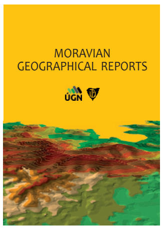

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Towards greener cities: Evaluating urban green space accessibility using the 3-30-300 rule exampled on the city of Olomouc (Czech Republic)

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Abstract

The 3-30-300 rule outlines key principles for urban greenery, emphasising its role in promoting human health, well-being, and quality of life. It calls for equitable access to green spaces and an integrated approach to urban development. This study introduces a transferable methodology for applying the 3-30-300 rule, focusing on Czech cities. A notable feature of the study is its usage of a deep learning tool combined with freely available public data. The methodology was applied to all residential buildings in the city of Olomouc, providing specific results at both citywide and individual rule-component levels. The study also addresses the rule's limitations, offering a realistic view of its practical application. This contributes to the broader discussion on the role of urban green spaces in creating more sustainable and liveable cities. The findings reveal that rule 3 is met for nearly all residential buildings in Olomouc. However, rule 30 appears unattainable in the city, with maximum neighbourhood canopy cover reaching only 22%. Only approximately 25% of residential buildings are situated within the recommended 300-metre radius of a park. Our research shows that the 3-30-300 rule is a feasible framework for measuring the availability of greenery in (Czech) cities; however, further methodological development is needed.

Keywords: 3-30-300, urban planning, green infrastructure, urban forestry, well-being

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1. Introduction

What should a contemporary city look like to provide everything a person of today needs? One can begin to answer this question by analysing the current form of our cities and objectively evaluating public space as a place that directly and indirectly influences every inhabitant and visitor. In cities the quality of the place where people spend their time is all the more important given that we are talking about an increasing number of people moving to cities (UNPD, 2019). Since the beginning of the 21st century there has been an ongoing trend of people moving to urban and highly urbanised areas, which has generally resulted in a steep increase in urbanisation and increased pressure and demands on the appearance, quality, and comprehensive planning of the urban environment (Samson, 2017). As early as 2018, approximately 55% of the world's population lived in urban areas (UNPD, 2019). The same upward trend continues and is not expected to change significantly in the near future (Samson, 2017). The growing number of people living in cities brings with it ever-increasing demands on the quality of the urban environment and the overall need to plan and adapt cities to make them the best possible places for people to live (Raihan, 2023).

Humans in urban environments are exposed to a large spectrum of stressors, ranging from insufficient light, air pollution, heat stress, the generally faster pace of a city, and the aforementioned large number of people. It is widely recognised that the availability of nature in the city, especially in the form of trees and green spaces, is becoming increasingly important for human health and quality of life (Astell-Burt & Feng, 2020; Astell-Burt et al., 2022). Urban green spaces can effectively influence the environment and reduce urban stress in a wide range of positive ways (UNECE, 2023; Browning et al., 2024; Nieuwenhuijsen, 2021). Green spaces in various forms – based on their functions, e.g. parks, sports fields, gardens, and private open spaces (Grabowski et al., 2022) – bring a range of benefits such as reducing temperature, improving air quality, reducing stress levels, promoting physical activity and social contact, and enhancing the physical and mental health of residents (Browning et al., 2024; Konijnendijk, 2021; Lottrup et al., 2015; Rugel et al., 2019).

In this respect, efficient distribution of urban green space across cities is currently one of the most important ways to improve the quality of the environment for urban dwellers and to improve the well-being of people exposed to urban stressors in general (Zhang et al., 2023; Grabowski et al., 2022). Despite similar measured temperatures, people consistently perceive forested areas as cooler than the surrounding environments. Forests can be used by urban planners as a nature-based solution to prevent our environment from causing heat stress (Gillerot et al., 2024). These benefits are invaluable for maintaining the viability of cities and the quality

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of life of their residents. Thus, access to green spaces has become an important added value for cities and almost a necessary and mandatory component of the urban environment (Weerasuriya et al., 2019). Today, every urban dweller can consider equal access to urban green spaces as a human right (Miles, 2022). Nevertheless, there are large differences in the availability of urban green spaces across cities and neighbourhoods, with different urban structures and diverse functions being very frequent (Konijnendijk, 2024; Kabisch et al., 2016). Such physical differences can, as in some US cities, even result in the inequality of accessibility to green recreational spaces for people of different social and ethnic backgrounds (Wen et al., 2013). Due to the aforementioned inequalities, there have been demands from the scientific community, urban planners, and municipalities, for a universally applicable and standardised approach to evaluating the availability of urban greenery, based on its lack and on people's needs (Konijnendijk, 2021). One modern approach to efficiently distributing green space in cities is to use the 3-30-300 rule, introduced in 2021 by Cecil Konijnendijk.

In this study, we will focus on the analysis of the 3-30-300 rule in terms of its real use and potential application for the Czech environment. The main objectives of this article are:

i. To create a general and transferable methodology that can be further applied in other (not only) Czech cities;

ii. To evaluate the fulfilment and significance of the 3-30-300 rule criteria in a medium-sized Central European city; and

iii. To discuss spatial differences between city districts with different urban morphology.

In this manuscript, we present a general methodology that is broadly applicable to different types of projects and research, specifically focused on planning the design of urban public spaces, taking into account the well-being of inhabitants and other factors affecting the value of individual places in a city. This methodology includes goal definition, data collection and analysis, strategic planning, implementation, and subsequent evaluation. We then apply this methodology to the specific case of the city of Olomouc, conducting a detailed analysis to demonstrate how these methodological approaches can be effectively used locally. This includes an evaluation of the results, which allows us to better understand the strengths and weaknesses of the applied methodology, and helps to clarify the limits of the application of the 3-30-300 rule in the Czech environment. Through this approach, we aim to provide a comprehensive overview of how theoretical approaches can yield practical benefits in the real world. This practical approach is grounded in the theoretical framework of the 3-30-300 rule, which offers measurable standards for enhancing urban green spaces and improving residents' quality of life.

2. Theoretical background

Before the establishment of the 3-30-300 rule, several principles and practices shaped the understanding of urban green spaces and their benefits. Urban greenery has historically been linked to climate moderation and public health; previous studies highlighted the importance of tree cover in mitigating urban heat islands (UHIs) and promoting biodiversity. For instance, research indicated that increased green coverage in urban areas is positively correlated with lowered temperatures and improved air quality (Kong et al., 2010). Furthermore, expectations for green space access had evolved, leading to informal community efforts and early policies aiming to ensure adequate greenery facilitated recreational opportunities and environmental justice (Koeser et al., 2024).

The background of the 3-30-300 rule arises from importance of greenery for urban health and well-being. Research shows that access to green spaces is associated with increased physical activity and improved mental health, contributing to overall community wellness (Konijnendijk, 2021; Nieuwenhuijsen et al., 2022). The proximity of parks encourages routine visits, which foster social interactions and physical activities, thus combating urban loneliness and related psychological issues (Konijnendijk, 2023). Furthermore, the presence of trees has been linked to environmental benefits, such as cooling of the urban environment (Janků et al., 2024), improved air quality (Selmi et al., 2016), and biodiversity support (Prevedello et al., 2017), making urban areas more resilient to climate change (Browning et al., 2024; Croeser et al., 2024). Moreover, green elements are perceived as comfortable and cooling features that contribute to overall outdoor thermal comfort (Lehnert et al., 2023; Květoňová et al., 2024). Additionally, the spatial distribution of urban green spaces significantly impacts their ecological effectiveness and the health of urban ecosystems. Research shows that a well-planned network of green spaces can improve ecological connectivity and resilience, enhancing urban sustainability, while optimising ecological service provision and the quality of urban living environments (Li et al., 2015; Chen et al., 2021). Conversely, fragmented green spaces can reduce urban ecological functions (Li et al., 2015), leading to issues like increased urban heat islands or urban heat load (Wang & Yang, 2024; Květoňová et al., 2024) and decreased biodiversity (Sharmin et al., 2024). Based on these findings, Konijnendijk addresses the need to integrate both natural and urban environments, which will increasingly become a necessary condition for well-developed cities that provide their inhabitants with the optimal living conditions (Konijnendijk, 2023; Konijnendijk, 2024).

An important aspect of the 3-30-300 rule pertains to its straightforwardness, providing a pass/fail benchmark for planners and communities to gauge urban greenness (Croeser et al., 2024). Ensuring that neighbourhoods meet these criteria can guide future urban planning initiatives, helping cities prioritise investments in green infrastructure (Torkfar & Russo, 2023). Additionally, such measures may promote equity in urban environments, as they ensure that even the most disadvantaged areas have essential access to nature, thereby bridging gaps in health outcomes across diverse socioeconomic groups (Koeser et al., 2024). The ongoing evaluation of urban access to nature through the 3-30-300 framework indicates that many cities worldwide fall short of these basic standards, exposing significant canopy deficits that necessitate urgent attention and action (Croeser et al., 2024). As urbanisation continues to accelerate, the relevance of the 3-30-300 rule as a tool for achieving greener, healthier cities is more important than ever.

The basis of the 3-30-300 rule is to emphasise three key aspects of urban green space in relation to human perceptions. Konijnendijk (2021) lists these three aspects as: the visuality of green space (i.e. people see and perceive the presence of green space), the proximity of green space (especially the degree of greening of the immediate neighbourhood), and the accessibility of green space (especially quality green space for leisure activities).

More specifically the first component, the ‘3’ in the rule, stipulates that from homes, schools, and workplaces, there should be a view of at least three trees. Several case studies have examined tree visibility and coverage in urban settings. The Master Plan for Barcelona's Trees (Guitard et al., 2017) was an early strategic document that aimed to increase urban tree coverage. In Florida, Koeser et al. (2024) focused specifically on tree visibility from windows. In Xiamen city, China, Zheng et al. (2024) analysed both tree visibility and compliance with canopy cover regulations. This criterion is designed not only to ensure a visual connection with nature but also to offer the psychological and aesthetic benefits that can arise from daily exposure to greenery (Browning et al., 2024; Nieuwenhuijsen et al., 2022). Empirical studies have demonstrated that such nature exposure is linked to reduced stress levels and improved mental health outcomes in urban populations, thereby endorsing the importance of the '3 trees' element as a public health as well as an environmental measure (Browning et al., 2024; Nieuwenhuijsen et al., 2022).

The second component, represented by '30', requires that at least 30% of a neighbourhood's area should be covered by tree canopy, an indicator that captures the density and quality of urban forests. This threshold is associated with multiple environmental benefits including improved local microclimates, reduced urban heat island effects, and enhanced air quality, which, in turn, indirectly support human health and social cohesion within communities (Croeser et al., 2024; Konijnendijk, 2023). It serves as a benchmark for urban planners to evaluate and compare neighbourhoods, ensuring that adequate tree cover is maintained or improved over time and thus acts as a driver for sustainable urban development (Browning et al., 2024; Konijnendijk, 2023).

The final component, denoted by '300', mandates that all residences be located within a 300-metre walking distance to the nearest public park or green space. This parameter is grounded in the notion that proximity to accessible green space increases opportunities for physical activity, social interaction, and leisure, which are all critical determinants of public health (Koeser et al., 2024; Croeser et al., 2024). A 300-metre distance is essentially equivalent to a five-minute walk, making it a practical and easily communicable standard to ensure that residents can regularly enjoy the benefits of urban greenery (Koeser et al., 2024).

Overall, the 3-30-300 rule is an emerging and promising framework designed to guide urban planners in the advancing application of green infrastructure in all types of cities, thereby enhancing the accessibility and benefits of urban green spaces. The main objectives and outcomes of applying the principles of the 3-30-300 rule should be to ensure equitable access to green space, promote sustainable development, and improve the environmental quality of individual urban areas and cities as a whole.

3. Methods and data

In 2021, Cecil Konijnendijk presented the rule of 3-30-300 for the first time (Konijnendijk, 2021). In 2023, he presented Evidence-based guidelines (Konijnendijk, 2023), and in 2024, Browning et al. (2024) presented an article about measuring the 3-30-300 rule. The recommendations from Konijnendijk's guidelines are listed in the methodology sections of each of the components, and we are applying them to the methodology we are proposing. Based on the guidelines we considered the most appropriate data sources, the advantages and disadvantages of each source are listed in Table 1. The key data source for analysis is public data, making this rule affordable for local policymakers. We use ArcGIS Pro and its tools to analyse the data.

3.1 Application (study area)

After establishing all the criteria (see 3.2, 3.3, 3.4), the rule was applied to the city of Olomouc. Individual criteria for specific parts of the rule were tested within sample areas (Fig. 5). Olomouc, situated in the eastern part of the Czech Republic, has a population of 102 thousand inhabitants and is the sixth largest city in the country (ČSÚ, 2024). Covering a total area of 103 square kilometres, the cadaster of Olomouc features a mix of agricultural areas (55%), urbanised land (31%), forests (11%), and water bodies (2%). A map of local climate zones (Geletič & Lehnert, 2016) is attached for a better understanding of the area (Fig. 1).

The city's history dates back to the 10th century. The historic core strongly reflects the influences of city fortifications that separated this part from the rest of the city until the mid-19th century. The historical centre primarily fulfils administrative and commercial functions and contains two of Olomouc's largest squares. This area was declared a cultural heritage site in 1971 (Ptáček et al., 2007). The historical city centre is surrounded by older residential buildings and a ring of parks (Smetanovy Sady, Bezručovy Sady and Čechovy Sady), which reflect the city's natural response to the need for green spaces through history (Daniel & Jirmus, 2023). The inner structure of the city was developed in the late 19th and the first half of the 20th century in three sectors, when it was mainly tenement and residential houses and functional buildings that were built north and south of the city's core. Villa districts with terraced houses were built in the west and east of the centre at the turn of the 19th and 20th centuries. The highest percentage of the

	Methods	Sources	Advantages	Disadvantages
Rule 3	Land cover maps	Urban Atlas – street tree layer	Data source for European cities (conurbation with 50,000 inhabitants and more)	Data only for locations included in the Urban Atlas, polygon layer, only larger groups of trees included, impossible to detect single trees
	Remote sensing + deep learning	ČÚZK – orthophoto	This type of data suits the tree detection tool, can detect single trees, polygons and point layers, can calculate shape area, data for every municipality in the Czech Republic, low percentage of errors	Incorrect count of trees in a group of trees, some of them are detected incorrectly
	Tree inventories	Terrain mapping	Accurate results	Impossible to cover the whole city, time-consuming, impossible to map trees on private property
	Questionnaires	Survey	Real count of trees from a window	Very subjective, depending on a chosen window, impossible to create the analysis for the whole city
	Window-view analysis	Photographies	Real count of trees from a window	Very subjective, depending on the chosen window, impossible to create the analysis for the whole city
Rule 30	Land cover maps	Urban Atlas – street tree layer	Data source for European cities	Data only for locations included in the Urban Atlas, only larger groups of trees included, inaccurate results
	Remote sensing + deep learning	ČÚZK – orthophoto	This type of data suits the tree detection tool, can detect single trees, polygons and point layers can calculate shape area, data for every city in the Czech Republic, low percentage of errors	Incorrect count of trees in a group of trees, some of them are detected incorrectly
Rule 300	Land cover maps	Urban Atlas – urban green space	Data source for European cities	Data only for locations included in the Urban Atlas, areas of UGS are inaccurate
		Cadastral plans	Data available for every municipality in Czech Republic, concrete data	Plans are from different year, need to check the actual state

Tab. 1: Methods and sources suitable for every part of the rule 3-30-300
Source: Authors' conceptualisation

population (more than 40%) lives in housing estates, either built as planned in the socialist era between the 1950s and late 1980s (in the northern, western, and southern parts of the city), or as new commercial development projects built mainly in peripheral areas or in close proximity to housing estates. Industrial zones dot the city's outskirts (Fig. 1).

In this study we analysed only the area of compact development (see Fig. 2). A compact city is defined as an area with an urban character of development, separated from suburban and rural areas. This concept includes higher density of buildings and a mix of functions such as housing, work, shops, and services, allowing residents to cover most of their daily needs on foot, by bike, or using public transport. The compact city promotes the sustainability of urban spaces, reduces car traffic, lowers emissions, and revitalises brownfields (Halás et al., 2013). The compact city area of Olomouc is approximately equivalent to one third of the administrative area (Fig. 2).

3.2 Rule 3

Browning et al. (2024) evaluated a Window-view analysis as the best method for determining 3 trees rule criteria, but by using this method, it is only possible to cover some of the city and it is very subjective. Tree inventories were chosen as a fair method, but there are many types. One option is to use public tree

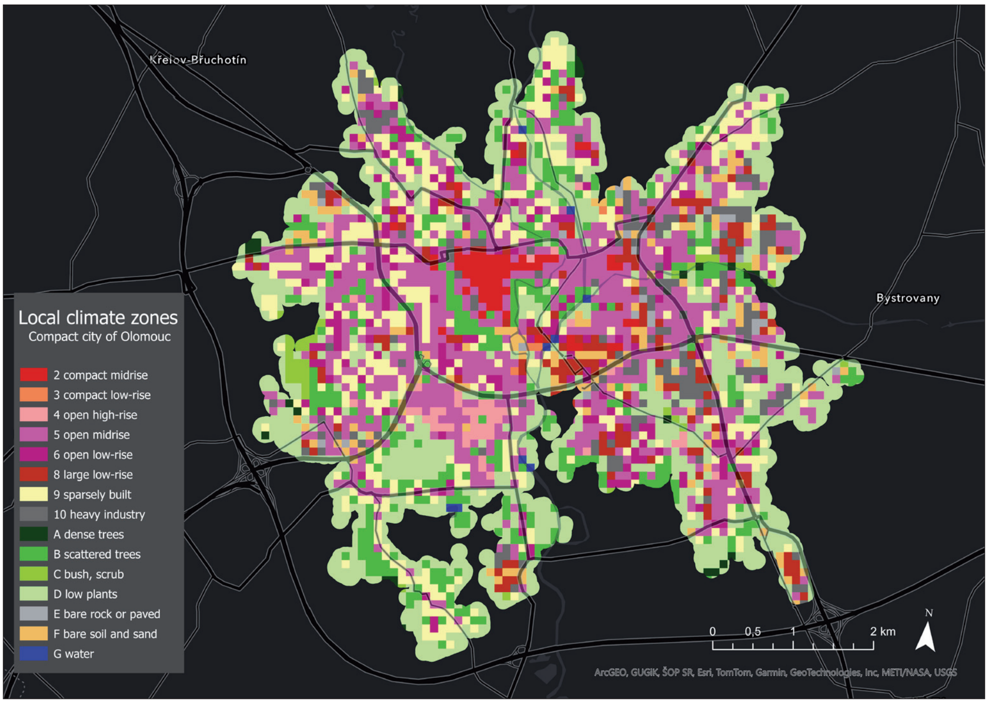

Fig. 1: Local climate zones in Olomouc (compact development used for the rule 3-30-300)
Source: Geletič & Lehnert (2016), authors' elaboration

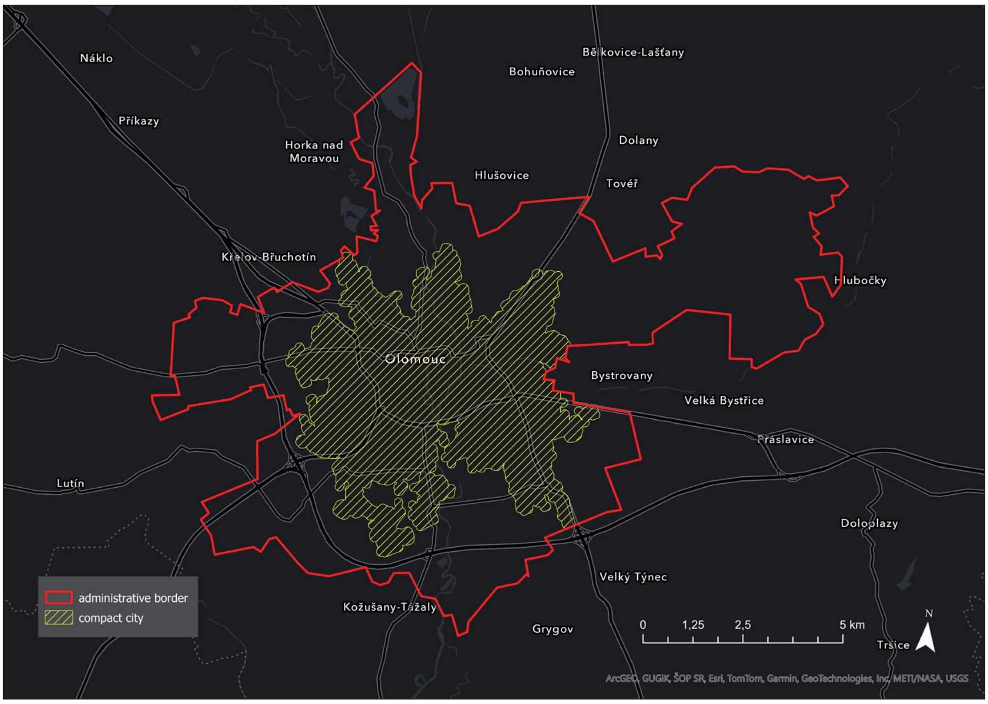

Fig. 2: Comparison between the administrative border and the compact city border (Olomouc)
Source: ArcČR 500 (2003), authors' elaboration

inventories, which are not available in all cities and mostly do not include non-public green infrastructure. Questionnaires are not ideal for reaching our goals because covering every address point in the city is not possible. Further, the Urban Atlas by Copernicus provides a polygon street tree layer; nevertheless, tree polygons do not reflect tree location correctly, and they show only groups of trees, so it is impossible to recognise single trees (Tab. 1). For this analysis, trees within 30 m of the building are counted. The choice of the 30 m distance is explained below.

Therefore, we decided to create inventories based on public data using deep learning tools. Esri provides the Tree Detection tool, which was focused on different types of forests and on data from the National Ecological Observatory Network (Weinstein et al., 2019; Weinstein et al., 2021). This deep learning tool is trained on 8-bit, 3-band high-resolution (10–25 cm) raster data. As an input for tree detection, we use orthophoto based on aerial imagery from the year 2023, which is free to download from the Czech Office for Surveying, Mapping and Cadastre (ČÚZK). The 'orthophoto' data resolution is 12.5 cm per pixel, which is well-suited as an input for the Tree Detection tool (ČÚZK, 2024a). The second data source for analysing the rule 3 is 'RÚIAN' (The Registry of Territorial Identification, Addresses and Real Estate). This source provides polygon layers of residential buildings so we can apply rule 3 to every residential building in the city.

In this methodology, there are a lot of variables that need to be tested. For this case we created six sample areas in Olomouc (Appendix 6). These areas are based on types of development in the Czech Republic (Ministry for Regional Development, 2022). The sample areas include: built-up areas of detached houses, the historical centre, housing blocks, street types, terraced houses and housing estates.

The Tree Detection tool is part of deep learning tools in ArcGIS Pro. As an output we have polygons with two attributes. The first attribute is a 'Shape area' and the second, more important, is 'Confidence'. For counting trees, we convert the polygon layer of detected trees to the point layer. The values of Confidence are from 0 to 100. The higher value of confidence means the higher confidence that the detected object is a tree.

First, we had to ensure that the objects detected were trees. The tree detection tool was utilised to identify false positive and false negative objects in the sample areas, with the assistance of orthophotos. Objects that were detected as trees but were not in fact trees are classified as false positives (e.g. chimneys, cars, pools, etc.), while objects that were trees but were not detected as trees are classified as false negatives. The specific proportions in each sample area are shown in Appendix 1–5. A correction of the detected object was needed, based on values of confidence. We started observing the object for the value 10–100 (Confidence), and then we continued with the next intervals. We were looking for incorrectly defined objects in 5 intervals of Confidence (Fig. 3). For the most accurate results, we chose to count objects with confidence greater or equal to 25. At this threshold, we observed the lowest percentage of error, with an almost equal proportion between false positive and false negative objects (Fig. 3). At the same time as the confidence value increases, well-established trees were selected and small trees were not included, which was verified by field research in all sample areas (Appendix 7).

Another task was to determine the ideal distance for counting trees. We tested the buffer zones for each residential object in sample areas at 10, 20, 30, 40, 50, and 60 metres distances. For each distance we calculated the overlaps with other buildings. Based on the analysis of overlaps we used a buffer of 30 metres distance from the buildings. The proportion of overlaps increases more rapidly in buffer zones bigger than 30 metres (Fig. 4). We also tested the suitable buffer distance visually. We created buffer zones for every residential building in sample areas and

Fig. 3: The graph of errors (total error and the proportion between false positive and false negative in the detected objects)
Source: Authors' research and calculations

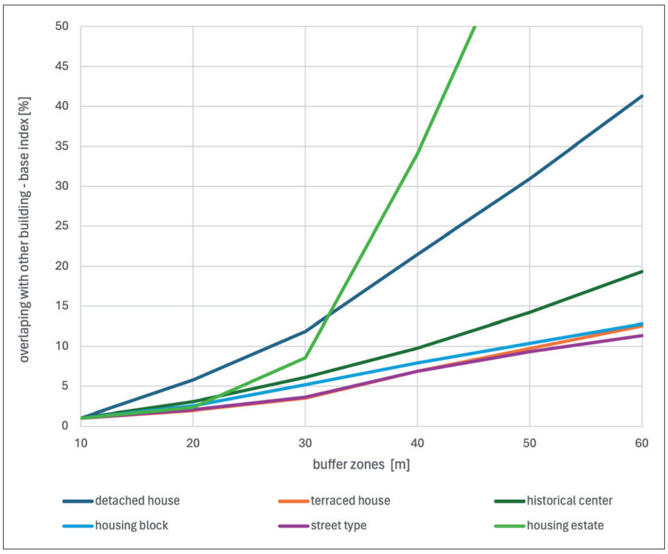

Fig. 4: Base index of calculating overlaps with another building for each sample area
Source: Authors' research and calculations

observed the most appropriate distance. The average distance between buildings is about 30 to 40 metres. This means we can see trees approximately 30–40 metres from the window. Based on these two methods we calculated the number of trees in 30-metre buffer zones.

Finally, we calculated the number of trees detected by tool tree detection after correction in a 30-metre buffer zone. For this calculation we used the tool 'Summarise Within'. We calculated the sum of trees for every single residential building in the selected city. Based on this analysis, we can say that there are at least three trees in a buffer zone for every single residential building. The biggest advantage of this method is that we can replicate it in every Czech municipality, and we have results for every residential building.

3.3 Rule 30

Another part of the rule involves calculating the percentage of canopy cover in a neighbourhood. To define neighbourhood, Chaskin (1997) and Weiss et al. (2007) recommend the use of geographically bound homogenous areas of limited size, or administrative units. Originally, we carried out tests using the smallest administrative units in the Czech Republic, but this has some disadvantages. These administrative units are of different sizes, and there is a problem with units that are on the borders of buildings and landscapes because it was possible that we could count trees outside the compact development, which would give us inaccurate results. Eventually, as a neighbourhood, we used a 300-metre buffer zone based on the WHO area for 5 minutes of walking. The 300-metre distance is also connected with the rule 300.

As a layer of canopy cover, we considered using data from the Urban Atlas because it has a polygon street tree layer. We compared it with other remote sensing data and field surveys, however it did not represent well the real distribution of trees, as only larger groups of trees were included in this layer. We decided to use the same layer as we used for rule 3 (see Section 3.2). The data obtained by the tree detection tool also contains the shape area attribute, providing the crown area (canopy) of each tree. Then we used the summarise within tool to calculate the sum of the shape area in each buffer of the dwelling. Based on this source we could calculate canopy cover in a 300-metre neighbourhood. Again, we could calculate canopy cover for every residential building in the selected municipality.

3.4 Rule 300

Network analysis was used for the application of the 300-metre rule. The source layer for analysis consists of data from the ZABAGED (Basic geographical database) package, specifically streets and roads. Access points were created for individual green spaces to enhance the quality of the analysis results. These access points were selected as the intersections between the road network and the urban green space (UGS) polygons. The definition of public urban green space plays a key role in the case of rule 300. Parks and other green spaces used for recreation need to be carefully selected and a basic knowledge of the area is important. Available orthophoto imagery is also used to verify the selection. Because the ZABAGED data does not provide the layers of UGS, the selection of green areas was based on cadastral plans provided by municipalities. This data source was chosen because cadastral plans are available for every municipality and allow efficient identification of green areas. It's important to assess each area individually to determine whether it meets the criteria for public urban green space. The assessment process involved analysing aerial imagery. Also, we used only UGS larger than 0,5 ha (Browning et al., 2024). We did not use the Urban Greenspace layer from the Urban Atlas, as a comparison revealed that these polygon layers are too generalised. Instead, we used network analysis to identify residential buildings from which it is possible to reach a park within 300 metres.

3.5 Evaluation of the fulfilment of the rule

The resulting map (Fig. 8) represents the percentage fulfilment of the rule for each residential building in Olomouc. The resulting map can take values from 0 to 100%. If all 3 sub-rules were met, all the resulting values would be 100%. Each of the rules can only be a maximum of 33.3% of the final assessment. Examples of the calculation of the total fulfilment of the rules are shown in Appendix 8. Results are categorised using quantiles.

4. Results

4.1 Rule 3

One of the main objectives of this study was the creation of a general and transferable methodology for the 3-30-300 rule which could be further applicable (not only) in Czech cities. This key part is logically presented in section 3. Methods and data. The results were followed up by an analysis of the spatial distribution and the fulfilment of the 3-30-300 rule criteria using the example of the city of Olomouc. Each part of the rule is visualised on an individual map (Figs. 5–7), followed by a map of all the criteria using the example of the chosen city (Fig. 8).

Almost 97% of the residential buildings in Olomouc comply with rule 3 (Fig. 5). This rule was quite easily fulfilled because the average number of trees in the buffer of 30 metres from the building was over 25. The lowest number of trees is in the central historical part of the city as the development is very dense and there is no space for trees and other greenery due to the narrow street network. Trees in courtyards are more common. The fact that the city centre is a culturally protected zone also means there are fewer opportunities to plant trees, at least well-established ones. Outside the historical centre, the number of trees in some peripheral areas is low, mainly due to the proximity of arable land or industrial development. In places of new development, the lower number of trees detected may be because there are small juvenile trees which are not captured by the Tree Detection tool.

4.2 Rule 30

None of the residential buildings achieved the criterion of having at least 30% of canopy cover in a neighbourhood, not even those in the immediate vicinity of the parks, where the maximum of 20.2% was only achieved by a few buildings (Fig. 6). This is because park vegetation is not only made up of trees, but mainly by low greenery, which is not included in the 3-30-300 rule. There are also wide roads near the parks that reduce the possible number of trees in the neighbourhood. The lowest values for this part of the rule are in the southeastern part of Olomouc, which is mostly industrial. Alternatively, the western part of Olomouc, where planned housing estates are located, has a higher canopy cover value (between 10–19.9%). These housing estates were built in the 60s and 70s and the trees there are older and well-established. In the historical centre, the canopy cover is low (less than 10%) as there is not a high number of trees (see Results of the rule 3).

4.3 Rule 300

Almost a quarter of the residential buildings in Olomouc have access to the nearest park within 300 m or less (Fig. 7). In the case of this rule we can observe spatial differences caused by the uneven distribution of the parks in the city. Rule 300 is fulfilled in areas that were planned, which means areas of green space created for the purpose of recreation as in the case of planned housing estates. Regarding the historical centre, the establishment of the surrounding parks is related to the demolition of the fortifications. In the case of newer developments (since the 90s), it is evident that central green areas are no longer planned. Furthermore, longer distances (more than 1,500 metres) to the nearest park exist in the eastern part of Olomouc because of the high number of industrial buildings.

4.4 Evaluation of the fulfilment of the rule

The maximum value of the fulfilment of this rule is 87% (Fig. 8). In Olomouc, the 100% rule was not met, as 30% of canopy cover was not achieved anywhere. The best results were achieved mainly in the areas of the housing estates that were built during the socialist period. The built-up housing blocks near the parks around the city centre are in the highest category (75–87%). Among the areas with a low percentage of compliance with the rule is the south-eastern part of the city where there are more industrial buildings and almost no areas of urban greenery. The resulting map also shows the differences between the western and eastern parts of Olomouc. This difference can be caused by different historical developments, the eastern part being more industrial, with the dominant type of development being a built-up area of detached and terraced houses. In contrast, the western part is more planned and the typical type of built-up area is a housing estate.

Finally, we assess the fulfilment of the 3-30-300 rule in land use/land cover (LULC) classification based on the well-recognised concept of Local climate zones (Stewart & Oke, 2012). The mean

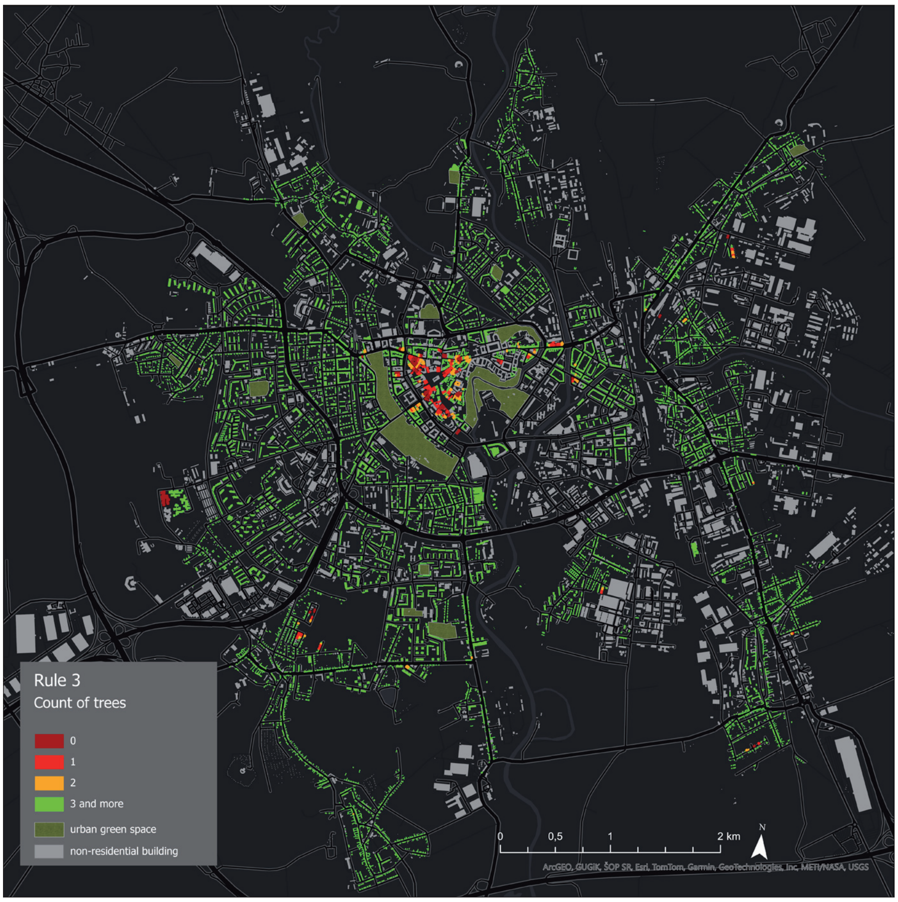

Fig. 5: Results of the rule 3 (case study: Olomouc)
Source: ČÚZK (2024b), authors' research and calculations

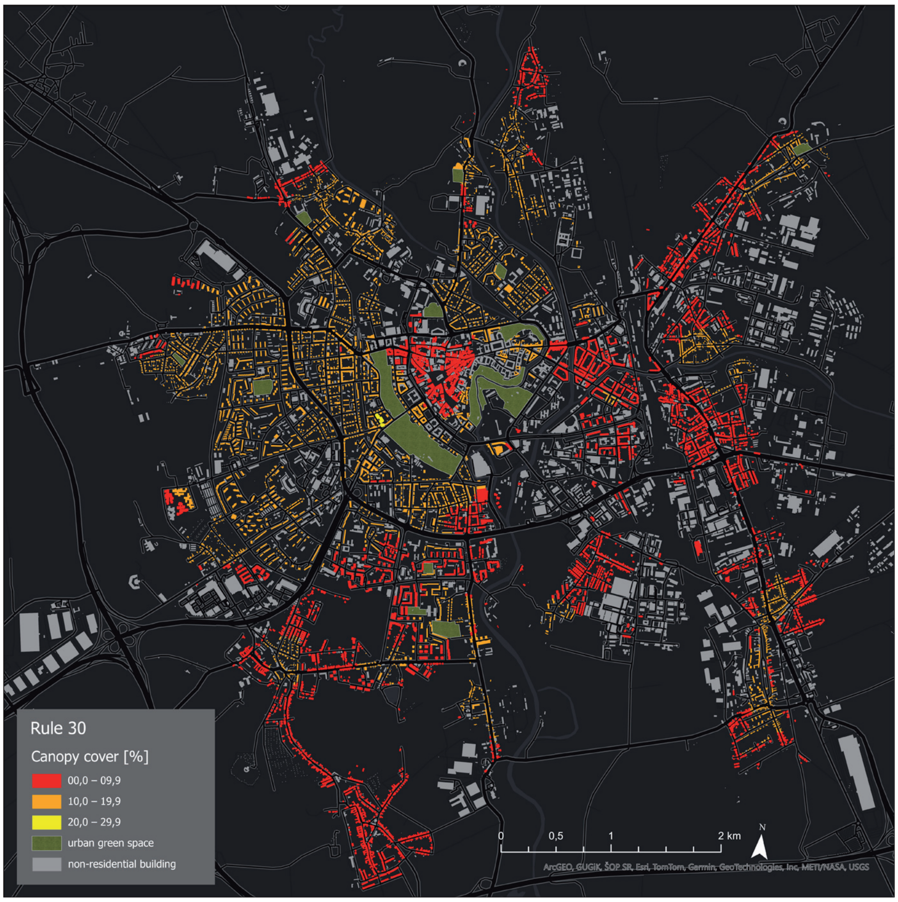

Fig. 6: Results of the rule 30 (case study: Olomouc)
Source: ČÚZK (2024b), authors' research and calculations

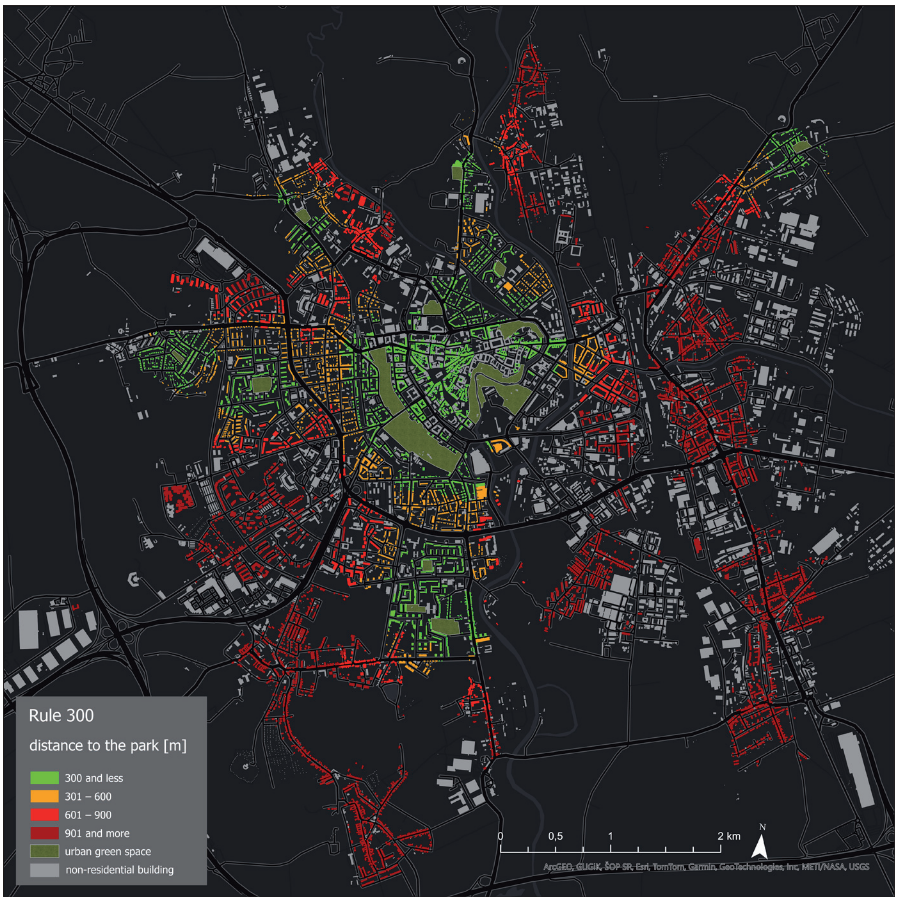

Fig. 7: Results of the rule 300 (case study: Olomouc)
Source: ČÚZK (2024b), authors' research and calculations

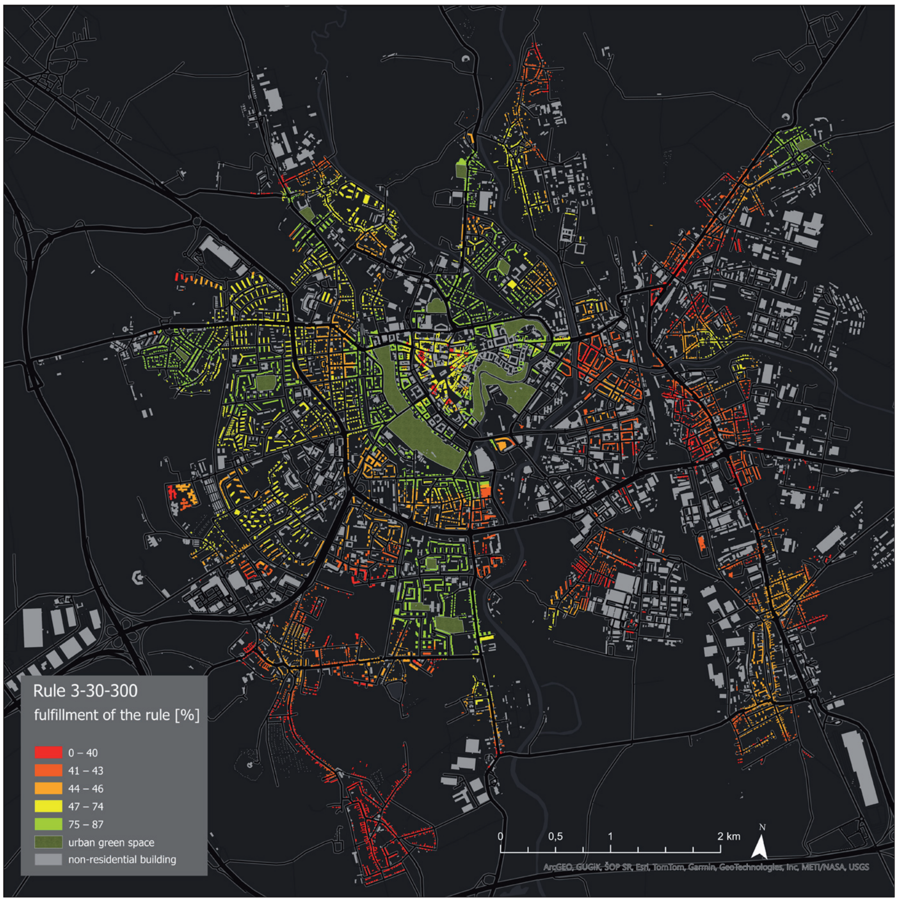

Fig. 8: Results of the fulfilment of the rule 3-30-300 (case study: Olomouc)
Source: ČÚZK (2024b), authors' research and calculations

value of the fulfilment of the 3-30-300 rule is calculated for each category of the Local climate zone (Fig. 9). Essentially, in areas of high population density of LCZ 2 (compact midrise) and LCZ 4 (open high-rise), the fulfilment of the rule is the greatest. In the case of LCZ 2, located in the city centre, it is particularly in Olomouc (which used to be a fortress town) that a substantial part of the households are located in the proximity of the central park ring (once areas behind the fortress). However, there is high intrazonal variability in the case of LCZ 2, as some households are still oriented towards urban squares with little or no greenery (the same is true for LCZ 5 open midrise). The good results for LCZ 4 confirm that several housing estates built under socialist planning generally provide good access to public greenery. On the other hand, in the case of LCZ 6 (open low-rise) and LCZ 9 (sparsely built), most of the greenery is in private gardens, which compromises the results. As expected, in the case of LCZ 8 (large low-rise) and LCZ 10 (heavy industry), the fulfilment of the rule is the lowest.

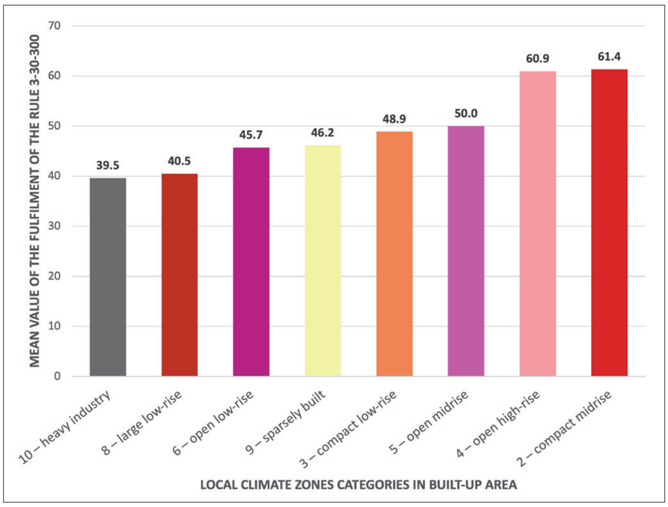

Fig. 9: Mean value of the fulfilment of the rule 3-30-300 for Local climate zone categories in built-up areas (Olomouc)
Source: Geletič & Lehnert (2016), authors' elaboration

5. Discussion

The 3-30-300 rule offers a standardised approach to evaluating the accessibility of urban greenery. One of its key advantages lies in its potential applicability across diverse geographic contexts. Introduced in 2021, the rule remains a relatively novel concept, with limited research available into its practical implementation (Konijnendijk, 2021).

This study represents one of the pioneering attempts to apply the 3-30-300 rule in a real-world urban environment. By focusing on the Czech city of Olomouc, it addresses both the practical and theoretical challenges that must be resolved to enable the broader, more universal application of the rule. The methodology outlined in this study aims to establish a replicable procedure for applying the 3-30-300 rule, with the goal of supporting its future standardisation in Czech cities and beyond.

5.1 Discussion of the results

Regarding visible 3 trees were achieved for almost all houses in Olomouc (using the method of counting the trees in a buffer zone). In a case study of Xiamen city (Zheng et al., 2024) being able to see three trees from the window was achieved for more than 79% of respondents. Another case study from Florida (Koeser et al., 2024) was based on questionnaires, and only more than a third of the respondents had three trees visible from their window. Nevertheless, the criterion for the visibility of the number of trees could be set a bit more strictly (see also section 5.2.).

In the case of the Olomouc, the value of 30% of canopy cover was unable to be reached. This part is difficult to achieve. The strategic document Master Plan for Barcelona's Trees from 2017 to 2037 (Guitard et al., 2017) has the goal of increasing the number of trees in the urban area of Barcelona to 30%. In the Chinese city Xiamen only 3.55% of residential buildings were fully compliant with the rule (Zheng et al., 2024). Another case study was created for the cities of Rheden, Velp, and Dieren in the Netherlands, and the analysis is captured through a web application and can be submitted to visualise the individual components of the rule (Rheden, 2024). In this case, it can be seen that the 30% coverage condition is met only in the peripheral parts of the city. The direct comparison of the results is not possible due to the utilisation of disparate approaches. In the case of Xiamen, a 500 m buffer for Rule 30 was employed; however, this is based on national sources (specifically, 500 m in this case is based on the Ministry of Housing and Urban-Rural Development of the People's Republic of China (Zheng et al., 2024)). In contrast, our analysis employs a 300-metre buffer, which is based on Rule 300. Furthermore, an alternative set of input data is provided for the purpose of analysis. Just because the goal of rule 30 was not achieved in many buildings does not mean that the rule is inappropriate. The rule is a challenge for cities to improve the accessibility of green infrastructure. If we calculated the percentage of canopy cover plus grassland, the value of canopy cover would be greater (see also 5.2).

Distances to the nearest park (300 rule) within the urban area of Olomouc varied according to administrative districts, with some districts having more accessible parks than others. In Xiamen, 11% of the buildings have access to the nearest park which is less than 300 m away (Zheng et al., 2024). In the case study of Florida, it is about 37% (Koeser et al., 2024). An important aspect of the analysis is the definition of urban green space and its input layer. Without knowledge of local conditions, it is difficult to decide which green areas meet all the parameters to be a public urban space in which leisure time can be actively spent. Some line-spacing green infrastructure in a city (e.g. green space around the river) can be also used for recreation if it does not meet the criteria to be a park. Based on these results, it can be discussed whether the components of the rule are set appropriately (see also section 5.2).

5.2 Limitations and application of the study and the rule

First, it is important to carefully choose a suitable data source for the analysis. In this study, we employed aerial data pertaining to the entire territory of the Czech Republic in order to examine rule 3 and rule 30. For the delineation of rule 300, we utilise cadastral plans, which are developed by each larger municipality. A potential limitation in this regard pertains to the inconsistent year of creation of these plans, necessitating cross-references with orthophotos, for instance. In another case study dedicated to the application of the rule, the analysis that was carried out in Xiamen City (Zheng et al., 2024) relied on satellite-based Google Earth data and the calculation of Fractional Vegetation Cover based on NDVI. However, the parameters for the rule themselves are different from those used in the analysis of Czech cities, and do not include the use of deep learning tools. However, similarly to Zheng et al. (2024), following the principles for the application of the rule, we also use only freely available data, which makes the rule suitable for a wide range of users such as urban planners, engineers, politicians and the engaged public.

Regarding the rule '3 trees' visible from a window, based on the analyses of the overlaps of trees and buildings, our analyses employ the criteria of 30 metres distance from a building, which is also in accord with Groeninzicht (2022). Data high resolution from remote sensing (Azeez et al., 2021; Katz et al., 2020; Seiferling et al., 2017) and Lidar data (Kakoulaki et al., 2021) are not free in the desired resolution, so we used aerial orthophoto data for the analyses.

The orthophoto data are free available for the entire area of the Czech Republic. As it is problematic to use generalised tools for tree detection (Weinstein et al., 2019), individual tree segmentation algorithms employing deep learning tools were proposed. The use of deep learning tools is always associated with a certain error rate. As for the error rate, we partially eliminated it by choosing an appropriate level of confidence, based on research in sample areas. Errors occur with the calculation of trees within larger clusters when using this tool. In the case of a cluster where there are 7 trees, 4 to 9 trees can be detected by using a deep learning tool. This error was not eliminated in this analysis, as it does not have a major impact on the overall result. The visibility of the trees differs from each window, depending on which direction the windows are facing and the height of the floor in a building. These differences are significant and it is not possible to uniformly decide whether a given building meets the rule, therefore the trees in the buffer zone are counted. The complexity of the determination and the effort to determine the visibility of 3 trees from a window as objectively as possible contrasts with the fact that basing the determination on the specific number '3' is not strongly supported by scientific evidence, but was chosen to connect with the numbers 30 and 300 from the communication perspective (Konijnendijk, 2023).

Regarding rule 30, the definition of the area of a neighbourhood in which canopy cover is counted was problematic. The authors of the 3-30-300 guideline should communicate this more specifically and we believe that this is a task for further research. Nevertheless, rule 30 is better supported by scientific evidence. The 30% canopy cover improves the quality of people's sleep and overall health (Astell-Burt & Feng, 2019). Even the results of the study by Iungman et al. (2023) say that achieving 30% canopy cover will decrease deaths from heat stress by a third. Ziter et al. (2019) also mention that a better cooling effect is achieved at 40% canopy cover. However, if we elaborate the effects of greenery on climate, it is obvious that the effect of greenery on climate differs with the type of greenery, the position of greenery (trees) in the built-up environment, and the building pattern/character of development (Bowler et al., 2010; Geletič et al., 2023). There also remain doubts in terms of assessing the accessibility of green space; the fact that only canopy cover is counted here, not other vegetation, may be problematic in this case. If grassland and other lower vegetation were also counted, 30% vegetation cover would be achieved in more cases. Browning et al. (2024) recommend using 30% green vegetation in arid areas. The results of Krüger et al. (2017) and Lehnert et al. (2021) suggest that in respect to weather and seasons, in some parts of the world even low vegetation can create positive environmental stimuli for citizens.

If we were to include 'parks' in the Rule 300 category, as publicly accessible areas of urban wilderness that perform park functions to a limited extent, the result would certainly be significantly more positive regarding a better overall balance for the entire city. However, from a methodological point of view, this step is problematic, if only because each town would need to have officially designated publicly accessible areas of urban wilderness, which would theoretically make the green areas somewhat regulated as there would be some demands on them in terms of human use, and thus they would lose their wilderness character. Access to green space can be also limited by some physical barriers (e.g. railways, highways). In the Olomouc case study, there is a spatial differentiation in green space accessibility in each part of the city. Some parts are at higher risk in terms of thermal stress. This is connected to the historical development of the city, especially in the industrial parts that were rebuilt into residential areas without the components of adaptive capacity (Shartova et al., 2024). Urban green space prevails in certain types of development; in Olomouc these are mainly in the socialist-built housing estates. Specifically found on the outskirts of the city, the function of UGS can be performed by green spaces that are not classified as UGS.

Concerning the novelty of the 3-30-300 rule, theoretical-methodical limits related to the relatively unchanging and egalitarian character of the rules are expected. They should be noted and discussed further. We understand and support the idea that the rule has to be generalised to a certain degree, easy to communicate and memorable to a wide spectrum of actors. However, concerning the experience we gained in our study, we criticise the fact that rule '3' is not more convincingly based on scientific evidence, and there is no more detailed guidance for the calculation of particular rules. It is also apparent that 3-30-300 thresholds can be considered by specialists from various disciplines dealing with urban greenery as very rigid when used to consider the environmental quality of life in particular cities. Furthermore, as indicated by Daniel and Jirmus (2023), green elements combined with green space should be located in a targeted and uniform manner in correlation with the needs of residents, and these could differ among neighbourhoods and cities. Therefore, the implementation of the 3-30-300 rule may be criticised by those who prefer free urban development and they may label the rule as leftist to socialist (it is probably not a coincidence that planned developments from the socialist era, with inherent public green spaces, achieve comparatively better results in Olomouc than modern housing estates with private greenery). In contrast, the 3-30-300 rule guarantees a kind of backbone mechanism for the improvement of public spaces in any city to improve social tensions. Therefore, based on our recent experience with the 3-30-300 rule we believe that it can efficiently serve as an essential primary analysis for comparing the accessibility of greenery in a city and among cities, and it should be further developed. Based on the above mentioned facts we suggest that in the future the 3-30-300 rule could be assessed in an index based on relative values (i.e. the extent to which the rules are met), which would also reduce the pressure on their strictly set threshold and allow appropriate values for this index to be set for different types of development/world regions.

Regarding the application of the 3-30-300 rule, it can serve local policymakers in the preparation of land use plans. The rule not only assesses the availability of green space, but also the spatial distribution of green space in the city, and not only for recreational purposes. At the same time, the utilisation of this rule facilitates the identification of locations that are deficient in green space. Given that freely available data are utilised, Czech local policymakers should already have access to these data; however, they do not have guidance (or even a tool) on how to perform the application of the 3-30-300 rule. In certain countries, notably those in northern Europe, the 3-30-300 rule has been incorporated into spatial planning. A notable example is the Yggdrasil project – The Living Nordic City (Konijnendijk et al., 2025). The potential exists for the creation of a guideline for the application of the 3-30-300 rule in Czech cities, following the example of the Yggdrasil project. In the Yggdrasil project, rule 3 is established using a buffer zone measuring approximately 25 metres. However, a 30-metre buffer zone was selected in this study, as it corresponds more closely to the built-up area in the Czech Republic. Rule 30 calculates again using a buffer zone, with the neighbourhood buffer chosen to be 500; however, in our analysis following the third component of the rule, we chose 300. In the case of the 300 rule, the Yggdrasil project uses remote sensing data in combination with Open Street maps. In contrast, our analysis proposes the utilisation of cadastral plans, which are recognised for their superior accuracy and capacity to identify high-quality green spaces.

6. Conclusion

This study is one of the first to employ an analysis of the newly proposed 3-30-300 rule in real urban environments. We found easily applicable and suitable approaches for using the rule and it was tested on the Central European city of Olomouc. In our case study, the threshold of 3 visible trees from a window was achieved in 97% of residential buildings, however the 30% canopy cover was not achieved in all cases. Distance to the nearest park depends on the type of development and the planned housing estates reached this threshold more easily than the industrial parts of the city. Rule 3 is generated by quantifying the trees (obtained by the deep learning tool) within a 30-metre buffer zone. For rule 30, the area of trees was considered, and the coverage in a 300 m buffer zone was counted following the third component of the rule. For rule 300, network analysis using access points was employed, and high-quality green spaces were selected using cadastral plans. Overall, our research shows that the 3-30-300 rule is a feasible method for measuring the availability of greenery in (Czech) cities. Our suggested method uses free public data and a deep learning tool so it can be easily used (not only) by local policymakers and is easily applicable to all buildings in a city. Without a doubt, the further development of the assessment of greenery in cities is important and is not just linked to climate change adaptation measures.

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Appendices

Appendix 1: Proportion of false negative and false positive objects in each sample area in interval of confidence 10–100
Source: Authors' research and calculations

Confidence interval			**10–100**	
Number of points	Trees detected	False positive	False negative	Error %
Detached houses	1,218	40	4	3.61
Terraced houses	617	26	2	4.54
Historical centre	153	32	2	22.22
Housing blocks	187	19	2	11.23
Street type	449	26	2	6.24
Housing estates	1,381	35	18	3.84

Appendix 2: Proportion of false negative and false positive objects in each sample area in interval of confidence 20–100
Source: Authors' research and calculations

Confidence interval			**20–100**	
Number of points	Trees detected	False positive	False negative	Error %
Detached houses	1,076	16	7	2.14
Terraced houses	528	10	3	2.46
Historical centre	91	5	2	7.69
Housing blocks	143	2	6	5.59
Street type	382	5	2	1.83
Housing estates	1,129	15	20	3.10

Appendix 3: Proportion of false negative and false positive objects in each sample area in interval of confidence 25–100
Source: Authors' research and calculations

Confidence interval			**25–100**	
Number of points	Trees detected	False positive	False negative	Error %
Detached houses	927	4	10	1.51
Terraced houses	439	5	12	3.87
Historical centre	76	2	1	3.95
Housing blocks	119	0	3	2.52
Street type	317	1	8	2.84
Housing estates	960	10	15	2.60

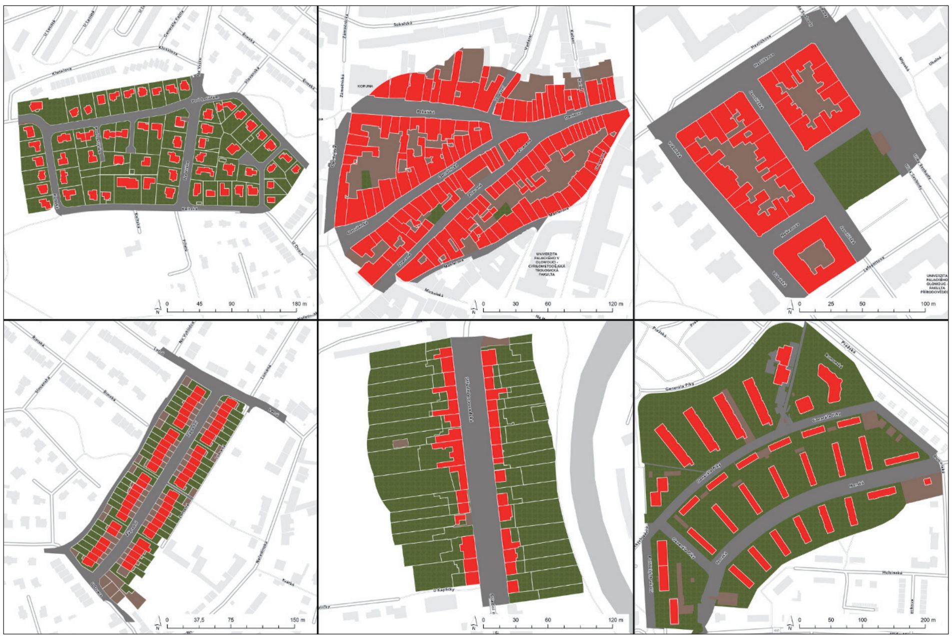
Appendix 4: Proportion of false negative and false positive objects in each sample area in interval of confidence 30–100
Source: Authors' research and calculations

Confidence interval			**30–100**	
Number of points	Trees detected	False positive	False negative	Error %
Detached houses	750	8	15	3.07
Terraced houses	349	3	18	6.02
Historical centre	63	0	5	7.94
Housing blocks	95	0	5	5.26
Street type	255	2	12	5.49
Housing estates	812	6	20	3.20

Appendix 5: Proportion of false negative and false positive objects in each sample area in interval of confidence 40–100
Source: Authors' research and calculations

Confidence interval			**40–100**	
Number of points	Trees detected	False positive	False negative	Error %
Detached houses	457	1	132	29.10
Terraced houses	192	0	65	33.85
Historical centre	41	0	19	46.34
Housing blocks	71	0	26	36.62
Street type	157	1	54	35.03
Housing estates	564	1	95	17.02

Appendix 6: Sample areas based on types of development in the Czech Republic, case of Olomouc
Source: ČÚZK (2024), authors' research and calculations



Appendix 7: Errors in different intervals of values of confidence in each sample area. Source: Authors' research and calculations

Type of development built-up area of	**Errors in different intervals of values of confidence (%)**				
	10–100	20–100	25–100	30–100	40–100
Detached houses	3.6	2.1	1.5	3.1	29.1
Terraced houses	4.5	2.5	3.9	6.0	33.9
Historical centre	22.2	7.7	3.9	7.9	46.3
Housing blocks	11.2	5.6	2.5	5.3	36.6
Street type	6.2	1.8	2.8	5.5	35.0
Housing estates	3.8	3.1	2.6	3.2	17.0
All types	8.6	3.8	2.9	5.2	33.0

Appendix 8: Examples of counting the fulfilment of the rule 3-30-300 Source: Authors' research and calculations

Rule 3	**Number of trees**	**Percentage of total score [%]**
	1	11.1
	3	33.3
Rule 30	**Canopy cover [%]**	**Percentage of total score [%]**
	10	10.001
	30	33.3
Rule 300	**Distance to the park [m]**	**Percentage of total score [%]**
	Less or equal than 300	33.3
	More than 300	0.0