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ARE OPEN DATA SUFFICIENT FOR LOCAL URBAN GREEN SPACE MAPPING? INSIGHTS FROM THE CZECH REPUBLIC

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ABSTRACT

Urban green space (UGS) plays a crucial role in enhancing quality of life in rapidly growing cities, providing essential ecosystem services, such as biodiversity support, climate regulation, and mental well-being. This study examines the use of open national datasets (ZABAGED, Consolidated Layer of Ecosystems (CLE), and Cadastre data) for mapping UGS in small towns (with population bellow 50,000) in the Czech Republic. The aim is to evaluate the suitability of these datasets for UGS identification, focusing on their level of detail and accuracy in comparison with data collected in the field.

The results show that ZABAGED is the most reliable dataset for identifying formal UGS, with a high overlay percentage with field data. Although the CLE and Cadastre data show potential in specific cases, such as identifying informal green space and other types of UGS, their overall accuracy is lower. The study also investigates the potential of combining different datasets to enhance UGS mapping accuracy. Additionally, while open datasets are valuable tools, certain limitations remain, especially in capturing complex or linear UGS features. Nevertheless, the findings highlight ZABAGED as the most suitable open dataset for UGS mapping in the Czech Republic at the national level. Its high reliability and regular updates (every 3-4 years) make it a promising source for long-term UGS monitoring and spatial analysis.

Keywords: urban green space, open data, field mapping, monitoring, Czech Republic

INTRODUCTION

Cities have been rapidly growing as the world population increases. People are not only searching for space in which to live and work but also need places close to nature where they can rest. One highly important factor affecting the quality of urban living is the presence of urban green space (Hansmann *et al*., 2007; WHO, 2017; Wang *et al*., 2019b). How much urban green space (UGS), at what distance and of what quality is needed to satisfy a population's needs? UGS or green infrastructure is currently a popular topic worldwide.

UGS as a part of green infrastructure, refers to multifunctional networks of green and blue spaces and the processes that govern their development (Benedict & McMahon, 2006; Ahern, 2007; Pauleit *et al*., 2011). UGS can make a major contribution to sustainable and resilient urbanization (Hansmann *et al*., 2007; Pauleit *et al*., 2019). The spatial and functional connection of individual areas of vegetation and the connection of such areas to the surrounding landscape strengthens the scope of their significance.

Many previous studies have documented that UGS is an important ecosystem service provider. The supporting ecosystem services of UGS enhance biodiversity (Wang *et al*., 2021), for instance, in the form of wildlife habitats, corridors and shelters (Kim *et al*., 2016; Yu *et al*., 2012; Zhang *et al*., 2019). The regulating ecosystem services of UGS contribute to cooling effect and thus mitigate the impacts of global warming (Lafortezza *et al*., 2009; Kong *et al*., 2014; Pauleit *et al*., 2017; Wang & Zhou, 2022). UGS also provides carbon storage (Jo & McPherson, 1995), positively affects air quality (Benedict & McMahon, 2006; Nowak *et al*., 2014) and water quality and supports the management of storm water (European Commission, 2013; Elmqvist *et al*., 2015). The cultural ecosystem services of UGS enhance public health and mental well-being while also offering opportunities for recreation and physical activity (Ahern, 2007; Kaczynski & Henderson, 2008; Schipperijn *et al*., 2010; Nowak *et al*., 2014). In addition, UGS contributes educational and aesthetic value (MA, 2005), and supplies essential resources such as food, forage, fibre, fresh water, and energy. It also supports local economies (Pauleit *et al*., 2017).

In the context of the new Nature Restoration Law of the European Union, UGS has been a major topic in the Czech Republic. The Nature Restoration Law aims to restore degraded ecosystems to enhance biodiversity, secure clean water and air, and mitigate global warming, among other objectives (European Commission, 2023). However, unified methods for mapping and eventually monitoring UGS at the national or regional level in towns are still lacking. Furthermore, spatial data on UGS and the assessment of its quality and accessibility are essential for effective urban planning and decision-making processes (Bobáľová *et al*., 2024).

Remote sensing is a widely used method for mapping UGS (Al-Taei *et al*., 2023; Kopecká *et al*., 2017; Liao *et al*., 2021; van Delm & Gulinck, 2011; Wang *et al.,* 2019a, 2019b). High-resolution satellite data (e.g., LANDSAT, IKONOS) enable relatively accurate results across large areas to be obtained. However, as Liao *et al*. (2021) concluded, remote-sensing data are expensive, time-consuming to gather and mostly limited in terms of time or space. Recent publications have used open datasets, such as Open Street maps, for UGS mapping (Ludwig & Zipf, 2019; Liao *et al*., 2021; Łaszkiewicz *et al*., 2022; Aamodt *et al*., 2023) or even street view services (such as Google Street View, Tencent Online Map), which enable the extraction of streetscape greenery (trees and green walls) from street view images (Li *et al*., 2015; Wang *et al*., 2019a; Hua *et al*., 2022). As noted by Rzotkiewicz *et al*. (2018), the advantages of street view images include low cost and ease of use; however, their limitations lie in image resolution as well as spatial and temporal coverage. A wide range of open data sources are currently used for UGS mapping and identification depending on the objective and spatial scale of the survey (European, national, regional, or local). European datasets, such as CORINE Land Cover (CLC) or Urban Atlas (UA) (EEA, COPERNICUS products), seem to be very useful because they cover almost all of Europe (CLC) and more than 800 cities across Europe (UA). However, they can be used only at the European or national level (Rusche *et al*., 2019; Skokanová *et al*., 2020; Liao *et al*., 2021; Aamodt *et al*., 2023). At the regional or even local level, such as a single town, national datasets are preferred because of their high resolution (Kabisch & Haase, 2014). In many European countries, datasets prepared by national land surveying agencies include compatible land use/land cover categories and are continuously updated (Morar *et al*., 2014; Skokanová *et al*., 2020), e.g., ATKIS (Amtliche Topographisch-Kartographische Informationsystem) in Germany, BDOT (Baza Danych Obiektów Topograficznych) in Poland and ZABAGED (Základní báze geografických dat) in the Czech Republic. In addition to ZABAGED, there are other national data sources in the Czech Republic that can be considered: the Consolidated Layer of Ecosystems of the Czech Republic or Cadastre data.

In recent years, numerous studies have focused on formal and/or informal UGS (Feltynowski *et al.*, 2018; Sikorska *et al.*, 2020). Urban planning in municipalities often concentrates on formal UGS, which includes broadly recognized categories, such as parks, green squares, cemeteries, street greenery, zoological and botanical gardens, and urban forests. These areas are generally located on public land and managed by public authorities. However, a significant portion of UGS in cities is unmanaged, situated on abandoned land and/or occupied by spontaneous vegetation (Ruprecht & Byrne, 2014). These spaces (e.g., urban wastelands and brownfields) are usually not integrated into the official public green space system. Recently, increasing attention has been given to semi-natural urban ecosystems, such as grasslands (Fischer *et al.*, 2020), which can have a wilder appearance than ornamental, designed parks. Nevertheless, such ecosystems are often used by residents for recreation (e.g., walking one's dog, relaxation), support biodiversity and provide many other important ecosystem functions in addition to heat regulation and evapotranspiration (Robinson & Lundholm, 2012; Püffel *et al.*, 2018; Rudolph *et al.*, 2017; Sikorska *et al.*, 2020).

The main objective of this study was to demonstrate the potential of using available open data for mapping urban green space by applying it in a case study performed in the Czech Republic. We aimed to find a digital dataset that could be considered the most relevant in the context of UGS mapping at the national level. The dataset was expected to be publicly accessible, up-to-date, and sufficiently detailed (i.e., high resolution) to enable reliable identification of UGS throughout the Czech Republic. Additionally, the pre-processing of the chosen dataset should be as simple as possible with minimal demands on labour, technical skills and software. To assess suitability of each data source for identifying UGS, a) we compared open datasets with field data (UGS mapped in the field); b) we evaluated differences between UGS categories (formal and informal) as well as among specific UGS types, based on comparing open data with field data. However, only UGS that was freely accessible to the public or open according to a defined schedule was considered, in order to reflect its potential for providing cultural ecosystem services, particularly recreation functions, to all residents. Consequently, private gardens were excluded from the analysis, although they constitute an important part of green infrastructure in cities (Green *et al.*, 2016).

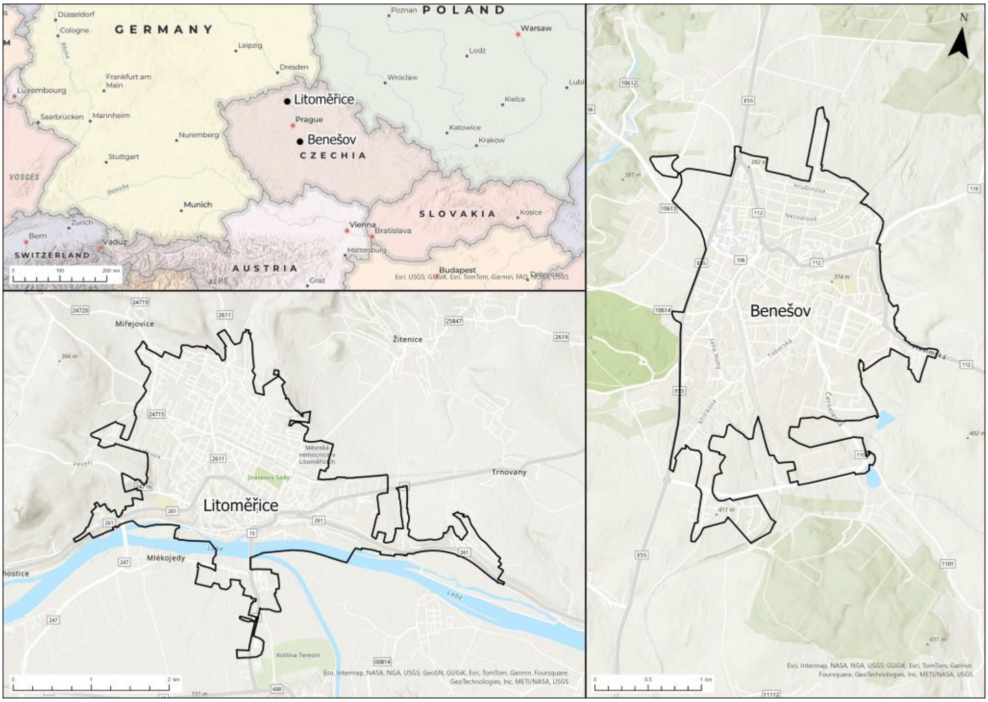
STUDY AREA

UGS was identified in two towns – Benešov and Litomeřice – in the Czech Republic. Both are classified as medium-sized, with populations ranging from 10,000 to 50,000 inhabitants.

Benešov is a small town situated in a hilly landscape approximately 30 km southeast of Prague, the capital of the Czech Republic. The study area comprised the built-up area of the town, as defined in the Territorial Plan of Benešov (2015), covering an area of 519.3 ha with a population of 15,354 (ČSÚ, 2021).

Litoměřice lies in the northern part of the country on the lowland bank of the Elbe River. The region around Litoměřice is one of the oldest permanently settled areas in the Czech Republic. The study area included the built-up area of the town, as defined in the Territorial Plan of Litoměřice (2015), with an area of 732.0 ha and 22,598 residents living in this part of the town (ČSÚ, 2021).

Fig. 1: Study areas



MATERIALS AND METHODS

From among the Czech national datasets, three databases were approved for UGS identification: ZABAGED, the Consolidated Layer of Ecosystems of the Czech Republic (CLE) and Cadastre data. These datasets cover the entire country and are freely available.

ZABAGED (created by CUZK – Czech State Administration of Land Surveying and Cadastre) is a vector-based dataset at a scale of 1:10,000. It is regularly updated every 3 to 4 years. ZABAGED 2020 was used for the present research. ZABAGED contains 131 types of geographic objects (settlements, communications, networks and pipelines, hydrology, administrative units including protected areas, vegetation and surface, and relief) (CUZK, 2020). The objects selected for UGS identification are presented in Table 1.

The CLE (produced by the AOPK – Nature Conservation Agency of the Czech Republic – and CzechGlobe – Global Change Research Institute of the Czech Academy of Sciences) is a vector layer of land cover created in 2012-2013. Updated data from 2021 were used. The CLE divides land cover into 39 classes on the basis of the CLC classification. It combines the following input data: the Habitat Mapping Layer (Biotope layer), ZABAGED, Digital Base of Water Management Data (DIBAVOD), Urban Atlas and CORINE Land Cover (AOPK, 2013, 2021). The classes defining UGS are presented in Table 1.

Cadastre data (administered by CUZK) constitute a vector layer of parcels and plots that contains information about parcel type (10 classes) and parcel use (30 classes). Cadastre data are updated continuously. The examined data were downloaded in January 2024. The majority of UGS is involved in a parcel type termed Others, which encompasses many different objects. The objects selected as UGS are listed in Table 1.

UGS selected from national datasets was compared with data obtained in the field in the two studied towns. For the fieldwork, basic topographic maps at a scale of 1:10 000 and ortophotomaps were used as background. Only public UGS (freely accessible to the public or open according to a defined schedule) was mapped. Private gardens were excluded from the analysis, as they primarily serve individual recreational purposes. The minimum UGS mapping unit was 100 m^2. The fieldwork was conducted during the vegetation season in 2021 and 2022 to collect quantitative and qualitative UGS characteristics (for further research), including UGS types (Tables 1 and 2).

The objects selected from the open datasets for UGS identification were grouped into two classes (see Table 1). As formal UGS, we take green spaces designated for recreation and managed by public authorities, e.g., public parks, green squares, residential green spaces, cemeteries, religious grounds, playgrounds, sport facilities, and urban forests (Feltynowski *et al*., 2018; Zhang & Chen, 2024). As informal UGS, we consider grounds with spontaneous vegetation, grassland and arable land, which are mostly unmanaged.

Table 1: Objects defined as urban green space (UGS) in different datasets

Field data		ZABAGED		Consolidated Layer of Ecosystems		Cadastre data	
Formal UGS	Informal UGS	Formal UGS	Informal UGS	Formal UGS	Informal UGS	Formal UGS	Informal UGS
Park	Semi-natural greenery	Ornamental garden and park	Arable land	Urban greenery, ornamental garden, park, cemetery	Arable land	Greenery	Arable land
Small park	Neglected greenery	Cemetery	Grassland	Sport and leisure facility	Grassland	Sport and leisure facility	Grassland
Greenery of civic facilities	Others	Sport and leisure facilities		Forest	Scattered greenery	Cemetery	Orchard
Greenery of sport and leisure facilities		Educational and cultural facilities			Shrubs	Cultural and educational ground	Barren soil
Greenery of housing facilities		Medical and social facilities				Forest	
		Forest					

Table 2: Urban green space types mapped in the field

TYPE OF URBAN GREEN SPACE	CHARACTERISTICS
Park	A landscaped area meticulously designed into a distinctive compositional entity, spanning over 0.5 hectares with a minimum width of 25 metres. This category includes urban parks, historical parks, and spa parks.
Small park	A smaller, landscaped space, typically up to 0.5 hectares, designed according to horticultural principles but not meeting the full criteria of a park. This UGS encompasses various types of mini-parks, vegetation around public transport stops, public buildings, playgrounds, etc.
Greenery of civic facilities	The green spaces surrounding civic amenities, including schools, health care facilities, hotels, stations, shopping areas, public buildings, banks, churches, cemeteries, monuments, etc.
Greenery of sport and leisure facilities	Areas dedicated to recreation and sport, including forest parks, leisure complexes, playgrounds, swimming pools and waterparks, campsites, and zoological gardens.
Greenery of housing facilities	The verdant spaces within residential settings, including housing estates, courtyard blocks, terraced houses, and detached homes. Publicly accessible.
Others	This UGS type includes scattered urban vegetation and reserved green space not categorized elsewhere.
Neglected greenery	Urban green space that has been abandoned or neglected, including wastelands, fallows, brownfields, quarries, and landfills.
Semi-natural greenery	Urban green space that closely resembles the natural environment.

* Types of UGS and characteristics according to the Czech State Standard number (ČSN 83 9001), revised.

For comparison purposes, we calculated five indicators for all the national datasets and the field data: a) the total area of UGS in the town; b) the number of UGS polygons in the town; c) the proportion of UGS in the town; d) the area of UGS per capita in the town; and e) the overlay of field data with national datasets as a percentage. The overlay was counted via the Union function in ArcGIS 10.8 (ESRI, 2020).

Subsequently, the UGS objects from all the national datasets, including field data, were divided into two groups—formal and informal (Table 1)—to determine the proportion and percentage of the overlay of these two groups. Finally, we examined which UGS types mapped in the field were better identified by which national dataset.

RESULTS

UGS mapped in the field in Benešov and Litoměřice covers comparable areas in both towns (16.5 % in Benešov and 17 % in Litoměřice). As shown in Table 3, both towns provide the same amount of UGS per capita, ensuring equal availability for each resident. A comparison of the field data with the open data revealed that the UGS identified by the open datasets covers a larger area than the UGS mapped in both towns. In Benešov, the proportion of UGS ranges between 20 % and 26 % of the town area and in Litoměřice between 17 % and 20 % of the town area. The most generous UGS area is found in the CLE data for both towns. However, the UGS area and proportion values most closely corresponding with the field data were found in the Cadastre data for both Benešov and Litoměřice. The same outcome was found when UGS area per capita was compared. However, the number of UGS polygons is two or more times greater than the number of mapped UGS polygons. ZABAGED provides the values most closely matching the field data, although they are approximately twice as high. The highest number of polygons is associated with the CLE in both towns (Table 3).

Table 3: Basic indicators of all urban green space in the towns Benešov and Litomeřice

	Benešov					Litomeřice				
Used datasets	Area (ha)	Number of polygons (No)	Proportion of UGS in the town area (%)	Area per capita (m^2)	Overlay with field data (%)	Area (ha)	Number of polygons (No)	Proportion of UGS in the town area (%)	Area per capita (m^2)	Overlay with field data (%)
Field data	85.6	71	16.5	55.8	100	126.2	109	17.2	55.8	100
ZABAGED	104.8	155	20.2	68.3	98.0	143.4	238	19.6	63.5	94.1
CLE*	134.5	372	25.9	87.6	65.4	146.8	778	20.1	65.0	36.2
Cadastre data	102.4	352	19.7	66.7	51.1	129.2	615	17.7	57.2	56.2

Note: *CLE - Consolidated Layer of Ecosystems

The overlay of the field data with those of the open datasets shows the best results for ZABAGED (overlay higher than 94 %) for both towns. While the overlay with the CLE data differs greatly between Benešov and Litoměřice, the overlay with the Cadastre data is similar in both towns but very low (over 50 %) (Table 3; Figs. 2 and 3).

Fig. 2: Overlay of urban green space mapped in the field with open data sources in Benešov – A) ZABAGED, B) Consolidated Layer of Ecosystems, C) Cadastre data

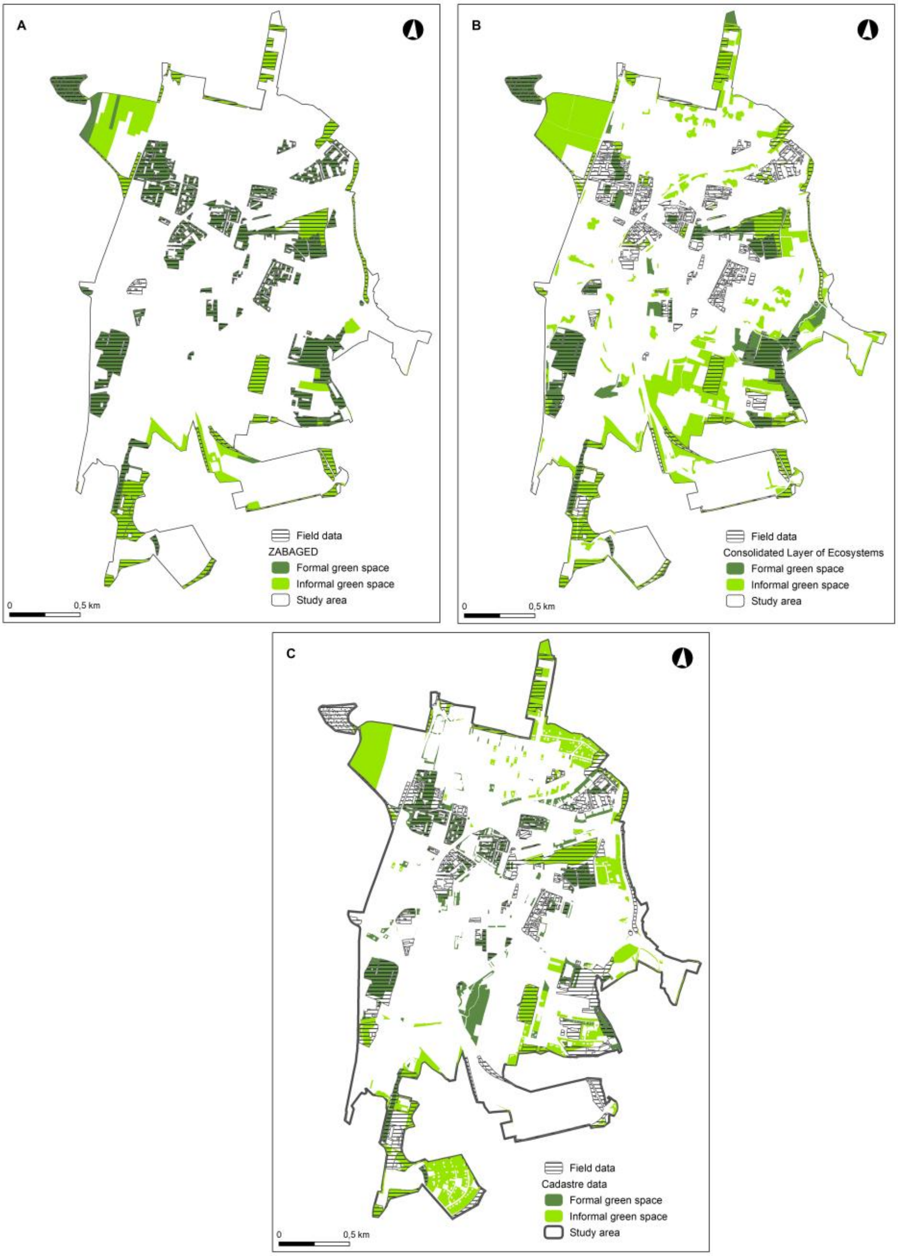


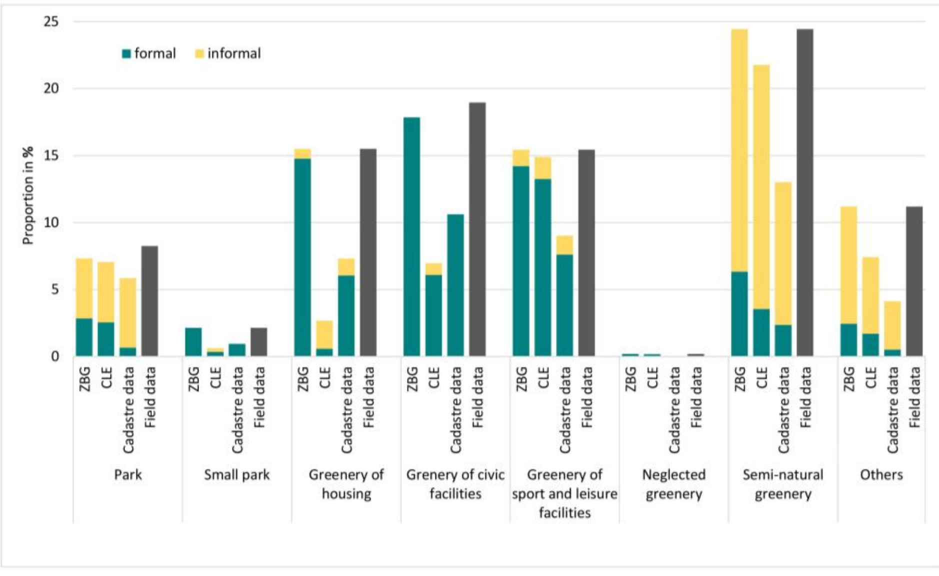
Fig. 3: Overlay of urban green space mapped in the field with open data sources in Litoměřice – A) ZABAGED, B) Consolidated Layer of Ecosystems, C) Cadastre data

When we consider the proportion of formal to informal UGS, there is a difference between Benešov and Litoměřice. According to the field data, Benešov has an almost threefold greater proportion of informal UGS (36 %) than Litoměřice, where only 13 % of the UGS is informal. The CLE and Cadastre data reveal an even greater proportion of informal UGS in Benešov (71 % and 62 %, respectively). Only the ZABAGED data show a greater share of formal UGS (56 %) than informal UGS (44 %) in Benešov. In contrast, formal UGS prevails in Litoměřice according to the field data (87 %). Similar results were obtained for the ZABAGED data (84 %). However, the Cadastre data identified only 60 % of the UGS in Litoměřice as formal, and the CLE identified even less (48 %).

The highest percentage of overlay of formal UGS was identified by ZABAGED in both towns (95.5 % in Litoměřice and 86.8 % in Benešov). In the case of informal UGS, the best overlay results were achieved by ZABAGED and the CLE in Benešov (75 % and 66.8 %, respectively) and by the CLE in Litoměřice (55 %).

Compared with the UGS types mapped in the field, the best identification of UGS types was achieved by the ZABAGED data in both towns (Figs. 4 and 5). In Benešov, Parks are well recognized by all open datasets. This is not the case in Litoměřice, where CLE data accurately identified only a very small portion of the town's park area. In contrast, the CLE recognized the Greenery of sport and leisure facilities very well in both towns. The CLE also identified informal UGS, such as Semi-natural greenery and Others, relatively satisfactorily in both towns. The Cadastre data were relatively successful in identifying Parks and Greenery of sport and leisure facilities in both towns. The Cadastre data were also more successful at recognizing Greenery of civic facilities in both towns. However, neither the CLE nor the Cadastre data recognized Greenery of housing facilities or Small parks satisfactorily (Figs. 4 and Fig. 5).

Fig. 4: Overlay of open datasets and urban green space types mapped in the field in Benešov

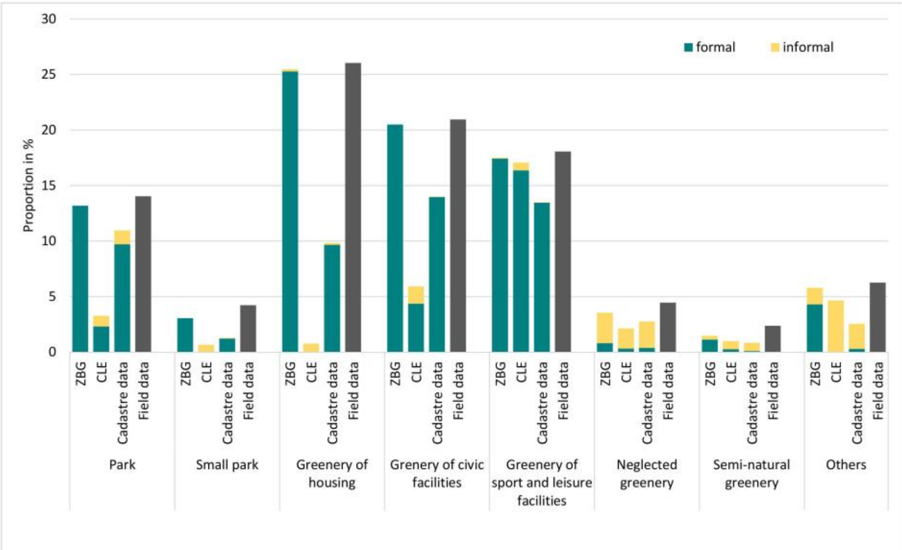


Note: The figure shows the percentage of formal and informal urban green space from open datasets that overlap with urban green space types mapped in the field. ZBG – ZABAGED, CLE – Consolidated Layer of Ecosystems.

Regarding formal UGS, Greenery of housing facilities, Greenery of civic facilities and Small parks were best identified by ZABAGED in both towns, as these areas overlap with the formal vegetation identified by ZABAGED. This also applies to Greenery of sport and leisure facilities, as well as to Parks in Litoměřice. In Benešov, Parks are located in grasslands (informal UGS in ZABAGED) in relatively high proportions (Figs. 4 and 5).

A comparison of informal UGS data is not very obvious. In Benešov, the majority of Semi-natural greenery and Others categories is overlapped with informal UGS identified in both ZABAGED and CLE datasets (Fig. 4). However, better results for informal UGS were achieved using CLE data in Litoměřice, especially within the Others category (Fig. 5).

Fig. 5: Overlay of open datasets and urban green space types mapped in the field in Litoměřice



Note: The figure shows the percentage of formal and informal urban green space from open datasets that overlap with urban green space types mapped in the field. ZBG – ZABAGED, CLE – Consolidated Layer of Ecosystems.

DISCUSSION

Generally, the open data used to identify urban green space in two towns achieved different results in this task. The most comprehensive and reliable data source was ZABAGED in Litoměřice as well as in Benešov (both over 94 % accuracy). The Cadastre data identified more than half of the UGS in both towns. The CLE was worse than the Cadastre data in Litoměřice but better than the Cadastre data in Benešov.

Public officials often use the Cadastre data provided by CUZK. These data are freely available and very accurate; however, some cadastres have not yet been digitalized, and certain parcels may not reflect the present state (Horáková *et al.*, 2022, Skokanová *et al.*, 2020). Moreover, the Cadastre data are very fragmented and split into small plots (in Benešov 1092 polygons and in Litoměřice 1326 polygons). This disadvantage can be mitigated by using the GIS tool Dissolve which reduced the final number of polygons (see Table 3).

The CLE dataset appeared to be unsuitable for identifying UGS. Its main limitation lies in the definition of UGS. In Litoměřice, the majority of UGS in Litoměřice includes private allotment gardens, which primarily serve individual recreation. In contrast, most UGS in Benešov is located within built-up areas (nearly 34 %). It is important to note that the CLE was originally developed to assess the value of the ecosystem services of habitats in the Czech Republic (Frélichová *et al*., 2014), rather than to serve for detailed UGS identification.

From this point of view, ZABAGED seems to be the most useful open dataset for our purposes. It provided sufficiently detailed and reliable identification of formal UGS (95.5 % in Litoměřice and 86.8 % in Benešov). It was less accurate in the case of informal UGS (75 % in Benešov but only 34.6 % in Litoměřice). Additionally, Skokanová *et al*. (2020) concluded that ZABAGED provided data with very good resolution on green infrastructure (such as public parks and ornamental gardens). Nevertheless, we are aware that the quality of ZABAGED depends on the skills of person processing the data and that not every site is as accurately identified as other sites.

In terms of pre-processing demands, all datasets require small adjustments in the sense of selecting objects or categories that describe urban green space (as mentioned in Table 1). Nevertheless, such adjustments are less time-consuming than field mapping or visual interpretation of orthophotos. Although these two methods provide the most detailed data, they are expensive, and therefore, their application is limited to small areas (Bobáľová *et al*., 2024).

On the basis of the data used, we were generally able to recognize important UGS, such as parks, cemeteries, the greenery of sport and leisure facilities, and residential greenery. However, the datasets are limited in their ability to identify UGS with linear shapes, e.g., alleys and tree lines along streets, other road or rail communications or water bodies. For example, vegetation around railway station and along town walls or even on squares was not recognized by ZABAGED in Litoměřice. These spaces are classified as Other areas in the town. In contrast, the squares in Benešov are classified correctly as Ornamental garden or park. The relevant difference can be the appearance of the square or possibly the tree canopy cover. Squares in Benešov are "greener" with substantial vegetation cover, whereas squares in Litoměřice are "more grey" with few trees or little vegetation. Surprisingly, these polygons in Litoměřice were overlaid by Scattered greenery from the CLE or by Greenery from the Cadastre data. Another problem is posed by orchards, which can be within a town and open to the public (mostly extensive tall-trunk orchards). This is the case for Benešov, where an orchard as a part of Klášterka Park is classified as Orchard and garden in ZABAGED. ZABAGED does not distinguish orchards and gardens separately. Therefore, this category was excluded from the analysis. Compared with orchards, private gardens generally predominate in cities, but they serve only for individual recreation. However, this problem can be resolved by using the Cadastre data, which classify orchards separately. Even the CLE classified such polygons as Urban greenery. Therefore, in certain cases, it can be useful to combine ZABAGED with the Cadastre data (e.g., with the object Greenery).

Forests were included in the formal UGS in our research, an approach similar to that of Sikorska *et al*. (2020) and Zhang & Chen (2024). No open data distinguish between forested parks, urban forests and forests (here, definition in general may be a problem), and there is a large forested park in one of our study areas, Litoměřice, which is classified as Forest in ZABAGED and as Greenery in the Cadastre data.

Skokanová *et al*. (2020) used the same data for producing green infrastructure maps at different scales in a study area, including open landscape and urban areas. One map used only the CLE (regional/national level), and another map applied a combination of several datasets, including ZABAGED and Cadastre data (detailed regional/local level). They suggested the combination of existing data to achieve better accuracy/detail. Nevertheless, following fieldwork and manual editing, digitizing were also applied to cover the entire green infrastructure. Our findings support similar conclusions: the ZABAGED data identified UGS mapped in the field more accurately and reliably than the CLE and Cadastre data. It has proven to be a suitable open dataset for identifying and quantifying public UGS at the national level. In certain cases, combining ZABAGED with the Cadastre data may lead to better results when aiming to refine UGS coverage for selected objects.

Datasets similar to ZABAGED in the Czech Republic were applied by Feltynowski *et al.* (2018) to identify urban green space in Poland (BDOT). They compared BDOT, Open Street maps, the Urban Atlas and satellite data. The BDOT data were the most comprehensive of the data sources used. Similar data produced by national land surveying agencies are also available in Germany (ATKIS), France (BD TOPO) and Slovakia (ZB GIS). Liao *et al.* (2021) compared six global and regional open land use/land cover datasets for UGS mapping in British cities and concluded that the FROM-GLC10 data (spatial resolution of 10 m) yielded the best results in terms of several measures (including overall accuracy and F1-score). The same data were used by Zhou *et al.* (2022) for mapping global UGS in more than 13,000 cities worldwide.

Many studies use global or European data for UGS identification (Kabisch *et al.*, 2016; Wicht & Kuffer, 2019; Liao *et al.*, 2021, Łaskiewicz *et al.*, 2022, Bobáľová *et al.*, 2024); however, their study areas are large cities and capitals. The Urban Atlas maps only European cities with populations greater than 50,000. We examined smaller towns with populations below 50,000. Although Benešov is covered by UA, it is an exception because of its location near Prague. Moreover, UA is too approximate for our purposes. A similar conclusion was published by Wicht & Kuffer (2019), who used UA and Open Street maps to compare the amount of urban green area in several European cities. They reported that UA detects less UGS than Open Street maps do.

The publications mentioned above focused on large cities, while research on small towns with fewer than 50,000 inhabitants remains limited. Identifying UGS is just as crucial for urban planning and decision-making processes in small towns as it is in large cities. Moreover, digital datasets have been compared with one another, and occasionally with data from satellite images, but no one has compared such data with real-state data identified in the field. This is another reason why the present research focused only on two towns. Data collection in the field is expensive because it makes large demands on labour and time. However, in certain cases, field mapping is irreplaceable.

In the context of the European Nature Restoration Law, a new challenge is how to collect data on UGS and how to monitor it in the future. ZABAGED has proven to be an effective source of data for identifying public UGS, applicable to nationwide monitoring initiatives, because of its high accuracy in recognizing UGS and because its data are updated every 3 to 4 years. Fieldwork itself or manual digitizing is not an option for monitoring UGS because both approaches are time-consuming and therefore not sustainable. These methods can be considered complementary in the case of uncertainties or inaccuracies.

CONCLUSION

In recent years, experts and decision-makers have paid more attention to urban green space and its mapping and monitoring in the context of global warming, biodiversity and the new European Nature Restoration Law. It is well documented that UGS provides many important ecosystem services that contribute to sustainable urban development and healthier living environments. However, unified methods for the identification of UGS are still under development. The majority of the relevant research publications have concentrated on large cities (with more than 50,000 inhabitants). The present study investigated which national open datasets can identify urban green space in small towns (with fewer than 50,000 inhabitants) of the Czech Republic with the best accuracy. We compared three national data sources (ZABAGED, the CLE and Cadastre data) with field data collected in two towns (Benešov and Litoměřice). In summary, the ZABAGED data overlapped the field data by more than 94 % in both towns. ZABAGED had the best results for formal UGS in both study areas, although it was less accurate in the case of informal UGS. In addition, most of the UGS types mapped in the field were identified very satisfactorily by ZABAGED in comparison with the CLE and Cadastre datasets. We acknowledge that this study was based on digital data from only two case study sites and that the quality and accuracy of ZABAGED may vary across towns. Nevertheless, no digital dataset can match the precision of field mapping or manual vectorization, although both methods are highly dependent on the skills of person processing the data. Despite this limitation, we recognize the potential of using ZABAGED for identifying public UGS and, potentially, for monitoring purposes in small towns, particularly due to its regular update cycle every 3 to 4 years.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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