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RESEARCH ARTICLE

# INVENTORY OF ADVERTISING INFRASTRUCTURE ALONG SELECTED STREETS OF KRAKOW

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ABSTRACT: The phenomenon of visual pollution, caused by the excessive use of public spaces for promotional purposes, have been a major concern for the landscape of Polish cities for a long time. The attempts in the enforcement of existing legal regulations on this issue have not achieved significant success so far. The article presents a photogrammetric approach for an inventory of advertising infrastructure on selected streets of Krakow to analyse selected provisions of the draft of the Landscape Resolution. A mobile mapping platform consisting of an immersive camera connected with GNSS/IMU sensors has been used during the acquisition of georeferenced panoramic images. Conducting photogrammetric measurements on these images, inventory of advertising infrastructure was done for 27.8 km of streets and 4 055 free-standing advertisements and advertisements on buildings were measured in total by the application of immersive photogrammetry techniques. Following the inventory phase, compliance of existing advertisements with the draft of the Landscape Resolution were examined by qualitative and spatial analysis. Results achieved by these analyses indicate that 69% of free-standing advertisements and 94% of advertisements on buildings inventoried on these selected streets are not compliant with the draft resolution and that in this resolution, the emphasis will be placed on the distances of advertisements from road intersections rather than distances between free-standing advertisements themselves.

## 1. INTRODUCTION

For many years, residents of Polish cities have been concerned about the problem of disruption of landscape harmony by various types of advertising infrastructure (billboards, banners etc.). The problem is particularly visible along main roads (Springer, 2013). Advertising media should be appropriately arranged and provide adequate information for people on the move but should not pose a danger to road users (fig. 1).

Good advertising, located in an appropriate and visible place often determines the development of a business, promotion of a service or goods (Mikosz, 2010), as well as the proper functioning and development of the local economy raising the standard of living, while an excessive amount of advertising can bring the opposite of the intended effects (covering the landscape (Klimczak, 2014), danger for drivers (Domke *et al.*, 2014)). The normalization of

the problem of visual pollution must comply with local communities or the authorities of a given area, but so far, the existing legal regulations have not been effectively enforced.


Figure 1. Disturbed spatial order on Zakopianska Street in Krakow. (authors' source)

Spatial order is disturbed in many Polish cities, inter alia, by excessive large-format advertising, covering buildings and fences with banners and too dense distribution of advertising media. Such a phenomenon is referred to as visual pollution, which is difficult to analyse due to the very large number and variability of advertising media. Visual pollution currently occurs in the public space of almost every Polish city.

Visual pollution was also analysed abroad. In the USA, Taylor and Taylor (1994) analysed the content of a sample of over 700 billboards whereas Kurtca *et al.* (2019) focused on comparing lidar and photogrammetry measurements of billboards in the Balgat district of Ankara in Turkey.

In 2015, the Landscape Act (2015) was passed by the Polish Parliament, which introduced changes in the definition of landscape, tools to foster its protection, as well as fees dependent on the area of advertising placed in public space. In February 2019, an inventory of advertising infrastructure on 13 streets in Krakow was commissioned by the Municipality of Krakow to analyse selected provisions of the draft of the Landscape Resolution (Kwiatek, 2020). The Landscape Resolution (2020) was passed by the City Council in July 2020.

The digital study is the result of the authors' interpretation of the provisions of the draft of the Landscape Resolution from February 2019. The study presents the problem only on selected streets of Krakow. Photogrammetric methods were applied in the measurements, which used panoramic images recorded by an immersive camera connected with IMU and GNSS in an immersive mobile mapping system.

## 2. PURPOSE AND SCOPE

This paper has been prepared in order to carry out an inventory of advertising infrastructure and to analyse to what extent the draft of the Landscape Resolution prepared by

the City of Krakow may affect changes in public space. One of the primary aims of this study is to verify the parameters set out in the draft (e.g. dimensions of advertisements, distances from buildings, distances from road axis intersections, etc.) on the basis of inventoried advertising infrastructure.

In the study, selected parameters concerning advertising media are checked. The basis for this task was the categorisation of advertisements in terms of their compliance with the proposed Landscape Resolution. It was decided to use a mobile mapping system that can very quickly perform an inventory of advertisements located along particular streets.

Only a few cases of inventories of advertising media in public spaces can be found in the literature. Listwan and Franczak (2014) performed an inventory of outdoor advertising placed along public roads around the Tatra Mountains on the Polish and Slovak sides of the mountains. A road section of 280 km was monitored and measured, but 30 evenly spaced sections of 5 km each were selected where an inventory of advertisements was made. This work was done manually by writing down the results on paper. Listwan and Franczak (2015) noted that the distribution of advertising depends on the volume of car traffic. A different approach to the inventory of advertising media was presented by Chmielewski *et al.* (2015), who focused on studying the visibility of billboards and banners in a selected part of Lublin. They measured distances from public roads to advertising media and assigned them to one of three categories based on the area of the advertising media. Zaremba (2015) counted advertisements on one of Warsaw's streets and found 90% of billboards that were produced by local companies advertising infrastructure. All the inventory examples shown above does not include the area of the advertisement carrier.

In this study, thirteen streets in Krakow were selected for the advertisement inventory: Brodowicza, Conrada, Dobrego Pasterza, Kalwaryjska, Klasztorna, Kobierzyńska, Makuszyńskiego, Malborska, Mazowiecka, Półłanki, Wadowicka, Wrocławska, Zakopiańska. In total, 27.8 km of streets were inventoried. The streets are located in three different zones defined in the draft resolution provided by the Cracow City Council. No advertisements were inventoried in Zone II or Zone III, Sub-area 1. Table 1 presents the name of the street, the letter abbreviations used in this digital study, the length of the street and the number of the zone in which it is located, as well as information as to whether it is an exit street. Figure 2 presents a summary of streets and zones on the map of Krakow. Zones are marked with Roman numerals and sub-zones with Arabic numerals.

## 3. METHODOLOGY

A prototype of an immersive mobile mapping system was used for the inventory of advertising carriers (Kwiatek, 2017). The prototype has been previously used to measure visual pollution e.g. in Zabierzów (Kwiatek, 2015; Kwiatek, 2016). The used immersive photogrammetric system integrates panoramic images with their location and rotation to enable the user to do metric measurements on panoramic images on the basis of photogrammetric

Table 1. Summary of data on selected streets in Krakow.

| Street in Krakow | Letter abbreviation for streets | Length of the streets [km] | Letter abbreviation for buildings | Zone | Is the street an exit street? |
|---|---|---|---|---|---|
| Brodowicza | B | 0.6 | BB | I | No |
| Conrada | C | 1.3 | BC | I | Yes |
| Dobrego Pasterza | D | 2.6 | BD | I | No |
| Kalwaryjska | J | 1.0 | BJ | Zone III Sub-area 3 | No |
| Klasztorna | L | 1.7 | BL | 670 m in Zone III Sub-area 2, the remaining part - Zone I | No |
| Kobierzyńska | K | 4.3 | BK | I | No |
| Makuszyńskiego | A | 1.3 | BA | I | No |
| Malborksa | R | 1.4 | BR | I | No |
| Mazowiecka | M | 1.1 | BM | I | No |
| Półłanki | P | 4.4 | BP | I | No |
| Wadowicka | O | 0.9 | BO | I | Yes |
| Wrocławska | W | 1.6 | BW | I | No |
| Zakopiańska | Z | 5.6 | BZ | I | Yes |

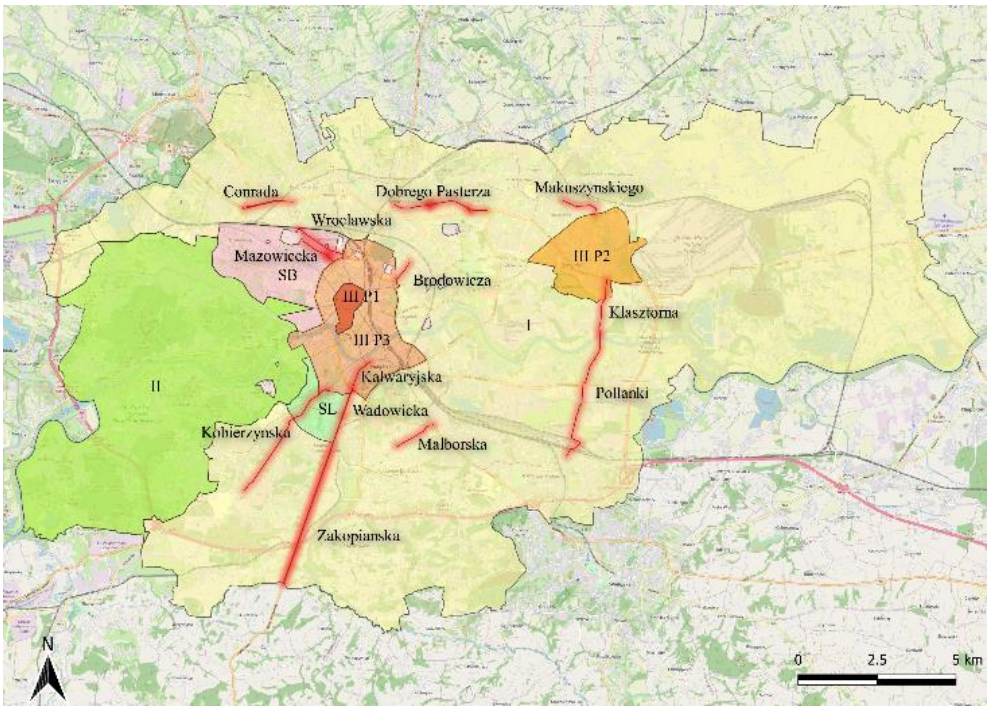


Figure 2. Overview of streets and zones on the map of Krakow, Poland. (Source: https://www.bip.krakow.pl/?bip_id=1&mmi=22515, accessed: 14.02.2019)

space intersection. All the advertisements that are visible to the panoramic camera are obtainable with the use of this system. The measurements of the advertisements were done manually. The measurement system consists of an advanced position recording system (GNSS system), an IMU system and an immersive camera - Ladybug 3, placed on the roof of the vehicle (fig. 3). It took two days for the immersive mobile mapping system to travel across 13 streets, which would have been unachievable using other surveying-based measurement techniques. The system captures images with a 360-degree field of view with a resolution of 5 400 x 2 700 px.

Figure 3 Immersive mobile mapping system placed on the roof of a car. (authors' source)

The measurement of advertising media in this study is based on immersive photogrammetry, which uses the assumptions of panoramic photogrammetry (Schneider and Maas, 2003; Schneider and Maas, 2005; Parian and Gruen, 2004; Kurczyński, 2014) and spherical photogrammetry (Fangi, 2007; Fangi, 2009). Immersive photogrammetry, proposed by Kwiatek and Tokarczyk (2014, 2015) uses 'faulted' spherical panoramas, where component images are projected onto the surface of a sphere and displayed as spherical panoramas with a common centre of projection. This results in errors on these panoramas that affect the accuracy of photogrammetric studies. By meeting certain measurement requirements (Kwiatek and Tokarczyk, 2018), the presented mobile imaging system can be used for photogrammetric 3D measurements of advertising carriers.

## 4. DEVELOPMENT OF A DIGITAL ADVERTISING INVENTORY

After recording panoramic images, photogrammetric measurements were taken for each street. In the first stage, all free-standing advertisements were measured, and in the next stage, advertisements on buildings were measured. The measurement results were then divided into compliant to the draft of the Landscape Resolution, non-compliant and out-of-scope advertisements. In the next stage, spatial analyses were carried out only on conforming advertising infrastructure.

Table 2 presents the number of registered panoramas, the number of free-standing advertisements and advertisements on buildings in selected streets in Krakow, the length of the street, and the average number of advertisements per 100 m of a given street. The graph (fig. 4) compares the average number of free-standing and building-mounted advertisements per 100 m of a given street. Immediately noticeable is the 1 km long Kalwaryjska Street (J), which contains an average of almost 47 advertisements on building structures over a distance of 100 m.

Table 2. A summary of the number of free-standing advertisements and advertisements on building structures in selected streets of the City of Krakow.

| Street in Krakow (letter abbreviation) | Number of panoramas | Number of free-standing advertisements | Number of advertisements on building structures | Length of the street [km] | Average number of free-standing advertisements per 100 m | Average number of advertisements on buildings per 100 m |
|---|---|---|---|---|---|---|
| B | 231 | 7 | 47 | 0.6 | 1.2 | 7.8 |
| C | 805 | 73 | 124 | 1.3 | 5.6 | 9.5 |
| D | 677 | 81 | 233 | 2.6 | 3.1 | 9.0 |
| J | 469 | 9 | 466 | 1.0 | 0.9 | 46.6 |
| L | 599 | 32 | 61 | 1.7 | 1.9 | 3.6 |
| K | 1 527 | 146 | 454 | 4.3 | 3.4 | 10.6 |
| A | 388 | 54 | 163 | 1.3 | 4.1 | 12.5 |
| R | 435 | 38 | 144 | 1.4 | 2.7 | 10.3 |
| M | 291 | 21 | 146 | 1.1 | 1.9 | 13.3 |
| P | 1 683 | 109 | 199 | 4.4 | 2.5 | 4.5 |
| O | 337 | 47 | 120 | 0.9 | 5.2 | 13.3 |
| W | 552 | 46 | 273 | 1.6 | 2.9 | 17.1 |
| Z | 1 629 | 290 | 672 | 5.6 | 5.2 | 12.0 |
| **Total** | **9 623** | **953** | **3 102** | **27.8** | | |
| **Average** | | | | | **3.4** | **13.1** |

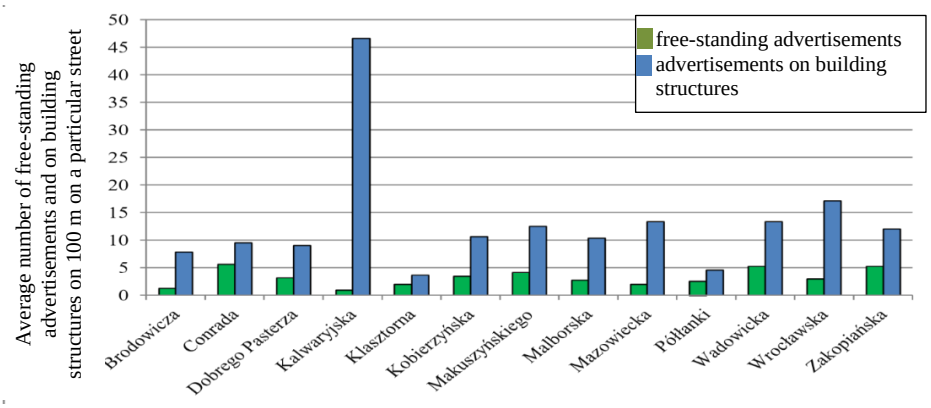


Figure 4 A summary of average numbers of free-standing advertisements and advertisements on building structures per 100 m of a given street.

Table 3 presents the total display area of free-standing advertising media and advertisements on building structures in selected streets in the city of Krakow. In addition, the number of roundels (*"okrąglak"*) whose display area is not included in the total area of free-standing advertising media is given. The average display area of an advertisement on a roundel is in the range of 10-12 $m^2$, so it can be assumed that 58 roundels may have a display area of approximately 700 $m^2$. Figure 5 shows a summary of the total area of free-standing advertisements and advertisements on building structures. In the case of total advertising surface area, Zakopiańska Street (Z) is the most significant (with a total of approximately 10 170 $m^2$). Figure 6 provides a visualisation of the intensity of the number of advertisements and the intensity of the surface area of advertising exposure in selected streets in the city of Krakow. Red colour presents the highest intensity of advertisements.

Table 3. Total area of free-standing advertisements and advertisements on building structures.

| **Street in Krakow** | **Total display area of free-standing advertising (without roundels) [$m^2$]** | **Number of roundels** | **Total area of advertising on building structures [$m^2$]** |
|---|---|---|---|
| Brodowicza (B) | 49.06 | 0 | 197.24 |
| Conrada (C) | 935.58 | 4 | 2 136.46 |
| Dobrego Pasterza (D) | 538.98 | 4 | 1 154.32 |
| Kalwaryjska (J) | 24.15 | 5 | 1 687.07 |
| Klasztorna (L) | 126.19 | 0 | 220.74 |
| Kobierzyńska (K) | 1 299.31 | 9 | 2 140.34 |
| Makuszyńskiego (A) | 256.33 | 0 | 941.07 |
| Malborksa (R) | 295.50 | 0 | 541.18 |
| Mazowiecka (M) | 30.74 | 12 | 550.44 |
| Półłanki (P) | 859.49 | 0 | 1 011.43 |
| Wadowicka (O) | 306.99 | 11 | 1 473.57 |
| Wrocławska (W) | 244.51 | 8 | 1 168.24 |
| Zakopiańska (Z) | 3 501.05 | 5 | 6 668.04 |
| **Total:** | **8 467.88** | **58** | **19 890.14** |

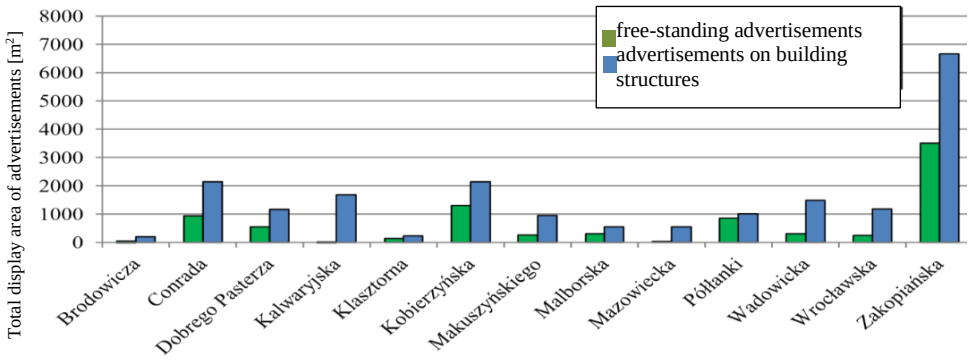


Figure 5. A summary of total display area of advertisements on selected streets of Krakow.

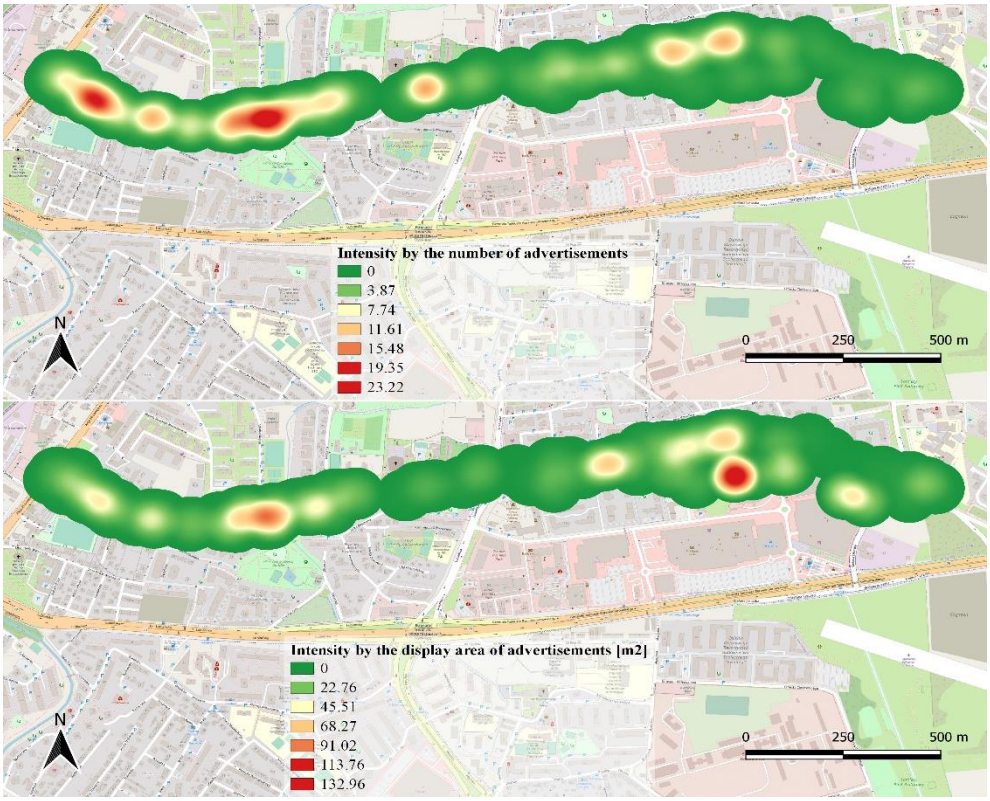


Figure 6. A visualisation of the number of advertisements and the display area of advertisements on Dobrego Pasterza Street in the City of Krakow

From Figure 6 it is possible to deduce a relation between the number of advertisements and their display area in selected street fragments. For example, Dobrego Pasterza Street has many advertisements, but most of them do not have a large display area.

Table 4 shows the registered attributes for free-standing advertising media and those located on building structures. The field name designation is sometimes abbreviated and is due to the small number of characters that can be used.

Table 4. Recorded attributes for free-standing advertisements and advertisements on building structures

| Designation | Explanation |
|---|---|
| **Id Ads** | a unique advertisement number comprising a street abbreviation and a three-digit advertisement number (over 500 for advertisements on buildings) |
| **Location type** | location of advertising<br>- free-standing<br>- on the building structure |
| **Type of advertisements** | the type of advertising in accordance with the definitions of the draft of the Landscape Resolution:<br>- Billboard<br>- Advertising panel<br>- Banner on scaffolding for the duration of the renovation (no measurement was taken for this type of advertising)<br>- Other advertising panels or other advertising devices<br>- Banner |
| **Spos.um.** | the way the advertisement is positioned:<br>- other<br>- on the fence<br>- at the bus stop<br>- on the pole of the lamppost |
| **Szyld** | information to determine whether an advertising medium is a signboard.<br>- T (yes)<br>- N (no) |
| **Rek_Polacz** | the building identifier is entered here, for which more information can be found in the database |
| **Pole_pion** | vertical position of the advertisement<br>- ground floor<br>- beyond the ground floor level |
| **Pow. (p)** | the measured area of the advertisement (p - means the measured value from the photogrammetric spatial forward indentation); expressed in $m^2$ |
| **Width** | width of the advertisement; expressed in m |
| **Height** | height of the advertisement; expressed in m |
| **Info** | additional textual information allowing clear identification of the advertising medium |
| **Screenshot** | information on the file that contains the screenshot of the advertisement |
| **Wys_Wzgled** | relative height of the advertising medium (height to top edge); expressed in m |
| **Wys_Dol_Kr** | height of the lower edge of the advertising medium; expressed in m |
| **Number_Usl** | indication of the affiliation of advertising media to the same area accompanying the service facilities |
| **LED** | whether the advertising medium is electronic |

Table 5 shows the registered attributes for buildings that are available when the database for the selected street is displayed.

Table 5. Registered attributes for buildings.

| Designation | Explanation |
|---|---|
| **Building Id** | a unique identifier for the building starting with letter B, followed by the symbol assigned to the street and then a three-digit number |
| **Building No.** | registration number of the building |
| **Prze_fasad** | information of whether the advertisement is on the front facade<br>- T (yes)<br>- N (no) |
| **Fasad_part** | information of whether the advertisement is on the ground floor<br>- T (yes)<br>- N (no) |
| **Pow. (p)** | the measured elevation area (p - is the measured value from the photogrammetric spatial forward intersection); expressed in $m^2$<br>Note: the area refers to the whole façade or to the ground floor façade depending on the information in the "**Fasad_part**" field |
| **Pow. (o)** | measured area of the façade in case it was difficult to measure 4 corners of the façade; expressed in $m^2$; Note: the area refers to the whole façade or to the ground floor façade depending on the information in the field "**Fasad_part**" |
| **Width** | width of façade; expressed in m |
| **Height** | height of façade; expressed in m |
| **Building height** | building height:<br>- other<br>- less than 9 m<br>- between 9-25 m<br>- over 25 m |

## 5. DEVELOPMENT OF DIGITAL ADVERTISING COMPLIANCE WITH THE PROVISIONS OF THE DRAFT OF THE LANDSCAPE RESOLUTION (SPATIAL ANALYSES)

The objective of the study was also to perform spatial analyses on the measured advertisements in the context of their compliance with the provisions of the draft of the Landscape Resolution prepared by the Municipality of Krakow on "Principles and conditions of location of small architectural objects, billboards and advertising devices, and fences in the area of the City of Krakow".

The following data obtained from photogrammetric measurements were used to perform spatial analyses:

- spatial data with attributes on free-standing advertising;
- spatial data with attributes for advertising on building structures;
- georeferenced panoramic images created by an immersive mobile system.

Spatial analyses were conducted in the following stages:

1) elimination of advertising inconsistent with the draft of the Landscape Resolution;

2) conducting spatial analyses for free-standing advertising in line with the draft resolution of the Landscape Resolution;
3) conducting analyses of advertising on building structures coverage for the ground floor and building façades.

### 5.1 Elimination of advertising inconsistent with the draft of the Landscape Resolution

Due to the very large number of advertisements located on the selected streets, it was necessary to select only those advertising carriers that meet the conditions in accordance with the draft of the Landscape Resolution. For this purpose, selected parameters were applied which allowed some advertisements to be removed before the process of spatial analysis. The following classifications of advertisements have been created (they are marked in the "Compliance" column):

- compliant - marked in green in the visualisations (fig.7);
- non-compliant - marked in red in the visualisations (fig.7);
- beyond the scope of the resolution - marked in grey in the visualisations.

Figure 7. Visualizations of compliant and non-compliant advertisements with the draft of the Landscape Resolution

The elimination of advertisements was performed in the following order. Firstly, advertisements were eliminated considering the division of the city into five zones (Zone I, Zone II, Zone III Sub-area 1, Zone III Sub-area 2, Zone III Sub-area 3). Next, considering whether a given advertisement is located on an exit street or not, non-compliant types of advertisements were eliminated, as well as those whose parameters did not comply with the draft of the Landscape Resolution. In the next stage of elimination, the distances to buildings and bus shelters were checked.

R (distance of the advertisements from road intersections) and dp (distance between two consecutive advertisements on one side of the roads) are two metric elimination parameters for advertisements which the exact values of them were not defined during the project time. One of the purposes of this project was to define which of these parameters would have bigger impact on eliminating the advertisements.

Table 6 presents the order of elimination of advertisements. A code was assigned to each step, which allows finding the appropriate layer in QGIS and checking which advertisements were removed at each step.

Table 6. Summary of the order of elimination of individual advertisements due to different parameters.

| **Task stage** | **Code assigned to a particular elimination stage** | **Type of advertising affected by elimination process** | **The condition that is fulfilled and therefore the advertisement is eliminated** |
|---|---|---|---|
| 1 | 2100 | Free-standing billboard | Zone III, Sub-area 2<br>Zone III, Sub-area 3 |
| 2 | 2200 | Billboard on a building structure | Zone III, Sub-area 2<br>Zone III, Sub-area 3 |
| 3 | 2300 | Other free-standing board or other free-standing carriers | Zone III, Sub-area 2<br>Zone III, Sub-area 3 |
| 4 | 2400 | Roundel ("okrąglak") | Zone I, excluding special zones |
| 5 | 3100 | Free-standing billboard | Exit street |
| 6 | 5100 | Banner | All, except signboards |
| 7 | 5200 | Advertising panel | All except those located at a bus stop, on a building up to 35 $m^2$ (a kiosk), on a toilet; on a petrol station within 50 m of a motorist's restaurant and on land accompanying services. |
| 8 | 5300 | Mast | All, except land associated with service facilities. |
| 9 | 6110 | Free-standing billboard | Display area other than 12 $m^2$<br>Display area other than 18 $m^2$ |
| 10 | 6120 | Free-standing billboard | Distance between the bottom edge of the billboard and the ground of less than 3 m |
| 11 | 6130 | Free-standing billboard | Height above 10 m |
| 12 | 6210 | Billboard on a building site | Display area other than 12 $m^2$<br>Display area other than 18 $m^2$ |

| | | | |
|---|---|---|---|
| 13 | 6310 | Pylon | Height above 6 m |
| 14 | 6320 | Pylon | Display area of a single advertisement over 4 $m^2$ |
| 15 | 6330 | Pylon | Length - more than 1.5 m |
| 16 | 6340 | Pylon | Width - more than 0.4 m |
| 17 | 6410 | Other free-standing board or other free-standing carriers | Display area greater than 5 $m^2$ |
| 18 | 6420 | Other free-standing board or other free-standing device | Height greater than 3.5 m |
| 19 | 6510 | Advertising panel | Height greater than 2.5 m |
| 20 | 6520 | Advertising panel | Width greater than 1.6 m |
| 21 | 6610 | Mast | Height more than 14 m |
| 22 | 6620 | Mast | Area greater than 6 $m^2$ |
| 23 | 6710 | Flagpole | Height greater than 12 m |
| 24 | 6720 | Flagpole | Height greater than 6 $m^2$ |
| 25 | 6810 | Advertising on a building site | The place on the building façade is "beyond ground floor level" |
| 26 | 6820 | Positioning | On the fence |
| 27 | 4100 | Free-standing billboard | Distance to building less than 10 m |
| 28 | 4200 | Other free-standing board or other free-standing carriers | Distance from shelter stop less than 15 m |
| 29 | 4310 | Roundels | Zone I, R [1]< 100 m and R < 50 m |
| 30 | 4320 | Roundels | Zone I, up to < 200 m [2] |
| 31 | 4330 | Roundels | Zone I, dp [3]< 40 m and dp < 20 m |
| 32 | 4340 | Roundels | Zone III, R < 100 m and R < 50 m |
| 33 | 4350 | Roundels | Zone III, dp < 80 m |
| 34 | 4360 | Roundels | Zone III, dp < 40 m and dp < 20 m |
| 35 | 3200 | Other free-standing board or other free-standing carriers | Outlet street and distance between free-standing advertisements of 500 m |

By applying the above steps of elimination of advertising carriers, only those advertisements that meet the provisions of the draft of the Landscape Resolution and are outside the scope of this resolution were left. This significantly reduced the number of advertisements that were taken into account in the spatial analysis. Table 7 presents the number of free-standing advertisements and advertisements on building structures before and after the elimination of advertisements that do not comply with the draft of the Landscape Resolution (additionally, values in percentages are indicated).

[1] - distance to road intersections
[2] - distance to other rounders
[3] - distance between consecutive roundels

Table 7. Numbers of freestanding and building advertisements before and after the elimination process.

| Task stage | Number of free-standing advertisements | Number of advertisements on building structures | Total advertisements |
|---|---|---|---|
| All advertisements before elimination process | 953 (100%) | 3 102 (100%) | 4 055 (100%) |
| Compliant advertisements after the elimination process | 286 (30%) | 177 (5%) | 463 (11%) |
| Non-compliant advertisements after the elimination process | 657 (69%) | 2 901 (94%) | 3 558 (88%) |
| Out of the scope of the resolution advertisements after the elimination process | 10 (1%) | 24 (1%) | 34 (1%) |

From Table 7 the selected streets have an average of 69% non-compliant free-standing advertisements and 94% non-compliant advertisements on building structures.

Summarizing the elimination process, it can be stated that the 13 streets selected for analysis have 88% of non-compliant advertising media. Table 8 shows the number of advertisements that were removed from the database after each stage of elimination process.

It might be noted that the highest number of advertisements detected to be non-compliant can be found among the freestanding billboards on the exit street (208 items - code 3100) and with an area other than 12 $m^2$ and 18 $m^2$ (100 items - code 6120). 92 other freestanding billboards or other freestanding advertising devices were categorized as non-compliant with the draft of the Landscape Resolution due to their display area exceeding 5 $m^2$ (code 6410). In the case of advertisements on building structures, most were classified as banners (except for signboards) (834 items - code 5100). These are generally banners placed on fences. Another parameter that led to the removal of a significant number of advertisements from the analyses was the placement of the advertising medium beyond the ground floor level (469 items - code 6810).

### 5.2. Spatial analyses for free-standing advertising in line with the draft of the Landscape Resolution

The aim of this part of the study is to check which of the parameters considering advertising as compliant will be the most optimal to introduce in the Landscape Resolution. Two parameters have been considered. One of them is the distance from the intersection of road intersection axes (it will be a circle with the radius R) and the other is the distance between consecutive free-standing advertisement carriers located on one side of the selected streets in the City of Krakow (dp). Two radii R (100 m and 50 m) and three distances dp (80 m, 40 m, 20 m) were considered in the spatial analysis. In this way 6 variants were obtained, which are summarised in Table 9.

Table 8. A process of elimination of further non-compliant advertisements to the draft of the Landscape Resolution.

| Order of elimination of non-compliant advertisements | Code assigned to a particular elimination stage | Free-standing advertisements | | Advertisements on building structures | | Total remaining advertisements |
|---|---|---|---|---|---|---|
| | | Eliminated | Remaining | Eliminated | Remaining | |
| 1 | 2100 | 9 | 938 | 0 | 3 117 | 4 055 |
| 2 | 2200 | 0 | 938 | 4 | 3 113 | 4 051 |
| 3 | 2300 | 25 | 913 | 0 | 3 113 | 4 026 |
| 4 | 2400 | 24 | 889 | 0 | 3 113 | 4 002 |
| 5 | 3100 | 208 | 681 | 0 | 3 113 | 3 794 |
| 6 | 5100 | 22 | 659 | 834 | 2 279 | 2 938 |
| 7 | 5200 | 11 | 648 | 9 | 2 270 | 2 918 |
| 8 | 5300 | 3 | 645 | 0 | 2 270 | 2 915 |
| 9 | 6110 | 10 | 635 | 0 | 2 270 | 2 905 |
| 10 | 6120 | 100 | 535 | 0 | 2 270 | 2 805 |
| 11 | 6130 | 2 | 533 | 0 | 2 270 | 2 803 |
| 12 | 6210 | 0 | 533 | 17 | 2 253 | 2 786 |
| 13 | 6310 | 20 | 513 | 0 | 2 253 | 2 766 |
| 14 | 6320 | 2 | 511 | 0 | 2 253 | 2 764 |
| 15 | 6330 | 0 | 511 | 0 | 2 253 | 2 764 |
| 16 | 6340 | 0 | 511 | 0 | 2 253 | 2 764 |
| 17 | 6410 | 92 | 419 | 0 | 2 253 | 2 672 |
| 18 | 6420 | 9 | 410 | 0 | 2 253 | 2 663 |
| 19 | 6510 | 1 | 409 | 0 | 2 253 | 2 662 |
| 20 | 6520 | 0 | 409 | 0 | 2 253 | 2 662 |
| 21 | 6610 | 0 | 409 | 0 | 2 253 | 2 662 |
| 22 | 6620 | 0 | 409 | 0 | 2 253 | 2 662 |
| 23 | 6710 | 0 | 409 | 0 | 2 253 | 2 662 |
| 24 | 6720 | 0 | 409 | 0 | 2 253 | 2 662 |
| 25 | 6810 | 0 | 409 | 469 | 1 784 | 2 193 |
| 26 | 6820 | 0 | 409 | 0 | 1 784 | 2 193 |
| 27 | 4100 | 28 | 381 | 0 | 1 784 | 2 165 |
| 28 | 4200 | 13 | 368 | 0 | 1 784 | 2 152 |
| 29 | 4310 | 0 | 368 | 0 | 1 784 | 2 152 |
| 30 | 4320 | 0 | 368 | 0 | 1 784 | 2 152 |
| 31 | 4330 | 0 | 368 | 0 | 1 784 | 2 152 |
| 32 | 4340 | 0 | 368 | 0 | 1 784 | 2 152 |
| 33 | 4350 | 0 | 368 | 0 | 1 784 | 2 152 |
| 34 | 4360 | 0 | 368 | 0 | 1 784 | 2 152 |
| 35 | 3200 | 82 | 286 | 0 | 1 784 | 2 070 |
| **Total** | | **661** | | **1 333** | | |
| **Other** | | | **286** | | **1 784** | **2 070** |

Table 9 shows the number of advertisements that will remain when the two selected parameters are introduced. The number of advertisements that will remain in relation to the number of conforming advertisements measured on the selected street is shown in red as a percentage.

Table 9. A summary of the number of free-standing advertisements and the percentage of advertisements that remain after the introduction of the two parameters: R and dp.

| Street | Number of advertisements | | The number of ads that will remain after entering two parameters (R and dp) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | Compliant | R=100 m dp =80 m | % | R=100 m dp =40 m | % | R=100 m dp =20 m | % | R=50 m dp =80 m | % | R=50 m dp =40 m | % | R=50 m dp =20 m | % |
| B | 7 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 25 | 1 | 25 | 1 | 25 |
| C | 73 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 25 | 1 | 25 | 1 | 25 |
| D | 81 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 23 | 10 | 23 | 12 | 27 |
| J | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| L | 32 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 15 | 2 | 15 | 2 | 15 |
| K | 146 | 67 | 2 | 3 | 2 | 3 | 2 | 3 | 16 | 24 | 19 | 28 | 20 | 30 |
| A | 54 | 30 | 4 | 13 | 5 | 17 | 5 | 17 | 8 | 27 | 9 | 30 | 10 | 33 |
| R | 38 | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 | 2 | 12 | 2 | 12 |
| M | 21 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 13 | 2 | 13 | 2 | 13 |
| P | 109 | 45 | 8 | 18 | 9 | 20 | 11 | 24 | 17 | 38 | 19 | 42 | 21 | 47 |
| O | 47 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 33 | 1 | 33 | 1 | 33 |
| W | 46 | 30 | 1 | 3 | 1 | 3 | 1 | 3 | 7 | 23 | 7 | 23 | 7 | 23 |
| Z | 290 | 13 | 1 | 8 | 1 | 8 | 1 | 8 | 6 | 46 | 6 | 46 | 6 | 46 |

The graph (fig. 8) illustrates the percentage of advertisements that will remain on a given street after introducing a distance from the axis of intersections equal to R = 100 m and three different values of the distance between free-standing advertisements (dp). The next graph (fig. 9) shows a similar relationship, but for R = 50 m. Reducing the radius distance R from 100 m to 50 m results in a significant increase in the number of advertisements that will remain. In the case of Zakopiańska Street, this will increase the number of free-standing advertisements from 8% (for R = 100 m) to 46% (for R = 50 m). Percentages have been used in the charts below to standardise the data collected.

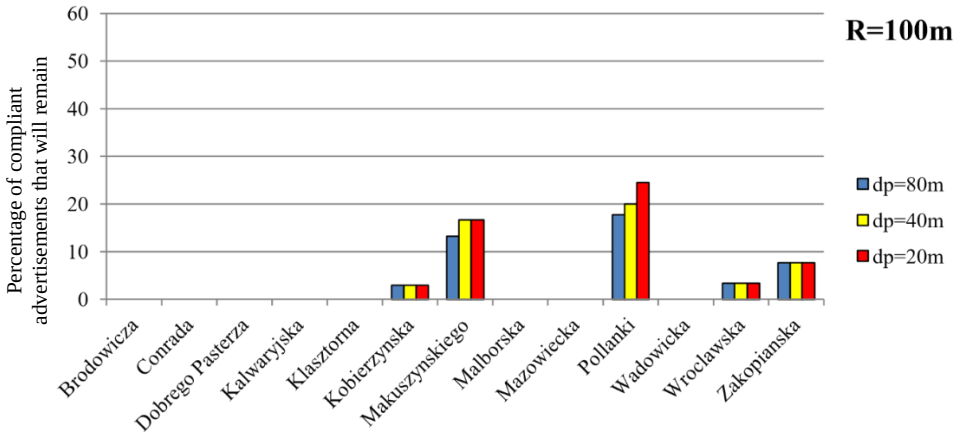


Figure 8. A percentage of complying free-standing advertisements that will remain after the introduction of R = 100 m and three dp values.

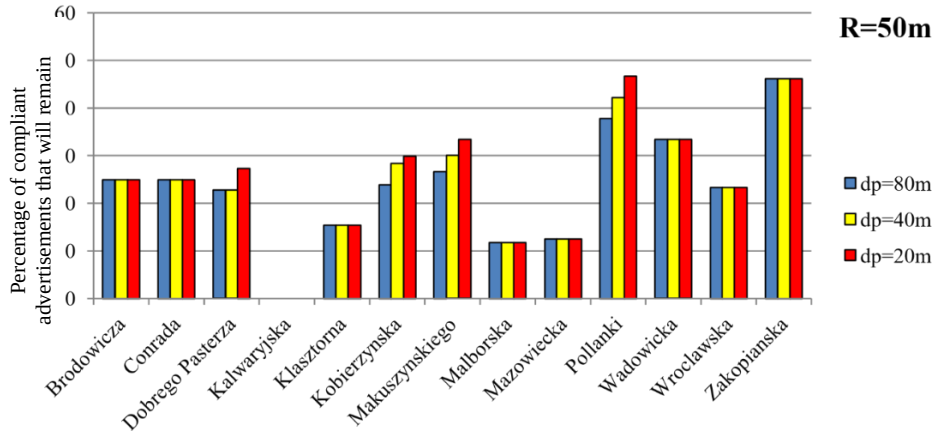


Figure 9. A percentage of complying free-standing advertisements that will remain after the introduction of R = 50 m and three dp values.

### 5.3 Analysis of advertising coverage for ground floor and building facades

The performance of spatial analyses also includes determining the location of advertisements on building structures, particularly on the ground floor front elevation and the front elevation of the building. For this purpose, the area of each advertisement located on the building was measured and the address of the building was determined. A list of advertising media located on the façade of the building was made, distinguishing whether the advertisements are located at ground floor level or beyond.

The statement considered the area of each advertisement, the sum of the areas of advertisements on the building and the sum of the areas of advertisements on the ground floor façade. These data were juxtaposed with the area of the ground floor façade and the area of the building façade, which were the basis for the calculation of the percentage of occupancy of advertisements on the ground floor façade and the percentage of occupancy of advertisements on the building façade.

The percentages obtained were verified against the provisions of the draft of the Landscape Resolution and the location of a given advertisement in the appropriate zone was considered. In Zone I, advertisements should occupy up to 25% of the ground floor front elevation, while in Zone III Sub-zones 2 and 3 - advertisements may only be placed on a maximum of 15% of the ground floor front elevation.

Table 10 presents the averaged values expressed as a percentage of advertising occupancy on the ground floor front façade and the number of façades where advertisements on buildings compliant with the draft of the Landscape Resolution are located. In addition, information is provided on the number of advertisements placed on the ground floor façade that are compliant and non-compliant with the draft of Landscape Resolution.

Table 10. A summary of the number of advertisements and average percentage of occupancy of advertising media on buildings for each street.

| Street in Krakow (abbreviation) | Number of building façades on which there are advertising carriers | Number of ground floor façades on which there are advertisements | Average value expressed as a percentage of occupied advertising on the ground floor façade [%] | Number of advertisements on the ground floor façade compliant with the draft resolution | Number of advertisements on the ground floor façade non-compliant with the draft resolution | Number of advertisements non-compliant with the draft resolution |
|---|---|---|---|---|---|---|
| B | 17 | 13 | 23.6 | 8 | 5 | 39 |
| C | 38 | 1 | 22.0 | 1 | 0 | 123 |
| D | 57 | 15 | 10.5 | 14 | 1 | 219 |
| J | 88 | 70 | 16.1 | 37 | 33 | 429 |
| L | 14 | 0 | 0.0 | 0 | 0 | 61 |
| K | 83 | 23 | 27.1 | 17 | 6 | 437 |
| A | 24 | 12 | 17.7 | 9 | 3 | 154 |
| R | 38 | 12 | 12.0 | 11 | 1 | 133 |
| M | 50 | 27 | 14.6 | 22 | 5 | 124 |
| P | 29 | 2 | 7.1 | 2 | 0 | 197 |
| O | 19 | 5 | 23.5 | 3 | 2 | 117 |
| W | 59 | 37 | 12.1 | 34 | 3 | 239 |
| Z | 156 | 28 | 22.2 | 19 | 9 | 629 |
| **Total** | **672** | **245** | | **177** | **68** | **2901** |
| **Average** | **52** | **19** | **16.0** | **14** | **5** | **223** |

## 6. SUMMARY

In the process of inventory of advertising media on 13 streets in Krakow, 4 055 free-standing advertisements and advertisements on building structures were measured. 69% of free-standing advertisements and 94% of advertisements mounted on building structures are not compliant with the draft of the Landscape Resolution prepared by the Municipality of Krakow in February 2019. With the average value of about 48 advertisements per 100m, Kalwaryjska street is the most crowded street with advertisements by the date of this study.

The results from the spatial analyses (fig. 8, fig.9) indicate that while defining the new constraints for the free-standing advertisements, the emphasis in the draft of the Landscape Resolution will be on the distance of free-standing advertisements from the road intersections (R) than the distance between consecutive free-standing advertisement on one side of the streets (dp).

Analysis of the placement of advertisements on the facades of buildings (particularly on the ground floor facades) revealed that 177 out of 245 advertisements comply with the draft resolution. However, the average value of advertising occupancy on ground-floor facades is 16% for all 13 inventoried streets in Krakow.

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## INWENTARYZACJA INFRASTRUKTURY REKLAMOWEJ WZDŁUŻ WYBRANYCH ULIC KRAKOWA

SŁOWA KLUCZOWE: chaos reklamowy, inwentaryzacja, panorama, mobilny system mapowania, fotogrametria sferyczna, fotogrametria immersyjna, Kraków, krajobraz

### Streszczenie

Zjawisko chaosu reklamowego spowodowane nadmiernym wykorzystaniem przestrzeni publicznej do celów promocyjnych od dawna budzi niepokój o krajobraz polskich miast. Próby egzekwowania obowiązujących regulacji prawnych w tej kwestii nie zakończyły się dotychczas znaczącym sukcesem. W artykule przedstawiono fotogrametryczne podejście do inwentaryzacji infrastruktury reklamowej na wybranych ulicach Krakowa w celu analizy wybranych zapisów projektu uchwały krajobrazowej. Do pozyskiwanie georeferencyjnych obrazów panoramicznych wykorzystano imersyjny system mobilny składający się z imersyjnej kamery połączonej z sensorami GNSS/IMU. Przeprowadzając pomiary fotogrametryczne na uzyskanych obrazach wykonano inwentaryzację infrastruktury reklamowej dla 27.8 km ulic. Stosując techniki fotogrametrii imersyjnej zmierzono łącznie 4055 reklam wolnostojących i reklam na budynkach. Po etapie inwentaryzacji sprawdzono zgodność istniejących reklam z projektem uchwały krajobrazowej za pomocą analizy jakościowej i przestrzennej. Wyniki tych analiz wskazują, że 69% reklam wolnostojących i 94% reklam na budynkach przy wybranych ulicach jest niezgodnych z projektem uchwały i że w tej uchwale większy nacisk zostanie położony na odległości reklam od drogi niż odległości między wolnostojącymi reklamami.

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