# The use of spatial data to identify land reserves for minimising the negative effects of COVID–19 pandemic on the example of selected districts of Warsaw

**Łukasz KUZAK, Marianna ULANICKA–RACZYŃSKA, Alina MACIEJEWSKA, Poland**

**Key words**: Access to land; Land distribution; Land management; Land readjustment; Spatial planning; Urban renewal

## SUMMARY

One of the most significant contemporary threats to the population is the pandemic of the coronavirus COVID–19 covering the entire world. The latest data shows that due to the pandemic, several hundred million people have fallen ill since the beginning of 2020. Mostly urban areas with high–density housing and limited access to services are affected. There is often a lack of time, resources, and space to develop primary services available near the place of residence. In the face of progressing urbanisation and expanding pandemic, it is necessary to rationally manage urban space, ensuring the use of unused, post–industrial areas on the one hand, and minimising the spread of the virus and, consequently, improving the health of residents on the other. One solution that has a beneficial effect in cities is the effective management of empty, undeveloped areas in the urban tissue.

This paper aims to show that commonly available spatial data can be successfully used to select investment locations related to mitigating the negative effects of the pandemic. Two districts of Warsaw were chosen for the study – one typically urbanised – Mokotów, the other with large undeveloped areas for construction – Białołęka. The study analysed the land reserves of these districts.

Spatial analyses of the data made it possible to identify optimal locations which constitute land reserves that can be used for essential services. Based on the analysis results, planners can effectively create a set of recommendations for local governments. Thanks to these recommendations, municipalities will be able to manage their land reserves and eventually adapt them for the purposes mentioned above.

As a result, it is expected that effective management of land reserves using publicly available spatial data will clearly improve preventive actions in case of an emergency such as a pandemic. In addition, the proposed design solutions are also universal, as based on the data on available field reserves and their status, management in emergencies will be possible such as a pandemic.

# The use of spatial data to identify land reserves for minimising the negative effects of COVID–19 pandemic on the example of selected districts of Warsaw

**Łukasz KUZAK, Marianna ULANICKA–RACZYŃSKA, Alina MACIEJEWSKA, Poland**

## 1. INTRODUCTION

One of the most significant contemporary threats to the population is the COVID–19 coronavirus pandemic sweeping across the globe. The latest figures show that several hundred million people have fallen ill due to the pandemic since the beginning of 2020. The problem mainly affects urban areas with high housing density and limited access to health services and facilities, which have recently struggled to serve patients of different health and age groups (Xie at al., 2020). There is often a lack of time, resources, and space to develop hospitals specifically dedicated to infectious diseases or first aid services available in the immediate vicinity of the residence.

Another challenge facing the world today is the armed conflicts taking place, for example, in Ukraine, the Middle East and Africa. One of the most noticeable effects, apart from war losses, is enormous waves of refugees. Receiving them in a dignified manner in countries that are safe for them is often a major logistical challenge. It is necessary to provide both medical facilities and, above all, accommodation for the duration of the crisis and until they find their final home. Temporary accommodation facilities are starting to be provided in closed shopping centres, factories or sports stadiums.

In the face of progressing urbanisation, as well as the occurrence of various crises, it becomes necessary to rationally manage urban space, guaranteeing, on the one hand, the use of unused, post–industrial areas and, on the other, minimising the spread of the virus, improving the health of residents or helping refugees or other people in emergencies. One of the solutions to benefit cities is the effective management of empty, undeveloped areas in the urban fabric and the practical introduction of greenery through the design of green infrastructure (Li, Zhang, 2022).

The aim of the study described in the article was:

1. preventing the effects of pandemics and other emergencies using the decision–making model of field reserve management;
2. supporting the decision–making process of selecting locations for investments related to reducing the harmful effects of pandemics and other emergencies on the lives of city residents.

In the long term, it will be possible to create recommendations and guidelines for municipalities to effectively manage land reserves under conditions of limited social mobility.

## 2. LITERATURE REVIEW

Many historically industrially used areas currently remain unused and constitute the city's land reserve with high potential for use in emergencies. Unfortunately, areas of former industrial activity constitute a very heterogeneous group that varies in terms of the size of individual areas, the proportion of open land or the state of preservation of industrial infrastructure (Van Liedekerke et al., 2013). Often, rational management of such areas is not easy due to their problematic conditions – they are often areas with unregulated ownership status, polluted or flood–prone areas (Rall and Haase, 2010).

So far, many solutions have been developed to manage vacant, undeveloped land effectively. These have primarily been tools based on brownfield sites. Examples of such solutions include the projects HOMBRE –Holistic Management of Brownfield Regeneration (Malina, Gumuła–Kawęcka, 2015), TIMBRE – Tailored IMprovement of Brownfield Regeneration in Europe (Bleicher, Bartke, 2013) or the CIRCUSE database (CIRCUSE: Managing Land Use for the Benefit of All–Projects, 2015).

In the face of the emergencies that occur, the rational management of land reserves has become an even greater challenge for many cities worldwide. Together with public green spaces, they are of vital importance for epidemiological constraints, playing a natural or ecological role and, above all, a social one (Majewska and Denis, 2022; Li, Zhang, 2022).

The COVID–19 pandemic had a significant impact on the scale of large urban centres around the world (Liu, 2020; Vaz, 2021; Xie at al., 2020) and smaller suburban localities (Majewska, Denis, 2022). Studies have noted a relationship between distance to basic needs services and the development of emergencies such as pandemics – areas characterised by poorer access to services were potentially more vulnerable places (Han et al., 2021). Mitigation of such emergencies can be implemented by combining local policies with spatial monitoring at the level of neighbourhood accessibility of important primary facilities in large cities (Vaz, 2021). Such measures can be implemented based on unused land, but this requires an adequate inventory of land reserves located within the unit's boundaries. The use of modelling methods and spatial analysis allows the management of urban space transparently and, consequently, to cope with crises (Di Giovanni and Chelleri L, 2019; Guliyev, 2020).

## 3. DATA SOURCES USED AND METHODOLOGY ADOPTED

Two districts of Warsaw were chosen for the study – one typically urbanised – Mokotów, the other with large areas not developed for housing – Białołęka.

Mokotów, which was incorporated into Warsaw in 1916, is a district dominated by buildings, some of which are residential villas and embassies, while others are housing estates. The western part of the district, Służewiec (commonly known as Industrial), is a remnant of the former industrial area but is now occupied mainly by modern office buildings. The area remaining undeveloped is the eastern part of the district – Siekierki and Augustówka. It is due

to, among other things, the flood risk and restrictions resulting from the industrial centres located there (e.g. EC Siekierki).

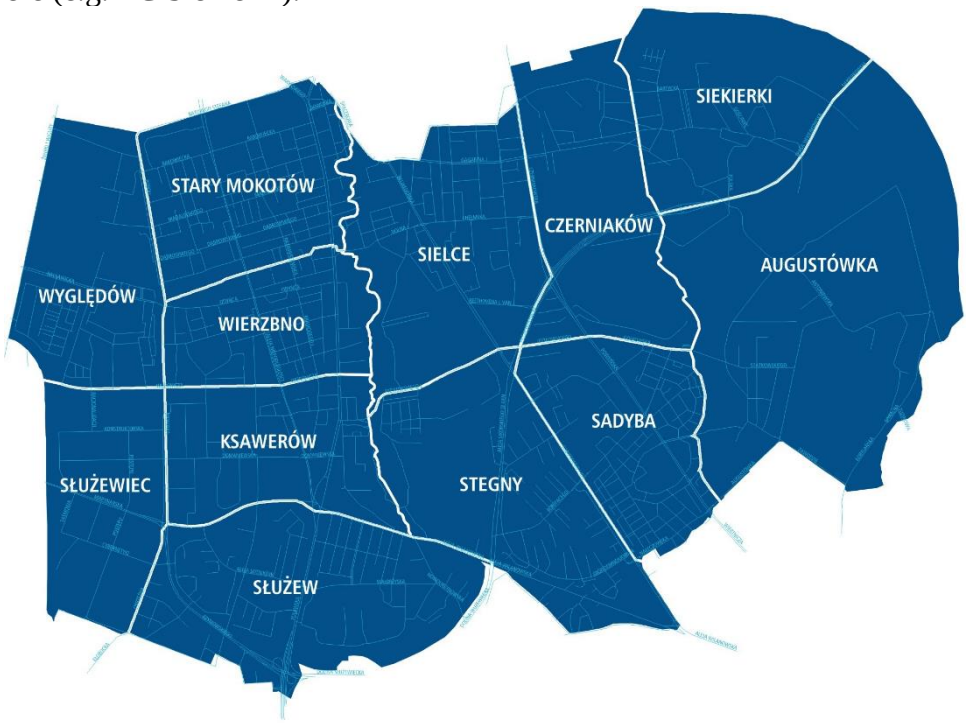


Fig. 1. Division of Mokotów district into MSI areas (Source: https://zdm.waw.pl)

Białołęka, as an outlying district annexed to Warsaw in 1951, is a much more diverse district. It is functionally divided into the following parts:

- industrial – which is located in the central, south–western part of the district (Żerań – activities of EC Żerań, Polfa Tarchomin SA, railway areas),
- residential areas with predominantly single–family housing – northern and mid–northern part of the district (e.g. Pludy, Henryków, Choszczówka) – areas of gradual suburbanisation,
- housing developments intermingled with farmland and village areas – eastern part of Białołęka (e.g. Grodzisk, Brzeziny, Kobiałka) – areas of gradual suburbanisation, often uncontrolled,
- high–density housing developments (clearly dominated by tall buildings) – central–western part of the district (e.g. Nowodwory, Tarchomin),
- forest areas in the northern part of the district (Białołęka Dworska).

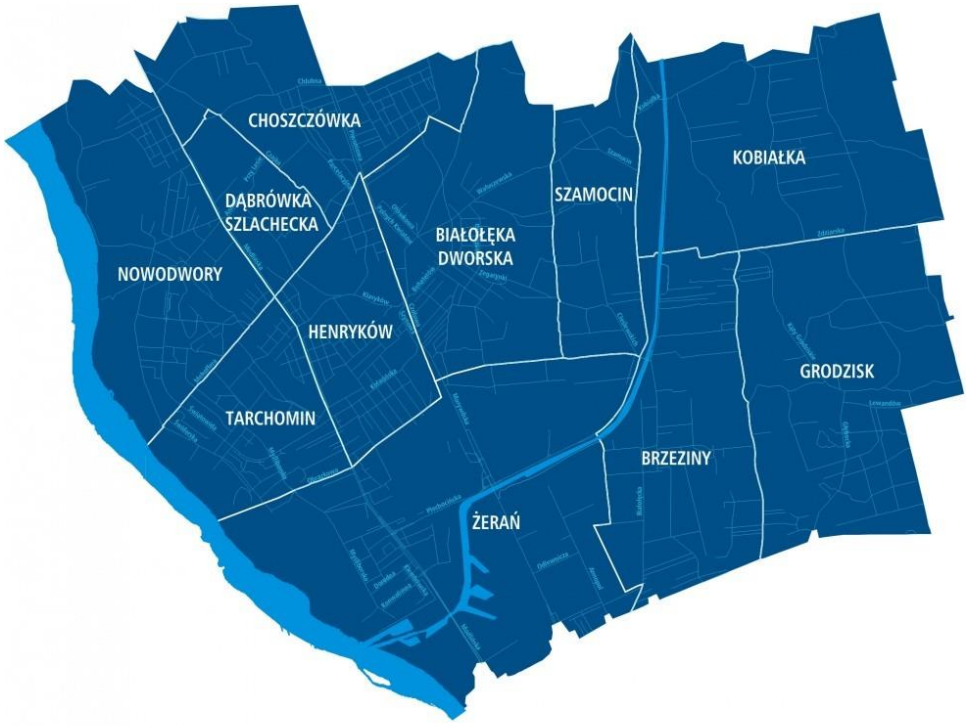

Fig. 2. Division of Białołęka district into MSI areas (Source: https://zdm.waw.pl)

The research analysed the field reserves of these districts based on a set of selected criteria:

- location,
- current usage,
- the legal and ownership status of the site,
- the findings of the local spatial development plan,
- pollution,
- neighbourhood.

The criterion for selecting land reserves is primarily the areas marked as unused and non–functional in the study of conditions and spatial development of the Capital City of Warsaw and the BDOT10k database of topographic objects. Additionally, the model also considered areas marked in the study as production and service areas, where no economic activity is currently taking place.

The first critical stage of the task was to collect the necessary data and information on available field reserves in selected districts of Warsaw. The following data sources were used for this purpose:

- Geoportal 2 – as regards the location of evidential parcels and their area;
- an orthophoto map to determine the current land use;
- the current local spatial development plans and the Warsaw Spatial Development and Management Study in terms of defining the current land use and the target anticipated function;

- land ownership map in terms of determining the legal and ownership status of individual sites;
- lists of historical land surface pollution of individual Warsaw districts and the Register of Historical Land Surface Pollution of the General Directorate for Environmental Protection – identifying potential historical pollutants affected by the analysed areas.

## 4. THE CRITERIA ADOPTED AND THE SELECTION OF AREAS TO BE DEVELOPED

In the procedure for identifying field reserves, the 1:10,000 Topographic Database was used as a basis. The following areas were selected from the said database:

- PTLZ – forest and wooded area,
- PTRK – shrubby vegetation,
- PTTR – grassy vegetation,
- PTGN – unused land,
- PTNZ – remaining undeveloped land,
- KUPG – industrial and economic complex,
- KUSK – a sports and recreational complex.

Subsequently, the following areas were eliminated: forests (as defined by the The Forest Act of 28 September 1991, land with a compact area of at least 0.10 ha), selected protected areas whose presence significantly limits the possibility of land development (Natura 2000 areas, nature reserves, national and landscape parks), areas intersecting with roads and directly adjacent to them, areas unsuitable for development because of the carrying capacity criterion (all organic soils) and the humidity criterion (soils of agricultural suitability complexes 1z, 2z, 3z, 8 and 9). Soil criteria were adopted in accordance with the methodology presented by Bielska and Oberski (2014). In the next step, areas smaller than 4000 m2 were excluded due to the assumption of use for functions of public importance. For the areas selected in this way, the ownership of the land was determined (with division into State Treasury land, land owned by the Capital City of Warsaw and private land), as well as its designation in local spatial development plans (the only spatial legal acts in Poland according to Spatial Planning and Land Development Act of 27 March 2003) and the possible occurrence of historical contamination of the earth's surface based on available lists obtained from individual districts and the register of the General Directorate for Environmental Protection.

A database was created to gather comprehensive information on land reserves located in selected districts based on the collected data. A total of 756 such areas were classified – 517 in Białołęka district and 239 in Mokotów district.

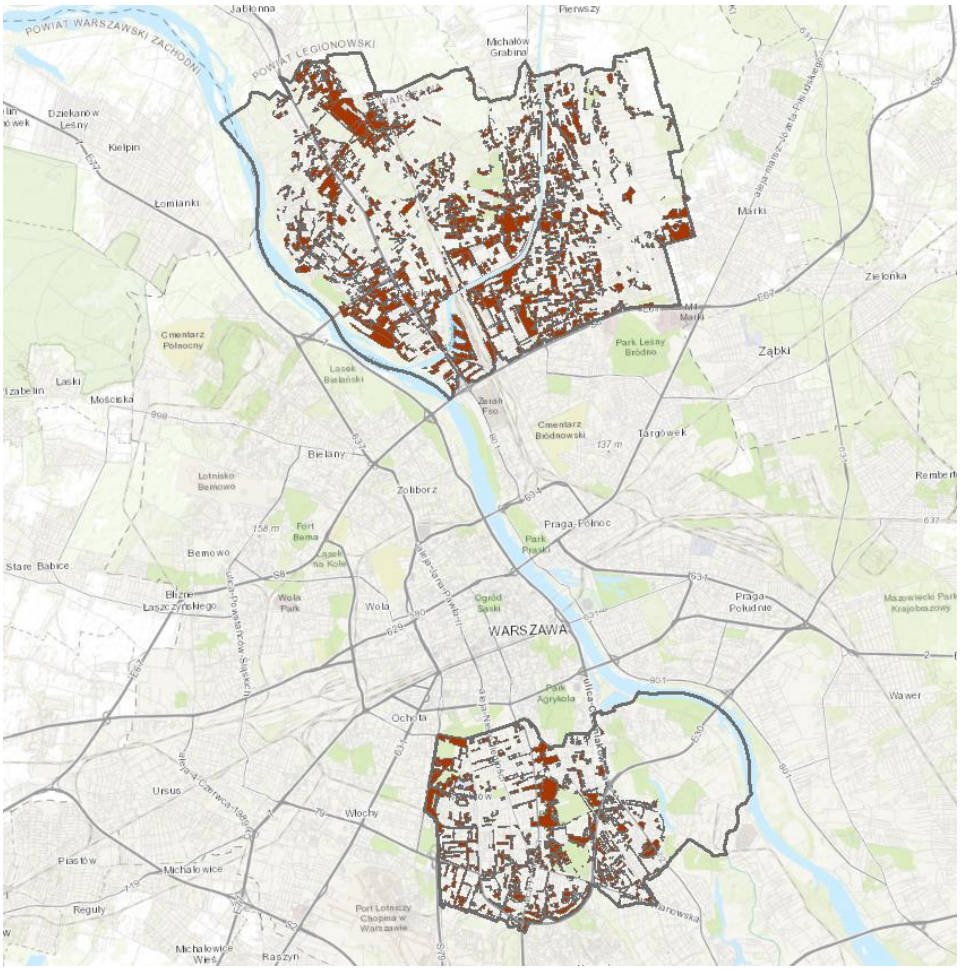

Fig. 3. Location of field reserves included in the created database (Source: own elaboration)

Based on the adopted criteria and the obtained database, a procedure was implemented to select areas that could serve as potential locations for constructing the required infrastructure, e.g. field hospitals, one–named hospitals, and temporary housing. For this purpose, the following selection from the available areas, made in ArcMap software, was formulated:

- an area of not less than 13 000 m2 (this is the average area of a single development quarter in Warsaw);
- the property of the City of Warsaw or the State Treasury (only in this case is it possible to develop it in the event of an emergency immediately);
- designation in local spatial development plans as residential, commercial, industrial or several of the above (i.e. mixed–use – residential–service, commercial–industrial, etc.);
- Sites that are not on the historical land surface contamination register (the threat of the existence of historical land surface contamination prevents the immediate use of the land reserve).

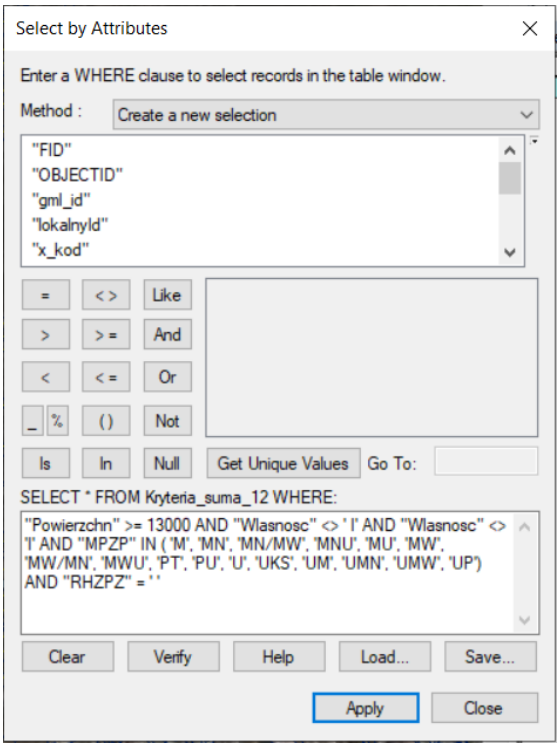


Fig. 4. Data selection procedure performed in ArcMap software (Source: own elaboration)

The procedure resulted in 14 areas located in Białołęka district and 9 areas located in Mokotów district. Their exact locations are shown on the attached maps. It is worth noting that a similar number of areas meeting the criteria were distinguished in both cases. It means that irrespective of whether it is an urbanised district or a developing one, it is possible to find areas that may be used in a crisis – both for the location of a temporary aid station and for permanent housing resulting from emergency needs.

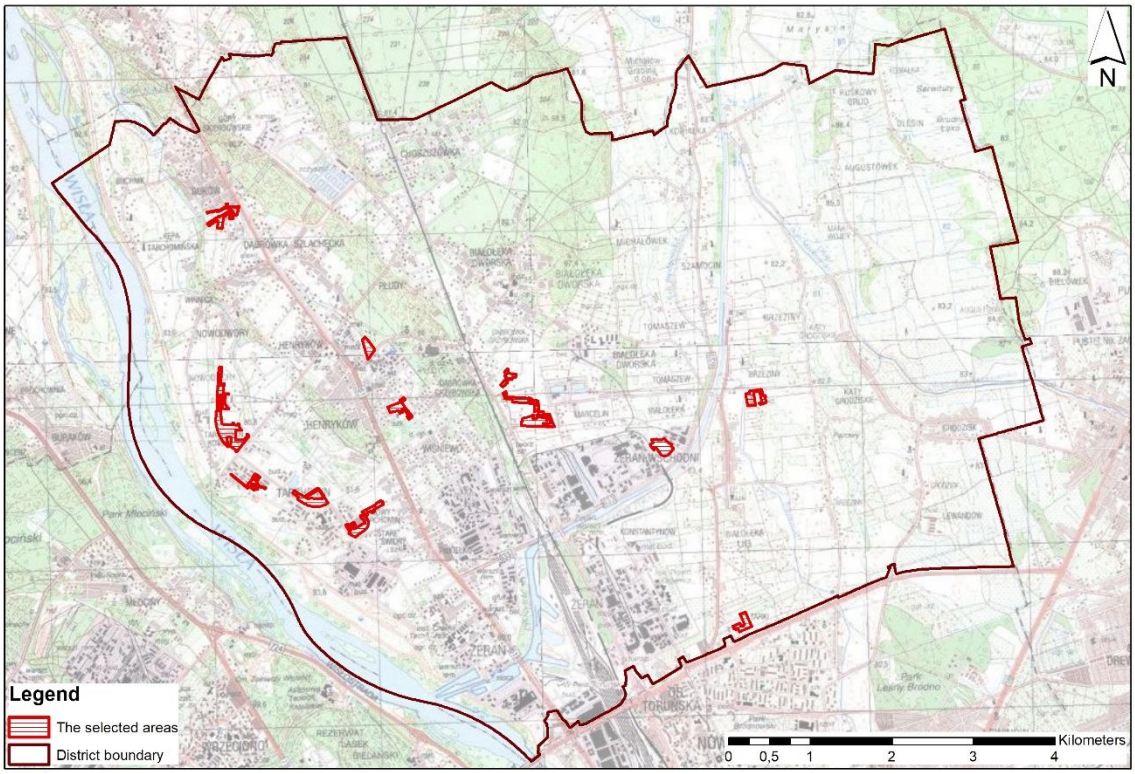


Fig. 5. Selected terrain reserves in the Białołęka district (Source: own elaboration)

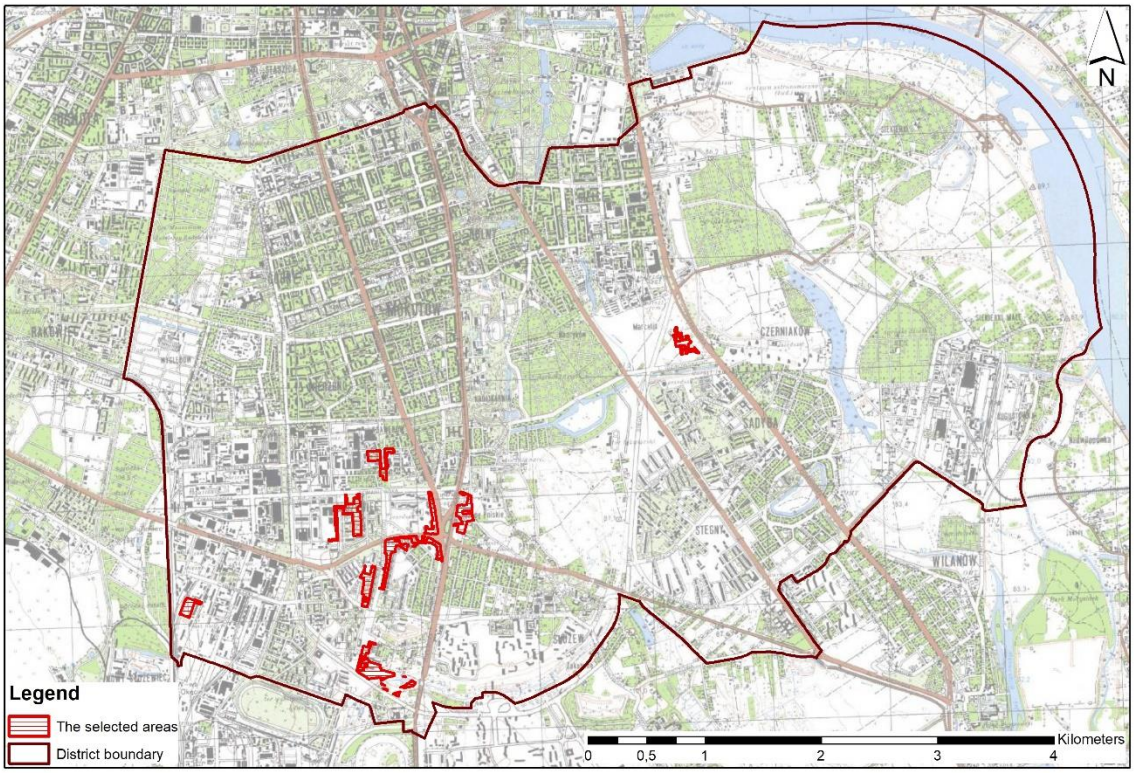


Fig. 6. Selected terrain reserves in Mokotów district (Source: own elaboration)

In order to make the final choice of the area optimal, the authors propose to use weighting of particular criteria based on a survey conducted among inhabitants or determined by an expert method. On this basis, it will be possible to identify needs and determine which factors are dominant in locating a given facility. A key element resulting from the residents' survey is the accessibility of the areas to potential customers and the demand in a given location. In addition, for the already selected area, it is recommended to create a set of guidelines, including tips on how to develop the area, taking into account the adopted share of biologically active surface or solutions minimising the negative impact on the surroundings. Depending on the situation, crisis development may constitute only a temporary element of the city space and should be planned in such a way that its effects will not be visible for many years to come.


Fig. 7–8. Example areas selected under the adopted procedure (Source: Google Maps)

Examples of selected areas include (pictured above) areas currently serving as undeveloped squares, wild car parks, and unmanaged green spaces, among others. These areas are currently undeveloped. Ultimately, under the provisions of local plans, residential or service development is planned to be located in this area. Therefore, they can be relatively easily developed in case of emergency, without carrying out complicated administrative procedures or liquidating the existing use.

## 5. THE EFFECTS OF APPLYING THE MODEL

As part of the task, a decision–making model was built based on a multi–criteria analysis of the site's suitability for immediate development as a one–named hospital and other facilities providing services related to pandemic mitigation and other emergencies. The data for the above analyses will come from the previously created database, and their wide range allowed for the identification of suggested locations, depending on the adopted set of criteria. On this basis, it is possible to create a set of recommendations aimed at helping municipalities to manage their land reserves in such a way that they can be adapted to the purposes mentioned above as soon as possible.

Due to their nature and accompanying ownership, planning and environmental conditions, the areas identified as a result of the analysis can be successfully developed to build the

infrastructure needed in emergencies e.g., field hospitals, one–room hospitals, temporary housing. Thanks to the created model, a limited number of possible locations where indicated in each district (from several to a dozen areas out of several hundred indicated in the initial database). In this way, decision–makers can quickly and easily find the optimal location for investment and start implementing it as soon as possible.
As a result, it is expected that the efficient management of field reserves will clearly contribute to improved preventive action in the event of an emergency such as a pandemic, as well as to a higher standard of living and health of the population. In addition, the proposed project solutions are also universal, as based on the data on available field reserves and their status, management in other emergencies will be possible.

## 6. SUMMARY AND FURTHER DEVELOPMENT OF THE METHODOLOGY

In the face of challenges facing contemporary societies and crises, sustainable development is a key strategy for building a stable future for our planet. Rational management of space, with particular emphasis on land reserves, and social decisions taken in this respect have a significant impact on achieving the objectives of sustainable development and, consequently, on improving living conditions nowadays as well as in the future.

The methodology of analysis proposed in the article, indicating the possibility of using land reserves for purposes related to the prevention of unforeseen emergencies, is an innovative and interdisciplinary approach to the subject of spatial planning, taking into account the importance of social responsibility, social awareness and the concept of the common good.

Shaping the space of modern cities should take place with the strong participation of modern society in achieving the objectives of sustainable development. It is reflected in the created model based on a survey conducted among the inhabitants of the Mazowieckie Voivodeship.

As part of the study implementation, a database of field reserves within the two analysed districts was created. The basic data sources included the database of topographic objects available to the City of Warsaw and lists of potential historical ground surface contamination obtained from district offices. In this way, prospective areas were selected which could serve as reserves and be developed in crises – post–industrial areas, disused areas, sports facilities, agricultural areas, green areas etc. Data were also obtained on historical pollution of the earth's surface for the Capital City of Warsaw area. In addition, the data collected in the database were supplemented by data from the land and building register concerning ownership and the decision on land development conditions and location of public purpose investments. The database created this way formed the basis for the decision–making model described above.

A survey is currently being carried out on a representative sample of the inhabitants of the Mazowieckie Voivodeship. The survey concerns the needs of respondents in an emergency, such as the COVID–19 pandemic and refugee influx. It is possible to determine what should be the primary determinant for selecting optimal spaces for adaptation for the purposes of first necessity services, new public spaces, or places for medical and humanitarian aid. Based on this, the criteria adopted in the analyses will receive their weights, on the basis of which it will

be possible to valorise the selected areas. The study will also be extended to other emergency destinations, such as document checkpoints, testing, vaccination, and other first contact points for people in emergencies, e.g. refugees or people affected by natural disasters (floods, large fires), and recreation areas crucial during the COVID–19 pandemic.

## REFERENCES


Bielska A., Oberski K., 2014, Wyłączenie spod zabudowy gruntów nadmiernie uwilgotnionych klasyfikowanych za pomocą narzędzi GIS, w: Infrastruktura I Ekologia Terenów Wiejskich, Vol. II/2/2014, ss. 411–421,

Bleicher, A., Bartke, S. (2013): Decision support for sustainable land re–use – international approaches and tools – Wsparcie procesu decyzyjnego przy ponownym użytkowaniu terenu z zachowaniem zasady zrównoważonego rozwoju. Międzynarodowe podejścia i narzędzia, in: Skowronek, J. (ed.): Innowacyjne rozwiązania rewitalizacji terenów zdegradowanych, Instytut Ekologii Terenów Uprzemysłowionych, Katowice, ss.183–189,

Di Giovanni G., Chelleri L., 2019, Why and how to build back better in shrinking territories?, w: DISASTER PREVENTION AND MANAGEMENT, Vol. 28 Issue 4, ss. 460–473,

Ec.europa.eu. 2015. CIRCUSE: Zarządzanie użytkowaniem terenu z korzyścią dla wszystkich– Projekty. [online] Available at: <https://ec.europa.eu/regional_policy/pl/projects/austria/circuse-managing-land-use-for-the-benefit-of-all> [Accessed 6 March 2022],

Guliyev H., 2020, Determining the spatial effects of COVID–19 using the spatial panel data model, w: Spatial Statistics, Vol. 38 (2020), ss. 1–10,

Li W., Zhang P., 2022, The Geographical Distribution and Influencing Factors of COVID–19 in China, w: Tropical Medicine and Infectious Disease, Vol. 7(3), 45, ss. 1–25,

Liu L., 2020, Emerging study on the transmission of the Novel Coronavirus (COVID–19) from urban perspective: Evidence from China, w: CITIES, Vol. 2020, ss. 103,

Malina G., Gumuła–Kawęcka A., 2015: Zrównoważona rewitalizacja „modelowego" terenu zdegradowanego z wykorzystaniem rozwiązań projektu Unii Europejskiej HOMBRE. in: Skowronek, J. (ed.): Innowacyjne rozwiązania rewitalizacji terenów zdegradowanych, Instytut Ekologii Terenów Uprzemysłowionych, Katowice, t. 7, ss. 165–182,

Majewska A., Denis M. et al., 2022, Pandemic resilient cities: Possibilities of repairing Polish towns and cities during COVID–19 pandemic, w: Land Use Policy, Vol. 113, ss. 1–15,
Morrow O., Parker B., 2020, Care, commoning and collectivity: from grand domestic revolution to urban transformation, w: URBAN GEOGRAPHY, Early Access July 2020,

Rall E.L., Haase D., 2011, Creative intervention in a dynamic city: A sustainability assessment of an interim use strategy for brownfields in Leipzig, Germany, w: Landscape and Urban Planning, vol. 100 (2011), ss. 189–201,

Xie X., Naminse E. R., Liu S., Yi Q., 2020, The spatial and temporal pattern of COVID–19 and its effect on humans' development in China, w: GLOBAL JOURNAL OF ENVIRONMENTAL SCIENCE AND MANAGEMENT–GJESM, Vol. 6, ss. 107–118,

Van Liedekerke M., Prokop G. et al., 2013, Progress in the Management of Contaminated Sites in Europe. EUR 26376. Luxembourg (Luxembourg), Publications Office of the European Union,

Vaz E., 2021, COVID–19 in Toronto: A Spatial Exploratory Analysis, w: Sustainability, Vol. 13, Issue 2, ss. 1–15,

The Forest Act of 28 September 1991 (Dz. U. 1991 No 101 poz. 444 with later d.),

Spatial Planning and Land Development Act of 27 March 2003 (Dz.U. 2003 No 80 poz. 717 with later d.).

## BIOGRAPHICAL NOTES

Łukasz Kuzak, M.Sc. Eng. – research and teaching assistant at the Faculty of Geodesy and Cartography at the Warsaw University of Technology, Department of Spatial Management and Environmental Sciences, specialises in the revitalisation of post–industrial areas and the use of spatial analyses in spatial development.

Marianna Ulanicka–Raczyńska, M.Sc. Eng. – research and teaching assistant at the Faculty of Geodesy and Cartography at the Warsaw University of Technology, Department of Spatial Management and Environmental Sciences, specialises in the revitalisation and rational management of post–industrial areas.

Alina Maciejewska, Prof. – professor at the Faculty of Geodesy and Cartography at the Warsaw University of Technology, Department of Spatial Management and Environmental Sciences, specialises in the revitalisation of post–military and post–industrial areas as well as reclamation and development of degraded areas, President of the Scientific Society for Revitalisation, in the years 2012–2020 Dean of the Faculty of Geodesy and Cartography of the Warsaw University of Technology

## CONTACTS

**M.Sc. Eng. Łukasz KUZAK**
Warsaw University of Technology
Faculty of Geodesy and Cartography
Warsaw, Poland
Email lukasz.kuzak@pw.edu.pl

**M.Sc. Eng. Marianna ULANICKA–RACZYŃSKA**
Warsaw University of Technology
Faculty of Geodesy and Cartography
Warsaw, Poland
Email marianna.ulanicka@pw.edu.pl

**Prof. Alina MACIEJEWSKA**
Warsaw University of Technology
Faculty of Geodesy and Cartography
Warsaw, Poland
Email alina.maciejewska@pw.edu.pl