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## Structure of Areas of Greenery within Cracow's City Blocks: Historical Transitions and Contemporary Development in the Context of Adaptation to Climate Change

### Struktura terenów zieleni w obrębie kwartałów zabudowy śródmiejskiej Krakowa – historyczne przemiany i współczesne zagospodarowanie w kontekście dostosowania do zmian klimatu

**Keywords:** historical urban layout, greenery in block development, types of greenery and accessibility, block gardens, climate change

**Słowa kluczowe:** historyczny układ urbanistyczny, zieleni w zabudowie kwartałowej, rodzaje zieleni i dostępność, ogrody śródblokowe, zmiany klimatyczne

#### Introduction

The city, as a living organism, constantly transforms due to socio-economic change. The transformation of heritage areas is not as sudden as that of other urban areas. However, the outcomes of these changes are also visible there and typically apply to the so-called soft landscape, of which greenery is an integral part. Megatrends that include globalization and metropolization<sup>1</sup> affect the space of historical city centers due to, among others, growing tourist pressure. Touristification is closely tied with downtown depopulation, commercialization of space and its adaptive reuse (e.g., as tourist infrastructure, parking spaces), which often takes place at the cost of greenery.<sup>2</sup> The presence of green areas in compact city structures, together with singular trees that provide shade, is increasingly appreciated. The reason for this is not only development density

and aesthetic considerations, but also climate change, which result in a perceptible heat island effect in urban areas. The need to protect greenery is discussed increasingly often, not only in the context of preserving historical layouts, but also that of improving resident access to green areas, improving a city's microclimate and stormwater retention.<sup>3</sup>

This paper discusses the green areas of the Old Town of Cracow, a city with a compact urban form and of medieval origin. Despite numerous restrictions on development, this area does change. New museums, hotels and other service buildings are being built and new public spaces are being designed.

This study covers the green areas of Cracow within Planty Park and Wawel Hill, independently of the size of their areas. This area includes city blocks with varied development, including townhouses, monasteries, churches, palaces, a university, a theater, and a royal

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castle. The boundary for the area under study was dictated by its historical layout, clearly identifiable within the city's spatial structure and further highlighted by the boundaries of the Old Town Cultural Park (2010).<sup>4</sup> The point of reference for the comparative analysis of greenery assets was provided by a garden catalog prepared for the area under study<sup>5</sup> (hereinafter referred to as the Catalog), which also defined the timeframe of the study: 1994–2021.<sup>6</sup>

The objective of the study was to assess the transitions in the accessibility structure of the Old Town's green areas. The paper also presents the structure of city blocks in the context of the presence of greenery, typically with housing development and atypical blocks, associated with other uses, such as religious or service use. Detailed research goals were focused on determining biologically active area assets and comparing them with the state from 1994, presenting the varieties and types of greenery present in the area under study, based on use and accessibility, and an analysis of historical development morphology in the context of greenery. Another research aim was to assess greenery assets and the potential to increase greenery parameters within the Old Town's urban layout in reference to planning provisions.

### Research methods

Research work was conducted along multiple trajectories and was divided into three stages. The first stage included a review of the literature<sup>7</sup> and archival materials. Data included in the Catalog, prepared in the years 1991–1994, was used. Starting information sources also included: garden registers,<sup>8</sup> monuments register entries, dendrological surveys, historical and landscape studies concerning individual gardens from the archives of the Cracow University of Technology Chair of Landscape Architecture, the Lesser Poland Voivodeship Monuments Conservator (MWKZ) and the National Archives in Cracow.

The second stage covered research on the existing state of greenery and changes in land use within the Old Town. It was conducted using the Geographic Information System (GIS). Data aggregation was based on vector graphics and raster data analysis. BDOT 500 databases and satellite images were sourced from the surveying and cartographic resources of the Office of the City of Cracow and the Office of the Marshall of the Lesser Poland Voivodeship. In addition, the data was updated during surveying and on-site analyses. Conclusions were formulated in the third stage.

Methodological problems occurred during comparative analyses due to differences in source data. In 2021, the analysis was based on digital data, while in 1991–1994, on data collected in the field. The field observation method was employed in both cases, yet the Catalog focused on the history of each site, plant types and forms, and not on land use and detailed area analysis, it featured no listings and statistics for garden areas.

### Urban structure and greenery

Cracow is a city whose origins date back to the sixth century. During the High Middle Ages, from the ninth to the thirteenth century, organic forms predominated in its urban layout. The year 1257 was crucial to the city's urban layout, when it was issued a charter based on the Magdeburg law (June 5, 1257). The charter determined the reach of a planned settlement network, and a medieval town with a regular layout was established. This initiated the development of an urban form that became the basis for placing the medieval center of Cracow, together with Wawel Hill, Kazimierz and Stradom, on the UNESCO World Heritage Sites List (149.65 ha) in September of 1978, as one of the first twelve such sites around the world. Here, the basis for inclusion was criterion four, according to which a site should be an exceptional case of a type of structure or an architectural complex that illustrates a significant stage in human history. The reasoning stressed the value of the historical and architectural center of Cracow, which, shaped over almost a millennium, is one of Europe's most notable artistic and cultural complexes.

Cracow's town charter made no references to its urban layout, with customary law coming into play instead. A regular, orthogonal layout was introduced, based on modular dimensions, adapted to existing pre-charter elements such as churches, monasteries, main transport routes and streets. The layout's delineation was based on a system of units of measure and area. The main housing blocks were demarcated. A grid-based layout of blocks was created, of which close to 25 blocks were intended for housing and service buildings. The base module that formed the urban structure was a full settlement plot that was 21x42 m. A town block, resembling a square with an 84 m long side in shape, consisted of eight full-sized plots, and after secondary divisions, of sixteen half-sized plots.<sup>9</sup> Scholars distinguish five types of parcellation of a regular old-town block into settlement plots.<sup>10</sup>

The placement of the plot front relative to the block's outline was key. For instance, in blocks abutting the market square, the fronts of four houses faced the square, while the remaining four, in pairs, faced the streets extending from the square.<sup>11</sup> Plots with development had an elongated shape (half-sized, with 1:4 front-to-side ratio). The primary layout that emerged in the development of housing plots was based on the townhouse from the front and an outbuilding that terminated the plot, and which also sometimes framed its side.<sup>12</sup> Between them there was a space was planned differently across history, either as a yard, courtyard, garden or orchard. Over time, formal greenery was introduced, although it was small in terms of area, as revealed by Janusz Bogdanowski.

The layout of the city, linked with the market square, was connected with Okół—a suburbium adjacent to the castle, with an axis in the form of Grodzka

Street, with Kanonicza Street running parallel. Plots were oriented with their fronts facing the street, and their structure was essentially similar to the section tied with the market square. From the south, the layout is terminated by Wawel Hill and the castle, situated near the Vistula River. The city was surrounded by a fortified line with a moat (built between the end of the thirteenth and the first quarter of the fourteenth century). After its demolition in the 1820s, the site was used to create Planty Park, a linear ring park. Monasteries were placed in the urban layout's blocks, especially along the outline of the walled city. At present, these include seven buildings out of the ten operating monasteries. Those abutting the walls had mostly been of pre-charter origin.

### Study of the Old Town's green areas

The form and function of city greenery stems from morphological transformations of settlement units that gave rise to the development of the city. In the case of historical development layouts, both large complexes of monastic buildings and various types of townhouses were of essential significance, as did other forms of development like palaces or public buildings which, within their own plots produced forms of greenery of varying scale. The base element of the city's morphology that is the town block (urban block) was used by Bogdanowski as a basis for introducing the term "block garden" into the literature. With this, Bogdanowski clearly showed the value of not only obvious sites like gardens accompanying monasteries, palaces, or public buildings, but also the compositional, aesthetic, and environmental value of townhouse gardens. At the time, this opposed the stereotypical perception of smaller greenery layouts that were seen as random plantings or unspecified greenery, whose value stemmed solely from forming a part of green substance assets. Bogdanowski's findings clearly demonstrated that the block garden, understood as a structured layout, irrespective of size, is an important element of urban greenery.<sup>13</sup>

In Cracow, only larger garden complexes, e.g., monastic ones, were initially covered by registers.<sup>14</sup> Studies of gardens in townhouse courtyards were initiated in the 1970s by Bogdanowski.<sup>15</sup> They focused on the buildings of the city center within the borders of Planty Park and buildings situated within the so-called second ring road (between Planty Park and Trzech Wieszczów Avenues) in the former districts of Nowy Świat, Piasek, Wesoła. The work, conducted from 1974 to 1991 in various teams supervised by J. Bogdanowski and W. Genga, was performed by: Z. Myczkowski, M. Swaryczewska, D. Uruska-Suszek, J. Więckowska, K. Fabijanowska and A. Zachariasz. Data concerning the gardens of the city center as surrounded by Planty Park was verified during the preparation of the Catalog. No comprehensive measures were taken afterwards.

### Typology of the green areas under study

In the Catalog,<sup>16</sup> gardens belonging to each property were marked on a plan of the city. The following regularities were observed. The greatest number of gardens survived in layouts with half-sized plots. They predominate along Sławkowska and Św. Jana streets and along Szewska and Floriańska streets, in the block near Planty Park. There was much less of them in blocks adjacent to the market square (six full blocks and two elongated blocks that encroached on Grodzka Street with their pre-charter layout). Only four gardens with addresses at the market square survived and all are contemporary and small. This stemmed partially from their renovations.

Greenery also accompanies palaces. According to the monuments register, there are fourteen palaces in the area under study, of which nine have gardens. These include: the courtyard garden in the Wielopolski Family palace (Cracow's city hall—3/4 Wszystkich Świętych Square) and the garden in the courtyard of the Bishops' Palace (3 Franciszkańska Street).

One exception is 15 Kanonicza Street with its gardens, many of which have valuable compositions. Some plots abut Planty Park. They are larger than half-sized plots, both in width and length, e.g., Kanonicza Street numbers 3, 5 and 7.

Since the Middle Ages, religious buildings like churches and monasteries have played a crucial role in the city's landscape. Monastic complexes were built on plots of varying size and were often redeveloped and remodeled. They are accompanied by gardens, often large ones, which stems from their peripheral location, near the walls (currently Planty Park).<sup>17</sup> Monasteries situated deeper inside the city have smaller gardens, of the courtyard type, e.g., a Jesuit garden at 8 Mały Rynek.

At present, every church in the Old Town has its own, usually very small, patch of greenery, such as the one near the St. Mary's Basilica. There are also those whose nearby trees were removed, e.g., the Church of the Holy Cross (they obscured the facade from the side of Planty Park). There are also other religious buildings, such as the calvary at 5 Reformacka Street, an extensive garden at the Church of the Holy Cross parish (23 Św. Krzyża Street) or the garden accompanying the Seminary (8 Podzamcze Street).

Another group is formed by gardens that accompany public buildings and that extend their function, such as: the Wawel Castle, the Jagiellonian University, a range of schools, banks, a theater, and museums. Typically, at least a part of such a garden was formal. This can be seen in many nineteenth-century sites designed in the styles of Historicism, Eclecticism or early Modernism, where architecture was supplemented by regular garden forms (e.g., the bank at 15 Szpitalna Street, the J. Słowacki Theater). They continue to be an inseparable part of urban space and stand out in the landscape, signify a place, and define the quality of public space.

Types of green areas identified in the Cracow's Old Town	small public gardens with landscaped greenery in the form of a parterre, an intermediate and a high level, often accompanying public buildings, co-forming formal spaces and setting the stage for architecture e.g. (Wszystkich Świętych Square in front of the Cracow City Hall, the J. Słowacki Theater, the Palace of Art)
	public parks—Planty Park and the areas around Wawel Hill
	greenery that accompanies squares and streets in the form of small beds or singular trees
	block gardens, divided into three types: courtyard gardens on plots with mixed-use housing and service townhouses, lawns in the courtyards of urban palaces, gardens constituting large areas of landscaped greenery accompanying religious buildings, institutions of culture, science and public buildings
	royal gardens at Wawel Hill, both historical and contemporary, within the defensive walls
Green areas identified by function stemming from the use of accompanying buildings	accompanying mixed-use residential and service townhouses (townhouses, urban palaces);
	accompanying science and education facilities (e.g. universities, scientific institutes, high schools)
	accompanying cultural facilities (e.g., theaters, museums, including Wawel Castle, the archaeological Museum);
	accompanying public and commercial buildings such as banks, hotels, stores, etc.
	accompanying religious buildings (churches, monasteries, a calvary, and their accompanying seminaries and parish buildings);
	squares and streets

Source: by authors, based on on-site analyses.

Fig. 1. Types of green areas in terms of its form and function stemming from the use of accompanying buildings in the Old Town area; by the authors.

Ryc. 1. Rodzaje terenów zieleni pod względem ich formy i funkcji wynikających z użytkowania otaczających budynków na obszarze Starego Miasta; oprac. autorki.

Spectacular discoveries have also been made since the Catalog's completion, such as the discovery of fragments of a sixteenth-century garden at Wawel Castle, at a terrace adjoining the eastern facade, in 2000. The garden was later recreated.<sup>18</sup>

This study focuses on green areas, understood as assets that supplement urban tissue. In line with this assumption, the types of green areas in terms of its form

and function stemming from the use of accompanying buildings were identified in the Old Town area (Fig. 1).

Six of the identified functional categories were deemed the most representative and that, due to the specificity of forms of development, form cohesive morphological groups. The service function category was found to be the most diverse, as it was formed by both townhouses and former urban palaces. To better present the specificity of

AREA BALANCE								
Primary use		Total site area [m <sup>2</sup> ]	Built-up area [m <sup>2</sup> ]	Undeveloped area [m <sup>2</sup> ]	Share of undeveloped area [%]	Biologically active area [m <sup>2</sup> ]	Share of biologically active area [%]	Non-permeable area [m <sup>2</sup> ]
Services (U)	banks	5359	3694	1665	31%	741	13.83%	924
	healthcare	1499	469	1030	69%	796	53.10%	234
	administration	11591	7211	4380	38%	1025	8.84%	3355
	hotels	42899	36598	6301	15%	883	2.06%	5418
	other services	13738	12255	1483	11%	30	0.22%	1453
Religious services (Uks)		98329	48887	49442	50%	19442	19.77%	29968
Science and education services (Ukn)		45321	30430	14891	33%	5123	11.30%	9768
Cultural services (Uk)		42848	23022	19826	46%	6483	15.13%	13343
Mixed-use housing and services (MWU)		161051	121481	39570	25%	9680	6.01%	29890
Streets and squares		239583	n/a	n/a	n/a	5126	2.14%	234457
Total		955936	284047	138588	n/a	49329	n/a	328810

Source: by authors, based on on-site analyses and data from the Municipal Spatial Information System (MSIP).

Fig. 2. State of greenery in the Old Town of Cracow in 2021, divided by building functions; by the authors.

Ryc. 2. Stan zieleni na Starym Mieście w Krakowie w roku 2021, z podziałem na funkcje budynków; oprac. autorzy.

Greenery accessibility	Green area in the Old Town, excluding Planty Park and Wawel Hill	Total green area in the Old Town	Primary components
Unrestricted access	25%	80%	Greenery of squares, streets, Planty Park, frontal gardens, beds and parterres and the greenery of Wawel Hill
Restricted access	25%	10%	Block gardens, gardens near service buildings, Wawel within the defensive walls
Inaccessible	49%	7%	Monastic gardens, private gardens

Source: by authors, based on on-site analyses and data from the Municipal Spatial Information System (MSIP).

Fig. 3. Old-Town greenery accessibility analysis; by the authors.  
Ryc. 3. Analiza zieleni Starego Miasta; oprac. autorki.

this category, four subcategories were isolated within it. They include buildings that offer accommodations (hotels, hostels), banks, public administration, and health-care.<sup>19</sup> Religious functions were analyzed in two subcategories: monastic complexes and churches. Cultural services such as museums and cultural institutions were another category, while functions of science and education encompassed academic institutions and various types of schools. The final category, that of residential functions, is difficult to define due to the high number of apartments for short-term lease, which are not recorded (Fig. 2). The successive decrease in the population of the Old Town, which has been observed for many years, is also a signal that many former residential spaces are now used as commercial premises.<sup>20</sup>

Another aspect investigated in this study is accessibility, which was explored in three categories, depending on the degree of accessibility to users. The accessibility analysis showed that generally accessible green areas include the greenery of squares, streets, frontal gardens, and parterres located in front of public, commercial or religious buildings. This group is characterized by its small areas. This is formal greenery that enriches the composition and aesthetics of urban interiors while having little utility. The size of green areas with various degrees of accessibility have been presented in figure 3. The analysis showed that the greenery of Planty Park, apart from its compositional value, clearly improves accessibility to greenery in the area under study. Furthermore, it should be added that inaccessible greenery consisted mostly of monastic gardens. This prompted an initiative by a group of urban activists that began in February 2021, and which culminated in a request sent to Pope Francis to allow Cracow's citizens even partial access to monastic gardens in the city center.<sup>21</sup>

Independently of the previously mentioned types, functions or accessibility, green areas are linked with the notion of biologically active areas. This is crucial in the context of improving a space's environmental quality. Biologically active areas are defined by the Ordinance of the Minister of Infrastructure of April 12, 2002, and their minimum percentages of site area are defined in planning documents to maintain a proper (depending on development density) balance between paved and permeable surfaces.

As shown by the analysis, a great variety of biologically active area to site area ratios was observed in the area under study. Seven ranges of its value were identified (Fig. 4). The variety stems from the morphology of each block and its function. As a result, the lowest ratio was found in blocks directly abutting the Main Market Square or those in its vicinity. Three blocks with no greenery were found. It should be noted that only one of these, located along the northern frontage of the Main Market Square, was full. The others had an irregular form and size, which contributed to the biologically active area to site area ratio being zero.

### Comparison of greenery presence in the Old Town area

Transformations in the development structure were found to be insignificant, although some courtyards were adapted for commercial uses.<sup>22</sup> Due to applicable heritage conservation forms, construction efforts were conservative and applied mostly to block interiors—the courtyards. Land use changes in the years 1992–2011 were found to be minimal, which stems from the urban form of this part of Cracow.<sup>23</sup>

The reasons behind the decrease in the ratio include outbuilding development growth, an increase in circulatory spaces (car parks) and the growth of outdoor gastronomic establishments. The increase in built-up area in the period between 1997 and 2021 was 11,045 m<sup>2</sup>. The scope of various works is illustrated by the number of construction permits issued (Fig. 5).

The most important changes focused on the blocks of Jana, and Pijarska streets, Floriańska Street—the Czartoryski Museum and hotels, 16 Św. Jana Street—gastronomic establishment, Św. Marka Street, Tomasz Street and Planty Park—service building and hotel, Grodzka Street—Wszystkich Świętych Square—Wyspiański Pavilion, buildings on the corner of Floriańska Street and the Main Market Square (2 Floriańska Street, 45 Main Market Square)—gastronomic establishment and bank. In terms of greenery type changes, the former municipal garden (Catalog item 119) near the Higher Seminary (once part of the Discalced Carmelites' monastic gardens) abutting Planty Park, which was divided and developed into a grassy sports pitch and the playground.

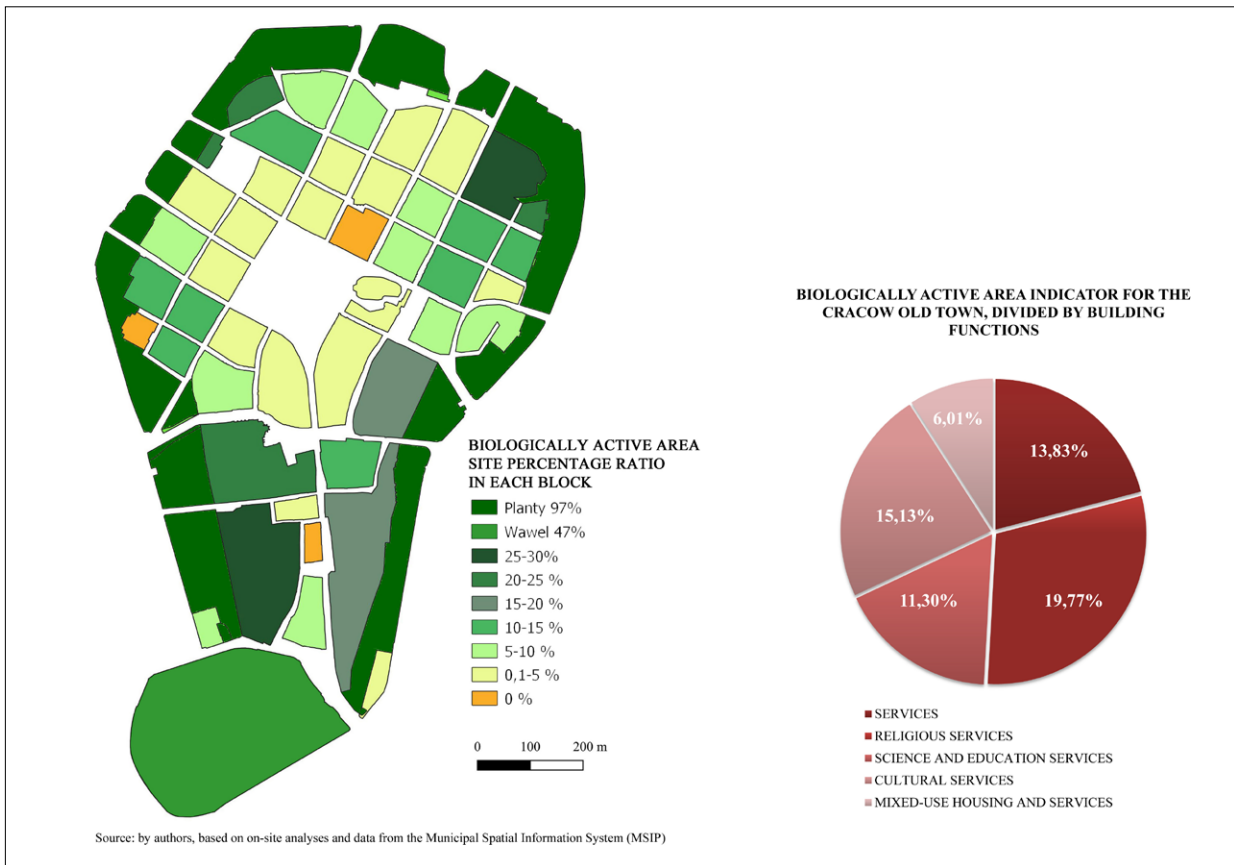


Fig. 4. Biologically active area site percentage ratio in each block and in relation to building function; by the authors.  
Ryc. 4. Współczynnik powierzchni biologicznie czynnej w każdym kwartale oraz z podziałem na funkcje budynku; oprac. autorki.

Construction permit issue date	Number of construction permits issued	Number of plots covered by permits
2014	114	100
2015	96	109
2016	63	64
2017	89	159
2018	13	14
2019	19	27
2020	93	112
2021	40	55
Total	527	640

Most common construction projects:

- Interior remodeling,
- Facade renovation,
- Replacement of windows/doors/restoration of walled-up apertures/walling in existing apertures/replacement of fire barrier doors
- Form of use change
- Construction/extension of electrical, plumbing, heating, gas utilities, ventilation, fire hydrant
- Remodeling and vertical extension of an outbuilding,
- Attic remodeling/roof truss renovation,
- Roofing replacement.

Source: by the authors, based on data from the Municipal Spatial Information System (MSIP).

Fig. 5. Construction traffic in the Cracow Old Town in the years 2014–2021; by the authors.  
Ryc. 5. Ruch budowlany na Starym Mieście w Krakowie w latach 2014–2021; oprac. autorki.

Paving was prevalent wherever the courtyards were in private hands and in complexes with religious buildings: the Church of St. Mark, monastic complexes of the Reformed Congregation of the Order of Friars Minor, the Presentation Sisters, the Orders of St. Francis, and St. Dominic. The changes mostly entailed providing parking spaces, which in certain cases heavily interfered with the structured greenery of gardens. Positive changes took place in the spaces of public squares: Św. Ducha, Szczepański, the Little Market Square, which had their parking spaces removed, and the first two saw the appearance of greenery. In addition, the Professor's Garden of the Jagiellonian University at Jagiellońska Street saw an increase in green area.

### Forms of green area conservation in the Old Town

The Monument Protection and Preservation Act (2003) defines the legal conservation of heritage sites and objects. The scope of a site's entry in the monuments register is crucial, as it should encompass the entire composed layout, i.e., in the case of historical townhouses it should also cover their gardens. The decision to enter a site in the register should include a precise list of all parts and elements of the historical complex (e.g., forms of greenery) as only then can there be a legal basis to protect the entire layout. Historical reconnaissance is important, as

Old Town green areas [m <sup>2</sup> ]			
	green area for each unit from the Catalog (1997)	green area for each unit from the Catalog (2021)	green area for the zone under study (2021)
blocks	66016	47060	49329
Wawel Hill	45561	45561	45561
Planty Park	190880	190880	190880
<b>Total</b>	<b>302457</b>	<b>283501</b>	<b>285770</b>

Source: by authors, based on *Parki i ogrody Krakowa w obrębie Plant z Plantami i Wawelem. Katalog parków i ogrodów w Polsce, vol. 1*, ed. J. Bogdanowski, Warszawa 1997, on-site analyses and data from the Municipal Spatial Information System (MSIP).

Fig. 6. Comparison of greenery in 1997 and in 2021; by the authors.  
Ryc. 6. Porównanie zieleni z lat 1997 i 2021; oprac. autorki.



Fig. 7. State of greenery of the Old Town in 2021 with changes in the urban structure and development; by the authors.  
Ryc. 7. Stan zieleni na Starym Mieście w roku 2021 ze zmianami w strukturze miasta i zabudowie; oprac. autorki.

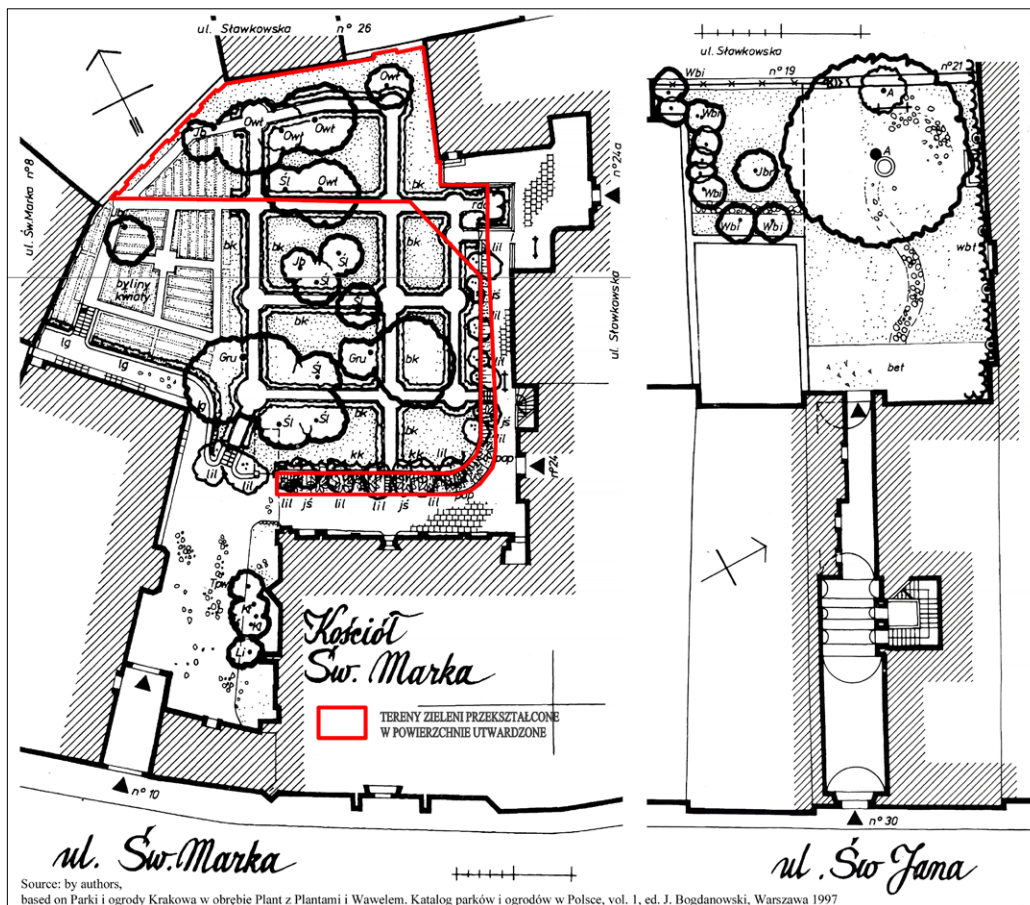


Fig. 8. Two exemplary gardens with a distinctive green composition – on the left a quarters layout, on the right a tree organizes the space. Visible transformation (decrease in green area amount noted within this analysis – as of 2021) in the garden at 10 Św. Marka Street (Catalog chart 9), marked in red; preserved garden layout at 30 Św. Jana Street (chart no. 67); by the authors.

Ryc. 8. Dwa przykładowe ogrody z charakterystycznymi kompozycjami zieleni: po lewej układ kwartałowy, po prawej przestrzeń organizowana przez drzewo; widoczne przekształcenia (obniżenie powierzchni zielonych odnotowane w analizie – stan na rok 2021) w ogrodzie przy ul. Świętego Marka 10 (Katalog, karta 9) zaznaczone na czerwono; zachowany układ ogrodu przy ul. Świętego Jana 30 (karta nr 67); oprac. autorki.

is assessing a site's value, its borders and area. The surroundings, i.e., the area around and near the monument, as specified in the decision to inscribe the monument in the register, is also crucial, e.g. to conserve visual assets and protect against adverse external factors. Some of these elements can be placed under conservation via local spatial development plan provisions, which are also a form of heritage conservation.<sup>24</sup>

The area under study is covered by a local spatial development plan that has been in effect since 2011.<sup>25</sup> In terms of greenery, the plan stipulates the duty to conserve existing greenery of the most valuable compositional layouts, e.g., of Planty Park, Wawel Hill, historical gardens and public gardens, and allows for the recomposition of certain green areas and the possibility of introducing new landscaped greenery composition in undeveloped areas.<sup>26</sup> The provisions of the local spatial development plan define full and partial conservation of development, with the former preventing any new development in courtyards or other alterations to their space. As stipulated in the plan (par. 8, section 8, point 3), built-up-to-site-area ratios and biologically active area ratios were not defined for properties under

full conservation. Another document that is in force in the area under study is the Old Town Cultural Park Protection Plan,<sup>27</sup> which elaborates on the local spatial development plan's provisions. The plan mandates the maintenance of historical greenery complexes, stresses the need for biodiversity and environmental assets, the improvement of the natural environment and preventing its decay.<sup>28</sup> These values are verified in the design documentation agreed by the restorer.

### Cultural heritage zone and climate change adaptation

The municipal policy of numerous cities, both around the world and in Poland, acknowledges improving the quality and attractiveness of urban space to residents and tourists and the associated adaptation to climate change as a major priority. One of the first efforts in this field is to increase the amount of green areas to provide greater stormwater absorptivity. Enhancing absorptivity parameters can be achieved by greenery and certain types of paved surfaces that, depending on the materials used, can be permeable to varying degrees. Green areas in-



Item no.	Type of surface	Overview of surface type – ecological value
1	Paved surface	Land cover that is impermeable to stormwater and air, without plant growth; using construction materials (concrete, asphalt, tiles or slabs with base courses with impermeable gaps)
2	Partially paved surface	Water- and air-permeable land cover, allows for plant growth and infiltration (clinker, gravel, tiles or slabs with a base course from sand and aggregate)
3	Half-open (permeable) surface	Fully water- and air-permeable surface, allows for plant growth and infiltration (grass, wood mosaic, mixed surface out of grass and stone)
4	Soil surface that allows for plant growth, no contact with ground	Surfaces without access to the ground, soil on the roofs of basements, garages, with a layer of soil no greater than 80 cm
5	Soil surface that allows for plant growth, no contact with ground	Surfaces without access to the ground, soil on the roofs of basements, garages, with a layer of soil greater than 80 cm
6	Soil surface that allows for plant growth, with contact with ground	Surfaces with access to the ground
7	Stormwater drainage into the soil, calculated per m <sup>2</sup> of the ground	Stormwater drainage into the vegetative layer that allows for absorption
8	Vertical gardens with a height of up to 10 m	Green walls on external building walls without windows and on freestanding walls, maximum height of 10 m
9	Green roofs	Extensive green roofs with a thin vegetative layer, intended for the planning of stonecrops, bryophytes and grasses. Such roofs do not require elaborate maintenance. Intensive green roofs, with a thicker vegetative layer that provide significant potential for garden arrangement: e.g. perennials, grasses, shrubs and small trees. Intensive green roofs require significant maintenance.

Source: by authors.

Fig. 9. Types of surfaces accounted for in Biotopflächenfaktor BFF calculations used in Berlin's landscape plans; by the authors.

Ryc. 9. Rodzaje powierzchni uwzględnionych w obliczeniach Biotopflächenfaktor BFF użyte w planach krajobrazowych Berlina; oprac. autorki.

clude not only classical parks or public gardens, but also green roofs, walls and any patch of greenery, and their design in a compact urban structure under conservation is a serious challenge. However, despite strict greenery preservation guidelines, legal regulations permit alterations that increase the amount of greenery and permeable surfaces. Despite these favorable provisions, this study proves that the Old Town's amount of green areas is being reduced (Fig. 6). This means that alterations in blocks should be monitored and inspired by good examples of increasing the amount of greenery and permeable surfaces (Fig. 7, 8).

Berlin is one such example. Its urban structure is different than Cracow's, but effective planning efforts to increase the amount of greenery in a densely developed city are a positive indication. Berlin has landscape plans in force, and some of them feature biologically active area ratios (Biotopflächenfaktor – BFF). This indicator is a numerical parameter that describes the share of an area that ensures natural vegetation in various types of development (Fig. 9). It defines the size of land covered by foliage that serve as a place of cultivating plants and fulfil environmental functions such as evaporation, absorption, filtering, rainwater drainage. Landscape plan guidelines with BFF indicators concern the replacement of paved surfaces with permeable ones, including greenery. However, alterations include site-dependent measures. Alterations include: introducing greenery (tall, low, vertical) into

courtyards, frontal gardens, roofs, facades, firewalls and fences. Changes in land surface area also applied when siting car parks and paved surfaces in parks, yards, and courtyards.<sup>29</sup>

### Summary and conclusions

Climate change affects every city, including heritage sites and zones where potential for action is limited, but the authors believe that they do not endanger their historical value. The City of Cracow 2030 Climate Change Adaptation Plan<sup>30</sup> points to climate threats in the Old Town areas as being: heat waves, torrential rains, floods, and air pollution concentrations. Remedial actions listed include increasing the amount of green areas and increasing paved surface permeability.

The objective outlined in the introduction, namely identifying the greenery asset pool in the Old Town, the degree of its transformation and the potential of its increase, was achieved. The Catalog was used as a reference point for illustrating changes in the area's structure. Data on the contemporaneous state of greenery (area and type) acted as comparative material. The Catalog lists 187 various types of green areas and Planty Park and Wawel Hill, which results in 189 items in total. Our analysis covered 39 additional gardens, which brought this number up to 228. Despite the increase in the number of units, a decrease in green area to 18 thousand m<sup>2</sup>/1.8 ha was observed (Fig. 5). It should be

noted that this value can have a margin of error due to the precision of numerical data used in both analyses.<sup>31</sup>

The findings of the analyses presented led to the following conclusions:

1. A significant loss of greenery was observed in the area under study, especially in yards and courtyards, with a visible tendency to increase the share of greenery in public spaces (e.g., Św. Duchy Square, Szczepański Square).
2. Local spatial development plan provisions were found to be insufficient to protect block gardens against alterations based on a reduction in biologically active surface amount.
3. There is a need for a greater and more comprehensive monitoring of alterations in terms of plot development within the jurisdiction of the voivodeship conservation officer.
4. Every block of the Old Town requires dedicated analysis to determine the potential to increase the amount of green and permeable areas with indications of specific solutions and their technical specifications.
5. There is a need to develop solutions to increase the amount of green areas and surfaces with varying degrees of permeability.
6. It is necessary to compile a design solutions catalog in the field of greenery: ground floors, surfaces, greenery on fire walls, walls, fences, roofs, facades, as well as changes that could be used in specific cases (e.g. climbers on racks, trellises, rain gardens).
7. Adapting cities to climate change should also cover listed heritage areas with adaptations of proposed action to their specificity and cultural values.

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- <sup>6</sup> The survey for the Catalog was ended in 1994.
- <sup>7</sup> Examples include *Kraków. Studia nad rozwojem miasta*, ed. J. Dąbrowski, Kraków 1957; M. Borowiejska-Birkenmajerowa, *Kształt średniowiecznego Krakowa*, Kraków 1975; B. Krasnowolski, *Lokacyjne układy urbanistyczne na obszarze ziemi krakowskiej w XIII i XIV wieku*, cz. 1, cz. 2, Kraków 2004, the state of the art was comprehensively discussed here; idem, *Lokacje i rozwój Krakowa, Kazimierza i Okołu. Problematyka rozwiązań urbanistycznych*, [in:] *Kraków. Nowe studia nad rozwojem miasta*, ed. J. Wyrozumski, Kraków 2007, p. 357–426.
- <sup>8</sup> A record is a simplified historical and compositional study of a historical garden with conclusions and conservation guidelines.
- <sup>9</sup> M. Borowiejska-Birkenmajerowa, op. cit.; B. Krasnowolski, op. cit.; M. Motak, *Historia rozwoju urbanistycznego Krakowa w zarysie: podręcznik dla studentów szkół wyższych*, Kraków 2019.
- <sup>10</sup> M. Łukacz, *Średniowieczne domy lokacyjnego Krakowa*, “Czasopismo Techniczne” 2011, No. 7–A, p. 67–98.
- <sup>11</sup> Ibidem; M. Motak, op. cit.
- <sup>12</sup> M. Łukacz, op. cit.; *Parki i ogrody*, op. cit.
- <sup>13</sup> Bogdanowski wrote of “single-tree gardens” acknowledged as having a thoughtful composition; cf. J. Bogdanowski, “Karty katalogowe ogrodów”, Kraków 1975–1978, Archives of the WMKZ; *Parki i ogrody*, 1997, op. cit.
- <sup>14</sup> *Parki i ogrody*, op. cit., p. 25–26.
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- <sup>16</sup> *Parki i ogrody*, op. cit.
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- <sup>18</sup> A. Zachariasz, *Zielony Kraków: dla przyjemności i pożytku Szanownej Publiczności*, Kraków 2019, p. 172–197.
- <sup>19</sup> Sites that represented a given function either entirely or in 75% were included. Those associated with accommodations and banks were acknowledged as an essential and formal element of the area’s landscape. Administrative and healthcare buildings are essential urban functions, hence the decision to list them.
- <sup>20</sup> Old Town district population: 2005 – 47319, 2010 – 44060, 2015 – 40622, 2019 – 30609; see: *Kraków w liczbach*, <https://www.bip.krakow.pl/?m-mi=6353> (accessed: 20 VI 2021).
- <sup>21</sup> M. Kursa, *Czy papież Franciszek pomoże w otwarciu klasztornych ogrodów w centrum Krakowa?*, “Gazeta Wyborcza”, 11 III 2021.
- <sup>22</sup> Since the Catalog’s publication in 1997.
- <sup>23</sup> “For almost thirty years (1983–2012) the share of major use categories has been similar (e.g. in 1983 the share of technical uses was 71.85%, in 1992 – 72.7%, in 2012 – 72.6%, and green uses amounted to 28.15%, 27.2% and 27.3%”; B. Luchter, op. cit., p. 139.
- <sup>24</sup> A. Zachariasz, op. cit., p. 28.
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- <sup>31</sup> One case for doubt is the amount of greenery at the Main Market Square, listed as 20 a, which disagrees with the sizes shown on the plan of this space.

## Abstract

Urban greenery is not limited to parks and public gardens, but also singular trees, green roofs, walls that beneficially affect the city's natural environment and minimize climate change consequences. This paper discusses the green areas of Cracow's Old Town, an area of medieval origin, compact urban form, surrounded by a park (Planty) established at the site of demolished fortifications. It depicts the structure of the development of its town blocks while accounting for the presence of greenery. Comparative studies were performed based on data included in a catalog of gardens from central Cracow from 1997, developed by a team led by Janusz Bogdanowski, compared with the present-day state. The study assessed changes in the structure, use and accessibility of greenery, while accounting for applicable planning provisions and potential for alterations. The asset pool of biologically active areas was identified and the varieties and types of greenery present in the area were presented, which enabled the demonstration of the extent of its transformation and the potential for its expansion.

## Streszczenie

Zieleń miejska to obecnie nie tylko parki i skwery, lecz także pojedyncze drzewa, zielone dachy, ściany, które korzystnie wpływają na środowisko przyrodnicze miasta i minimalizują skutki zmian klimatycznych. W artykule rozważano tereny zieleni Starego Miasta w Krakowie, obszaru o średniowiecznym rodowodzie, zwartej formie urbanistycznej, okolone parkiem (Planty) założonym w miejscu wyburzonych fortyfikacji. Pokazano strukturę kształtowania bloków urbanistycznych z uwzględnieniem obecności zieleni. Studia porównawcze przeprowadzono na podstawie danych zawartych w katalogu ogrodów centrum Krakowa z roku 1997, opracowanym przez zespół pod kierunkiem Janusza Bogdanowskiego, zestawionych ze stanem współczesnym. Oceniono zmiany zachodzące w strukturze i użytkowaniu zieleni oraz dostępności do niej, uwzględniono aktualne zapisy planistyczne oraz możliwość potencjalnych przekształceń. Określono zasób terenów biologicznie czynnych, ukazano rodzaje i typy zieleni występującej na badanym obszarze, co pozwoliło zobrazować stopień jego przekształceń i możliwości jego powiększenia.