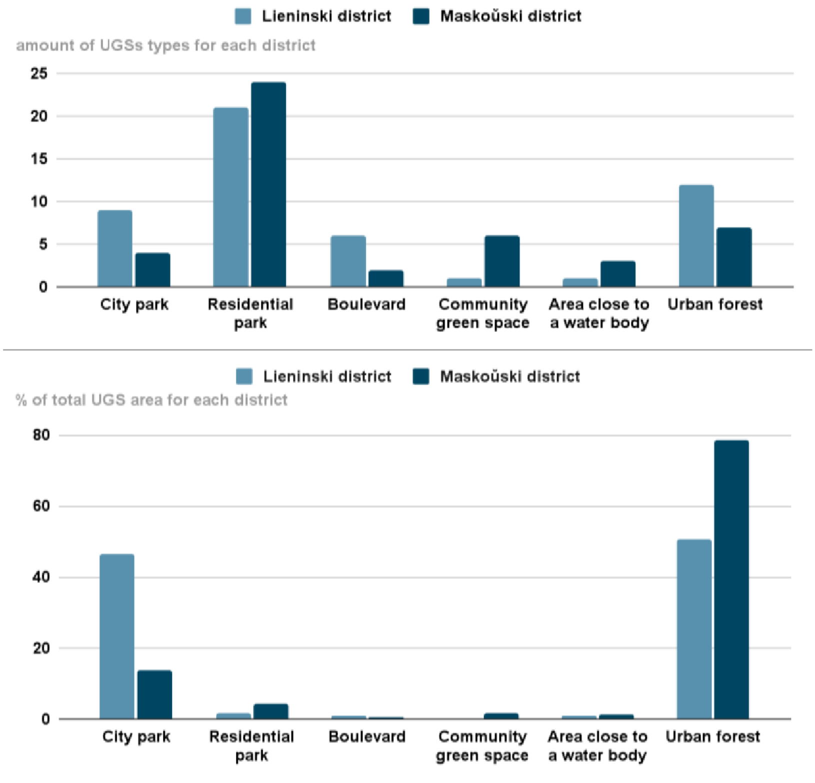

Figure 5.1.3 Comparison of composition of UGS types in Brest by each district according to their amount (top) and % (down) of total UGS area

It is worth mentioning that community green spaces due to their small areas were excluded as a separate type of UGS for creating maps on UGS provision (Appendices 3, 4), but were considered as residential parks with the respect to their significance (city/district).

5.1.2 Population data of Brest

The population data was derived from the annual demographic book compiled by the Belarusian Statistical Committee and issued in January 2022 (Belstat, 2021).

At the end of the year 2021, the population of the city of Brest is 352.3 thousand people. According to the data provided by the Department of Architecture in the Brest Council on the distribution of the population by administrative districts of Brest

(Belstat, 2021), 109.6 thousand people (31.1%) live in the Lieninski district of the city, 242.7 thousand people (68.9%) live in the Maskoŭski district. The city of Brest is characterized by annual population growth. Over the past five years, from 2016 to 2021, the city's population has increased by 18.3 thousand people (Figure 5.1.4). The annual population growth rate was 0.9-1.3%.

The increase in the city's population occurred both due to positive natural growth and a positive balance of migration: natural population growth for 2016-2021 was estimated at 7.3 thousand people, while migration caused growth - 11.1 thousand people.

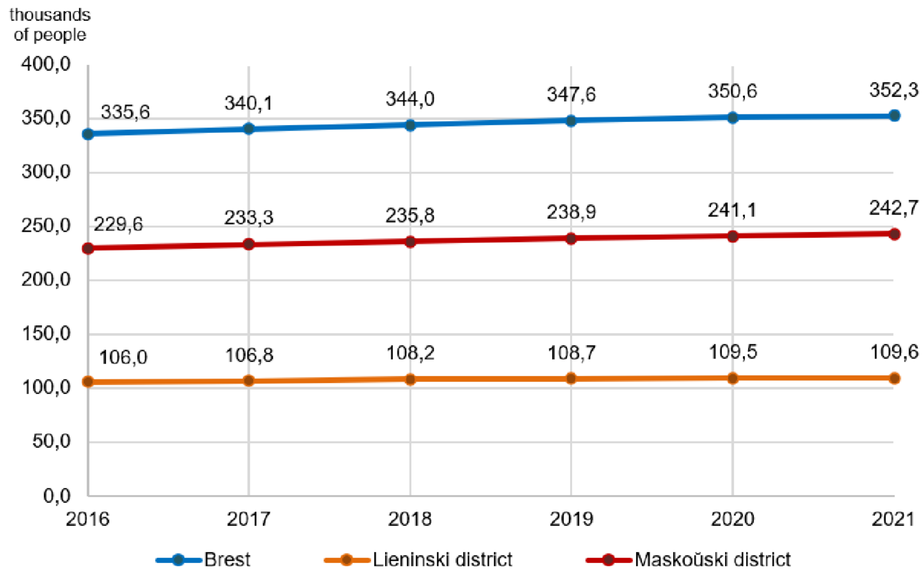

Figure 5.1.4 Population dynamics by administrative districts of Brest by years

Considering population trends for the period 2016-2021, the population of Brest in the forecast period may reach 371.0 thousand people by the end of 2025, and by the end of 2030 years - 383.0 thousand people. The average annual population growth rate is expected to be about 0.9-1.0% (Belstat, 2021). An increase in the city's population is expected as a result of positive natural and migration growth in the coming years, as well as due to new multifamily and low-story residential development that is taking place in the city as a key part of implementation of densification strategy.

In this research, in order to perform calculations of the residents' UGS provision within the city, 86 and 142 plots of multifamily and low-story residential blocks (respectively) were allocated, which corresponds to the existing Brest' administrative division described in the Methodology chapter (Figure 4.1.6).

According to the Master plan (DAB, 2019), the Brest' housing stock amounted to 8866.1 thousand m² of the total area of residential housings, among them: 6687.9 thousand m² (75.4%) of high-density residential development (multifamily), and 2178.1 thousand m² of low-density residential development (private) (24.6%). The share ratio of population by types of residential development is 79.5% to 20.5% in favor of multifamily development. As of January 2021, an average housing provision was 25.2 m²/capita, including 23.9 m²/capita for multifamily development and 30.2

m²/capita for low-story development. At present, 75.4% of the total housing stock accounts for multifamily development, and 24.6% for low-story development.

In order to reach better clarity, the research considers UGS provision and data required for it (e.g., population data) for each district separately. Within the Lieninski district, 106 blocks were specified, among them: 40 blocks of high-density (multifamily) residential development (MFRD) and 66 blocks of low-density (private) development (PRD) with 79.6 and 30.0 thousand of residents, respectively. Maskoŭski district is composed of 46 blocks of MFRD and 76 blocks of PRD with the population of 200.5 thousand and 42.2 thousand residents (respectively). All data was calculated in QGIS and presented in aggregated form in Table 5.1.4. The numbers in parentheses for each type of development refer to numbers of residential blocks used for mapping (Appendices 1, 2).

Table 5.1.4 Population distribution according to type of residential blocks by each district in Brest

District / type of block	**Amount**	**Area of blocks, ha**	**Area of housing stock, m²**	**Population, in thousands**
Lieninski (in total)	**106**	**1888.8**	**3983.6**	**109.6**
MFRD (101-140)	40	252.0	2742.0	79.6
PRD (201-266)	66	1636.8	1241.5	30.0
Maskoŭski (in total)	**122**	**2312.6**	**4882.5**	**242.7**
MFRD (301-346)	46	729.0	3945.9	200.5
PRD (401-476)	76	1583.6	936.6	42.2
TOTAL for the city	**228**	**4210.4**	**8866.1**	**352.3**

In terms of population, **the Lieninski district** is dominated by residential blocks with a population of up to 250 people (37 residential blocks). Among PRD, blocks with the population less than 250 people are prevailing (31 blocks). They are located both in the central part and in the peripheral part of the district (Appendix 1). 72.6% of the district population live in MFRD, which comprises only 13.3% of the total residential area of the district.

Based on the block division presented in Appendix 1, the distribution of the MFRD of blocks according to the density of the housing stock is as follows:

- low-rise MFRD (1-5 floors) - 195.3 thousand m² (11 blocks);
- medium-rise MFRD (6-9 floors) - 304.1 thousand m² (6 blocks);
- high-rise MFRD (>10 floors) – 2242.7 thousand m² (23 blocks).

The distribution of the PRD of blocks according to the density of the housing stock is as follows:

- high-density PRD (size of a plot 0.02-0.04 ha) – 95.4 thousand m² (5 blocks);
- medium-density PRD (0.04-0.10 ha) – 207.3 thousand m² (8 blocks);
- low-density PRD (0.10 to 0.15 ha) - 938.8 thousand m² (53 blocks).

High-density PRD blocks are located mainly in the central part of the district.

The Maskoŭski district is dominated by residential blocks with a population of less than 250 people (33 blocks) and residential blocks with a population of more than 1500 residents (39 blocks). The densest blocks are among MFRD (>10 floors) which are located within areas of new construction. Among the blocks of PRD prevail the ones with less than 250 residents (30 blocks). They are located both in the central part and in the peripheral parts of the district (Appendix 2). 56.9% of the district population live in MFRD, which comprises 31.5% of the total residential area of the district. The distribution of the MFRD in the district according to the density of the housing stock is as follows:

- low-rise MFRD (1-5 floors) - 937.9 thousand m² (22 blocks);
- medium-rise MFRD (6-9 floors) - 1920.8 thousand m² (15 blocks);
- high-rise MFRD (more than 10 floors) - 1087.2 thousand m² (9 blocks).

The structure of private residential development (PRD) of the district according to the density of the housing stock is distributed as follows:

- high-density PRD (area of a plot 0.02-0.04 ha) - 38.0 thousand m² (2 blocks);
- medium-density PRD (0.04-0.10 ha) - 382.0 thousand m² (14 blocks);
- low-density PRD (0.10-0.15 ha) - 516.6 thousand m² (60 blocks).

Blocks of high-density PRD are located mainly in the center of the district (Appendix 2).

An average population density for MFRD blocks in the Lieninski district is 301.50 residents/ha, while in PRD is around 18.34 residents/ha. The Maskoŭski district has 266.53 residents/ha for MFRD blocks and 26.65 residents/ha for PRD blocks on average. The city's average population density (only the living zone comprising blocks is considered) is 83.67 residents/ha.

Figure 5.1.5 shows that PRD blocks from two city districts do not differ between each other in terms of population density, which may be explained by relatively identical areas of private plots within the urban area and similar number of people in each household. Despite widespread application of a density indicator in finding UGS provision in urban areas across the revised studies, the present research uses population data for that purpose. Choosing a population data per block instead of density can be also justified by disparities in size of residential blocks: some of them have big areas with a few housing units within it, meanwhile small blocks in terms of area can be highly developed accommodating thousands of residents.

As a result, two maps for each city district were created representing the number of residents living within each residential block defined by colors, where the blocks colored in red represent more than 1500 inhabitants living in the block, and light-yellow stands for less than 250 inhabitants within the block (Appendices 1, 2). Fragments of maps can be found below (Figure 5.1.6).

Current city zoning was used as a background for creating the maps. It represents zones according to diverse types of activities, e.g., industrial, living, public zones. The research objective of the present part is population by residential blocks; hence the living zone is the only one under consideration. Other zones (together with their subtypes) are provided within this part of the research for better visualization.

Block	Area	Population	Density
201	42,37	777	18,34
202	62,72	1 150	18,34
203	29,77	546	18,34
204	22,01	404	18,36
205	40,65	745	18,33
206	20,45	375	18,34
207	9,69	178	18,37
208	32,44	595	18,34
209	13,91	255	18,33
210	39,27	720	18,33

Block	Area	Population	Density
401	27,05	721	26,65
402	11,30	301	26,64
403	9,80	261	26,63
404	29,84	795	26,64
405	50,61	1 349	26,65
406	3,94	105	26,65
407	81,00	2 159	26,65
408	61,87	1 649	26,65
409	15,77	420	26,63
410	11,31	301	26,61

Figure 5.1.5 Population densities in PRD of Lieninski (left) and Maskoŭski (right) districts derived from the QGIS tables of attributes

The GIS analysis applied in this part differentiates residential blocks according to their population. Population data is used to evaluate the number of residents living within the UGS service area (that corresponds to a particular UGS accessibility radius), which then can be translated into UGS provision per capita numbers. This part also gives an understanding of the most and least densely populated city's residential areas, which may form a general idea about residential blocks with highest and lowest UGS provision.

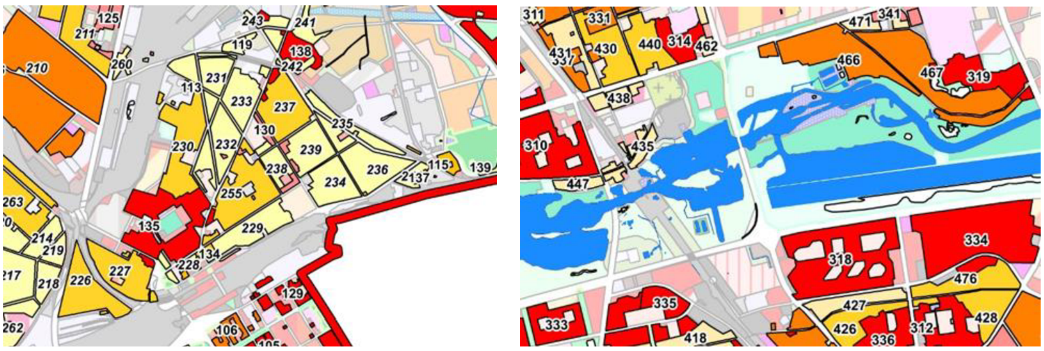

Figure 5.1.6 Fragments of maps representing population within residential blocks in the Lieninski (left) and Maskoŭski (right) districts of Brest (Appendices 1, 2)

5.1.2 Assessment of UGS provision

UGS provision per capita in Brest was calculated in two ways. The first way is based on summarization of UGS areas by type of their significance (city or district). Results of this part help to identify which UGSs types the city, or a certain district lack the most. It gives general understanding on the level of UGS provision for residents, while the second part of calculations deals with assessment at a neighborhood scale considering the residential blocks. The research object of this part is a network of residential blocks. The calculations here are based on summarization of population data for each residential block that falls within the accessibility radius (AR) of a particular green space of district (0.03-5 ha size) and city (>5 ha size) significance.

The ARs may vary for UGSs according to their size and recreational value (ARs are described in Table 4.1.1).

The formula described in the Methodology helps to define an aggregated UGS provision per capita. It is calculated for each district and for the city in general based on areas of UGSs of city and district significance. Calculations are made separately for each UGS significance (city and district). It is due to differences between types in service areas of UGSs (AR is 5 km for city and 1 km for district significance), which means they can encompass different populations living in the residential blocks. This indicator also considers a coefficient of recreational value based on criterion 4 in Appendix 5, which is also mentioned for analyzed types of UGS in Table 5.1.1.

$$UGS\ p.p.c. = Sc/d \times Cr \times 10{,}000\ /\ \sum Nr$$

Note: *UGSp.p.c.* - urban green space provision per capita (m^2/resident);
Sc - an area of UGS of city significance (ha), *Sd* - an area of UGS of district significance (ha);
Cr - coefficient of recreational value;
Nr - number of residents of a residential block related UGS service area.

According to the local legislation, recommended numbers for UGS provision for Brest (large cities with a population over 100,000 inhabitants) are 7 m^2/resident of UGSs of district significance and 8 m^2/resident of UGSs of city significance. The calculations below were processed for total areas of UGS types, not specifying equipped green spaces among them. In the city scale considering the total population for the year 2021, a calculation for UGSs of city (Sc) and district (Sd) significance looks as follows:

$$\boldsymbol{UGS\ p.p.c.(city\ 2021)} =$$
$$\boldsymbol{Sc}(577.1 \times 1 + 8.41 \times 1 + 12.20 \times 1 + 5.31 \times 1 + 10.78 \times 1 + 1047.98 \times 0.1) \times 10{,}000/352{,}300 = \boldsymbol{20.40\ m^2/capita}$$
$$\boldsymbol{Sd}(5.55 \times 1 + 38.11 \times 1 + 1.99 \times 1 + 6.29 \times 1) \times 10{,}000/352{,}300 = \boldsymbol{1.47\ m^2/capita}$$

For further analysis presented in the Discussion chapter, calculations for the year 2030 with a foreseen population of 383,000 residents were also made:

$$\boldsymbol{UGS\ p.p.c.(city\ 2030)} =$$
$$\boldsymbol{Sc}(577.1 \times 1 + 8.41 \times 1 + 12.20 \times 1 + 5.31 \times 1 + 10.78 \times 1 + 1047.98 \times 0.1) \times 10{,}000/383{,}000 = \boldsymbol{18.76\ m^2/capita}$$
$$\boldsymbol{Sd}(5.55 \times 1 + 38.11 \times 1 + 1.99 \times 1 + 6.29 \times 1) \times 10{,}000/383{,}000 = \boldsymbol{1.36\ m^2/capita}$$

In terms of the districts, the calculations on UGS provision based on current population data look as follows:

$$\boldsymbol{UGS\ p.p.c(Lieninski)} =$$
$$\boldsymbol{Sc}(494.01 \times 1 + 0.56 \times 1 + 11.19 \times 1 + 1.95 \times 1 + 540.26 \times 0.1) \times 10{,}000/109{,}600 = \boldsymbol{51.25\ m^2/capita}$$
$$\boldsymbol{Sd}(17.65 \times 1 + 0.67 \times 1 + 0.52 \times 1) \times 10{,}000/109{,}600 = \boldsymbol{1.72\ m^2/capita}$$

$$\boldsymbol{UGS\ p.p.c(Masko\breve{u}ski)} =$$
$$\boldsymbol{Sc}(83.09 \times 1 + 7.85 \times 1 + 1.68 \times 1 + 5.31 \times 1 + 8.83 \times 1 + 507.72 \times 0.1) \times 10{,}000/242{,}700 = \boldsymbol{6.49\ m^2/capita}$$
$$\boldsymbol{Sd}(5.55 \times 1 + 20.46 \times 1 + 1.32 \times 1 + 5.45 \times 1) \times 10{,}000/242{,}700 = \boldsymbol{1.35\ m^2/capita}$$

A preliminary analysis of UGS provision in the city- and district-scale results presented above shows that provision of UGSs of district significance (residential parks with AR of 1 km) does not meet the recommendation of at least 7 m²/capita (or WHO recommendations of 9 m²/capita of UGSs in walking proximity without specifying a type of significance). The scale of an issue becomes even more evident when only equipped UGSs are considered: provision of green spaces of district significance is only 1.18 m²/capita, while for UGS of city significance this number is 11.05 m²/capita.

Table 5.1.5 shows UGS provision results for the whole city and districts in their aggregated form marking in bold the ones that do not meet recommendations on UGS provision. The area of deficit green spaces in hectares was also calculated and specified in parentheses. These areas are supposed to be added to the existing UGS network of the city to reach recommended values for UGS provision. Based on the results of the first part, it is evident that the city lacks UGSs of district significance, which can be proved by small numbers of UGS provision per capita both for the whole city in total and for each district separately. As to provision of equipped UGSs, the numbers of additional UGS areas necessary to meet local recommendations would be even higher. Further analysis of results together with discussion of this issue is provided in the next chapter.

Table 5.1.5 UGS provision numbers based on present population data (2021) according to the study areas (in parenthesis: deficit areas of UGSs in hectares)

Study area	UGS provision (m²/capita)			
	In total for all UGSs		Only for equipped UGSs	
	City significance	District significance	City significance	District significance
Brest	20.40	**1.47* (194.10 ha)**	11.05	**1.18**
Lieninski district	51.25	**1.72 (57.84 ha)**	27.51	**1.13**
Maskoŭski district	**6.49 (36.23 ha)**	**1.35 (137.34 ha)**	**3.62**	**1.21**

* - Numbers in bold do not meet recommendations on UGS provision

The second part of calculations on UGS provision considers a population of each residential block as a basis. The maps show provision of UGSs of city (Appendix 3) and district significance (Appendix 4) for all the residential blocks in the Brest urban area. The aerial imagery of Brest is used as a background. For the UGSs of city significance, the recommendation of 8 m²/capita is met for the population living in 70 out of 86 residential blocks of multifamily residential development (MFRD) and 74 out of 142 private residential development (PRD) with the population of 210,022 and 44,789 residents living within them, respectively. The total number of residents living in these residential blocks is over 254,811 people (around 72.3% of the total population of Brest).

The highest indicators of provision with objects of the system of UGSs of city significance of the Lieninski district and the entire city of Brest are typical for the blocks of the historical center of the city - over 17 m²/person. The highest indicators of the provision of residential blocks of the Maskoŭski district are typical for the northernmost clusters of blocks - over 16 m²/capita. The least UGS provision of city significance is in the eastern part of the city with UGS provision around 4-5 m²/capita on average, among them 16 blocks of MFRD and 35 blocks of PRD with the population of 70,051 and 27,442 inhabitants living in these residential blocks, respectively. The total population of residential blocks below 8 m²/capita of provision of UGS of city significance is 97,493 residents (27.7% of the city population) (Figure 5.1.7). The provision of UGSs of city significance considering population of each block is illustrated in a form of a map (Appendix 3).

As to provision of green spaces by district significance per capita and by city blocks, the situation is completely the opposite: none of 228 residential blocks meet the recommendation of >7 m²/person of UGS of district significance. In other words, the population of the entire city is not fulfilled with UGSs in walking proximity of less than 1 km (or 15 minutes' walk) from their residences (Figure 5.1.7).

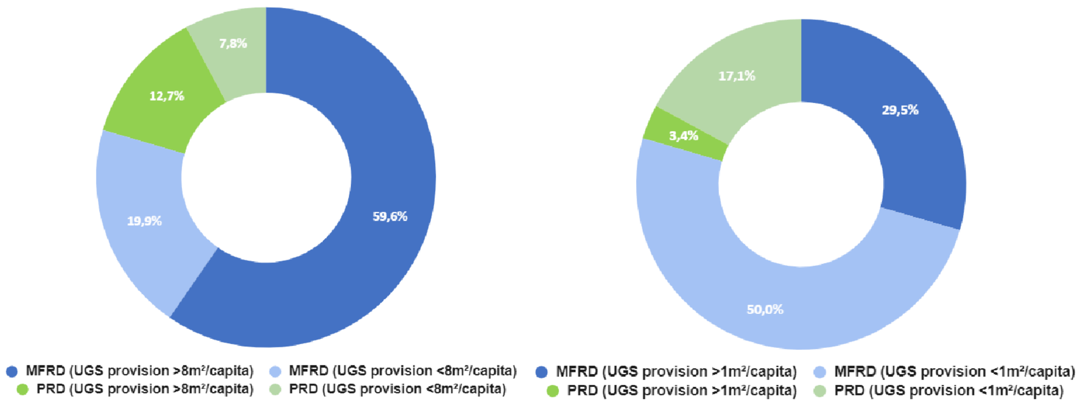

Figure 5.1.7 Proportion of the Brest population living in residential blocks (multifamily - MFRD; private – PRD) regarding provision for UGS of city significance – left; district significance – right

The residents of those blocks that are physically close to UGSs of district significance do not have a recommended area of green spaces per person, despite the fact that their residences are located within a service area of UGS (which is 1 km). 60,323 residents from 117 residential blocks of private development (PRD) have less than 1 m² of UGS of district significance per person, and the 176,292 residents from 61 blocks of multifamily residential development (MFRD). The total population of these blocks is 233,615, which comprises 67.2% of the city population.

Moreover, 85 out of 132 blocks of PRD (64%) and 28 out of 86 blocks of MFRD (33%) have no UGSs of district significance in a walking proximity at all (0 m²/capita), which makes some of these blocks the most disadvantaged ones in terms of provision of green spaces in the city. Almost all residential blocks with zero values are located in the north and north-eastern parts of the city. In population numbers, it corresponds with 49,020 and 49,630 residents respectively, or 28% of the city population. High number of disadvantaged blocks in private residential development may be explained by spatial arrangement of UGS network elements in the city: green spaces of public use are normally located in public areas, while city residents living in private development feel less need in public green spaces, considering the fact that most of households have their own green courtyards within allotments. The provision of UGSs of district significance considering population of each block is illustrated in a form of a map (Appendix 4).

The closest numbers in provision of UGS of district significance to a recommended one are among 3 residential blocks in the Maskoŭski district (2 of them - PRD, 1 - MFRD): **441** (provision of UGS of district significance - 5.21 m²/capita with 16.05 m²/capita of UGS of city significance), **467** (3.13/8.58 m²/capita respectively), and **309** (6.70/16.09 m²/capita, respectively). The most disadvantaged blocks with lowest numbers of UGS provision per capita (less than 7 m²/capita for UGS of city significance and 0 m²/capita for UGS of district significance) are listed in Table 5.1.6.

Table 5.1.6 List of the most disadvantaged residential blocks in Brest in terms of provision per capita of UGSs of city and district significance

	Number of block	Population	UGS provision (m²/capita)	
			city significance	district significance
MFRD (3 blocks)	101 121 323	37 1807 478 **TOTAL: 2322**	4.95 6.71 4.37	0
PRD (13 blocks)	206 207 244 251 252 407 443 444 445 450 451 454 470	375 178 1644 1998 768 2159 2200 844 86 184 1595 191 490 **TOTAL: 12712**	2.20 2.74 6.18 4.37 5.57 2.22 5.00 5.55 4.24 4.85 4.85 2.86 4.58	

Despite the fact that the city population is relatively supplied by UGSs of city significance which have a service area with AR=5 km (72.3% of the total population), it does not meet a sufficient number of UGS of district significance (AR=1 km) per person in all residential blocks across Brest. The results show that scarcity of UGSs of district significance has a generalized scope and that the UGS network needs to be modified within the whole city, not only in particular block clusters. This issue together with an explanation of the research' results is discussed in the following chapter.

5.2. Evaluation of urban green spaces by residents

The questionnaire conducted within the research aims to evaluate residents' perception towards green spaces in Brest, and particularly neighborhood green spaces (NGS) as an inherent part of the city's UGS network.

The first group of questions (Q1.1-1.3, see Table 4.2.1) presents age and sex structure of the respondents (Figure 5.2.1). Women participated in the questionnaire more than men (65.5% to 34.5% respectively). Respondents aged 18-30 formed the biggest age group among all participants (48.3%). One of the main limitations of the online questionnaire was reaching elderly people (especially aged over 65) since they are not widely presented on the Internet. Only 6 respondents aged over 65 took part in the survey. Given the fact that people of this age group are considered one of the most vulnerable ones to the absence of UGSs in walking proximity and small numbers of UGS provision (Sikorska et al., 2020; Wolch et al., 2014), it would be more representative for the research to interview specifically this group. Online means of holding a questionnaire, such as Google forms, should be also complemented with an offline face-to-face approach, where responses are taken from respondents directly during their visits to green spaces. Other limitations of holding the questionnaire are described in the Discussion chapter.

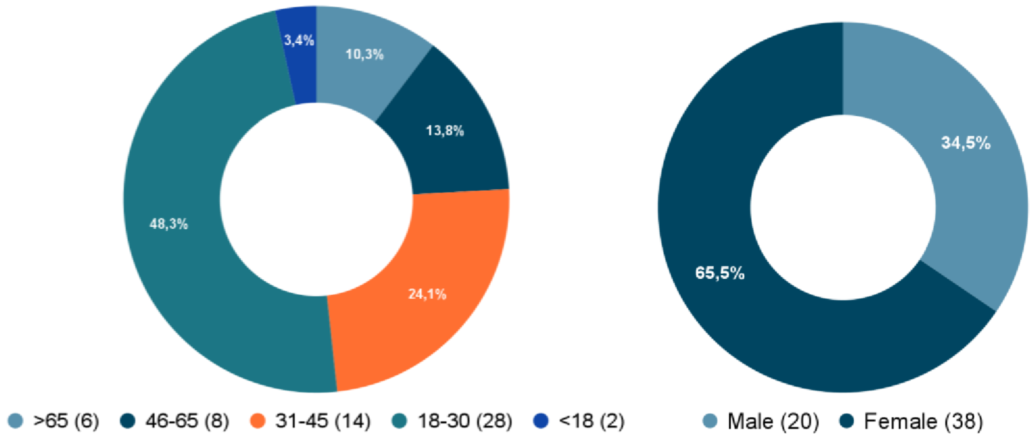

Figure 5.2.1 Age (left) and sex (right) structure of respondents

The biggest clusters among respondents are women aged 18-30 (18 respondents), men aged 18-30 (10 respondents), women aged 31-45 (10 respondents). The smallest clusters are women aged over 65 (2 respondents), men aged 46-65 (2 respondents), and women under 18 years (2 respondents). Men under 18 years are not presented in the questionnaire (0 respondents).

The third question in the first part of the questionnaire identifies places of residences of the respondents. A map below shows a location and number of responses with respect to type of a residential development: private residential development (PRD) is marked with green color, while multifamily residential development (MFRD) is marked with red (Figure 5.2.2). It is worth noting that multiple responses (up to 6) could have come from the same location. This is explained by way of disseminating the questionnaire when the respondents were targeted via local chats on Telegram messenger. In some cases, respondents distributed the questionnaire form among members of their household, which also explains groups of responses coming from one place of residence.

The biggest part of Brest was covered by the survey, however, several parts of the city (north, north-west, south-east) have only a few responses or do not have them at all. The number of respondents from the Lieninski district accounts for 24 (6 of which are living in the PRD). As to the Maskoŭski district, the number of respondents is 34 (2 of them are living in the PRD).

In terms of type of a residential development, 50 out of 58 respondents live in multi-story housings (MFRD), while only 8 respondents live in private buildings (PRD). Reaching residents living in the PRD was considered as one of the main factors limiting a representativity of the results. This is due to a fact that residents living in this type of residential development do not normally use local chats for communication between neighbors as the ones living in multifamily residential development.

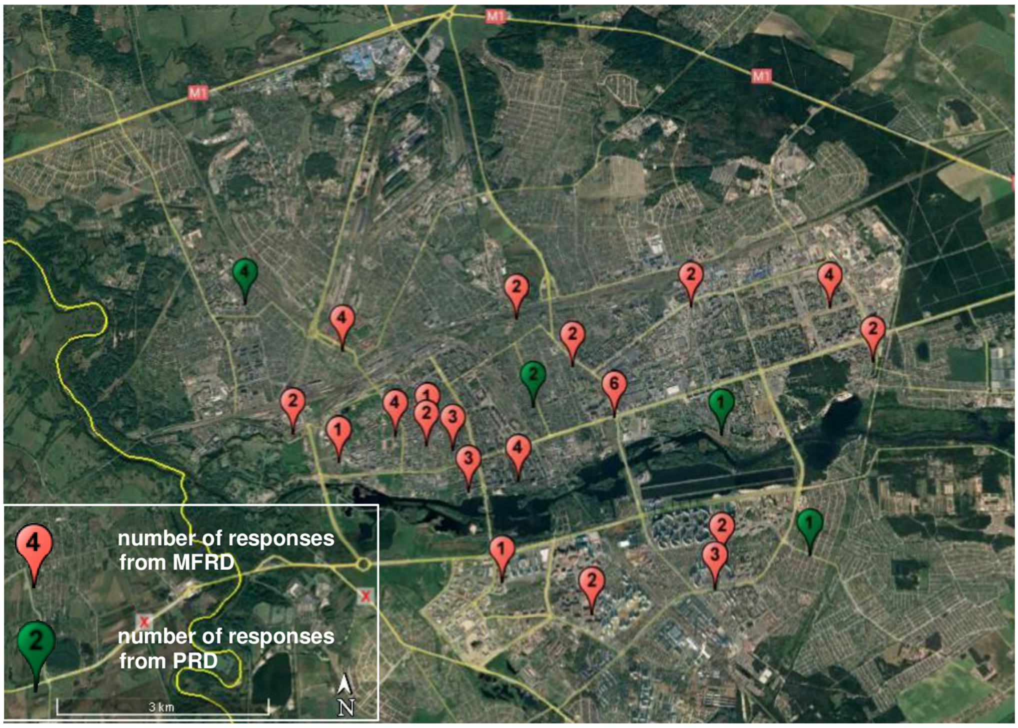

Figure 5.2.2 Map for the respondents' distribution in Brest with respect to a type of residential development (Image from Google Earth; Credits: author)

The issue of low UGS provision is generally less acute for residents from PRD since they have their own private backyards that serve them for recreation and other purposes. However, this fact cannot justify general scarcity of green spaces in PRD since people are required green spaces of comparably generous size (over 1 ha) for sufficient recreation (WHO Regional Office for Europe, 2016).

5.2.1 Evaluating a role of UGS of city and district significance

The second part of the questionnaire (Q2.1-2.8, see Table 4.2.2) aims to evaluate the network of green spaces of city and district significance. These UGSs (city parks, urban forests, residential parks, boulevards) are considered publicly accessible, which means that people can freely enter these spaces without being charged for it. Also, there are no restrictions on use of infrastructure and amenities, unless these elements are not specified for a particular type of recreation (e.g., attractions in an amusement park normally have pricing). UGSs elements located in the city center are considered of city significance.

According to the results of an overall perception of Brest' UGS network, almost a half (n=28, 48.3%) of respondents find their city relatively 'green' (value 4). The same share corresponds to values 2 (n=10, 17.2%) and 3 (n=18, 31.0%), which may be translated as rather not 'green' and moderately 'green', respectively. Two people find the city perfectly 'green' (3.4%). None of the respondents answered that the city is not 'green' at all (Figure 5.2.3).

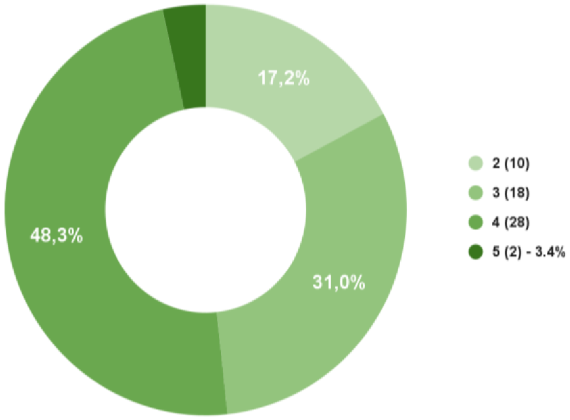

Figure 5.2.3 Respondents' perception of UGSs in Brest, where 1 - the city is not 'green' at all, 5 - the city is perfectly 'green'

This states that the city's UGS network is perceived by residents mainly positive, however, the results may be solely referred to quantitative measures rather than qualitative ones. Indeed, a considerable share of the city is occupied by green spaces of public use (11.7% of the total area), but this fact does not necessarily reflect the current state of the research object. Other factors, such as presence of infrastructure and level of maintenance of UGSs, are assessed within the survey.

Frequency of visits among respondents is as follows: 31.0% of residents (n=18) visit UGSs 1-3 times per week, while 12.1% (n=7) state that they visit them almost every day. At the other extreme are 29.3% (n=17) of respondents stating that they visit green spaces 1-3 times a month and 27.6% (n=16) of visitors who do it once per month or even rarely. No respondents who do not visit UGSs at all were found. Also, no obvious correlation between age and/or sex structure and frequency of visits was identified (Figure 5.2.4).

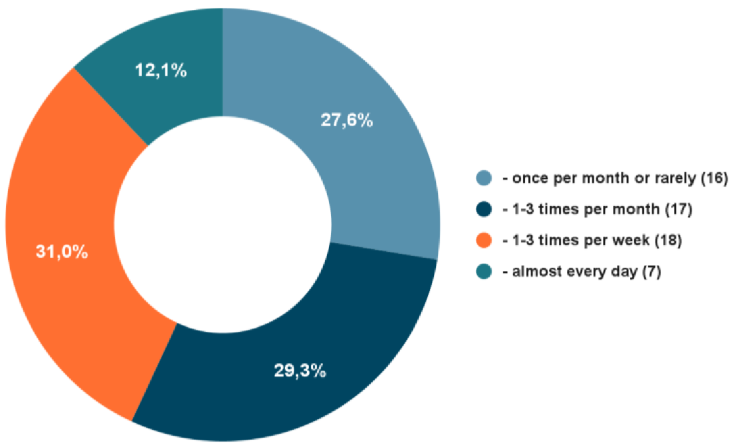

Figure 5.2.4 Frequency of visits to UGSs in Brest among respondents

The next question aimed to identify the most popular activities in UGSs among the respondents. Several options were offered, and the participants could choose multiple of them or write their own answer. A list of options with numbers of responses looks as follows: **self-time (walking, sitting, contemplating)** - 36 responses; **meeting with friends/colleagues** - 33 responses; **family time, playing with children** - 20 responses; **passing by** - 19 responses; **physical activity (running, cycling, team**

sports, yoga, etc.) - 16 responses; **celebrations/parties and picnics** - 6 responses; **dog walking** - 2 responses. The most frequent combination of activities is self-time, meeting with friends/colleagues, and passing by - 8 respondents chose this set of activities in the questionnaire. None of the respondents proposed their own type of activity. A relatively strong correlation between age of the respondents and chosen types of activity was found. Respondents aged 18-30 (n=6) and 31-45 (n=9) visit UGSs to spend time with a family and/or play with children, while the respondents from other age groups did not state that. Apart from that, chosen types of activities are not correlated with age/sex of the participants.

The fourth question from the second group sought to find the most popular UGSs among the respondents. A list of the most visited and recognized green spaces (in the author's opinion) located in the city center was provided. The respondents could list their own favorite UGSs. Among specified ones, the respondents chose the most: **Central Park** (also known as 1st of May Park) - 25 responses; **Memorial Park Brest Hero-Fortress** - 24 responses; **City embankment** - 20 responses; **City garden** - 17 responses; **Mukhavets eco-trail** - 16 responses; **Warriors-Internationalists Park** - 14 responses; other UGSs specified by the respondents: **Ikonnikava Residential Park** (1 response), **Light Alley** (1 response), **Liberty Square Boulevard** (1 response).

An analysis of the results did not show correlations between stated UGSs and residences of the respondents. It is assumed that in most cases choosing a favorite UGS is mainly based on people's preferences (which are shaped by their positive experience of visiting particular UGSs in the past) rather than on a distance factor. For instance, a stated Ikonnikava Residential Park (equipped UGS of district significance, 1.4 ha size) is located in the south-central part of Brest, but the respondent's place of residence is in the east of the city, more than 3 km far from the stated UGS.

Apart from the above-mentioned residential park, other respondents chose only UGSs of the city significance. An exclusion of the UGSs of district significance by the respondents may be justified by more diverse functions, bigger sizes, and better infrastructure in the UGSs of city significance, as well as lack of these qualities among UGSs of the district significance.

Paradoxically, among myriads of several types of green spaces across Brest (there are 96 UGSs of public use in the city), the respondents voluntarily constrained themselves only with nine of them. Six out of nine selected UGSs that were listed as options within the questionnaire, which can bias the respondents towards choosing proposed options. All of the reported UGSs are located in the city center and can be considered well-equipped and regularly maintained.

This fact together with different recreational activities presented in these UGSs form the respondents' preference towards it. At the same time, less equipped UGSs with small number of presented activities are neglected by the participants, even though these UGSs may be located in close proximity to their residences. Also, no clusters of the same responses were identified.

In order to find a duration of visit to favorite UGSs, a matrix type of question was chosen, in which the respondents were asked to choose multiple options with respect to duration of their visit according to days of a week (Table 5.2.1). Two extremes are identified: short-time (<30 minutes) visits during weekdays (n=28) and longer walks (30-60 minutes, and more) during weekends (n=24, n=27, respectively).

The most common combinations of answers are less than 30 minutes during weekdays and more than 60 minutes during weekends (n=12); less than 30 minutes during weekdays and 30-60 minutes during weekends (n=11).

Table 5.2.1 Number of respondents' answers regarding a duration of visits to UGSs with respect to a day of a week

	<30 min	30-60 min	>60 min
weekend	4	24	27
weekday	28	14	2

The next three questions (Q2.6-2.8, Table 4.2.2) aimed to define a travel time needed for residents to reach their favorite UGSs. Also, it showed preferable means of transport and overall level of satisfaction of reaching green spaces. Table 5.2.2 is based on results of a matrix question, which aimed to define a travel time with respect to the most preferable means of mobility that the respondents use for that purpose. As in the question above, the participants could choose several options. The second column named *'cycling, etc.'* represents non-motorized individual means of mobility (scootering, skating, etc.). This matter was described within the survey form.

Table 5.2.2 Number of respondents' answers regarding a travel time to UGSs with respect to preferred means of transport

	walking	cycling, etc.	public transport	private car
<15 min	17	12	4	19
15-30 min	20	9	15	4
>30 min	8	3	4	-

The results show that most of the respondents (45 out of 58, or 77.6%) prefer reaching their favorite UGSs on foot, even if in many cases (28 out of 45, or 62.2%) it takes longer than the recommended values of 15 minutes' walk to green spaces. Non-motorized means of mobility are mainly used for short-term distances (less than 15 minutes ride), while three respondents stated that they use them for rides longer than half an hour. Relatively considerable number of the respondents (15 out of 58, or 25.9%) stated that they also prefer using public transport to reach UGSs, and it takes them from 15 to 30 minutes for that purpose. A large number of the respondents (19 out of 58, or 32.8%) use their private cars to get to their favorite green spaces. This can be considered a fast solution for residents living far from the city center (where most of the well-equipped and maintained UGSs are located) to visit their preferable green spaces. A relatively developed road infrastructure in the cities of Belarus together with lack of cycling and walking infrastructure encourages people to use motorized vehicles more than other non-motorized means of transport.

No strong correlation between the respondents' residences and a travel time and/or preferable means of transportation was identified. Several evident aspects are worth emphasizing:

- The respondents living far from the central green spaces (which were majorly chosen as the favorite ones among the respondents) tend to use public transport more, and for most of them it takes over 15 minutes of a travel time to reach their destinations;
- Even though the respondents are living in a walkable proximity to the UGSs of their interest, they prefer using private cars in order to reach them. This is also applicable to the substantial number of participants who reported that walking more than 15 minutes or even more than 30 minutes to reach the UGSs is considered an acceptable time.
- Also, a factor of age does not play the key role in results: some of the respondents aged over 65 (n=2; total number: 6) stated that they spend 15-30 minutes of walking to reach their UGSs, and they find this time acceptable (the respondents' perception of a travel time is a subject of the next question, which is explained below).

The next question aimed to understand whether the residents find their travel time and means of transport for reaching favorite UGSs appropriate. Five options were provided: (1) yes, I find a travel time appropriate; (2) yes, but I would prefer getting to the UGSs on foot; (3) no, I do not find it appropriate; (4) not sure; (5) other. The second option gave the participants an opportunity to reflect on their usual means of transport they use to reach the UGSs. 19 respondents chose this option, among them people who spend over 30 minutes of walking (n=4), less than 15 minutes of driving a private car (n=5), and 15-30 minutes of having a ride on a public transport (n=5) to reach preferable UGSs.

These results demonstrate the residents' desire of having more walkable surroundings and their general understanding of advantages of this type of environment. It also indirectly states that these respondents who use cars for quick rides to UGSs do realize all the benefits (personal, such as reducing fuel costs, and public, e.g., improving air quality) coming from a walkable environment in the urban area and ready to change their mobility patterns if proper infrastructure would emerge. Apart from that, one respondent who uses a car for less than 15 minutes' drive and public transport for 15-30 minutes rides found a travel time unacceptable (the option 'no' was chosen on specified question), which can be explained by remote residence (south-east of the city). Other respondents (n=38) reported affirmatively on the posed question.

The last question (Q2.9) in the second group of the questionnaire aimed to identify the main obstacles of not visiting the UGSs more frequently. The respondents were able to choose multiple numbers of listed options or produce their own ones. Among specified options, the participants chose the most the following ones:

- Lack of free time - 43 responses;
- Weather factor - 18 responses;

- Poor maintenance of UGSs (unmowed vegetation, presence of litter, faulty amenities, etc.) - 16 responses;
- UGSs are located too far - 12 responses;
- feeling of unsafety (due to traces of vandalism, graffiti, presence of drunk people, etc.) - 11 responses;
- No playgrounds, sports grounds - 9 responses;
- Non-inclusive environment (elevated curbs, too many stairs, no railings) - 8 responses;
- Lack of infrastructure (unpaved paths, no lighting, no resting areas, etc.) - 6 responses;
- Other - 3 responses (provided below);
- Fear of being attacked by (unleashed) dogs - no responses found.

Lack of free time (n=43) was found to be a main limiting factor among the participants in their level of use of the UGSs. It also forms one and only evident cluster of answers: 19 out of 58 respondents (32.8% of the total number of respondents) chose only this option. Weather factor (n=18) appeared to be one of the prevailing factors limiting more frequent visits to the city's UGSs. Poor maintenance (n=16) and lack of infrastructure (n=6) together with the absence of sport grounds (n=9) and non-inclusive environment (n=8) may be merged in one group representing a poor level of infrastructure and maintenance. Feeling of unsafety (n=11) can be indirectly caused by poor level of maintenance, which allows to add this factor to the above-mentioned group. These factors are found limiting by 31 unique respondents. Also, 12 respondents stated that a factor of distance limits them from visiting the UGSs more frequently. In 9 cases, the residences reported by the respondents were fairly far from the UGSs located in the central part of the city. This states that the factor of distance may be limiting in frequency of UGS use, which is also proved by different studies provided in the Literature review chapter. The structure of limiting factors in a form of a chart is provided below (Figure 5.2.5).

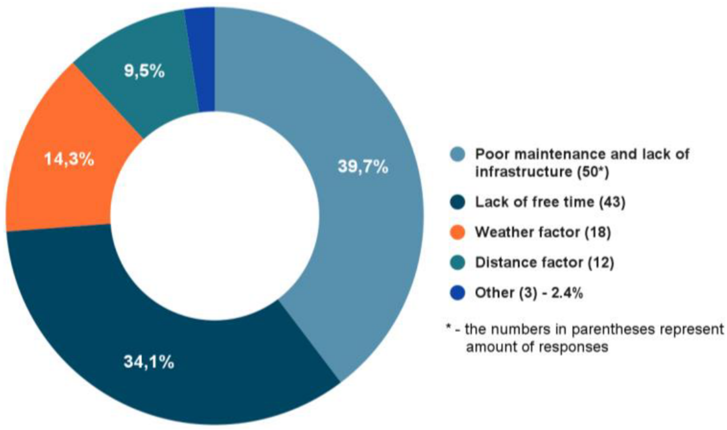

Figure 5.2.5 Structure of factors limiting more frequent use of the Brest' UGSs

Poor maintenance and lack of infrastructure was considered the main obstacle that limits the respondents visiting the city's UGSs more frequently. Such a considerable number of answers also corresponds with a share of unequipped green spaces among the city's UGS network, which is around 75% (see Table 5.1.2). Even though the respondents consider Brest a relatively 'green' city (Figure 5.2.3), this fact is not correlated with lack of infrastructure and insufficient maintenance in UGSs of city/district significance. The quantity (availability) of green spaces in the city cannot solely encourage the residents to visit UGSs more frequently. A qualitative aspect, in this regard, may be a decisive one, which is proved by the results.

According to the local legislation, UGSs (e.g., city parks, residential parks) are formally designated and regularly maintained, but in many cases, they are not sufficiently provided with infrastructure and maintenance, which makes these UGSs less attractive to visitors. Half of the city parks of city significance (6 out of 12, or 16% of area) do not have proper infrastructure: usually, they end up with a network of paved pathways in moderate state and lighting along the main trails. Urban forests, which comprise a big share in the residents' UGS provision due to their large area (61.16% of the total UGS area in Brest), do not have equipped or formally designed areas at all. In most of the cases, trash bins, benches, and other recreational infrastructure (playgrounds, sport grounds, resting areas) in above-mentioned UGSs (which in total comprise over 78% of Brest' UGSs of the city significance) are presented sporadically or not presented at all.

Another common obstacle of not visiting UGSs more frequently is lack of free time (43 responses). This may be explained by the respondents' age structure, where 86.2% of them are aged 18-64, which corresponds to working period in the country. A weather factor was reported as a limiting factor by 18 respondents. Even though the weather in Brest does not significantly differ from the other Belarusian cities, the city has a bit more sun hours and less rain events, which should positively affect the frequency of the UGS use. Nevertheless, the number of visits normally drops down during the winter period. Indeed, low temperatures and snowfall can be found discouraging from visiting the green spaces, however, it may be offset by proper and prompt maintenance in the UGSs during the winter period, which will allow the residents feeling more comfortable and safer outside.

A distance factor was found limiting by 12 respondents. As stated above, 9 out of 12 respondents are living more than 15-minutes' walk from their favorite UGSs reported in the questionnaire (eastern and southern parts of the city). 8 out of 9 respondents also mentioned that they take public transport for 15-30 minutes rides (in 5 cases) and a private car for less than 15 minutes ride (3 cases), and that they would like to reach the UGSs on foot rather than using motorized means of transport. Even though the number of respondents does not fully allow comparing the questionnaire results with the outcomes from the first part of the research (spatial analysis in QGIS), several evident aspects derived from cross-sectional analysis are worth emphasizing:

- Respondents (n=6) living in residences (blocks 305, 308) with low provision of UGS of city significance per capita (<8 m^2 capita) find their city rather not 'green' (Q2.3), and would prefer reaching favorite UGSs on foot (n=4) or do not find a distance to their UGSs acceptable at all (n=2);
- Residential parks and other UGSs of district significance are not considered favorite ones among the respondents, even though they are located in close proximity to their residences. This fact is also applicable to residences within the blocks with critical values of UGS provision of district significance (<1 m^2 capita). Only central UGSs of city significance (8 out of 9) met the respondents' needs in

recreation, however, lack of maintenance and poor infrastructure were also found a reason limiting the respondents to visit these spaces more frequently;

- No correlation between remoteness of UGSs from residences and age of the participants was found.

Apart from that, three respondents who decided to express their concerns limiting their use of the city's UGSs mentioned the following factors:

- mistletoe tree infestations and overall poor state of trees, especially poplars (the participant kindly specified the area - the east of the city), which is *'discouraging'*;
- lack of amusement activities and attractions, including food courts and fast-food joints;
- no connectivity between elements of the UGS network, and lack of connection of the UGSs with the public transport network.

The further reflections on the results are provided in the Discussion chapter.

5.2.2 Evaluating a role of NGS

The third group of questions (Q3.1-3.8, see Table 4.2.3) in the questionnaire aimed to assess the respondents' perception of neighborhood green spaces (NGSs) and identify readiness among residents in potential renovations of these spaces. It is assumed that NGSs (courtyards, playgrounds, community gardens, etc.) may potentially serve as compensatory element in the UGS network fulfilling people's needs in recreation and contact to nature, which can be critically important for residents of those residential blocks that lack any of UGSs (city/district significance) in their immediate surroundings.

The first question within the group found a level of use of NGS and a number of users among the respondents. Within the third group of questions, the respondents were asked to reflect on particular NGSs that they are using the most. The results were as follows (Figure 5.2.6):

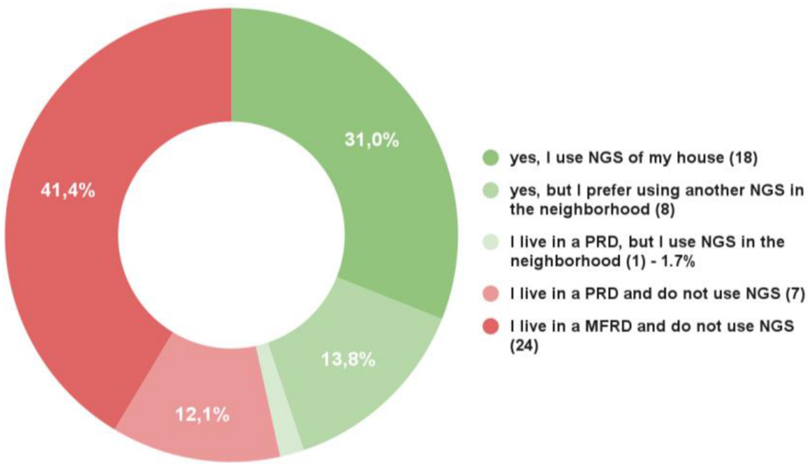

Figure 5.2.6 Stated use of NGS among the respondents

18 respondents (31.0%) reported that they use NGS close to their residences (MFRD), 8 (13.8%) - use NGS that is not adjacent to their residences (MFRD), 1 (1.7%) respondent living in PRD use NGSs in the neighborhood. Total number of NGS

users among respondents: 27 (44.8% from the total number of respondents). At the same time, 31 respondents (55.2%) reported that they do not use NGSs: 24 of them live in a MFRD (43.1% from the total number of respondents) and 7 - in a PRD (12.1%).

Small numbers on NGS use among respondents living in private houses (PRD) are evident: in most of the cases, they have private yards within their plots, which may serve these residents as a place for recreation. Reasons for the considerably small number of NGS users living in MFRD (n=18) and, in the opposite, large number of those residents who do not visit their NGSs (n=24) are explained by analysing further questions. Also, it is worth noting that 9 participants (8 from MFRD and 1 from PRD) prefer visiting other NGSs which are not directly allocated to their places of residence. It may be caused by lack of infrastructure and/or poor maintenance in an allocated NGS, which motivates people to visit other ones with better qualities. In general, most of the respondents (55.8%) do not consider their NGS as a place for recreation.

Also, all 12 participants who stated that distance factor is limiting for them in using UGSs of the city/district significance more frequently (Figure 5.2.5), stated that they use their NGSs.

Those participants (n=27) who answered affirmatively on the previous question were asked to specify main reasons for visiting NGSs. Among them: **sitting/walking/contemplating** - 20 responses; **getting fresh air** - 14 responses; **enjoying nature and the sun** - 12 responses; **doing chores (beating rugs, fixing a car/bike, etc.)** - 11 responses; **playing with children in the yard** - 10 responses; **talking to neighbors/meeting friends** - 8 responses; **exercising, workouting, etc.** - 3 responses; **doing team sports** (football, basketball, etc.) - 3 responses; **dog walking** - 2 responses; **gardening (planting flowers, growing plants, etc.)** - 2 responses; embellishing (any form of art and decoration) - no responses; other - no responses. The most common combination of activities reported by the respondents is (n=7) as follows: sitting/walking/contemplating, getting fresh air, enjoying nature and the sun. No obvious correlations between participants' age and/or sex and reported activities were found.

The next question provided the respondents with a matrix consisting of infrastructure elements (rows) and their possible states (columns). The question aimed to identify the respondents' satisfaction with existing infrastructure elements in their NGSs, and, if they do not have some of them, define a level of their necessity within these spaces. The respondents were asked to leave one answer in each row (Table 5.2.3). The results of this question may be useful for understanding what infrastructure elements the residents lack and what of them they find of the first necessity for their NGSs.

In terms of presence of listed infrastructure elements within the respondents' NGSs, it may be concluded that even though a large part of the elements is presented in NGSs, a lot of them are in poor condition and need to be fixed or modified. Following elements are considered the most presented in the NGSs: **trash bins** - 37 responses; **benches** - 35 responses; **diverse vegetation** - 27 responses; **lighting** - 26 responses; **paved paths** - 25 responses; **playground** - 20 responses; **sports ground** - 14 responses; **dog park** - 11 responses; **bike parking** - 4 responses.

Table 5.2.3 Respondents' evaluation of infrastructure elements in NGSs

	Presented in my NGS and I am satisfied with its state	Presented in my NGS, but I would prefer it to be fixed	Not presented in my NGS, but will be nice to have it	Not presented in my NGS, and I do not need it
benches	35	19	3	1
trash bins	37	14	7	-
paved paths	25	22	9	-
playground	20	24	6	2
diverse vegetation	27	18	13	-
sports ground (football, basketball)	14	18	20	6
lighting	26	19	11	2
dog park	11	12	23	12
bike parking	4	6	38	10

The second column represents a level of condition of infrastructure elements and the respondents' demand on their repair. The list of elements presented in the NGSs but needed to be fixed looks as follows: **playground** - 24 responses; **paved paths** - 22 responses; **lighting** - 19 responses; **benches** - 19 responses; **sports ground** - 18 responses; **diverse vegetation** - 18 responses; **trash bins** - 14 responses; **dog park** - 12 responses; **bike parking** - 6 responses.

The third column shows infrastructure elements that are not presented within the respondents' NGSs but were found important to have. This column indicates a demand for altering NGSs and identifies the elements that are nowadays missing within the NGSs the most. The list of the elements looks as follows: **bike parking** - 38 responses; **dog park** - 23 responses; **sports ground** - 20 responses; **diverse vegetation** - 13 responses; **lighting** - 11 responses; **paved paths** - 9 responses; **trash bins** - 7 responses; **playground** - 6 responses; **benches** - 3 responses. The results derived from the column may serve as one of the pieces of evidence of the residents' demand for renovating their NGSs, with specifying elements that are found the most relevant among residents.

The last row presents the respondents' perception of the overall necessity of infrastructure elements listed in the question. The results there are mainly subjective and reflect personal attitude towards each element. The attitude, in turn, is shaped by a set of outdoor activities in which a particular respondent may be involved. The answers derived from this column may help to identify an understanding of importance of critical infrastructure elements among respondents and find the elements that may be found redundant. A list of the elements looks as follows: **dog park** - 12 responses; **bike parking** - 10 responses; **sports ground** - 6 responses; **lighting** - 2 responses; **playground** - 2 responses; **benches** - 1 response; **trash bins, paved paths, diverse vegetation** - no responses found.

First three rows represent critical elements of infrastructure: benches, trash bins, and a network of (paved) paths. As to the first element, the prevailing number of respondents (n=35, or 60.0%) stated they have it in their NGSs, while additional 19 respondents (32.8%) said that benches in their NGSs need to be fixed. Three unique respondents stated that all three elements are not presented in their NGSs, and it would be good to have them. The group of critical elements can also be composed of three more elements: lighting, playground, and vegetation. In all cases, above-mentioned elements were found redundant (the last column) only by three unique respondents (total number of responses - 5). This fact states that most of the participants understand importance in having a set of critical elements of infrastructure in their NGSs, and in many cases express their demand in their repair.

The last three elements were found to be of least necessity: sports ground (n=6), dog park (n=12), and bike parking (n=10). Two unique respondents stated for all of them. Paradoxically, the same elements were found to be the most preferable to have (third column) by a fairly substantial number of respondents (number of unique respondents choosing all three options - 13; total number of responses - 81). The most striking result was identified regarding a demand to have bike parking in their NGSs: 38 out of 58 respondents (65.6%) selected this option, which makes it the biggest number of responses per one option in this question.

It is worth mentioning that all 38 respondents live in a multifamily residential development, which partly explains the high demand for designing a bike parking in their courtyards. From the author's personal experience, it may be really uncomfortable to get your bicycle (or scooter, etc.) out to the street living on a ninth floor in a multistory apartment building. Having a bike parking in a NGS where they can be stored would, in turn, encourage the residents using them more frequently.

The next question (non-obligatory) asked the respondents to reflect on other infrastructure elements that they find important to add to their NGSs. Five answers were derived: an equipped shaded resting point, arbours; an equipped place for car/bike fixing; outdoor gym; separate attraction elements from a playground, such as swings; underground waste containers. Apart from that, several respondents found it important to report about issues regarding NGSs, which was made in this section. Among issues are the poor condition of the resting area adjacent to the Vasnyatsova ponds (eastern part of Brest), lack of vegetation in surrounding NGSs, unmanaged brownfields throughout the city.

The next question is based on an assessment of five statements related to several characteristics (recreational potential, safety, vegetation content, level of maintenance). The statements were assessed by the respondents using a scale from 1 to 5, where 1 - totally disagree, 5 - totally agree. The following table presents a number of responses for each scale regarding each statement.

The results from the first statement shows that most of the respondents (44 out of 58, or 75.9%) consider their NGSs unsuitable or only moderately suitable (value 3) for recreational purposes, while only 14 respondents (24.1%) find their NGSs suitable for recreation. These outcomes may be corresponded with the considerable number of the respondents stating that they do not use their NGSs at all (53.5%). It also correlates with large numbers reported on poor condition of infrastructure elements within the NGSs that should be repaired (Table 5.2.3). This fact discourages the residents from using their NGSs, especially for recreational purposes.

The second statement evaluates a feeling of safety within the NGSs among respondents. Even though no respondent selected the first value (which refers to total disagreement with a statement), the number of respondents that would agree with the statement is not exceedingly high (50%). The third statement echoes the second one with one modification: the respondents were asked to reflect not on their individual safety, but on the safety of their children who spend time in NGSs close to their residences. It was assumed that numbers for the statement on children's safety would be bigger towards disagreement. This was proved by the results: the biggest part of the respondents (58.6%) finds their NGSs unsafe for children, while only 24 (41.4%) of them consider green spaces close to their homes relatively safe (value 4), or totally safe (value 5).

The fourth statement asked the respondents to reflect on the level of maintenance in their NGSs. The results are correlated with the numbers from the previous question (Table 5.2.3) regarding the infrastructure elements within the NGSs that should be repaired. 39 out of 58 respondents (67.2%) consider their NGSs poorly maintained or find them moderately maintained, while only 21 respondents (36.2%) consider them relatively maintained or well-maintained.

The fifth statement aimed to find the participants' perception of vegetation content in their NGSs. As in the previous statement, the results are correlated with the numbers of the respondents from the above-mentioned question (Table 5.2.3) where 31 out of 58 participants (53.4%) stated that vegetation in their NGSs should be either modified or added as a new element. 55.2% (n=32) of participants are dissatisfied with the vegetation in their NGSs, while only 44.8% (n=26) of them are relatively satisfied or fully satisfied with it.

Table 5.2.4 The respondents' assessment of the statement regarding characteristics of the NGSs, where 1 - totally disagree, 5 - totally agree with a statement

Statement	1	2	3	4	5
I consider my NGS as a place to relax	14	15	15	8	6
I feel safe in my NGS	-	11	18	19	10
The NGS is a safe place for children	6	14	14	17	7
The NGS is kept in good condition and always maintained (mowed grass, good infrastructure, etc.)	18	3	16	9	12
I like the vegetation of my NGS	8	10	14	18	8
TOTAL:	**36**	**53**	**77**	**71**	**43**

In overall, the results show that the respondents are moderately satisfied with the quality of their NGS regarding its recreational aspect, safety factor, level of maintenance and vegetation content, which corresponds to the value 3. This result, of course, cannot be considered acceptable by the researchers and urban planners, and possible ways of improving residents' perception towards NGSs should always be looked at.

The next question provided the respondents with five statements which they may agree or disagree with. The statements aimed to identify possible changes in frequency of use of the NGSs amid COVID-19 pandemic period, their readiness for a personal contribution in changing the NGSs and overall understanding of potential benefits of using these green spaces, such as better social cohesion between neighbors and place attachment. Also, the respondents' attitude towards public use of semi-public spaces, which are NGSs, was assessed. The results look as follows:

- My NGSs could be utilized more diverse than they are now - 41 responses (total numbers of the respondents - 58);
- I would like to be more involved in activities within my NGS, if there will be some (maintaining the area, planting seedlings, etc.) - 31 responses;
- NGSs can only be used by the residents of the adjacent house/houses - 20 responses;
- Spending time in NGSs could help me get to know my neighbors better - 18 responses;
- I started to use my NGSs more often amid COVID-19 - 13 responses.

The results show the respondents' understanding of the unleashed potential of their NGSs, which corresponds with the first statement: 41 participants stated (70.7%) that NGSs of their residences may be used more diversely. However, only 31 respondents (53.4%) expressed their will in participating in local activities to make NGSs more suitable for recreation and other residents' needs. Only 20 participants (34.5%) agreed that semi-private spaces such as NGSs may only be used by local residents living within the same block. This result may be partly explained by small numbers of the respondents using their NGSs (only 44.8%), which means that most of the respondents cannot fully associate themselves with spaces near their residences. It also may be explained by a transit character of many NGSs in cities with a spatial pattern like in Brest, when people's shortest routes to reach their destinations are usually lying through blocked NGSs located within a residential development. Residents, wittingly or not, pass by NGSs; otherwise, their routes may take way more time. In this regard, many residents would argue that NGSs are supposed to be private spaces accessible only for people living nearby.

18 respondents (31.0%) agreed that spending more time in NGSs would help them to get to know neighbors better. It can be considered that most of the residents (69.0%) do not see their NGSs as a place for boosting social cohesion, and/or do not consider this as a valuable benefit personally for them and for a neighborhood in general. Only 13 respondents (22.4%) stated that they started visiting their NGSs more often amid COVID-19 pandemic. Relatively small number of respondents, again, proves that the residents in general do not consider their NGSs for recreation. Choosing between having a rest in a low-functional NGSs with a minimum infrastructure and a residential park with no better qualities in a walking proximity, the residents would rather choose the second option. And this is not surprising, as UGSs of city/district significance have more advantages (size, vegetation content, more diverse infrastructure elements,

even if they are poorly maintained, etc.) than NGSs.

Two final questions provided the respondents with potential ways of utilization of the NGSs in post-socialist residential development and encouraged them to reflect on how their adjacent spaces may be utilized in a new way. Green roof as a first example was chosen. Prevailing number of the participants (44, or 75.9%) stated that they want to use rooftops of their residences as a space for recreation. Twelve respondents (20.7%) found it difficult to answer, and 2 more respondents (3.4%) stated that they do not want to use their rooftops for recreation. No respondent stated that they already use this space.

Green buffers within setback distances between buildings was chosen as the second type of space in a residential environment that can be modified for residents' recreational use. The results turned out to be less unequivocal as it was in the first case: only 30 respondents (51.7%) reported that they would like to use this space for recreation, while 16 (27.6%) participants had a negative response. Also, ten (17.2%) participants could not answer this question, and two respondents (3.4%) stated that they already use these spaces for recreation. The results of two questions on potential modifications of spaces in a neighborhood are provided below (Figure 5.2.7).

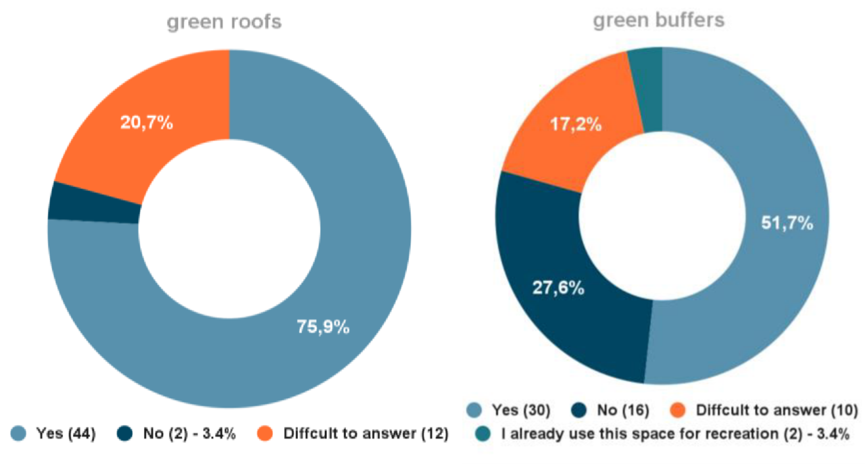

Figure 5.2.7 Stated demand for modification of rooftops and green buffers into spaces for recreation among the respondents

The difference between two types may be related to an extent of exposure of such spaces to private spaces within residences. A public space located on a rooftop of a residential building is not exposed to someone's private space, while the one located within a green buffer may be found disturbing for residents living in the first floors. To sum up, it can be said by the results that the respondents feel that their NGSs may be utilized better and express their will in changing their residential environment in order to have a space for recreation in their immediate surroundings.

No respondents sent photographs of interesting examples of neighborhood green spaces in the city, however, two of them were interested in the research and left their credentials for further communication. It is important to mention that most of the respondents do not mind having more suitable NGSs that may be used for recreation despite the fact that nowadays adjacent territories are not considered a valuable asset for this purpose.

6. Discussion

This chapter raises the role of neighborhood green spaces that they might play for residents in Brest. The author's reflections on the results may be applicable for Belarusian cities in general since most of the issues related to the UGS network can be met throughout the country. Also, it proposes potential ways of renovating and adding functionality to NGSs based on residents' preferences derived from the questionnaire part.

Brest' UGS network. The basis of the existing network of UGSs of public use consists of equipped and regularly maintained green spaces of generous size - city parks and residential parks of city and district significance. These spaces are located in the southwestern part of the Lieninski district - the natural and historical park of the memorial complex "Brest Fortress", the Central Park (also known as 1st May Park), City Garden, a park near the embankment of the Mukhavets River (with the embankment itself), series of central boulevards. In the western and northwestern part of the Lieninski district, there are plots of urban forest.

It should be noted that most of the equipped and well-maintained UGSs of the city are often located adjacent to water bodies (Mukhavets and Zakhodni Buh rivers) and also the main transport corridors of the urban area – which also corresponds with areas of highest recreational demand in the city: multifamily residential development with highest numbers of population is located there. The role of the Zakhodni Buh and Mukhavets river floodplains has been significant for shaping the city throughout the entire period of its development. It is primarily associated with the geographical features of the city location. The city has been sprawling in two directions: south-north (along the right bank of the Zakhodni Buh river) and east-west (along the Mukhavets river). The core of the city is located on the rivers' confluence. The right bank of the Zakhodni Buh river serves as a natural border between Poland and Belarus, which predetermines the city' borders on the west.

According to the Master Plan (DAB, 2019), it is planned to develop floodplain areas of the Mukhavets river to explore the tourist and recreational potential of the territory. This should be done with the respect of structural elements of the National Ecological Network located within the floodplains. It comprises a transborder ecological corridor 'Zakhodni Buh' CE1 and an ecological core "Buh" R2 together with a corridor "Lyasnaya" CR2 which are adjacent to the territory of the city.

Issues of UGS provision. Non-fulfilment of the requirements on provision of UGS of district significance is found to be a widespread issue. None of 228 residential blocks in Brest does not meet a recommendation (MAC, 2016) of 7 m^2/capita. This means that, even if residents of a particular block are living within an established AR (1 km), they still lack the number of green spaces which is estimated in square meters. In overall, the city lacks 194.1 ha of UGSs of district significance and 36.23 ha of UGSs of city significance. The provision numbers for UGS of district significance do not exceed 2 m^2/capita throughout the blocks. 64% of private residential development and 33% of multifamily residential development do not have such green spaces at all (0 m²/capita). An average provision among blocks for UGS of district significance is 1.47 m²/capita. The situation may seem even more dramatic if the foreseen population for the year 2030 is considered: this number will comprise 1.36 m²/capita.

A significant scarcity of UGSs of city and district significance is observed in the eastern part of Brest. The only UGSs presented in the eastern part are large plots of urban forest and three UGSs of city (1) and district (2) significance - all these spaces are unequipped and are not regularly maintained. The central part of the Lieninski district (cluster of residential blocks 232, 238, 255, etc.) is also subjected to lack of UGSs of city/district significance. The only UGS presented in this part are concentrated in the far southwestern part and are represented by four residential parks, one of which is a central residential park of a city significance (near the main railway station).

According to the Brest Master plan for the year 2030 (DAB, 2019), several aims to achieve regarding UGS network in the city are established:

- Developing measures for the further improvement of maintenance of existing elements of the UGS network;
- Enhancing the distribution of UGS of district significance across the city;
- Providing improvement of UGSs in the floodplain of the Mukhavets river;
- Binding elements of UGSs into a continuous network;
- Establishing community gardens in residential blocks, further establishment of green spaces within areas of community centers (nowadays there are only seven community green spaces in the city with a total area of 11 ha).
- Achieving number of 15 m²/capita of UGS provision for every residential block (number is comprised of 8 m²/capita for UGS of city significance and 7 - for UGS of district significance);
- Adhering to recommendations on vegetation content within residential blocks for new residential development provided by the Ministry of Architecture (MAC, 2016);
- Providing proper maintenance for UGSs in the city, especially for boulevards and residential parks.

Apart from large unoccupied vegetated areas within the floodplain rivers, other spaces may be used for adding UGS elements, among them brownfields and unused areas of factories located within the city borders. Many of these areas together with car roads correspond to the gray color of the zoning layout used for maps on the population number by residential block (Appendices 1, 2). Unfortunately, the current Master plan does not provide suggestions on relocation of shop floors of manufacturing areas to the city fringes. Nowadays, a considerable part of areas of state-owned factories are not utilized, sitting abandoned. Most of the factories were built in the Soviet era with typical for that period large scale of construction. A trade-off solution may be found in decreasing areas of the factories which are not occupied by active shop floors. Abandoned post-factory areas may be used for establishing new green spaces. This approach addresses issues on UGS provision of district significance and tackles densification process which makes designing new green spaces of big sizes (over 1 ha) in cities almost unachievable.

In general, the recommendations provided in a text part of the Master plan give hope that the city will reach estimated numbers in UGS provision by the year 2030 and link the network by adding new UGS elements and improving existing ones, however, multiple factors may obstruct this process such as inadequate financing and lack of political will among responsible bodies.

Methodology limitations. Choosing an accessibility radius (AR) for UGSs according to their type of significance is considered one of the steps shaping further calculations on UGS provision and overall results of the research. Taking a 1 km distance for the service area of UGSs of district significance is based on the local legislation and the existing urban layout of the city which is characterized by large (unexploited) spaces between residential buildings in a residential environment. A radius of 300-500 meters cannot be considered applicable for the study area. It can be assumed that in case of taking lower values for UGS' accessibility radiuses than one 1 km may create a situation when residents of certain residential blocks will not even get out of their semi-public spaces on their way to the nearest NGSs. Also, an overall pattern of the city shaped by soviet urban planning policy with wide streets and large intersections do not contribute to residents' accessibility to UGSs. As to AR for UGSs of city significance (5 km), it is also taken based on the local legislation (MAC, 2016).

Discrepancies in housing stock (hence, population number as well) and sizes of residential blocks also limited precision of derived data. For instance, certain residential blocks with big areas are presented by only one medium-story building with small numbers of population, while other comparably smaller blocks have much more dense residential population. This fact did not allow comparing UGS provision between residential blocks by taking an indicator of population density, which is used more commonly across studies on UGS provision assessment.

Several aspects limiting derived data within the questionnaire part is also worth attention. Small sampling (n=58) cannot be considered representative for some of the questions, especially the ones seeking to find correlation between proximity of UGSs to residences and frequency of their use among elderly people (over 65 years). This demographic group is presented only by 6 respondents.

The question on favorite UGSs may bias the respondents' answers (Q2.4, Table 4.2.2). It is easier to voluntarily limit yourself by options provided by the author rather than reflect on the question, produce a unique answer, and type it in a box 'other.' It is assumed that even though not all residential parks may be found at respondents' liking, they cannot be fully neglected from a discussion. This assumption can be partly proved by three participants who reported their own options naming their favorite places in the city. An open type of question is found more appropriate for this question, where respondents are asked to specify names of their favorite UGSs.

An issue of irregular maintenance of UGSs and NGSs. One of the factors limiting use of UGS of city/district significance more frequently is lack of infrastructure and poor maintenance. This issue is also applicable for NGSs: 63.5% of the respondents (n=31) in the questionnaire stated that they do not use NGSs adjacent to their residences, which is also proved by small numbers of those ones who consider NGSs as a place to relax (24.1%). In addition, the questionnaire helped to detect a poor maintenance of infrastructure elements in NGSs (and their general scarcity) as one of the key issues affecting small numbers on use of these spaces. Nevertheless, the participants see unexplored potential of their NGSs and express a readiness for potential renovations and further use of these spaces.

An issue of insufficient maintenance of NGSs is widespread across the country. In most cases, these spaces are not maintained by the local organization due to their informal status in the city's UGS network. Specifying these UGSs to a separate category (UGSs of a neighborhood significance) prevents them from being subjected to regular maintenance. Local state-based organizations responsible for management of the UGS network are not entitled to provide a service for NGSs. Nowadays, a monopolistic communal service enterprise (based on the Ministry of Housing and Utilities of Belarus) is the only entity that provides maintenance of NGSs in residential development across the country. This service is paid from the residents' utilities for maintenance of adjacent territories, which usually do not have enough budget even for regular maintenance, not to mention a renovation processes. In many cases, residents of adjacent buildings are the ones who take actions to keep their spaces in order: holding cleaning days, fixing infrastructure, decorating at their own cost.

Potential ways of renovating NGSs. To renovate their spaces, the residents are required to inform their local communal service company about future interventions within spaces. Currently, there are mechanisms that may help residents to get the local entity involved in the process of renovation. Based on the author's experience, the most common help from communal service companies may be in providing equipment and staff, but the residents are responsible for elaboration of an action plan on renovation and need to cover all the expenses related to it. Several positive examples of specified form of partnership were met in the country. These projects are held by initiative-taking residents who managed to get residents from their vicinities united during activities, fostering social cohesion between neighbors: 'Огородик И10' ('*Ogorodik I10',* literally: 'Kitchen garden I10') - one of the first community gardens in the country launched in Minsk in 2019); 'Наш двор Молодечно' ('*Nash dvor Maladziečna'*, literally: 'Our courtyard Maladziečna') – the project aimed at improving infrastructure in NGSs in Maladziečna, Belarus.

Grouping in various activities has become customary among residents in Belarusian cities with a similar population as in Brest. Driven by social and infrastructure issues during the last years (COVID-19 outbreak, the presidential elections in 2020 and following persecution of civic society, breakdowns of critical infrastructure elements like water supply network in large cities in 2020), residents has started to tackle issues by themselves when local authorities were failed to prevent these issues or at least helped people to deal with outcomes. Established connection between neighbors has been a tangible result of tackling mutual problems. Nowadays, it is manifested in forms of local chats in messengers and social networks where residents of a particular neighborhood discuss urgent issues. This network of the chats (which nowadays exists in each large city across the country in some way) was used by the author for disseminating the questionnaire among the residents in Brest.

Homeowner associations (HOA) show better coordination in actions and overall cohesion between residents. The process of negotiation in this type of entity is conducted faster and more productive. It is mainly because residents of HOAs directly feel attachment to their place of residence and its surroundings which is manifested in regular contributions and engagement in mutual activities. Also, a HOA-based type of entity allows residents to maintain their NGSs by collective effort without involving a communal service company. Currently, there are 6 HOAs in Brest with a total population of over three thousand inhabitants. Each HOA has been established in multifamily residential blocks with a privately-owned housing stock after the construction process has been finished. Not being bound by mutual agreements, the residents managed to cooperate and establish a community-based form of entity. Usually, NGSs in homeowner associations are much more well-maintained and more attractive for people's use. Also, social interaction between residents is much more intense and fruitful in such communities rather than in ordinary residential blocks. Establishing such a form of entity can be a steppingstone towards further renovation in NGSs, with or without engagement of local authorities in this process.

It is worth mentioning that nowadays there is no alternative for state-based communal service enterprise providing maintenance in the residential environment in the Belarusian cities. With the highest probability, residents will be ready to pay more for having their courtyards clean and well-maintained, if a private company with a sufficient level of service would appear in the market.

Currently, two approaches for NGS renovation may be found in Belarus: a top-down and bottom-up. A top-down approach involves city-driven transformations where local authorities seek to renovate surrounding spaces and infrastructure. They can, for example, rebuild housings or do other major changes. Sometimes city/district administration tries to establish public spaces for residents. And then there are situations when a local responsible body 'built' a playground, but no one from the surrounding area uses it. When local authorities built it, no one asked if a playground was needed there. But it was built, and it turned out to be not relevant, since the surrounding area is populated by elderly and there are no children living there anymore.

There is another approach - "bottom-up". It is launched by the residential block's initiative group. But getting united in it, residents have an opportunity to make only frivolous, minor interventions. The problem in this case is the difficulty of joint coordination, so the Belarusian communities that have already formed seem to be valuable. Usually, people begin to unite only for tackling urgent problems, and calling them to unite behind a certain positive activity is least likely to be just as the same.

In the author's opinion, the renovation process should be mixed, where there is a symbiosis between the two approaches. Participatory practices are crucial during this process. In Belarus, the public is usually involved in a discussion on the post-project stage, which has more informative rather than discursive character. In this case, it is too late altering the project according to people's expressed demands, and only trivial things may be changed. Renovating a NGS, though, is a complex process which requires an explicit analysis of residents' actual needs and preferences. As mentioned by Byrne & Sipe (2010) regarding UGSs, *'no two parks are the same'.* This may be applicable to neighborhood green spaces as well. Each NGS needs to represent its clientele based on their age structure, types of activities, needs, etc. Population survey and public discussions should be conducted to get a clear picture of future renovation of NGS. Infrastructure elements then may be installed regarding a vision.

Participation of residents within a NGS' renovation should be addressed in each of three project stages: *pre-project, designing*, and *post-project*. At the first stage, residents are involved directly, at the second stage, the project is conducted by specialists under residents' supervision, and at the third stage, residents leave their feedback and suggestions on further improvement.

I) Pre-project stage. Analysis of census data and current preferences of residents, as well as spatial data on the existing state of NGS (its morphology, vegetation content, infrastructure, etc.) is conducted first. Then, based on the analysis, a technical task is written with the involvement of residents, local businesses, and other interested parties (stakeholders). As a last step of the pre-project stage, a concept of future NGS is elaborated. This requires constant continuous work with residents, where specialists offer residents options and edit the project based on residents' feedback. Normally, the last step is processed multiple times until stakeholders and specialists will find a compromise solution.

II) Designing stage. During the second stage the residents are asked their opinion less: professional architects elaborate a plan and all necessary documentation according to which the builders will implement the project. Nevertheless, the presence of public supervision is highly important. It can be conducted by a working group consisting of active residents, local businesses, local deputies, and experts living in the area. The final part of the second stage is construction works, in which builders are engaged in the implementation of the plan.

III) Post-project stage. The third stage is needed for critical thinking of the project' results. It is important for specialists to get feedback on the success or failure of the work done and be ready to work on the mistakes. Also, a further task of the initiative group may be the development of a public space program to enrich renovated areas with activities.

Today, residents' urge in renovating and embellishing their surrounding areas may be explained by general unattractiveness of semi-public spaces common for post-soviet residential development. These attempts in renovation are manifested in various DIY interventions: self-made benches and trash bins close to residence' entrances, resting areas and outdoor gyms in courtyards, decorative elements within buildings' setback distances, and many more (Figure 3.3.3). All these interventions are aimed to bring more life and order in NGSs and make them suitable for recreational use.

In many cases, achieving tactical changes in surroundings does not require special education and big finances. Also, local authorities, contrary to common belief, usually do not interfere with this process, and even may be of help. The main obstacle for starting the process of renovation in the author's opinion seems to be lack of communication and trust between residents.

There are several examples of interventions and activities that may help residents to renovate their surroundings and get to know each other better. These suggestions are derived from WHO report (2017) on interventions in UGSs and are adapted with respect to local context:

- *Decorating a balcony and façade.* This is, perhaps, the easiest and the most affordable way for residents to alter surroundings. External elements like balconies and facades (Figure 6.1, A) are considered semi-private spaces (Krier, 1998), meanwhile they are completely visible from outside. For example, decorating balconies during New Year is becoming increasingly popular in large cities in Belarus: by doing this, residents bring a holiday spirit and create a positive atmosphere in surrounding areas. Also, vegetation presented in a private balcony or facades are found visually pleasant.
- *Organizing a gathering.* Good example of an activity that can gather people from the neighborhood - a cleaning day. Also, so-called *block parties* without a particular agenda had become popular during 2020 as a result of a wave of anti-government protests that had taken place in most of the Belarusian cities. These events helped neighbors to get to know each other and establish horizontal relations that are giving fruits till now.
- *Do-It-Yourself (DIY) interventions.* There is a myriad of ways to contribute to NGSs, and some residents are already using their creativity to improve their surroundings. Creating a new street furniture, modifying an existing one or simply planting and gardening may be done without big expenditures. However, these interventions should be found aesthetically pleasing by an entire block population, but not only by a creator's (Figure 3.3.3).
- *Street art.* Different murals and decorative installations are usually found pleasing by people. These elements may diversify residential surroundings, which in post-socialist cities is uniform and unattractive (Figure 6.1, B).
- *Fund-raising and expertise.* Attracting funders may increase possibilities in renovating an NGS. Also, students from the Department of Architecture in local universities may be involved in elaborating a plan for renovation.
- *Short-term interventions.* Tactical short-term changes in a residential environment may be useful to understand whether a newly designed space is going to work the way it has been planned (Figure 6.1, D). These alterations are made fast, usually done out of everyday material and do not require a lot of money and staff. The main aim is to observe residents' interaction with a new space and estimate ways of how it can be better woven into a neighborhood fiber in the future.

Figure 6.1 (picture D) represents one of successful examples of public space interventions that was started as a temporary tactical change. In this case, a road passage in residential environment has been subjected to alterations. An initiative group from a neighborhood in Maladziečna (Belarus) with experts aimed to establish public space which nowadays can be considered one of the main meeting points for residents in the city. It all started with a blockage of a road passage within a residential area for weekends. Local entrepreneurs (mainly street food places) were invited to present their production for the weekend. Nowadays, it is a full-time public space that has been deeply woven into the city's fiber.

Figure 6.1 Examples of interventions in multifamily residential development:
A) Home plants on an external windowsill of multifamily building (Rimini, Italy)
B) Street art in a post-soviet residential block (Minsk, Belarus)
C) Bike parking in a rear green buffer of a 6-story building (Munich, Germany)
D) Short-term alteration in a street (Maladziečna, Belarus) (Credits: author)

The questionnaire's results show that, for example, bike parking is found to be a desirable infrastructure element in NGSs by the most of respondents (n=38, 65.6%). People usually lack this element in their courtyards, which indirectly discourages them from using bicycles more frequently. It is especially applicable for the ones living in high-story residences: carrying a bike up and down may indeed be challenging. Green buffers representing setback distances can be used for setting a bike parking. In many cases, setback distances are wide enough for that purpose, and potential disturbances to residents living on ground level may not be considered significant (Figure 6.1, C).

Rooftops in multifamily residential development are found to be an important asset for potential recreational use among most of the respondents (n=44, or 75.9%). Technically, it is feasible for residents to get access to their own house' rooftops and convert them into semi-public space for residents of a particular house. In practice, however, this operation is severely complicated by multiple harmonization of further actions required by state bodies (The Ministry of Housing and Utilities and The Ministry of Emergency Situations are among them). Given this fact, state obstructions and lack of political will may be also listed among factors limiting the development of UGS provision in Brest and in Belarusian cities in general.

Role of NGS as a compensatory element in the UGS network. Speaking of NGSs and their potential role as compensatory elements in the UGS network of the city, it is important to define other green spaces, inside and outside of the urban area, which may serve people for recreation. For instance, residents may compensate for a lack of green spaces in residential surroundings by visiting nature spaces outside of a city. People in regional centers in Belarus usually seek to escape to a countryside for leisure, especially during weekends. Considerable number of residents have a house in a rural area, which stimulates them to be exposed to nature more regularly. Spending less time in UGSs during workdays may be easily compensated by going out to a summerhouse in a rural area for a weekend. This fact does not devalue the role of UGSs and their provision for residents but explains people's motives in not visiting UGSs more frequently. Nevertheless, even by refraining from visiting UGSs, residents may benefit from them indirectly (subchapter 3.2.2).

Nature-like character of a space may be found within an urban area as well. Certain types of informal green spaces (IGSs), such as brownfields, may be used by residents as compensatory spaces for recreation. These places are found important by residents due to their proximity to residences and unmaintained nature-like vegetation (Rupprecht & Byrne, 2017). According to urban planning policy, the cities in Belarus and Brest in particular have taken courses for densification and compaction of urban areas in their borders, which means that IGSs such as brownfields will be subjected to development in the future. This means that certain IGSs located close to people's residences will not play the role of compensatory elements in the city's UGS network.

The Belarusian cities like Brest still have one big advantage over highly dense counterparts, for instance, in Europe: an abundance of vacant space. This essential asset presented both in semi-public spaces (large unutilized courtyards and green buffers), public spaces (brownfields, unmanaged floodplains and other IGSs), and parts of unutilized industrial zones of factories within the urban area is yet to be explored. In contrast, many European cities like London, Paris, Amsterdam take full advantage of every piece of spare space to weave into the urban fabric numerous opportunities for relaxing, exercising, or just escaping from the noisiness and rush of an urban life. Such spaces make the urban environment more diverse and attractive for living, regardless of population density. In this regard, Brest should take advantage of large unmaintained spaces and free unnecessary ones (e.g., unused factory spaces) to establish a more vivid environment for residents.

The question of wise use of vacant space in the Belarusian cities is still pending. Local urban planners are aware of the importance of green spaces in urban areas, however, usually the numbers on its provision can be neglected for the sake of denser development and more critical infrastructure like parking lots. Developers are obliged to provide residents of the future development with a minimum level of vegetation coverage within multifamily residential blocks. In existing post-socialist residential development, these numbers were easily achieved due to large spaces in between buildings that usually correspond to setback distances (green buffers). However, current development approaches for newly built residences aim to provide maximum housing for residents. Lack of green coverage in backyards is usually compensated by adjacent unexploited vacant lots on the city fringes that are not intended for people's use.

More dramatic fact is that developers do not fully provide residences with public infrastructure and services (grocery stores, pharmacies, hospitals, educational facilities, etc.) that would meet the residents' demand. Usually, non-governmental business tries to fulfill this niche providing residents living in newly built multifamily residential blocks with services, but it can be made to a certain extent: the role of government in critical aspects like public healthcare and education cannot be fully fulfilled. In contrast, post-socialist multifamily blocks normally lack a presence of non-governmental business in surroundings due to low population densities. Usually, it will not be profitable to open business in these residences. This fact refers to the Krier's (1998) scheme of public-private space ratio (Figure 3.3.2): having too much public spaces in residential blocks (70-80%) reduces numbers of population density within a certain area which cannot be found encouraging by non-governmental business.

Do we really need a renovation for NGSs? Reflecting on the role of neighborhood green spaces (e.g., courtyards, playgrounds in residential areas, community gardens) it is important to raise a question of overall necessity for their renovation. NGSs nowadays are facing big competitiveness coming not only from other types of UGS and public spaces in general, but from people's diversified activities and lifestyles. Spending free time in a courtyard can no longer be as captivating as it used to be a decade ago. A broad spectrum of different activities suggested by modern technologies is steadily replacing the role of NGSs as a place for leisure.

In terms of UGS' network elements, it is more probable that residents would prefer visiting bigger green spaces with various activities presented there (like parks) rather than their courtyards. Well-designed NGS will attract more residents from adjacent houses, but to what extent? And which is more fundamental, is it worth duplicating functionality of formally designed UGSs of city/district significance for NGSs? This question remains open. In the author's opinion, the processes of renovation of UGSs of city/district significance should go first. One of the biggest advantages of UGSs over NGSs is size, regardless of level of maintenance and other characteristics. UGSs of bigger sizes can fit more vegetation content, amenities and infrastructure, recreational activities, etc. Bigger size of UGSs encourages people to spend more time there. According to the WHO report (WHO Regional Office for Europe, 2016), only long-term visits in green spaces for recreation may positively affect human's health and well-being.

Nevertheless, NGSs of the most disadvantaged residential blocks (Table 5.1.6) in terms of green space provision (both city/district significance) are needed to be renovated in the first place. Ideally, two above-mentioned processes should go alongside: this will provide equitable provision of green spaces across the city, both quantitatively and qualitatively, and gives residents from the most disadvantaged areas an alternative space for recreation in their immediate surroundings.

7. Conclusion

Spatial analysis of provision of urban green spaces (UGSs) per capita in Brest revealed generalized scarcity of green spaces of district significance across the city. Critical number of 1 m^2 of UGSs per resident is not met by 67.2% of the population. The most disadvantaged residential blocks with smallest UGS provision numbers (both for green spaces of city and district significance) were defined.

By visual analysis and personal site visits, assessment of the general state of green spaces in the city was conducted. Small number of well-equipped and regularly maintained UGSs are considered key limiting factors. This fact proved by the results of the questionnaire which detected a low level of maintenance and lack of infrastructure as the key factor limiting more frequent use of green spaces among respondents. A long distance from a residence to the nearest UGS, as assumed in this study, was not found to be the most important factor.

The role of neighborhood green spaces (NGSs) is assessed by means of the questionnaire. Most of the respondents do not use their current NGSs (n=31, 53.5%) but find their unexplored potential. 70.7% (n=41) of the participants think that their NGSs could be utilized more diversely than they are utilized now. Lack of infrastructure and poor maintenance are also found to be the key factor limiting people's use of green spaces adjacent to their residences. An overall demand for renovation of NGSs among the respondents was found. Several proposals for potential NGS interventions were identified with the respect to local context.

During the work, a certain expertise was acquired. The research consists of visual analysis of the elements of the UGS network implemented by personal field visits and analysis of aerial imagery via Google Earth. Spatial analysis conducted via QGIS software, as well as holding the questionnaire were found to be useful methods and may be applied in further studies. Processing and explaining of the results are practiced within the research. Knowledge of the local legislation and overall understanding of the subject is gained. Above all, networking as a result of several interviews with local experts is established.

In general, stated goals have been met by the research. However, identifying correlations between age of respondents and importance of a distance factor to UGSs was not fully achieved due to small sampling of the questionnaire. It is found more representative conducting face-to-face interviews during field visits to target elderly respondents.

The author identified provision of green spaces with respect to their recreational value and types of their significance. Type of significance (city or district) is related to a size, location, and recreational value of UGS. Level of maintenance and presence of amenities in UGSs are also taken into consideration. This approach helps to divide UGSs in terms of their recreational value and identifies a share of equipped ones which are considered more suitable for people's recreation.

UGSs' accessibility radiuses ARs are set, and provision of green spaces are calculated for the population of each residential block in Brest. This is done with respect to potential overlaps of ARs that represent service areas of several UGSs for each residential block. This approach helps to distribute equal shares of UGSs' sizes among residential blocks that fall within multiple ARs and find an actual number of square meters provided for the population of each residential block.

The research defined infrastructure elements of highest demand among the respondents that needed to be repaired and added the most in NGSs such as bike parking, playground, and paved paths. Potential interventions to renovate their NGSs with respect to the local context and analysis of existing factors limiting this process were provided. Unexplored potential of NGSs that is found needed to be explored by the respondents may be considered the key outcome of the study.

Further research needs to be done on estimating potential of these spaces in meeting the residents' demand for recreation in their immediate surroundings. The role of informal green spaces (IGSs) as a compensatory space for recreation in immediate surroundings is also considered an important direction for further research.

Defining critical areas across the city with the lowest numbers may help to prioritize future actions for urban planners in renovating NGSs within the disadvantaged districts, considering these green spaces as a possible compensatory element that may help to fill gaps in urban green spaces in walking proximity.

It is suggested to renovate the city's UGSs alongside the NGSs from the most disadvantaged blocks. This will provide equitable provision of green spaces across the city and gives residents from the residences that lack green spaces of city/district significance an alternative space for recreation in their immediate surroundings.

8. References

1. AERTS R., BRUFFAERTS N., SOMERS B., DEMOURY C., PLUSQUIN M., NAWROT T.S., HENDRICKX M., 2021. Tree pollen allergy risks and changes across scenarios in urban green spaces in Brussels, Belgium, *Landscape and Urban Planning, 207,* p. 9.
2. AHERN J., 2007. Green Infrastructure For Cities: The Spatial Dimension, *Cities of the Future: Towards Integrated Sustainable Water and Landscape Management. IWA Publishing*, p. 267-283.
3. ALCOCK I., WHITE M.P., PAHL S., DUARTE-DAVIDSON R., FLEMING L.E., 2020. Associations between pro-environmental behaviour and neighbourhood nature, nature visit frequency and nature appreciation: Evidence from a nationally representative survey in England, *Environment International*, *136*, p. 1-10.
4. ALLEN J.A., SETÄLÄ H., KOTZE D.J., 2020. Dog Urine Has Acute Impacts on Soil Chemistry in Urban Greenspaces. *Frontiers in Ecology and Evolution, 9,* p. 8.
5. ALMANZA E., JERRETT M., DUNTON G., SETO E., ANN PENTZ M., 2012. A study of community design, greenness, and physical activity in children using satellite, GPS and accelerometer data, *Health & Place*, *18*, 1, p. 46-54.
6. AMBIENTE ITALIA RESEARCH INSTITUTE (AIRI), 2003. European Common Indicators Towards a Local Sustainability Profile. *Final project report*, *Milan, Italy,* p. 212.
7. AMOLY E., DADVAND P., FORNS J., LÓPEZ-VICENTE M., BASAGAÑA X., JULVEZ J., ALVAREZ-PEDREROL M., NIEUWENHUIJSEN M.J., SUNYER J., 2014. Green and Blue Spaces and Behavioral Development in Barcelona Schoolchildren: The BREATHE Project, *Environmental Health Perspectives*, *122*, 12, p. 1351-1358.
8. ARAM F., HIGUERAS GARCÍA E., SOLGI E., MANSOURNIA S., 2019. Urban green space cooling effect in cities. *Heliyon*, *5*, 4, p. 31.
9. ASTELL-BURT T., FENG X., KOLT G.S, 2014. Neighbourhood green space and the odds of having skin cancer: multilevel evidence of survey data from 267072 Australians. *J Epidemiol Community Health, 68,* 4, p. 370-374.
10. ASTELL-BURT T., FENG X., KOLT G.S., 2013. Does access to neighbourhood green space promote a healthy duration of sleep? Novel findings from across-sectional study of 259 319 Australians, *BMJ Open, 3*, p. 6.
11. BARBOSA O., TRATALOS J.A., ARMSWORTH P.R., DAVIES R.G., FULLER R.A., JOHNSON P., GASTON K.J., 2007. Who benefits from access to green space? A case study from Sheffield, UK, *Landscape and Urban Planning*, *83*, 2-3, p. 187-195.
12. BAYCAN-LEVENT T., NIJKAMP P., 2009. Planning and Management of Urban Green Spaces in Europe: Comparative Analysis, *Journal of Urban Planning and Development*, *135*, 1, p. 1-12.
13. BELARUSIAN STATISTICAL COMMITTEE (BELSTAT), 2021. Census data report, online:https://www.belstat.gov.by/upload/iblock/158/1584531a2b89fa1a0945f6dc809ff268.pdf, accessed 21.02.2022.
14. BENEDICT M.A., MCMAHON E., 2006. Green infrastructure: linking landscapes and communities, *Washington, D.C., U.S., Island Press,* 299 p.

15. BERARDI U., GHAFFARIANHOSEINI A., GHAFFARIANHOSEINI A., 2014. State-of-the-art analysis of the environmental benefits of green roofs, *Applied Energy*, *115*, p. 411-428.
16. BERDEJO-ESPINOLA V., SUÁREZ-CASTRO A.F., AMANO T., FIELDING K.S.,YING OH R.R., FULLER R.A., 2021. Urban green space use during a time of stress: A case study during the COVID-19 pandemic in Brisbane, Australia, *People and Nature, 3*, 3, p. 597-609.
17. BOLUND P., HUNHAMMAR S., 1999. Ecosystem services in urban areas, *Ecological Economics*, *29*, 2, p. 293-301.
18. BOONE-HEINONEN J., CASANOVA K., RICHARDSON A.S., GORDON-LARSEN P., 2010. Where can they play? Outdoor spaces and physical activity among adolescents in U.S. urbanized areas, *Preventive Medicine*, *51*, 3, p. 295-298.
19. BOSCH VAN DEN C.K., 2021. Promoting health and wellbeing through urban forests – Introducing the 3-30-300 rule, online: https://www.linkedin.com/pulse/promoting-health-wellbeing-through-urban-forests-rule-cecil, accessed 11.01.2022.
20. BOUZAROVSKI S., SALUKVADZE J., GENTILE M., 2011. A Socially Resilient Urban Transition? The Contested Landscapes of Apartment Building Extensions in Two Post-communist Cities, *Urban Studies*, *48*, 13, p. 2689-2714.
21. BRATMAN G.N., HAMILTON J.P., HAHN K.S., DAILY G.C., GROSS J.J., 2015. Nature experience reduces rumination and subgenual prefrontal cortex activation, *PNAS, 112,* 28, p. 8567–8572.
22. BYRNE J., SIPE N., 2010. Green and open space planning for urban consolidation – A review of the literature and best practice, *Urban Research Program, Issues Paper 11, Griffith University, Brisbane, Australia,* p. 1-60.
23. COHEN B., 2006. Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability, *Technology in Society*, *28*, 1-2, p. 63-80.
24. COHEN S., LEZAK A., 1977. Noise and Inattentiveness to Social Cues, *Environment and Behavior*, *9*, 4, p. 559-572.
25. COLEY R., KUO M., SULLIVAN W., 1997. Where Does Community Grow? The Social Context Created by Nature in Urban Public Housing, *Environment and Behavior*, *29*, p. 468-494.
26. COPERNICUS, 2018. URBAN ATLAS IN THE EU, online: https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018, accessed 29.11.2021.
27. CZEMBROWSKI P., KRONENBERG J., 2016. Hedonic pricing and different urban green space types and sizes: Insights into the discussion on valuing ecosystem services, *Landscape and Urban Planning*, *146*, p. 11-19.
28. DALLIMER M., TANG Z., BIBBY P.R., BRINDLEY P., GASTON K.J., DAVIES Z.G., 2011. Temporal changes in greenspace in a highly urbanized region, *Biology Letters*, *7*, 5, p. 763-766.
29. DARKHANI F., TAHIR O.M., IBRAHIM R., 2019. Sustainable Urban Landscape Management: An Insight Into Urban Green Space Management Practices in Three Different Countries, *Journal of Landscape Ecology*, *12*, 1, p. 37-48.
30. DEPARTMENT OF ARCHITECTURE OF BREST (DAB), 2019. Brest Master plan, online: http://mas.gov.by/uploads/files/Ekologicheskij-doklad-SEO-Generalnyj-plan-g.Bresta.pdf, accessed 09.02.2022.

31. DOICK K.J., ATKINSON G.E., CORDLE P., GIUPPONI N., 2013. Investigating design and provision of access facilities as a barrier to woodland use, *Urban Forestry & Urban Greening*, *12*, 1, p. 117-125.
32. EEAC, 2009. Towards Sustainable European Infrastructures. Network of European Environment and Sustainable Development Advisory Councils (EEAC), statement, *European Commission*, online: https://ec.europa.eu/environment/nature/ecosystems/pdf/SWD_2019_193_F1_STAFF_WORKING_PAPER_EN_V4_P1_1024680.PDF, accessed 05.02.2022.
33. EKKEL E.D., VRIES S. DE, 2017. Nearby green space and human health: Evaluating accessibility metrics, *Landscape and Urban Planning*, *157*, p. 214-220.
34. ELMQVIST T., SETÄLÄ H., HANDEL S. N. , PLOEG S. VAN DER, ARONSON J., BLIGNAUT J.N., GÓMEZ-BAGGETHUN E., NOWAK D.J., KRONENBERG J., GROOT R. DE, 2015. Benefits of restoring ecosystem services in urban areas, *Current Opinion in Environmental Sustainability*, *14*, p. 101-108.
35. FULLER R.A., GASTON K.J., 2009. The scaling of green space coverage in European cities, *Biology Letters*, *5*, 3, p. 352-355.
36. GASCON M., TRIGUERO-MAS M., MARTÍNEZ D., DADVAND P., ROJAS-RUEDA D., PLASÈNCIA A., NIEUWENHUIJSEN M.J., 2016. Residential green spaces and mortality: A systematic review, *Environment International*, *86*, p. 60-67.
37. GENTIN S., 2011. Outdoor recreation and ethnicity in Europe—A review, *Urban Forestry & Urban Greening*, *10*, 3, p. 153-161.
38. GILES-CORTI B., BROOMHALL M.H., KNUIMAN M., COLLINS C., DOUGLAS K., NG K., LANGE A., DONOVAN R.J., 2005. Increasing Walking. How Important Is Distance To, Attractiveness, and Size of Public Open Space? *American Journal of Preventive Medicine, 28,* p. 169-176.
39. GRAHN P., STIGSDOTTER U., 2003. Landscape planning and stress, *Urban Forestry & Urban Greening*, *2*, p. 1-18.
40. GRAZULEVICIENE R., DANILEVICIUTE A., DEDELE A., VENCLOVIENE J., ANDRUSAITYTE S., UŽDANAVICIUTE I., NIEUWENHUIJSEN M.J., 2015. Surrounding greenness, proximity to city parks and pregnancy outcomes in Kaunas cohort study, *International Journal of Hygiene and Environmental Health*, *218*, 3, p. 358-365.
41. GREENSPACE SCOTLAND GUIDANCE, 2008. Greenspace quality – a guidance to assessment, planning and strategic development, *Scotland, U.K.*, online: https://www.nature.scot/sites/default/files/2017-06/A1018183%20-%20Developing%20Open%20Space%20Standards%20-%20Guidance%20and%20framework%20-%20June%202013.pdf, accessed 21.02.2022.
42. GUO L., MAGHIRANG R.G., 2012. Numerical Simulation of Airflow and Particle Collection by Vegetative Barriers, *Engineering Applications of Computational Fluid Mechanics*, *6*, 1, p. 110-122.
43. HARTIG T., MITCHELL R., VRIES S. DE, FRUMKIN H., 2014. Nature and Health, *Annual Review of Public Health*, *35*, 1, p. 207-228.
44. HECKERT M., 2013. Access and Equity in Greenspace Provision: A Comparison of Methods to Assess the Impacts of Greening Vacant Land, *Transactions in GIS*, *17*, 6, p. 808-827.

45. HICKMAN C., 2013. 'To brighten the aspect of our streets and increase the health and enjoyment of our city': The National Health Society and urban green space in late-nineteenth century London, *Landscape and Urban Planning*, *118*, p. 112-119.
46. HOGENDORF M., OUDE GROENIGER J., NOORDZIJ J.M., BEENACKERS M.A., LENTHE F.J. VAN, 2020. Longitudinal effects of urban green space on walking and cycling: A fixed effects analysis, *Health & Place*, *61*, p. 102-264.
47. HUNTER R.F., CLELAND C., CLEARY A., DROOMERS M., WHEELER B.W., SINNETT D., NIEUWENHUIJSEN M.J., BRAUBACH M., 2019. Environmental, health, wellbeing, social and equity effects of urban green space interventions: A meta-narrative evidence synthesis, *Environment International*, *130*, p. 104-117.
48. ICF REPORT, 2008. Quantifying the greenhouse gas benefits of urban parks, *The Trust for Public Land, San Francisco, CA, U.S.*, p. 64.
49. IKIN K., BEATY R.M., LINDENMAYER D.B., KNIGHT E., FISCHER J., MANNING A.D., 2013. Pocket parks in a compact city: how do birds respond to increasing residential density?, *Landscape Ecology*, *28*, 1, p. 45-56.
50. KABISCH N., HAASE D., 2014. Green justice or just green? Provision of urban green spaces in Berlin, Germany, *Landscape and Urban Planning*, *122*, p. 129-139.
51. KACZYNSKI A.T., POTWARKA L.R., SMALE B.J.A., HAVITZ M.E., 2009. Association of Parkland Proximity with Neighborhood and Park-based Physical Activity: Variations by Gender and Age, *Leisure Sciences*, *31*, 2, p. 174-191.
52. KAPLAN R., KAPLAN S., RYAN R., 1998. With People in Mind: Design And Management Of Everyday Nature. *Bibliovault OAI Repository, the University of Chicago Press*, p. 26-29.
53. KIM J., KAPLAN R., 2004. Physical and Psychological Factors in Sense of Community: New Urbanist Kentlands and Nearby Orchard Village, *Environment and Behavior*, *36*, 3, p. 313-340.
54. KIM M., RUPPRECHT C.D.D., FURUYA K., 2018. Residents' Perception of Informal Green Space—A Case Study of Ichikawa City, Japan, *Land*, *7*, 3, p. 102.
55. KLEEREKOPER L., ESCH M. VAN, SALCEDO T.B., 2012. How to make a city climate-proof, addressing the urban heat island effect, *Resources, Conservation and Recycling*, *64*, p. 30-38.
56. KRIER L., 1998. Architecture: Choice Or Fate, *Papadakis Publisher*, 232 p.
57. LACHOWYCZ K., JONES A.P., PAGE A.S., WHEELER B.W., COOPER A.R., 2012. What can global positioning systems tell us about the contribution of different types of urban greenspace to children's physical activity?, *Health & Place*, *18*, 3, p. 586-594.
58. LAFORTEZZA R., CARRUS G., SANESI G., DAVIES C., 2009. Benefits and well-being perceived by people visiting green spaces in periods of heat stress, *Urban Forestry & Urban Greening, 8*, 2, P. 97-108.
59. LANGEMEYER J., WEDGWOOD D., MCPHEARSON T., BARÓ F., MADSEN A.L., Barton D. N., 2020. Creating urban green infrastructure where it is needed – A spatial ecosystem service-based decision analysis of green roofs in Barcelona, *Science of The Total Environment,* 707, p. 15.

60. LEE K.E., SARGENT L.D., WILLIAMS N.S.G., WILLIAMS K.J.H., 2018. Linking green micro-breaks with mood and performance: Mediating roles of coherence and effort, *Journal of Environmental Psychology*, *60*, p. 81-88.
61. LEE K.E., WILLIAMS K.J.H., SARGENT L.D., FARRELL C., WILLIAMS N.S., 2014. Living roof preference is influenced by plant characteristics and diversity, *Landscape and Urban Planning*, *122*, p. 152-159.
62. LEE K.E., WILLIAMS K.J.H., SARGENT L.D., WILLIAMS N.S.G., JOHNSON K.A., 2015. 40-second green roof views sustain attention: The role of micro-breaks in attention restoration, *Journal of Environmental Psychology*, *42*, p. 182-189.
63. LEFEBVRE H., 1968. THE RIGHT TO THE CITY, *Anthropos,* p. 166.
64. LINDEMANN-MATTHIES P., MARTY T., 2013. Does ecological gardening increase species richness and aesthetic quality of a garden?, *Biological Conservation*, *159*, p. 37-44.
65. LÕHMUS M., BALBUS J., 2015. Making green infrastructure healthier infrastructure, *Infection Ecology & Epidemiology*, *5*, p. 1-10.
66. LWIN K.K., MURAYAMA Y., 2011. Modelling of urban green space walkability: Eco-friendly walk score calculator, *Computers, Environment and Urban Systems*, *35*, 5, p. 408-420.
67. MAAS J., SPREEUWENBERG P., WINSUM-WESTRA M., VERHEIJ R., VRIES S. DE, GROENEWEGEN P., 2009. Is Green Space in the Living Environment Associated with People's Feelings of Social Safety?, *Environment and Planning A*, *41*, p. 1763-1777.
68. MADGE C., 1997. Public Parks And The Geography Of Fear, *Tijdschrift voor Economische en Sociale Geografie*, *88*, 3, p. 237-250.
69. MAHMOUDI FARAHANI L., MALLER C., 2019. Investigating the benefits of 'leftover' places: Residents' use and perceptions of an informal greenspace in Melbourne, *Urban Forestry & Urban Greening*, *41*, p. 292-302.
70. MATISOFF D., NOONAN D., 2012. Managing contested greenspace: neighborhood commons and the rise of dog parks, *International Journal of the Commons*, *6*, 1, p. 28-51.
71. MAZZA L., G. B., L. D., GANTIOLER S., L. L., C. M., KAPHENGST T., A. M., RAYMENT M., TEN BRINK P., DIGGELEN R., 2011. *Green Infrastructure Implementation and Efficiency*.
72. MCCARTHY D., SAEGERT S., 1978. Residential density, social overload, and social withdrawal, *Human Ecology*, *6*, 3, p. 253-272.
73. MCINTYRE N.E., KNOWLES-YÁNEZ K., HOPE D., 2000. Urban ecology as an interdisciplinary field: differences in the use of "urban" between the social and natural sciences, *Urban Ecosystems*, *4*, 1, p. 5-24.
74. MCPHEE D., 2011. Marine Park Planning and Recreational Fishing: Is the Science Lost at Sea? Case Studies from Australia, *International Journal of Science in Society*, *2,* 2, p. 23-37.
75. MEFTAUL I.M., VENKATESWARLU K., DHARMARAJAN R., ANNAMALAI P., MEGHARAJ M., 2020. Pesticides in the urban environment: A potential threat that knocks at the door, *Science of The Total Environment, 711*, p. 55.
76. MERRIAM-WEBSTER. Definition of the word 'neighborhood', statement, *Merriam-Webster,* online: https://www.merriam-webster.com/dictionary/neighborhood, accessed 21.02.2022.

77. Metspalu P., Hess D.B., 2018. Revisiting the role of architects in planning large-scale housing in the USSR: the birth of socialist residential districts in Tallinn, Estonia, 1957–1979, *Planning Perspectives*, *33*, 3, p. 335-361.
78. Ministry of Architecture and Construction (MAC), 2016. The rules on urban green space provision, online: http://mas.gov.by/uploads/documents/Metodicheskie-rekomendatsii-po-proektirovaniju-Pravila-provedenija-ozelenenija-naselennyx-punktov.pdf, accessed 12.02.2022.
79. Molloy J., Albert R., 2008. Managing Wet Weather with Green Infrastructure, *Sixth Annual Greening Rooftops for Sustainable Communities Conference, Awards and Trade Show, 1.1, Baltimore, MD, U.S.,* p. 1-12.
80. Morbidity and Mortality Weekly Report (MMWR), 2012. Centers for Disease Control and Prevention, *U.S., 61*, 19, p. 344-347.
81. Moreno C., Allam Z., Chabaud D., Gall C., Pratlong F., 2021. Introducing the « 15-Minute City »: Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities, *Smart Cities*, *4*, 1, p. 93-111.
82. Moscow Urban Planning Committee (Moscow UPC), 2021, online: https://stroi.mos.ru/gallery/3127, accessed 21.02.2022.
83. Mouratidis K., 2021. Urban planning and quality of life: A review of pathways linking the built environment to subjective well-being, *Cities*, *115*, p. 103-229.
84. Natural Capital Committee, 2015, online: https://www.gov.uk/government/publications/natural-capital-committees-third-state-of-natural-capital-report-government-response, accessed 21.02.2022.
85. Neringa Utaraitė, online: https://www.facebook.com/groups/909520205919428/, accessed 11.02.2022.
86. Nielsen A.B., Bosch M. van den, Maruthaveeran S., Bosch C.K. van den, 2014. Species richness in urban parks and its drivers: A review of empirical evidence, *Urban Ecosystems*, *17*, 1, p. 305-327.
87. Nielsen T.S., Hansen K.B., 2007. Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators, *Health & Place*, *13*, 4, p. 839-850.
88. Nor A., Abdullah S., 2019. Developing Urban Green Space Classification System Using Multi-Criteria: The Case of Kuala Lumpur City, Malaysia. *Journal of Landscape Ecology*, *12,* 1, p 16-36.
89. Nowak D.J., Crane D.E., Stevens J.C., 2006. Air pollution removal by urban trees and shrubs in the United States, *Urban Forestry & Urban Greening*, *4*, 3-4, p. 115-123.
90. OECD, 2012. OECD Environmental Outlook to 2050: The Consequences of Inaction, *OECD (OECD Environmental Outlook).*
91. Pathak V., Tripathi B.D., Mishra V.K., 2008. Dynamics of traffic noise in a tropical city Varanasi and its abatement through vegetation, *Environmental Monitoring and Assessment*, *146*, 1, p. 67-75.
92. Penakalapati G., Swarthout J., Delahoy M.J., McAliley L., Wodnik B., Levy K., Freeman M.C., 2017. Exposure to Animal Feces and Human Health: A Systematic Review and Proposed Research Priorities, *Environmental Science & Technology*, *51*, 20, p. 11537-11552.

93. PHAM T.-T.-H., APPARICIO P., SÉGUIN A.-M., LANDRY S., GAGNON M., 2012. Spatial distribution of vegetation in Montreal: An uneven distribution or environmental inequity?, *Landscape and Urban Planning*, *107*, 3, p. 214-224.
94. PITTMAN S., RODWELL L.D., SHELLOCK R., WILLIAMS M., ATTRILL M., BEDFORD J., CURRY K., FLETCHER S., GALL S.C., LOWTHER J., MCQUATTERS-GOLLOP A., MOSELEY K., REES S., 2019. Marine parks for coastal cities: A concept for enhanced community well-being, prosperity and sustainable city living, *Marine Policy*, p. 103.
95. RAKHSHANDEHROO M., AFSHIN S., MOHD YUSOF M.J., 2017. Terminology of Urban Open and Green Spaces, *11th ASEAN Postgraduate Seminar, APGS 2017, Faculty of Built Environment, University of Malaya, Malaysia,* p. 9.
96. ROGERS J., 2013. Green, brown or grey: green roofs as 'sustainable' infrastructure, *Sustainable Development and Planning, WIT Press, 6*, p. 323-333.
97. RUPPRECHT C., BYRNE J., 2017. Informal urban green space as anti-gentrification strategy?, Just Green Enough: Urban development and environmental gentrification*, Routledge,* p. 209-226.
98. RUPPRECHT C.D.D., BYRNE J.A., 2014. Informal urban greenspace: A typology and trilingual systematic review of its role for urban residents and trends in the literature, *Urban Forestry & Urban Greening*, *13*, 4, p. 597-611.
99. RUPPRECHT C.D.D., BYRNE J.A., 2014. Informal Urban Green-Space: Comparison of Quantity and Characteristics in Brisbane, Australia and Sapporo, Japan, *PLoS ONE*, *9*, 6, p. 17.
100. SADLER J., BATES A., HALE J., JAMES P., 2010. Bringing cities alive: the importance of urban green spaces for people and biodiversity, *Urban Ecology*, *Cambridge, Cambridge University Press (Ecological Reviews),* p. 230-260.
101. SÄUMEL I., HOGREFE J., BATTISTI L., WACHTEL T., LARCHER F., 2021. The healthy green living room at one's doorstep? Use and perception of residential greenery in Berlin, Germany, *Urban Forestry & Urban Greening*, *58*, p. 13.
102. SAVARD J-P.L., CLERGEAU P., MENNECHEZ G., 2000. Biodiversity concepts and urban ecosystems, *Landscape and Urban Planning*, *48,* p. 131-142.
103. SCHIPPERIJN J.J., 2010. *Use of Green Spaces. Forest and Landscape Research, 45*, *Frederiksberg, Denmark,* p. 155.
104. SCHMIDT M., 2009. Rainwater harvesting for mitigating local and global warming, *Fifth Urban Research Symposium 2009, Marseille, France*, p. 15.
105. SCOTTISH GOVERNMENT, 2011. Green infrastructure: design and placemaking, *PS Group Scotland, Edinburgh, U.K.,* p. 1-28 .
106. SENDI R., KERBLER B., 2021. The Evolution of Multifamily Housing: Post-Second World War Large Housing Estates versus Post-Socialist Multifamily Housing Types in Slovenia, *Sustainability*, *13*, 18, p. 19.
107. SHANAHAN D.F., LIN B.B., BUSH R., GASTON K.J., DEAN J.H., BARBER E., FULLER R.A., 2015. Toward Improved Public Health Outcomes From Urban Nature, *American Journal of Public Health*, *105*, 3, p. 470-477.
108. SHEPLEY M., SACHS N., SADATSAFAVI H., FOURNIER C., PEDITTO K., 2019. The Impact of Green Space on Violent Crime in Urban Environments: An Evidence Synthesis, *International Journal of Environmental Research and Public Health*, *16*, 24, p. 19.

109. SIKORSKA D., ŁASZKIEWICZ E., KRAUZE K., SIKORSKI P., 2020. The role of informal green spaces in reducing inequalities in urban green space availability to children and seniors, *Environmental Science & Policy*, *108*, p. 144-154.
110. AYDIN S.M.B., ÇUKUR D., 2012. Maintaining the carbon–oxygen balance in residential areas: A method proposal for land use planning, *Urban Forestry & Urban Greening*, *11*, 1, p. 87-94.
111. SIMIĆ I., NJEGIC T. (BAJIC), Green and blue spaces: integral urban design as a toolkit for climate change adaptation in the case of smaller settlements in Vojvodina region, *Conference Proceedings, 2nd International Scientific Conference, RESPAG 2013, Belgrade, Serbia,* p. 1116-1125.
112. SISTER C., WOLCH J., WILSON J., 2010. Got green? addressing environmental justice in park provision, *GeoJournal*, *75*, 3, p. 229-248.
113. SMARGIASSI A., GOLDBERG M.S., PLANTE C., FOURNIER M., BAUDOUIN Y., KOSATSKY T., 2009. Variation of daily warm season mortality as a function of micro-urban heat islands, *Journal of Epidemiology and Community Health*, *63*, 8, p. 659-664.
114. STEWART O.T., MOUDON A.V., FESINMEYER M.D., ZHOU C., SAELENS B.E., 2016. The association between park visitation and physical activity measured with accelerometer, GPS, and travel diary, *Health & Place*, *38*, p. 82-88.
115. SULLIVAN W., KUO M., DEPOOTER S., 2004. The Fruit of Urban Nature: Vital Neighborhood Spaces, *Environment and Behavior*, *36*, p. 678-700.
116. SUTTON R., 2014. Aesthetics for Green Roofs and Green Walls, *Landscape Architecture Program: Faculty Scholarly and Creative Activity*, *UN-Lincoln, U.S.,* p. 19.
117. TAVERNIA B.G., REED J.M., 2009. Spatial extent and habitat context influence the nature and strength of relationships between urbanization measures, *Landscape and Urban Planning*, *92*, 1, p. 47-52.
118. TAYLOR L., HOCHULI D.F., 2017. Defining greenspace: Multiple uses across multiple disciplines, *Landscape and Urban Planning*, *158*, p. 25-38.
119. THE LIFE PLANT ACT, 2003. 86-Г, from 21.02.2003, Belarus, online: https://pravo.by/document/?guid=3871&p0=h10300205, accessed 14.02.2021.
120. THE STATE CODE OF LAND, 2008. 425-3, from 23.07.2008, Belarus, online: https://kodeksy-by.com/kodeks_rb_o_zemle.htm, accessed 14.02.2022.
121. TROJANEK R., GLUSZAK M., TANAŚ J., 2018. The effect of urban green spaces on house prices in Warsaw, *International Journal of Strategic Property Management*, *22*, p. 358-371.
122. TWOHIG-BENNETT C., JONES A., 2018. The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes, *Environmental Research*, *166*, p. 628-637.
123. U.S. GLOBAL CHANGE RESEARCH PROGRAM (USGCRP), 2017. Fourth National Climate Assessment (NCA4), *Washington, D.C., U.S.,* online: https://science2017.globalchange.gov/, accessed 21.02.2022.
124. ULRICH R., 1983. Aesthetic and Affective Response to Natural Environment, *Human Behavior & Environment: Advances in Theory & Research*, *6*, p. 85-125.

125. UNITED NATIONS, DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS, POPULATION DIVISION, 2019. *World population prospects Highlights, 2019 revision Highlights, 2019 revision*.
126. URBAN REDEVELOPMENT AUTHORITY GUIDANCE, 2019. Building Setback from Boundary, online: https://www.ura.gov.sg/Corporate/Guidelines/Development-Control/Non-Residential/Commercial/Building-Setback, accessed 12.02.2022.
127. VALE D.S., SARAIVA M., PEREIRA M., 2016. Active accessibility: A review of operational measures of walking and cycling accessibility, *Journal of Transport and Land Use*, *9*, 1.
128. VALLEJO B.M., ALOY A.B., ONG P.S., 2009. The distribution, abundance and diversity of birds in Manila's last greenspaces, *Landscape and Urban Planning*, *89*, 3, p. 75-85.
129. VAN RENTERGHEM T., 2018. Chapter 3.8 - Green Roofs for Acoustic Insulation and Noise Reduction, dans PÉREZ G., PERINI K. (dirs.), *Nature Based Strategies for Urban and Building Sustainability*, *Butterworth-Heinemann,* p. 167-179.
130. VRIES S. DE, DILLEN S.M.E. VAN, GROENEWEGEN P.P., SPREEUWENBERG P., 2013. Streetscape greenery and health: stress, social cohesion and physical activity as mediators, *Social Science & Medicine (1982)*, *94*, p. 26-33.
131. WEEKS J.R., 2010. Defining Urban Areas, dans RASHED T., JÜRGENS C. (dirs.), Remote Sensing of Urban and Suburban Areas, Dordrecht, Springer Netherlands*, Remote Sensing and Digital Image Processing*, p. 33-45.
132. WEILER S.K., SCHOLZ-BARTH K., 2009. Green Roof Systems: A Guide to the Planning, Design, and Construction of Landscapes Over Structure, *John Wiley & Sons, Inc., Hoboken, NJ, U.S.,* p. 322.
133. WELL F., LUDWIG F., 2020. Blue–green architecture: A case study analysis considering the synergetic effects of water and vegetation, *Frontiers of Architectural Research*, *9*, 1, p. 191-202.
134. WHITE E.V., GATERSLEBEN B., 2011. Greenery on residential buildings: Does it affect preferences and perceptions of beauty?, *Journal of Environmental Psychology*, *31*, 1, p. 89-98.
135. WHO REGIONAL OFFICE FOR EUROPE, 2016. Urban green spaces and health: A review of evidence. Full report, p. 91.
136. WHO REGIONAL OFFICE FOR EUROPE, 2017. Urban green space interventions and health: A review of impacts and effectiveness. Full report, p. 203.
137. WŁODARCZYK-MARCINIAK R., SIKORSKA D., KRAUZE K., 2020. Residents' awareness of the role of informal green spaces in a post-industrial city, with a focus on regulating services and urban adaptation potential, *Sustainable Cities and Society*, *59*, p. 11.
138. WOLCH J., JERRETT M., REYNOLDS K., MCCONNELL R., CHANG R., DAHMANN N., BRADY K., GILLILAND F., SU J.G., BERHANE K., 2011. Childhood obesity and proximity to urban parks and recreational resources: a longitudinal cohort study, *Health & Place*, *17*, 1, p. 207-214.
139. WOLCH J.R., BYRNE J., NEWELL J.P., 2014. Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough', *Landscape and Urban Planning*, *125*, p. 234-244.

140. WOLFF M., HAASE D., 2019. Mediating Sustainability and Liveability—Turning Points of Green Space Supply in European Cities, *Frontiers in Environmental Science*, *7*, Article 61, p. 1-14.
141. WORLD HEALTH ORGANIZATION (WHO), 2012. Health Indicators of sustainable cities in the Context of the Rio+20 UN Conference on Sustainable Development: Initial findings from a WHO Expert Consultation, p. 6.
142. YOKOHARI M., BOLTHOUSE J., 2011. Planning for the slow lane: The need to restore working greenspaces in maturing contexts, *Landscape and Urban Planning*, *100*, p. 421-424.
143. YUEN B., NYUK HIEN W., 2005. Resident perceptions and expectations of rooftop gardens in Singapore, *Landscape and Urban Planning*, *73*, 4, p. 263-276.

List of Appendices