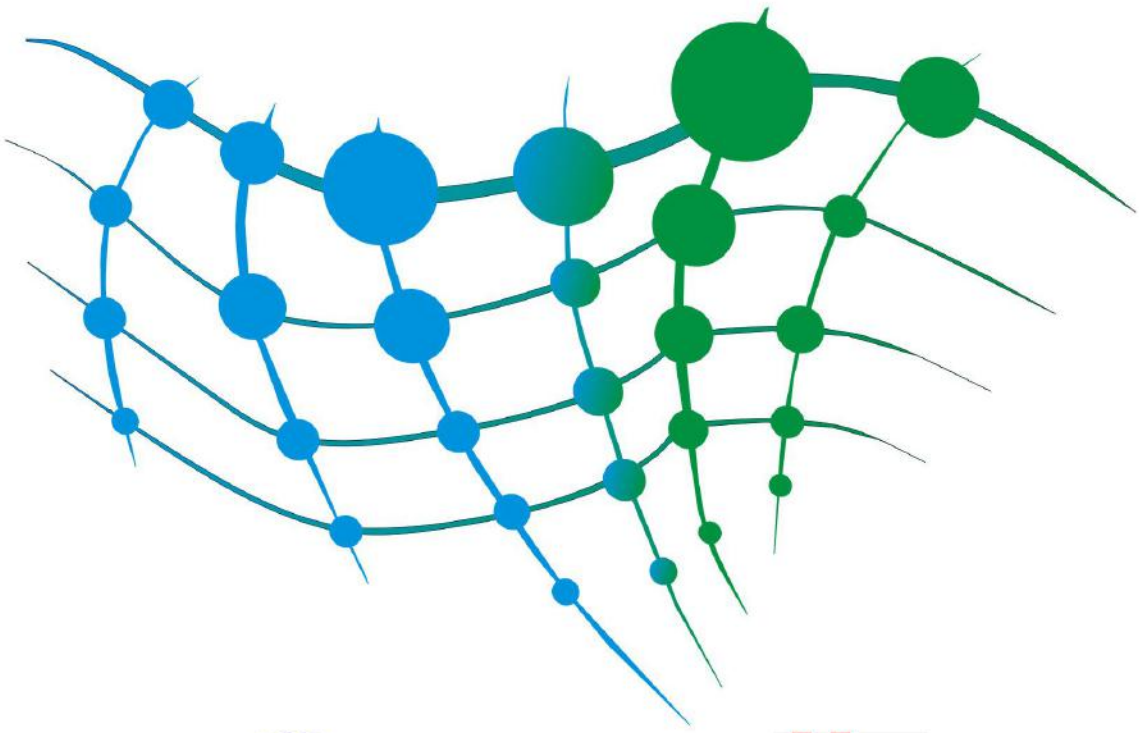
2022
SEMI-ANNUAL
Vol. 2
No. 1

ISSN 2720-2682

GIS Odyssey Journal

Previously: Conference proceedings (GIS Odyssey)



SILGIS Association

Croatian-Polish
Scientific Network

Vol. 2 No. 1 (2022): GIS Odyssey Journal

DOI: https://doi.org/10.57599/gisoj

The electronic version of the journal is the primary one.

The articles published in the “GIS Odyssey Journal” have been given a favourable opinion by the reviewers designated by the Editorial Board.

Cover designer: Assist. Prof. Anna Żemła-Siesicka Ph.D., University of Silesia in Katowice, Poland
Technical support: Assist. Prof. Krzysztof Świtała, Ph.D., Cardinal Stefan Wyszyński University in Warsaw, Poland

ISSN 2720-2682 (on-line)

Publisher: SILGIS Association, Będzińska Street 39/401, 41-200 Sosnowiec
tel. +48 32 3689716, e-mail: silgis@us.edu.pl, www.silgis.us.edu.pl
Co-publisher: Croatian-Polish Scientific Network, e-mail: cpsn@us.edu.pl, www.cpsn.us.edu.pl

Contact: gisjournal.us.edu.pl, www.us.edu.pl

Articles:

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.5

Agnieszka Dawidowicz[1], Magdalena Nowak[2]

THE CONCEPT OF URBAN GREENERY MANAGEMENT BODIES (UGMB) ORGANIZATIONAL STRUCTURE RESPONSIBLE FOR THE IMPLEMENTATION OF GREEN INFRASTRUCTURE IN EU MEMBER STATE OF POLAND

Abstract: The European GREEN SURGE project analyzing the best European practices in urban green infrastructure (GI) management showed that there is a lack of uniform solutions on national levels. The implemented GI are locally initiated and have the scope of selected cities. There is a need to standardize approaches to GI development in all cities of EU member states. An important current goal is to develop organizational assumptions for GI implementation. Standardization of the organizational structure of UGMB is necessary in order to give the right access and management licenses to, for example, create and operate an urban greenery information system. The main objective was to develop an organizational concept for Urban Greenery Management Bodies (UGMB) in line with the Urban Greenery Management System (UGMS) concept and key Green Infrastructure benefits. Three main competency poles responsible for optimal GI implementation are identified e.g. planning (expert body), administration (regulatory body), and field operations (executive body). The proposed concept of UGMB organizational structure can be a model for other EU member states, but also for other countries applying for EU membership.

Keywords: green infrastructure, urban greenery management, spatial data infrastructure, geoportal, city greenery authority

Received: 22 June 2022; accepted: 2 July 2022

[1] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Institute of Spatial Management and Geography, Department of Land Management and Geographic Information Systems, Olsztyn, Poland, ORCID ID: https://orcid.org/0000-0002-8445-3095, email: agnieszka.dawidowicz@uwm.edu.pl
[2] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Institute of Spatial Management and Geography, Department of Land Management and Geographic Information Systems, Olsztyn, Poland, ORCID ID: https://orcid.org/0000-0002-4685-6811, email: magda.nowak@uwm.edu.pl

Introduction

The quality of urban green spaces is a key factor in making cities attractive and viable places to live in. Urban green spaces play an important role in improving the livability of towns and cities (Baycan-Leven & Nijkamp, 2004). Public green spaces are regarded as "oases in concrete jungles" that increase the value of the real estate (Szczepańska et al., 2016). The development of urban greenery was particularly influenced by European Commission guidelines and standards (EC, 2012a; 2013, 2016) recommending the implementation of consistent green policies and the development of Green Infrastructure (GI). The relevant documents often emphasize the importance of green information systems that support the establishment and management of GI (Nowak et al., 2020). Dedicated Geographic Information Systems (GIS) should play an important role in urban greenery management. These systems not only can facilitate GI development, but they can also raise public awareness on the significance of public green spaces in cities. According to Mazza et al. (2011), the importance of GI in cities should be promoted through dedicated campaigns, and best practices should be communicated to the public. Greening projects undertaken in public-private partnerships (PPP) should receive greater support, and payments for ecosystem services should be introduced (Mazza et al., 2011). However, despite extensive research and the availability of GI guidelines, the implementation of green information systems supporting urban greenery management continues to be problematic in the EU (Naumann et al., 2011). These difficulties are associated mainly with lack of funding, insufficient experience in implementing different stages of GI projects, and lack of economic incentives because the benefits of GI are difficult to assess in financial terms. A universal and consistent urban greenery management system (UGMS) has not been developed in Poland to date. Databases on green infrastructure are created individually by Polish cities, subject to their financial capabilities. As a result, decisions concerning urban greenery are usually issued for individual development projects (Biejat, 2017a).

The absence of a comprehensive approach to urban greenery management results from a flawed urban planning system in Poland and a general disregard for public spaces (SAO, 2017). There are no laws mandating the development and implementation of IT systems dedicated to urban greenery management. Natural resources are managed based on the provisions of local strategic documents, local environmental protection programs, and local land use plans. The relevant regulations are often highly generalized, which obstructs the implementation of comprehensive solutions for environmental protection and management. Local regulations have been drafted and implemented by selected Polish cities. For example, Kraków has introduced local standards for the establishment and management of public green spaces (Biejat, 2017a). The implementation of comprehensive solutions for urban greenery management is also problematic due to weak communication between experts, public administration bodies, and local residents, as well as poor access to the relevant data (Sendzimir Foundation, 2019).

Polish conditions in terms of GI implementation do not diverge glaringly from those of other European countries. The European GREEN SURGE (GS) project (Pauleit et al., 2019) analyzing the best European practices in urban green infrastructure management showed that there is a lack of uniform solutions on national levels. The implemented GI are locally initiated and have the scope of selected cities e.g. in Barcelona (Spain), Bari (Italy), Berlin (Germany), Edinburgh (UK), Ljubljana (Slovenia), and Malmö (Sweden). There is a need to standardize approaches to GI development in all cities of EU member states. An important current goal is to develop organizational assumptions for GI implementation. Standardization of the organizational structure of UGMB is necessary in order to give the right access and management licenses to, for example, operate UGMS.

Having in mind the organizational problems mentioned above and assuming as a goal the implementation of the UGMS concept proposed by Dawidowicz et al. (2022), which assumes the use of the land administration system platform referred to as the Integrated Real Estate Information System (IREIS), and the INSPIRE Geoportal service (INSPIRE, 2007) to create a nationwide information system, it is necessary to develop functional assumptions of the UGMB organizational structure responsible for GI implementation in Poland.

A uniform UGMS for the whole country requires a clear model of competencies for establishing, updating databases, and responsibility for the entries made, similarly to a real estate cadastre or a land register. Hence, the main objective was to develop an organizational concept for Urban Greenery Management Bodies (UGMB) in line with the UGMS concept (Dawidowicz et al., 2022) and key Green Infrastructure benefits (EC, 2012b). Therefore, current legal regulations related to the objectives of GI development were reviewed and in-depth interviews were conducted with surveying the employees of public agencies responsible for urban greenery management in five, big Polish cities (Warsaw, Kraków, Poznań, Gdańsk, and Olsztyn) to identify current organizational structures, based on which groups of entities will be distinguished and classified in the context of competence activities.

The proposed organizational concept of UGMB should deliver numerous benefits. Above all, it should enable Polish decision-makers to develop regulations for cohesive standards for creating effective institutional structures as the optimal solution for GI implementation. The UGMB concept should support inter-institutional cooperation towards a comparison of GI policies enacted in different cities, thus facilitating the identification and promotion of green cities. The concept would also play an important role in raising public awareness of the importance UGMB and their competences towards the development of green infrastructure in cities. It also would increase the local residents' sense of responsibility and encourage them to participate in the creation and protection of urban greens (Kronenberg, 2012a) together with UGMB. The proposed concept of UGMB organizational structure can be a model for other EU member states, but also for other countries applying for EU membership.

Desk research – literature review

Organizational structures responsible for greenery management in Poland. Analysis of the reports on GI development (Biejat, 2017a, 2017b) and review of the legal statutes of selected entities responsible for greenery management in Poland (Organizational Regulations ZDZIT Olsztyn, 2022; Organizational Regulations ZZM Kraków, 2022; Organizational Regulations ZZ Warszawa, 2022; Organizational Regulations GZDiZ Gdańsk, 2022; Organizational Regulations ZZM Wrocław, 2022) revealed the current state of organizational structures, which can be described as multi-entity competence. Urban greens are managed by a variety of institutions, often with overlapping competencies, and the planning and management process is not cohesive. The responsibilities of the managing institutions and departments are determined arbitrarily by the local authorities. Municipal greens are managed by environmental protection departments, municipal investment departments, waste management departments, property management departments, road administrators, and building conservation authorities. Polish municipalities adopt local land use plans, environmental protection programs, and local strategies, but cohesive green infrastructure plans are still rarely in place. For many municipalities, urban greenery is not a priority despite the fact that the management of green spaces is one of their statutory responsibilities. Therefore, the budgets for the development of green infrastructure are very modest, and the relevant responsibilities are fragmented (Biejat, 2017b).

More specifically, urban green spaces are managed by different authorities, subject to the size and type of the city. In some cities, urban greenery is managed by the Municipal Gardener. In Kraków, Łódź, and Wrocław, the relevant duties are vested in Urban Greenery Boards which are responsible for maintaining municipal parks, pocket parks, green squares, cemeteries, and roadside vegetation. In other cities, including Jaworzno, urban greens are managed by separate institutions, such as the Municipal Property Management Board or the Municipal Road and Bridge Board. In the Municipal Property Management Board, the Urban Greens Department and the Municipal Gardener are responsible for planning and maintaining green spaces that are open to the public. The remaining greenery, including roadside trees, vegetated roundabouts, selected parks and new projects, are managed by the Municipal Road and Bridge Board. Residential greenery and greenery surrounding public utility buildings such as schools and health care facilities are managed by property administrators.

In Olsztyn, urban greenery is the responsibility of the Municipal Gardener and the Road, Greenery and Transport Authority which maintains urban green spaces, municipal forests, and national forests administered by the Olsztyn Municipality, and the Department of the Environment which deals mainly with environmental protection issues. In Warsaw, urban greens are managed by several institutions. Every city district has an Environmental Protection Department that maintains parks, green squares, and pocket parks. District authorities are also responsible for roadside vegetation. The only exception are roads with public transport where vegetation is managed by the Municipal Road Authority. The Greenery Department of the Capital City of Warsaw administers the

areas taken over from the Municipal Sanitation Board (streets with public transport) as well as areas situated along the banks of the River Vistula. Urban green spaces maintained by district authorities will also be managed by the Greenery Department in the future (Biejat, 2017a).

The concept of Urban Greenery Management System (UGMS). The UGMS concept (Dawidowicz et al., 2022) involves the creation of a universal and standardized information system covering the entire country to support GI development. The concept takes into account the trends and experiences gathered from the analysis of existing green area IT solutions, and the results of the technological architecture analysis of the Integrated Real Estate Information System (IREIS), which is an important element of Poland's Spatial Data Infrastructure (SDI), (Dawidowicz & Źróbek, 2016). The integration of IREIS, INSPIRE Geoportal with UGMS as a sector sub-module (Fig.1) is expected to facilitate the creation of a standardized data model based on ISO 19152 standards for Land Administration Domain Model (LADM), (ISO 19152, 2012; Bydłosz, 2015). This innovative approach involves the development of a national information system for urban green space management, as part of the NSDI (National Spatial Data Infrastructure), and offers a technological perspective on the evolution of SDI and land administration system. This solution closely contributes to the following Sustainable Development Goals (UN-GGIM, 2015): (11) Sustainable cities and communities, (13) Climate action, (15) Life on land.

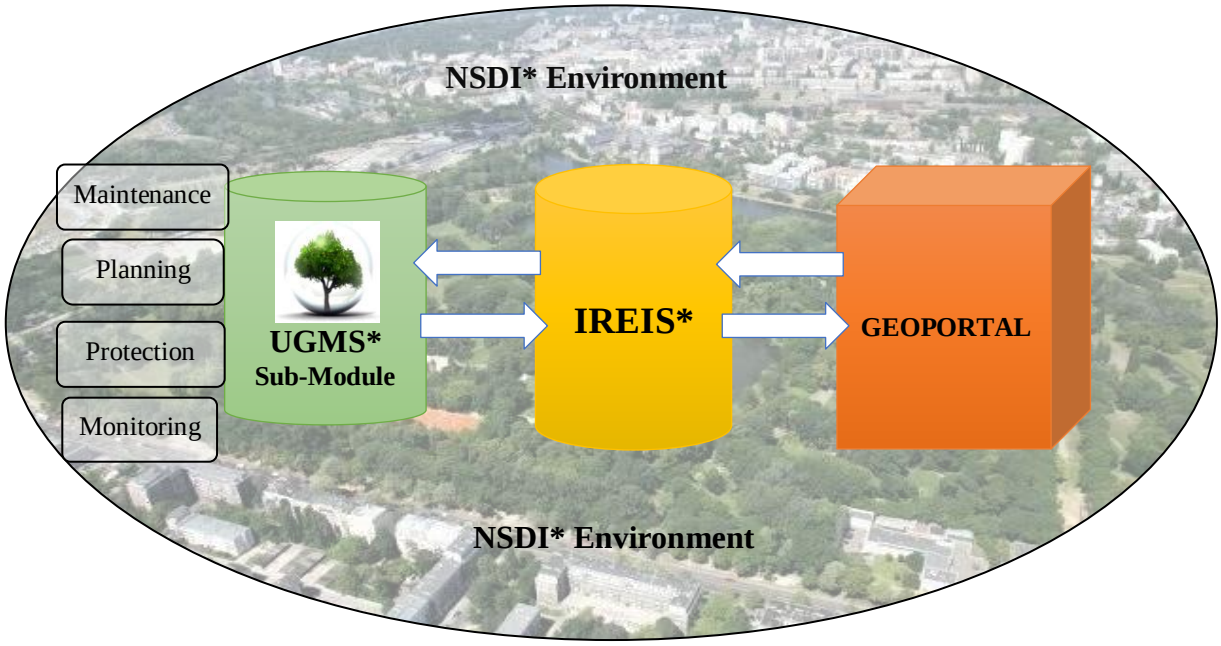
The UGMS database will be based on the results of urban greenery inventories. Selected types of data can also be collected by municipal employees responsible for UG maintenance. The relevant information would be collected with the use of a dedicated inventory form and it would be entered into the database as a UGMS sub-module in the IREIS environment. The data collection process should rely primarily on the existing sources of information from IREIS and Geoportal. The UGMS should cover urban green spaces that are owned, co-owned, or administered by the city.

The main functional assumptions of UGMS are:

- collection and analysis of data concerning green areas,
- monitoring of changes in green areas in the context of adaptation to climate change,
- introduction of green-blue infrastructure solutions to cities,
- identification of ecosystem services provided by trees,
- cooperation between administration units in the management of green areas,
- social participation in the process of creating green areas,
- data analysis for adapting different tree species to changing urban conditions,
- analyses of the benefits provided by trees.

In particular, the UGMS will collect data in 15 thematic groups, i.e.: urban greenery (basic and supplementary data, including maintenance and management of urban greenery), address data, physical attributes of land parcels, legal status (RRR), land and planning, infrastructure, soil and water conditions, nature conservation sites, protected

monuments, climate, environmental pollution and threats, habitats and protected species, technology/machines, market, cooperation, and support.



Abbreviations: UGMS – Urban Greenery Management System, IREIS – Integrated Real Estate Information System, NSDI – National Spatial Data Infrastructure

Fig. 1. The technological environment of UGMS
Source: own elaboration

Materials and methods

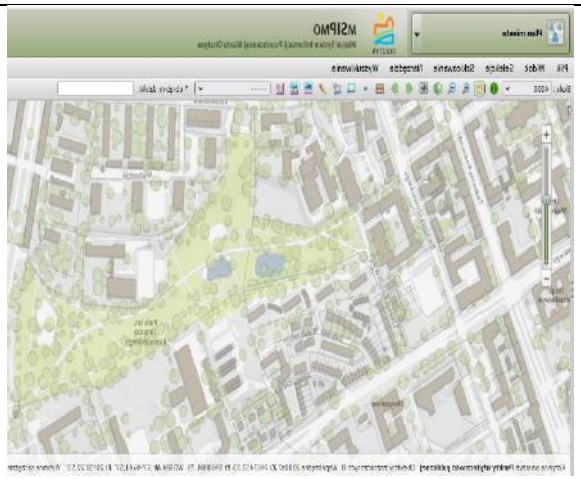
An empirical study was carried out with the involvement of qualitative methods to achieve the research objective of developing a concept of UGMB organizational structure consistent with the concept of UGMS for the entire country and key Green Infrastructure benefits. The research builds on the preliminary results of the developed UGMS concept (Dawidowicz et al., 2022), which was proposed after an in-depth analysis of existing EU green policy documents, national legislation, and good practice in the implementation GI in Poland and selected EU countries. Logically inducing, a model of organizational structure of urban greenery management bodies (UGMB) was proposed based on the model of UGMS functionality developed by Dawidowicz et al. (2022) and analysis of organizational regulations of units responsible for greenery management in selected cities, which were validated during the survey. The digital questionnaire was sent to various institutions dealing with greenery maintenance, i.e. environmental protection departments, urban greenery departments, and city offices in five Polish cities. The survey was conducted in October-December 2020.

Study area

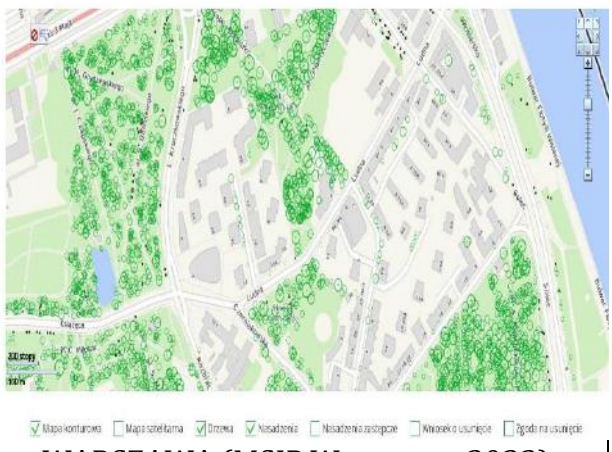
The cities selected for the analysis are regional capitals, the largest cities in five Polish regions (Warszawa, Kraków, Poznań, Gdańsk, and Olsztyn – Fig. 2) and diverse in terms of the state of GI implementation.

Fig. 2. Map of Polish regions. Location of research objects
Source: own elaboration

Each of these cities has a publicly available, customized spatial information system to support greenery management (Fig. 3). Unfortunately, these systems are poor in environmental and greenery information with respect to the dataset highlighted in the UGMS concept.



OLSZTYN (MSIP Olsztyn, 2022)



WARSZAWA (MSIP Warszawa, 2022)

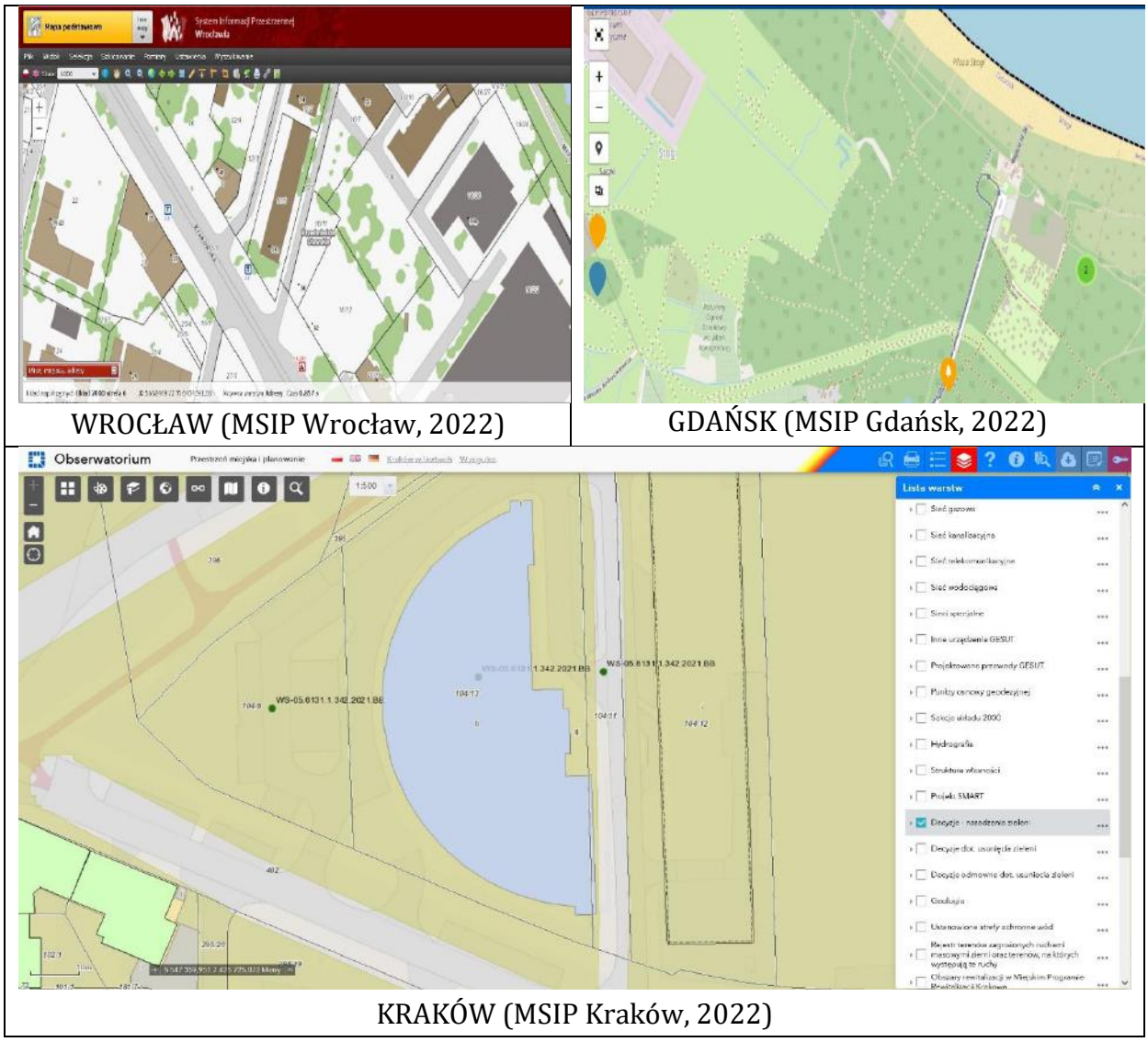


Fig. 3. View of the urban spatial information systems in analyzed cities
Source: own elaboration

Results and discussion

Organization of green space management units. The analysis of the organizational bylaws of the greenery management units showed diversity in the area of hierarchy of entities and their competences. The analysis was presented in tabular form (Table 1).

As can be seen from the comparative analysis in Table 1 most of the organizational units managing urban greenery are organized in the form of budget units. Exceptionally in Olsztyn, the urban greenery planning department is directly subordinated to the President of the City. The analysis of the competencies of the Urban Greenery Management Office allowed for distinguishing 3 competence levels for urban greenery development i.e. for planning, administering, and managing/field operations of urban greenery.

Table 1. Urban greenery management bodies in selected Polish cities

City	The entity responsible for greenery management	Subordinate units	Competencies
Gdańsk	Gdańsk Road and Greenery Authority (GRGA) – Director	1)Deputy Director for Public Space a) Greenery Department, b) Public Space Development Department 2)Deputy Director for Management a) Cleaning Department	1) GRGA manages municipal cemeteries, municipal forests, parks, playgrounds and urban green areas and trees. 2)Construction and maintenance of city information system, management of streetcar and bus infrastructure, construction and maintenance of street lighting and road engineering structures and green areas, construction and maintenance of illumination of historical buildings, buildings and monuments. 3) Issuing opinions or approving investors' intentions on the facilities covered by the activity within the scope specified in special regulations, keeping property records of managed municipal property.
Kraków	Municipal Greenery Authority in Kraków – Director	1.Deputy Director for Greenery. Greenery 1) Forest and Nature Team 2) Investment and Renovation Projects Team 3) Greenery Division, within which there are: 4) Positions for Parks Maintenance 5) Positions for Maintenance of	1) The responsibilities of the City Landscape Architect include creating a consistent image of green areas, integrating the activities of various entities in shaping green areas, and taking action for the harmonious development of the green area system. 2) The scope of responsibilities The Greenery Department is responsible for all matters related to care and maintenance of high and low greenery, removal and planting of trees and shrubs in

		Greenery in Nowa Huta 6) Greenery maintenance positions 7) Position for Maintenance of Urban Greenery 2. City Landscape Architect; 3. Team for Krakow in Greenery 4. Stand-alone position for GIS	roadways, parks, and landscaped areas, together with small architecture.
Olsztyn	Olsztyn Road, Greenery and Transport Authority in Olsztyn (ORGTA) – Director	1) Deputy Director of Maintenance - Greenery maintenance department - Road cleaning and greenery department - Urban Forestry Department	Supervision and maintenance of playgrounds, low greenery, high greenery in road lanes, nature monuments.
	Department of Urban Planning and Architecture of the Olsztyn City Hall – Director	1)Position for urban greenery. Urban greenery 2)Position for image of urban spaces 3)Coordinator for city aesthetics	1) Undertaking activities related to the overall harmonious and aesthetic image of the City. 2) Planning and implementing greenery concepts in the City and supervising the development of city green areas.
Warszawa	Warszawa Greenery Authority (WGA) – Director	1) Green Space Programming Department 2) Green areas maintenance deputy director a) Horticultural Coordination Department b) Divisions of	1) planning, fundraising, programming, designing, constructing, upgrading, and renovating greenways, as well as water facilities and passive protection against flooding, as well as acting as an investor in other investment programs and tasks; 2) carrying out planting, maintenance, inspection and

		garden areas 1-9 c) Department for Project Documentation Arrangements 3) the Deputy Director for Development and Investment a) Greenery Development Department 4) the Deputy Director for Economic and Administrative Affairs a) Administration and Economic Department	undertaking activities related to maintenance of trees, shrubs and low greenery; 3) promoting the landscape of the Capital City of Warsaw, particularly its elements of animate and inanimate nature and public space, as well as activating, initiating and conducting dialogue with the residents of the Capital City of Warsaw.
Wrocław	Municipal Greenery Authority in Wrocław – Director	Assistant Director for Greenery: 1) Greenery Department 2. Land Resources Department 3) Arrangements Department Landscape architect 1) Urban Landscape Architect Department Deputy Director for Investment 1) Investment preparation and execution department 2) Project Manager Department	1) management of green areas, municipal forests, state forests transferred to the Municipality of Wroclaw for management, together with small architecture and water and drainage facilities located in these areas; 2) coordinating activities related to the development, revalorization and revitalization of green areas and conducting repairs and municipal investments in this area; 3) management of water and drainage facilities of the Wrocław Municipality managed by the Management Board; 4) implementation of the following programs: dispersed greenery, improvement of aesthetics and recreational development of the city.

Source: own study

The survey

Survey questionnaires were forwarded by email to 50 sectoral experts, 10 in each analyzed city, and completed questionnaires were returned by 34 respondents. The questionnaire contained open-ended and closed-ended questions relating to daily problems and information needs in urban greenery management. The survey covered administrative units responsible for all levels of GI development, in:

- Olsztyn (Olsztyn Road, Greenery and Transport Authority; Department of Urban Planning and Architecture of the Olsztyn City Office; Chief Landscape Architect),
- Wrocław (Municipal Greenery Authority; Chief Urban Landscape Architect; Department of Urban Greenery; Department of Land Resources; Technical Documentation Department; Investment Department),
- Kraków (Municipal Greenery Authority),
- Warszawa (Warszawa Greenery Authority, including three Garden Zone departments; Real Estate Management Department; Green Landscaping Department; Green Infrastructure Department; Water Department; Participatory Budget Department),
- Gdańsk (Gdańsk Road and Greenery Authority).

The different names of the institutions show the lack of uniformity in the organizational structures of UGMB.

The anonymous survey form consisted of 7 questions, of which questions 6 and 7 were extended questions and concerned the identification of spatial data needs necessary for the tasks and functions of the spatial information system. The first five were metric questions. The first two were about the name of the institution where the respondent works and the city. The third question asked about the length of employment at the current institution broken down into less than 2 years, 2 to 5 years, 5-10 years, 10-15 years, and over 15 years. A significant majority, 72%, of the current UGMB staff consists of employees with 5-10 years of length of employment. This result indicates that these employees are experienced and rather satisfied with their jobs as they have not changed jobs before. The fourth question concerns education with division into those related to maintenance of greenery (compatible with the profession) and others, and the fifth one concerned the type of competence with division into 3 groups of competence: greenery planning, greenery management/execution, administration/regulation. In this case, the responses were rather surprising, as only 61% had a background consistent with their professions, overwhelmingly in planning. The fifth closed choice question with the last option open (other: enter) concerned the type of duties performed in the position. The obtained answers enabled the identification of competencies in relation to the job position. It was assumed that due to the small research group, every answer, even a single one, would be included in the scheme. In this way, particularistic tasks within the three groups of subjects were identified.

The planning entity is responsible for all matters related to the care and maintenance of greenery, as well as the removal and planting of trees and shrubs in

roads, parks, greens, and residential green areas. In addition, his duties include creating a consistent image of green areas, integrating the activities of various entities in the field of shaping green areas, and taking action for the harmonious development of information systems on green areas. Creates reports: on suitability of plant species to changing climatic conditions, on replacement plantings. It strives for the development of green areas and cooperates with other departments for the development of urban greenery. Planning is carried out by a team consisting of specialists in urban planning, landscape architecture, public participation, etc.

The administering entity is responsible for preparing regulations or adapting them to top-down recommendations and providing instructions to the entity directly managing greenery. The administrator creates reports on species of removed trees and reasons for their removal, analyzes data on the availability of places for replacement planting, and creates reports on the amount of replacement planting done by investors. Issues permit for tree removal.

The managing entity consists of inspectors dealing with particular types of greenery and specialists reporting to them. The task of inspectors is to supervise the work of specialists and perform tasks assigned by the planning entity. The specialists' duties include executive activity in the field of urban greenery maintenance, as well as carrying out repairs on urban green areas. The number of inspectors depends on the types of greenery found in the city and their area. In the team of managing entities there is also a person for contact with residents. His task is to receive notifications from residents concerning the need for intervention in the field of greenery maintenance. Residents submit their comments by phone, online or via an app.

Considering the survey responses and relating them to the following key Green Infrastructure benefits (EC, 2012b):

1) Enhanced efficiency of natural resources – Maintenance of soil fertility, Biological control, Pollination, Storage of freshwater resources;
2) Climate change mitigation and adaptation – Carbon storage and sequestration, Temperature control, Storm damage control, Erosion control;
3) Disaster prevention – Reduction of the risk of forest fires, Flood hazard reduction, Regulation of water flows;
4) Water management – Water purification, Water provisioning, Reduction of soil erosion, Maintaining/enhancing soil’s organic matter, Increasing soil fertility and productivity, Mitigating land take, fragmentation and soil sealing, Improving land quality and making land more attractive;
5) Land and soil management – Higher property values;
6) Conservation benefits – Existence value of habitat, species and genetic diversity, Bequest and altruist value of habitat, species and genetic diversity for future generations, Multifunctional resilient agriculture and forestry;
7) Agriculture and forestry – Enhancing pollination, Enhancing pest control;
8) Low-carbon transport and Energy – Better integrated, less fragmented transport solutions;

9) Innovative energy solutions;
10) Investment and employment – Better image, More investment, More employment, Labour productivity;
11) Health and well-being – Air quality and noise regulation, Accessibility for exercise and amenity, Better health and social conditions;
12) Tourism and recreation – Destinations made more attractive, Range and capacity of recreational opportunities;
13) Education – Teaching resource and 'natural laboratory';
14) Resilience – Resilience of ecosystem services;

a list of fit-for-purpose UGMS functionalities has been developed (Table 2).

Table 2. List of UGMS functionalities assigned to different types of tasks urban greenery management bodies (UGMB)

Responsible entity	Duties / tasks	UGMS Functionality
Planning (expert body)	Expenditure planning	Generation of lists of urgent maintenance works
	Expenditure monitoring, planning replacements for the most expensive services	Generation of reports on greenery maintenance costs
	Acquisition of funds from other sources	Generation of reports on the sources of financing for urban greenery
	Monitoring public tenders	Reminders on upcoming public tenders, financial settlements for greenery maintenance services
	Surveying local residents' expectations regarding urban greenery	Generation of reports on participatory greening
	Modifying the list of recommended tree species for urban areas	Generation of reports on tree species damaged by hurricanes
	Modifying the list of recommended tree species for urban areas	Generation of reports on tree species that are most resistant to climate change
	Environmental monitoring / environmental protection plans	Systematic analyses for monitoring urban green areas
	Evaluations of maintenance services and their future consequences	Analyses of tree maintenance services
	Planning replacement plantings	Coordination of replacement plantings

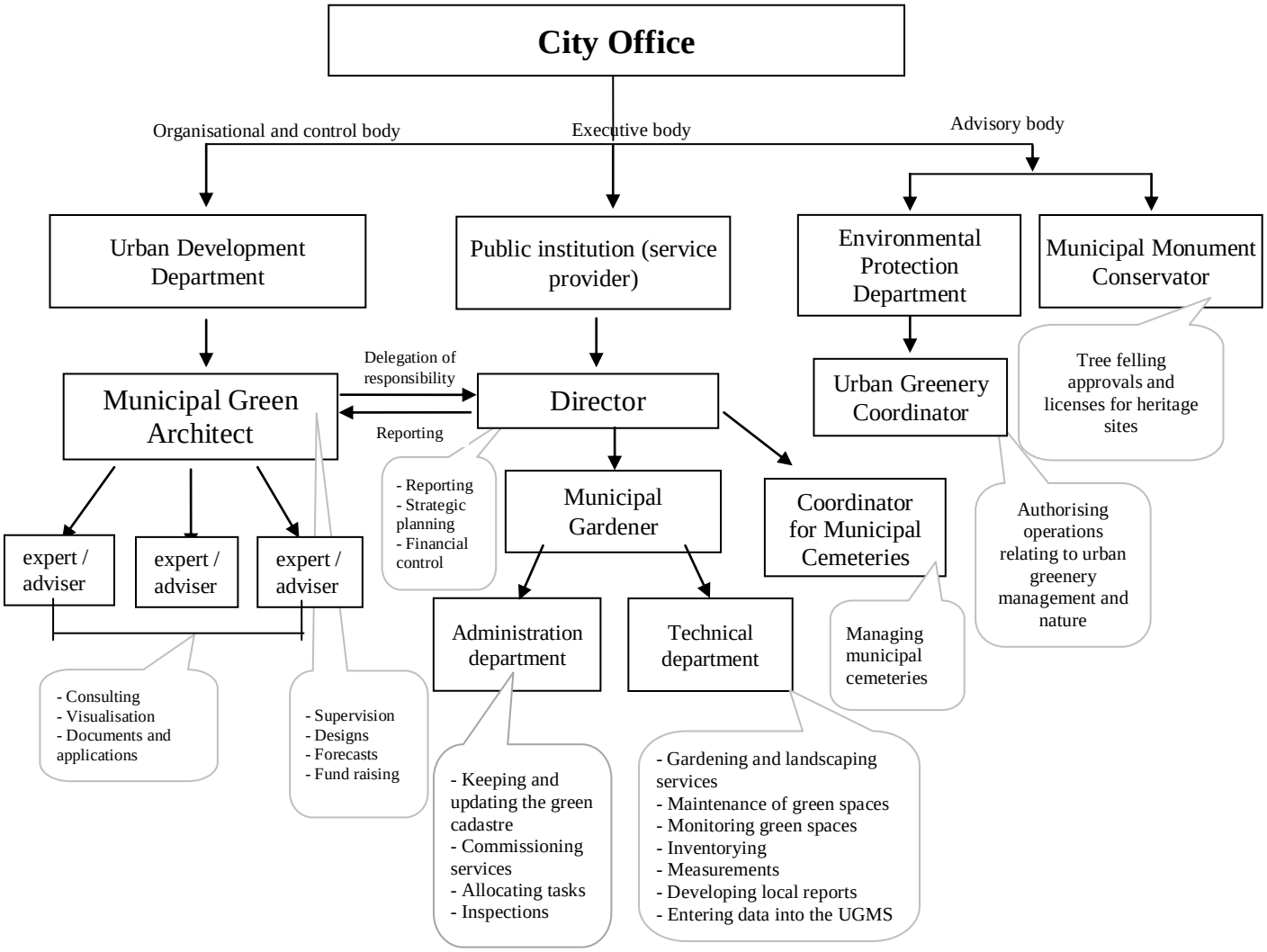
	Expenditure planning, analysis of tree species that require maintenance	Analyses of street tree inventories (range of tasks)
	Recommending changes in municipal regulations	Observance of tree protection laws in urban areas
Administration (regulatory body)	Selection of tree species for planting	Analyses of the number of removed tree species and reasons for removal
	Selection of tree species for replacement plantings	Generation of reports on tree species for replacement plantings
	Monitoring replacement plantings, recommending changes in the existing procedures to eliminate planting defects	Generation of reports on the feasibility of replacement plantings
	Assessment of replacement plantings	Generation of reports on service teams performing replacement plantings
	Analyses of energy benefits, stormwater benefits, esthetic value, and social benefits, air quality control	Generation of reports on ecosystem services
Field operations (executive body)	Planning field operations	Tree safety alerts
		Alerts on upcoming maintenance and planting operations
		Alerts on upcoming greenery development projects
	Coordination of field operations	Inspections of tree and shrub maintenance in a given district

Source: Dawidowicz et al. (2022)

The concept of UGMB organisational structures

In view of the large number of urban green spaces and the considerable fragmentation of the relevant responsibilities (Lisicki, 2009), the proposed UGMS should be a locally-centralized system with a clear division of tasks within the organizational structure of city offices. According to Łukaszkiewicz (2013), the allocation of responsibility to various bodies of local administration and other organizations compromises the effectiveness of management. Diffusion of responsibility leads to a conflict of interest and contributes to erroneous decisions (Łukaszkiewicz, 2013). Effective coordination and management require the division of competencies on the

macro and micro scales. The proposed UGMS will feature a tripartite division of authority in the management of urban green spaces. These powers can be exercised by the existing departments in city offices, but dedicated work posts should be created to guarantee that the collected data is transparent and cohesive when combined from local databases on the national scale. The tripartite system would be composed of organizational and control bodies, executive bodies, and advisory bodies. All three bodies should be represented in every city office (Fig. 4). This setup will ensure harmonization of UGMB structure and allow for future expansion of UGMS towards suburban areas.



Source: own elaboration

In the UGMS locally-centralized organizational hierarchy, urban greenery will be supervised by the Municipal Green Architect who will report only to the city mayor on matters relating to the management of urban green spaces. The Municipal Green Architect will supervise the implementation of a cohesive and long-term policy on urban green spaces and will participate in the development of revitalization strategies and plans, local zoning plans, and other policy papers related to urban greenery. The architect will work closely with other public institutions, city departments, and external

organizations to integrate the process of managing urban green spaces. The architect will supervise a team of experts in landscape architecture, urban management, and other fields. The team will be responsible for developing and maintaining green spaces by participating in public bids, commissioning and inspecting services, maintaining and updating an inventory of green spaces, as well as planning and developing green projects. The environmental protection department in the city office will issue tree felling licenses, indicate the location, number, and species of replacement trees, and will carry out local inspections. The Municipal Monument Conservator will approve tree felling in heritage sites and will issue the appropriate licenses. The Municipal Cemetery Authority will manage green areas in cemeteries.

Discussion and conclusions

The study revealed that the current UGMB in Poland is characterized by a multiplicity and inconsistency of competencies. The lack of uniformity of UGMB structures across the country may make it difficult to develop and implement standardized regulations concerning GI development. Such a disorganized organizational structure will be even more disruptive to the launch of UGMS, because the different divisions of competencies may hinder the allocation of access licenses and the granting of authority to use UGMS. The division of competencies into 3 raisers is universal, as it refers to key Green Infrastructure benefits and can be implemented in other European Union countries. It is necessary to continue to monitor the effectiveness of the implementation of GI principles in cities and emerging concepts in the area of GI development in order to optimize the resource and organization of UGMB.

References

Baycan-Levent T., Nijkamp P. (2004). Urban green space policies: A comparative study on performance and success conditions in European cities. No 22, Serie Research Memoranda from VU University Amsterdam, Faculty of Economics, Business Administration and Econometrics.

Biejat K. (2017a). Zarządzanie oraz ochrona zieleni w polskich miastach. Raport. (*Management and protection of green areas in Polish cities. Report*). Retrieved on 20 February 2018 from https://uslugiekosystemow.pl/wp-content/uploads/2017/09/Raport_Zarzadzenie_Zielenia.pdf

Biejat K. (2017b). Zarządy zieleni miejskiej – sposób na zielone miasto? In: Przestrzeń Miejska, 4, 40–43 (*Municipal greenery management – a way to a green city?*). Retrieved on 20 January 2018 from https://www.przestrzenBi-miejska.pl/artykul/zarzady-zieleni-miejskiej-sposob-na-zielone-miasto [access: 12.10.2021].

Bydłosz J. (2015). The application of the Land Administration Domain Model in building a country profile for the Polish cadastre. Land use policy, 49, pp. 598–605. https://doi.org/10.1016/j.landusepol.2015.02.011.

Dawidowicz A., Nowak M., Gross, M. (2022). Land administration system and geoportal service for the need of a fit-for-purpose national urban greenery management

system (UGMS). The concept for the EU member state of Poland. Acta Scientiarum Polonorum Administratio Locorum, 21(1), 53–81.

Dawidowicz A., Źróbek R. (2016, June). Hierarchical development of the spatial data infrastructures as a globalization trend. In 2016 Baltic Geodetic Congress (BGC Geomatics) (pp. 147–153). IEEE.

EC (2012a). Science for Environment Policy. In-depth Reports. The Multifunctionality of Green Infrastructure. March 2012. https://ec.europa.eu/environment/nature/ecosystems/docs/Green_Infrastructure.pdf [access: 18.06.2022].

EC (2012b). Studies on Green Infrastructures are available at: http://ec.europa.eu/environment/nature/ecosystems/studies.htm#implementation, adapter [access: 13.04.2019].

EC (2013). COMMISSION STAFF WORKING DOCUMENT. Technical information on Green Infrastructure (GI). Brussels, 6.5.2013SWD(2013) 155 final . Accompanying the document COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. Green Infrastructure (GI) — Enhancing Europe's Natural Capital. {COM(2013) 249 final}.

EC (2016). Supporting the Implementation of Green Infrastructure, Trinomics B.V. http://ec.europa.eu/environment/nature/ecosystems/docs/green_infrastructures/GI%20Final%20Report.pdf [access: 20.03.2017].

INSPIRE, 2007. Directive 2007/2/Ec Of The European Parliament And Of The Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32007L0002&from=pl [access: 14.03.2019].

ISO 19152 (2012). Geographic information – Land Administration Domain Model (LADM). Accessible at https://www.iso.org/standard/51206.html [access: 12.03.2020].

Kronenberg J. (2012a). Bariery dla utrzymania drzew w miastach i sposoby pokonywania tych barier. (*Barriers to urban tree maintenance and how to overcome these barriers*). In: Zrównoważony Rozwój – Zastosowania 3, 31–49. Retrieved on 20 January 2018 from http://www.sendzimir.org.pl/images/zrz_3_pl/02_bariery_dla_utrzymania_drzew_w_miastach.pdf

Lisicki P. (2009). Zielony wizerunek stolicy (*Green image of the capital*). Zieleń Miejska 1, pp. 20–22.

Łukaszkiewicz J. (2013). Nasadzenia zastępcze drzew w miastach – główne problemy z decyzjami administracyjnymi (*Plant replacement trees in cities – main problems with administrative decisions*), Zrównoważony Rozwój – Zastosowania 4, pp. 27-37. Retrieved January 25th, 2018 from http://sendzimir.org.pl/sites/default/files/wzr4/wzr4-2.pdf)

Mazza L., Bennett G., De Nocker L., Gantioler S., Losarcos L., Margerison C., Kaphengst T., McConville A., Rayment M., ten Brink P., Tucker G., van Diggelen R. (2011). Green Infrastructure Implementation and Efficiency. Final report for the European Commission, DG Environment on Contract ENV.B.2/SER/2010/0059, Institute for European Environmental Policy, Brussels and London.

MSIP Kraków (2022). https://msip.um.krakow.pl/kompozycje/?config=config_plan.json&_ga=2.65831142.954143463.1655726410-1994621132.1655726410 [access: 13.06.2022].

MSIP Olsztyn (2022). https://msipmo.olsztyn.eu/imap/https://msip.um.krakow.pl/kompozycje/?config=config_plan.json&_ga=2.65831142.954143463.1655726410-1994621132.1655726410 [access: 13.06.2022].

MSIP Warszawa (2022). https://zzw.waw.pl/mapa-warszawy/ [access: 13.06.2022].

MSIP Wrocław (2022). https://gis.um.wroc.pl/imap/?gpmap=przyroda [access: 13.06.2022].

MSIP Gdańsk (2022). http://www.gis.gdansk.pl/#portfolio [access: 13.06.2022].

Naumann S., McKenna D., Kaphengst T., Pieterse M., Rayment M. (2011). Design, Implementation and Cost Elements of Green Infrastructure Projects. Final report. European Commission, Brussels. https://ec.europa.eu/environment/enveco/biodiversity/pdf/GI_DICE_FinalReport.pdf [access: 18.05.2021].

Nowak M., Dawidowicz A., Źróbek R., Tuyet M.D.T. (2020). Identification of development determinants of green information systems for urban areas–Polish case study. Acta Scientiarum Polonorum Administratio Locorum, 19(1), pp. 45–60. https://doi.org/10.31648/aspal.4456

Pauleit S., Ambrose-Oji B., Andersson E., Anton B., Buijs A., Haase D., van den Bosch C.K. (2019). Advancing urban green infrastructure in Europe: Outcomes and reflections from the GREEN SURGE project. Urban Forestry & Urban Greening, 40, pp. 4–16. https://doi.org/10.1016/j.ufug.2018.10.006

Regulation (2013). Regulation of the Council of Ministers of 17 January 2013 on the Integrated Real Estate Information System (Journal of Laws 2013, item 249), (in Polish: Rozporządzenie Rady Ministrów z dnia 17 stycznia 2013 r. w sprawie zintegrowanego systemu informacji o nieruchomościach (Journal of Laws, 22 February 2013), www.isap.sejm.gov.pl [access: 15.12.2015].

Organizational Regulations ZDZIT Olsztyn (2022). https://bip.zdzit.olsztyn.eu/pliki/18012022_REGULAMIN_ORGANIZACYJNY_ZDZIT.pdf [access: 16.05.2022].

Organizational Regulations ZZM Kraków (2022). http://docplayer.pl/63698592-Regulamin-organizacyjny-zarzadu-zieleni-miejskiej-w-krakowie-dzial-i-postanowienia-ogolne.html [access: 16.05.2022].

Organizational Regulations ZZ Warszawa (2022). https://zzw.waw.pl/2018/05/18/struktura/?b=56 [access: 16.05.2022].

Organizational Regulations GZDiZ Gdańsk (2022). https://bip.gdansk.pl/gzdiz/ [access: 16.05.2022].

Organizational Regulations ZZM Wrocław (2022). https://www.zzm.wroc.pl/ [access: 16.05.2022].

SAO (Supreme Audit Office) (2017). Report of the Supreme Audit Office. Urban Greenery Management. https://www.nik.gov.pl/plik/id,15863,vp,18378.pdf [access: 6.06.2019].

Sendzimir Foundation (2019). Report on access to information relating to the management and protection of urban greenery 2018. https://uslugiekosystemow.pl/wp-content/uploads/2019/01/Raport_dostep_do_informacji_o_zieleni.pdf [access: 10.02.2022].

Szczepańska A., Krzywnicka I., Lemański L. (2016). Urban Greenery as a Component of Real Estate Value, Real Estate Management and Valuation, vol. 24, no 4, pp. 79–87. DOI: 10.1515/remav-2016-0032.

UN-GGIM (2015). United Nations Committee of Experts on Global Geospatial Information Management, 2015. The Application of Geospatial Information – Land Administration and Management UN-GGIM Version 3.1, 13 July 2015. http://ggim.un.org/knowledgebase/KnowledgebaseArticle51948.aspx [access: 02.03.2020].

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.25

Anna Bielska[1], Robert Łuczyński[2], Natalia Sajnóg[3], Katarzyna Sobolewska-Mikulska[4]

USE OF PUBLIC REGISTERS FOR SELECTED SOLUTIONS WITHIN THE SMART VILLAGES CONCEPT

Abstract: The concept of Smart Villages is essential for the development of rural areas, in terms of both creating new job opportunities and the quality of life in the countryside. It is based on modern tools and technologies improving the quality of life with better resources and a lower environmental impact. Many different solutions can be implemented within the Smart Villages concept, depending on the needs and potential of a given area. The article aims at the determination of the possibility of using data obtained from public registers for the needs of Smart Villages solutions. The research was carried out in the Mazowieckie Voivodeship in Poland. Selected solutions for rural development in the Smart Villages approach were indicated. The structure of farms, registration plots, and land use were determined. Areas requiring remedial processes such as agricultural land consolidation were marked. Data necessary to implement measures in rural areas were identified, and the possibilities of obtaining them from public registers were indicated. The data is necessary to diagnose the current state and determine further actions, including analyses aimed at taking measures for the sustainable development of rural areas. It was assumed that their acquisition would reduce the costs and time needed to implement the selected solutions within Smart Villages.

Keywords: Smart Villages, public registers, rural land development

Received: 13 June 2022; accepted: 17 July 2022

[1] Warsaw University of Technology, Faculty of Geodesy and Cartography, Department of Cadastre and Land Management, Poland, Warsaw, ORCID ID: https://orcid.org/0000-0001-6615-7578, email: anna.bielska@pw.edu.pl

[2] Warsaw University of Technology, Faculty of Geodesy and Cartography, Department of Cadastre and Land Management, Poland, Warsaw, ORCID ID: https://orcid.org/0000-0001-5887-2176, email: robert.luczynski@pw.edu.pl

[3] Warsaw University of Technology, Faculty of Geodesy and Cartography, Department of Cadastre and Land Management, Poland, Warsaw, ORCID ID: https://orcid.org/0000-0001-8758-4122, email: natalia.sajnog@pw.edu.pl

[4] Warsaw University of Technology, Faculty of Geodesy and Cartography, Department of Cadastre and Land Management, Poland, Warsaw, ORCID ID: https://orcid.org/0000-0003-1685-1486, email: katarzyna.mikulska@pw.edu.pl

Introduction

The well-established Smart City concept has given rise to formulating the assumptions for the concept of Smart Villages. Although the Smart Village concept is based on the broader Smart City concept, the problems faced by urban and rural areas appear to be completely different, and therefore require different solutions.

The Smart Villages concept has emerged to address the need to implement the EUROPE 2020 agenda in the rural development policy. The implementation of the concept should align with the objectives and recommendations of Cork 2.0 (2016). The declaration addresses the expectations and aspirations of rural areas, and identifies ten policy orientations for the use of their potential (Fig. 1).

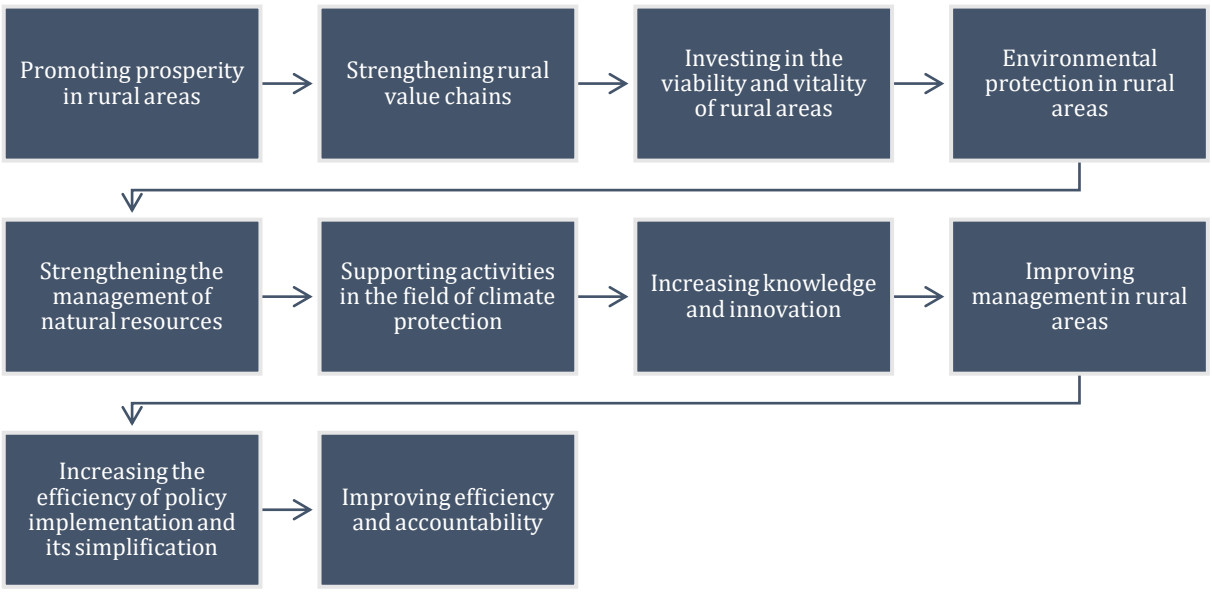


Fig. 1. Strategic directions of the rural areas policy using their potential
Source: Own study based on the Cork 2.0 Declaration (2016)

According to the document of the European Commission (2017), "Smart villages are rural areas and communities that build on their existing strengths and assets, as well as new opportunities to develop added value, and where traditional and new networks are enhanced by means of digital communications technologies, innovations, and better use of knowledge for the benefit of inhabitants". Therefore, the concept proposes no single solution, but is based on the needs and potential of each territory, the desires of the community, and cultural environments. Ultimately, the initiators of changes are members of the local community cooperating with local authorities. Smart Villages can therefore be understood as communities that do not want to wait for changes, but want to take initiative. The innovativeness of Smart Villages involves among others changing and shaping attitudes – from reactive (surrendering to events, lack of commitment) to proactive (setting and achieving goals). The concept of Smart Villages is based on solutions tailored to the needs and potential of a given territory. It includes

technological investment in infrastructure, business development, human capital, possibility and community building, good governance, and citizen engagement. The implemented intelligent solutions may refer to several issues (Fig. 2).

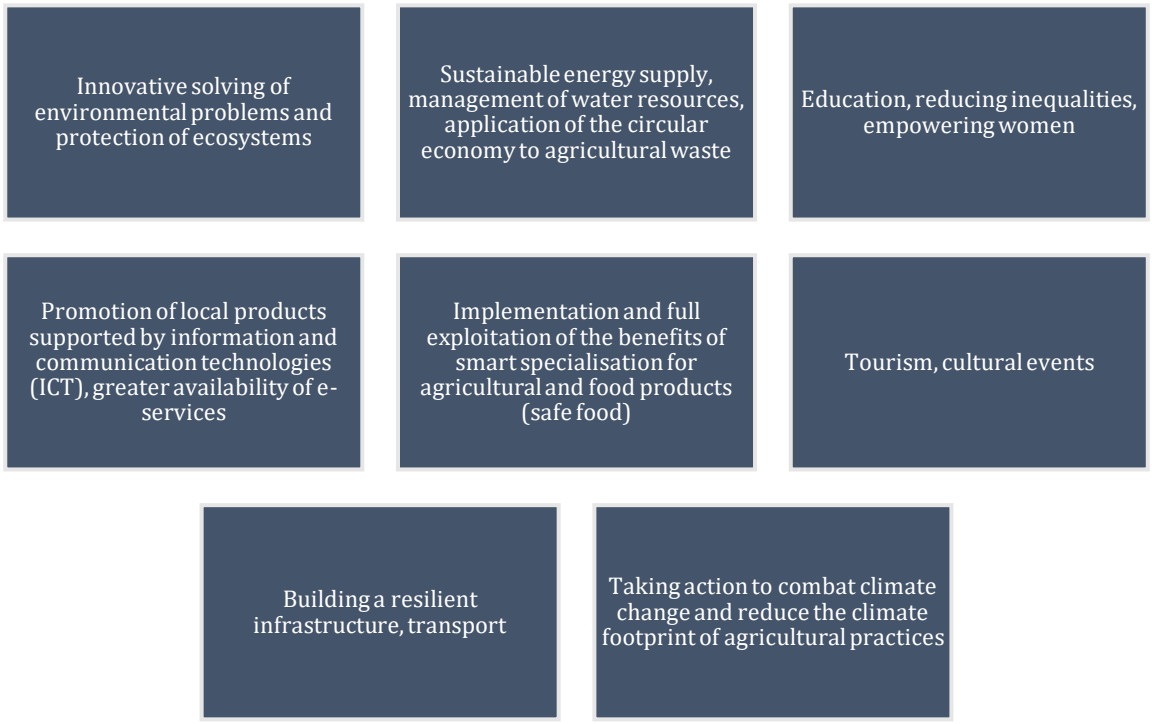


Fig. 2. Scope of smart solutions in rural areas
Source: Own study

The Smart Villages concept therefore covers three main areas of intelligent solutions, and examples of areas of activities within them (Table 1).

Table. 1. Fields of smart solutions and selected areas of their actions

	Fields of smart solutions		
	Public services	Public management	Entrepreneurship
Example areas of intervention	energy (RES)	e-administration	precision farming
	security (video surveillance)	waste management (container filling sensors)	online trading (local products)
	remote education	spatial planning	rural tourism (based on smart solutions)
	public transport	environmental quality monitoring (air quality sensors)	sharing equipment (specialised equipment)
	e-health	meetings and online consultations with locals	countryside incubators

Source: Own elaboration based on Inteligenta wieś, 2019

The article aims at the determination of the possibility of using data obtained from public registers for the needs of Smart Villages solutions. The research was carried out in the Mazowieckie Voivodeship in Poland. Selected solutions for rural development in the Smart Villages approach were indicated. The structure of farms, registration plots, and land use were determined. Areas requiring remedial processes such as agricultural land consolidation were marked. Data necessary to implement measures in rural areas were identified, and the possibilities of obtaining them from public registers were indicated. The data is necessary to diagnose the current state and determine further actions, including analyses aimed at taking measures for the sustainable development of rural areas. It was assumed that their acquisition would reduce costs and shorten the time needed to implement selected solutions within Smart Villages.

Selected public systems and registers

The introduction of solutions related to the implementation of the concept of Smart Villages is closely associated with the acquisition of data on rural areas, collected at various levels of government and local government administration and in numerous databases and public registers. Below is a brief description of selected systems that in the author's opinion are essential for the discussed topic.

Real estate cadastre – an information system maintained for the entire country by starosts, ensuring the collection, updates, and sharing, uniformly for the country, information on land, buildings, and premises, their owners, and other entities that own or manage such land, buildings, or premises (Act, 1989).

The real estate cadastre includes information regarding:

- land – its location, boundaries, areas, types of land use and their valuation classes, designation of land and mortgage registers, or collections of documents, if they were established for the property that includes land;
- buildings – their location, purpose, utility functions, and general technical data;
- premises – their location, utility functions, and usable space (Act, 1989).

Soil science classification of land – dividing soils into valuation classes according to their production quality, determined based on soil genetic characteristics, conducted by starosts (Act, 1989).

Cadastral map – data from the land and building register database are visualised in the form of a cadastral map with the following content:

- boundaries and numbers of registration plots;
- border points;
- contours of buildings with an indication of the type of building or their blocks, if any, as well as the numbers of the top storeys of structures or their unions, or the lowest storeys of underground buildings or their blocks marked with a negative number;
- contours of land use and their markings;
- classification contours and their designations;
- boundaries of the units of the primary three-tier territorial division of the state and registration precincts, along with their markings, occurring in the area of the map;

- other elements that do not conflict with the registration data but improve the legibility of the content of the map;
- names of streets and squares and the corresponding order numbers, as well as names of watercourses, water reservoirs, and other physiographic objects;
- graphic symbols of a square grid, at least two of which, visible in the map area, should be described with coordinates (Regulation, 2021).

Basic map – large-scale cartographic study prepared for the entire country by starosts, containing information on the spatial location of geodetic control points, cadastral plots, buildings, land contours, classification contours, network of utilities, structures, construction devices, and other topographic objects, as well as selected descriptive information about these objects (Act, 1989).

Geoportal (https://www.geoportal.gov.pl/) – a website run by the Head Office of Geodesy and Cartography serving as the central node for the Spatial Information Infrastructure, and mediating access to spatial data and related services. The geoportal provides access to data from the following databases:

- topographic map – cartographic elaboration at scales from 1:10 000 to 1:100 000 with general geographic content, with particular emphasis on topographic objects;
- state register of borders – an official reference database that uses data on the territorial divisions of the country;
- state register of geographical names – official reference database using data on geographical names;
- state register of basic geodetic, gravimetric, and magnetic networks – contains information, data (including archival ones), as well as collections of observations and studies of observation results concerning points of the basic geodetic, gravimetric, and magnetic network for the area;
- general geographic object database – a vector (object) database containing the spatial location of the most important topographic objects along with their basic descriptive characteristics;
- orthophotomap – a raster image of the terrain surface, created as a result of processing of aerial or satellite images;
- numerical terrain model – a point representation of the height of the terrain, along with an interpolation algorithm that allows for calculating height at any point in the area for which the model was built;
- numerical model of land cover – representation of land surface along with objects protruding above such surface such as: buildings, trees, bridges, viaducts, and other infrastructure elements;
- LIDAR (Light Detection and Ranging) – measurement data from ALS (Airborne Laser Scanning) – representation of the terrain in the form of a cloud of measurement points with specific XYZ coordinates;
- database of topographic objects – a vector database containing the spatial location of topographic objects along with their basic descriptive characteristics; the content

and detail of the BDOT10k database generally corresponds to a traditional 1:10 000 scale topographic map;
- real estate cadastre;
- land utilities databases – information on the existing and planned land utilities, cables, and related devices;
- BDOT500 – topographic objects collected in databases, together with among others the objects of land and building records, as well as with utilities objects, constituting the content of the basic map;
- database of detailed geodetic control networks – contains information on the points of detailed horizontal and altitude geodetic control networks;
- other databases, not included in the National Geodetic Resource – presented in the form of WMS services.

Land and mortgage registers – kept to establish the legal status of real estate. Keeping land and mortgage registers is within the competence of district courts. The land and mortgage register contains the following four sections:
- the first one includes the designation of real estate and entries of rights related to its ownership;
- the second one includes entries on ownership and perpetual usufruct;
- the third one is intended for entries on limited property rights, except for mortgages, entries of restrictions on the disposal of real estate or perpetual usufruct, and entries of other rights and claims, except for claims related to mortgages;
- the fourth one is intended for mortgage entries (Act, 1982a).

Central Statistical Office (CSO) (https://stat.gov.pl/) – Portal of Public Statistics, containing among others information on the results of the National Census of Population and Housing, Agricultural Census, and results of other statistical surveys.
The scope of the National Census of Population and Housing includes the following information:
- natural persons permanently residing and temporarily staying in apartments, buildings, and other inhabited premises that are not apartments in Poland;
- natural persons not constituting residents;
- apartments, buildings, collective accommodation establishments, and other inhabited non-dwellings.

General agricultural census – includes all farms of natural persons (individual farms), and legal persons, as well as organizational units without legal personality, and covers the following topics: land use, sown area, farm animals, fertilization, plant protection, farm buildings, tractors, agricultural machinery and equipment, economic activity, structure of household income with the user of an individual farm, economic activity, fish farming, and breeding.

List of beneficiaries of the common agricultural policy (http://beneficjenciwpr.minrol. gov.pl/) – contains data on the beneficiaries of the Common Agricultural Policy 9 and all undertakings related to the agricultural sector

undertaken by the European Union to fulfil the provisions of the Treaty on the Functioning of the European Union, and information on received payments.

Materials and methods

The following materials were used in the study:

- Cadastre – data on the number of registration plots, area of cadastral precincts in the voivodship (source: district collective statements from 2021);
- Database of land and building records – vector layer of the plot (source: Poviat Geodetic and Cartographic Documentation Centres and https://www.geoportal.gov.pl/rejestry);
- State Register of Borders (source: http://www.gugik.gov.pl/pzgik/dane-bez-oplat/dane-z-panstwowego-reresses-granic-i-powierzchni-jednostek-podzialow-terytorialnych-kraju- prg);
- Statistical data from CSO (2010; 2020) (source: Local Data Bank).

The research was employed the following methods: literature review, observation methods, spatial and multi-criteria analyses.

The determination of the needs of land consolidation in communes of the Mazowieckie Voivodship employed qualitative and quantitative assessment. The qualitative assessment included the determination of factors and parameters influencing the needs of land consolidation. The quantitative assessment involved quantifying parameters characterising the factors and determining the amount of the land consolidation needs index. The study used the basic and advanced functionalities of ESRI's ArcGIS Desktop software package, allowing for the collection, analysis, and processing of spatial data.

Study area

The Mazowieckie voivodship, selected as the study area (Fig. 3), is a significant food producer. The sown area in the Mazowieckie Voivodeship covers 11.8% of the total sown area in the country. Livestock production accounts for 18.5% of the national production for cattle, 13.4% for pigs, and 21.6% for poultry, respectively (CSO, 2021). Out of the total number of farms, 62% are farms with only plant production, and 37.5% are farms with plant and animal production (CSO, 2021). Agriculture in Mazowieckie is particularly characterised by a high share in the national production of fruit and vegetables (18% of the total vegetable production in the country), fodder crops, potatoes, milk, meat, and eggs (CSO, 2021). Territorial specialisation is observed in agricultural production. The southwest and central part of the voivodeship are areas with dynamically developing vegetable and orchard production, the northwest part specialises in poultry production, and the north-eastern part – dairy production (Sulmicka, 2013; CSO, 2017;2019).

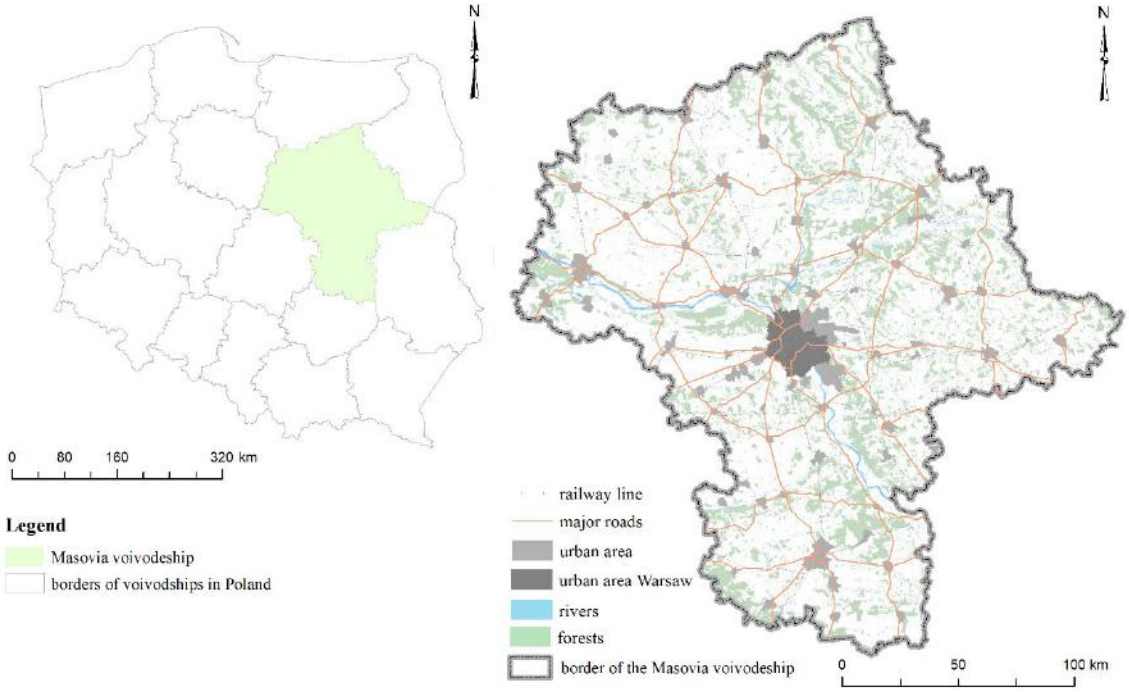


Fig. 3. Location of the study area
Source: Own study based on the Database of Topographic Objects and the State Register of Borders

According to the preliminary results of the General Agricultural Census in 2020 (CSO, 2021), the total number of farms in the Mazowieckie Voivodeship was 208 thousand. In comparison to the General Agricultural Census in 2010, it decreased by 21 thousand, i.e. by 9.1%. Individual farms dominating agriculture (207 thousand) accounted for 99.6% of all farms. The average area of agricultural land per 1 farm in the Mazowieckie Voivodeship in 2020 was 9.4 ha (with the national average of 11.1 ha). It is worth emphasising that the environmental potential of some communes designated as so-called Masovian granary regions is used to a low degree (no developed cultural factors), indicating areas of production reserves. Due to the high disproportion in intra-regional development, difficult situations in rural areas are particularly severe in the Mazowieckie Voivodeship. Paradoxically, traditional agriculture, until recently considered obsolete, is now becoming modern, and its products are more and more socially desirable, although its further development requires a new approach (Sulmicka, 2013). Improving the profitability of agriculture in Mazowieckie is crucial for its further development. Actions to strengthen such improvements include giving farmers better access to markets to ensure they get a more significant share of the prices of the sold goods. Another chance to increase farmers' income is by developing the local agri-food industry (Sadowski et al., 2015).

Results and discussion

In the analysis of potential actions under Smart Villages (presented in Table 1), spatial planning was selected as a public management measure for the Mazowieckie voivodship. Due to the diversity of rural areas in the voivodship, and the need for their transformation, the land consolidation process was indicated as an example tool implementing the provisions of planning documents. In the example of this process, requiring a detailed and comprehensive approach and offering the possibility of introducing individual design solutions adapted to the area, the necessary data from systems and public registers were identified, and the chances of obtaining them were indicated. The conducted multi-criteria analyses considering the spatial structure of plots and farms show that 86 of the communes in the Mazowieckie Voivodship require land consolidation and improvement of the ownership structure of registration plots (Fig. 4). The total area of these communes is 665 216 ha, or 19% of the area of the Mazowieckie Voivodeship.

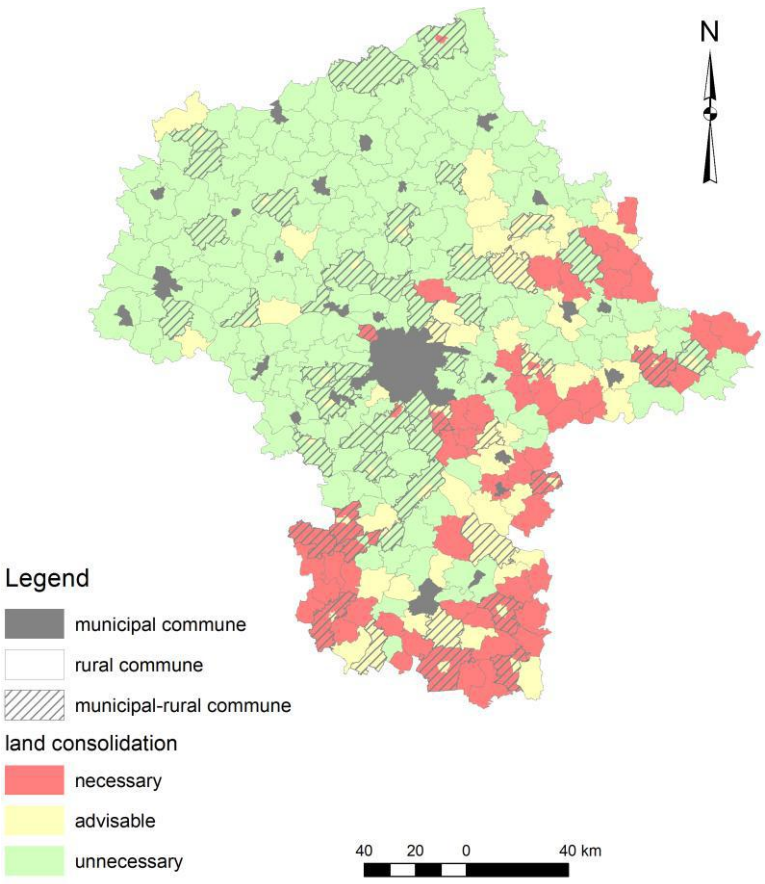


Fig. 4. Need for land consolidation in the Mazowieckie Voivodship
Source: Own study

Selected actions under Smart Villages, i.e. spatial planning, and an example implementation tool of the activities mentioned above, i.e. land consolidation, are presented in Fig. 5. Land consolidation aims at creating more favourable management conditions in agriculture and forestry by improving the area structure of farms, forests, and forest land, rational shaping of land layouts, and adjusting real estate boundaries to the system of water melioration devices, roads, and topography. At the same time, the land consolidation project should consider the provisions of the local spatial development plan (Act, 1982b; Bielska, 2016). Land consolidation is a tool for achieving the goals of multifunctional rural development (Sobolewska-Mikulska & Stańczuk-Gałwiaczek, 2018). The conducted consolidation proceedings resulted in the improvement of the development opportunities of rural areas in Poland (Siuta, Żukowski, 2018; Krupowicz et al., 2020). The analysed activity is part of the intelligent field of public management.

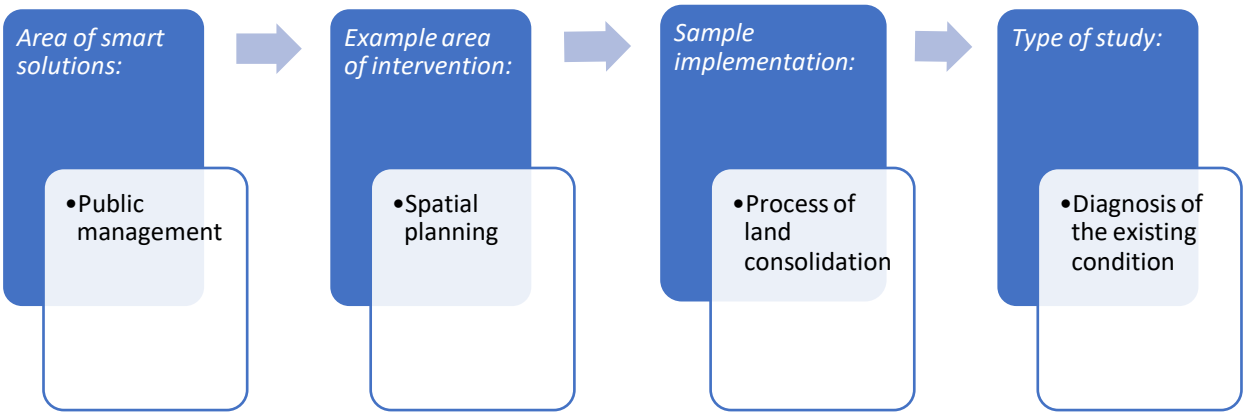


Fig. 5. Diagram showing the selected measure and its implementation
Source: Own study

The first stage of the land consolidation process should involve a diagnosis of the existing condition through the preparation of several thematic studies, including those in the field of planning conditions, socio-economic conditions, conditions of the natural environment, structure of land use and management, infrastructure, and directions of agricultural production. The aforementioned research requires obtaining up-to-date and complete data from reliable sources. Table 2 presents the summary of critical data essential to develop a diagnosis of the existing condition as part of the land consolidation process, along with determining their availability in public registers.

Table 2. Summary of data necessary to develop a diagnosis of the existing state as part of the land consolidation process with the determination of their availability in public registers

Diagnosis of the existing condition – main thematic studies	**Necessary data**	**Public register**	**Link to the website or place where the data was collected**
General characteristics of the object with the analysis of planning acts	Location – geographical and administrative with a graphic presentation related to the commune and poviat	Database of Topographic Objects	https://www.geoportal.gov.pl
	Local spatial development plans / study	Spatial development – planning studies	https://www.geoportal.gov.pl
Socio-economic conditions	Basic statistical data on demography	Central Statistical Office – Local Data Bank	https://stat.gov.pl/
Conditions of the natural environment	Land relief	Digital terrain model	https://www.geoportal.gov.pl
	Geological data	Detailed Geological Map of Poland, scale 1: 50 000	https://www.pgi.gov.pl/oferta-inst/wydawnictwa/atlasy-i-mapy/geologiczne.html
	Protected areas	Forms of nature protection	https://geoserwis.gdos.gov.pl/mapy/
	Environmental resources	Data bank on natural resources	https://geoserwis.gdos.gov.pl/mapy/
	Data on water resources	State Water Holding – Polish Waters	https://www.geoportal.gov.pl
	Complexes of agricultural usefulness of soils	Soil and agricultural map	Voivodeship or Poviat Geodetic and Cartographic Documentation Center (PODGIK)
Land use structure	Type of land use	Real estate cadastre	https://www.geoportal.gov.pl lub PODGiK
	Soil quality class	Real estate cadastre	https://www.geoportal.gov.pl lub PODGiK
Land governance structure	Land owner (Registration groups)	Real estate cadastre	PODGiK
	Area of private farms	Real estate cadastre	PODGiK
	Number of farms	Real estate cadastre	PODGiK
	Number of registration plots on the farm	Real estate cadastre	PODGiK
	Legal status of the property	Real estate cadastre	https://ekw.ms.gov.pl/eukw_ogol/menu.do
Infrastructure	Data on public roads	Basic map	https://www.geoportal.gov.pl lub PODGiK
	Condition and needs in the field of basic water melioration	State Water Holding – Polish Waters	https://www.geoportal.gov.pl
	State and needs in the field of specific water drainage	State Water Holding – Polish Waters	https://www.geoportal.gov.pl
	Technical infrastructure – water, gas, sewage	Basic map	https://www.geoportal.gov.pl or PODGiK
Agricultural production directions	Type and quantity of agricultural production	General Agricultural Census	https://stat.gov.pl/ or a commune competent for the place

Source: Own study

As evidenced above, several critical data for analysis can often be downloaded from a single source. Data integration in a single public system would undoubtedly be a good solution for streamlining several activities within the scope of intelligent actions. Such activities are undertaken, but at a smaller scale, i.e. within the competence of the authorities responsible for given systems. A single system integrating all data within intelligent solutions is a serious challenge, not only for technological, but also for administrative reasons. The above may also constitute a risk in terms of the reliability and protection of this data.

Conclusion

The analysis involved indication of the primary data and presentation of registers in which such data are collected, together with relevant links or access places. They allow for effective and quick access to information regarding the study area. Without immediate access to up-to-date information, studies on the concept of Smart Villages would be impossible to implement. The development of a diagnosis within various fields and areas of intelligent intervention, i.e. spatial planning and process of land consolidation, is an activity that can be considered universal in obtaining data. It should however be emphasised that the specificity of regions at this stage of their development may result in the demand for information of a different qualitative and quantitative nature. The development of a diagnosis requires obtaining a lot of data on various phenomena and factors, and making them available through multiple public registers. The summary presented in the article is an excellent example of the fact that knowledge about the possibility of obtaining data can reduce the costs and time of the implemented activity, and increase its impact and the scope of solutions.

References

Act, 1982a. Act of 6 July 1982 on land and mortgage registers and mortgage (Journal of Laws of 2019, item 2204, of 2021, item 1177, 1978, of 2022, item 872, 1374).

Act, 1982b. Act of 26 March 1982 on land consolidation and exchange (i.e., Journal of Laws of 2021, item 1912, of 2022, item 32).

Act, 1989. Act of 17 May 1989, Geodetic and Cartographic Law (Journal of Laws of 2021, item 1990)

Bielska A. (2016). Rola prac geodezyjnych w nowoczesnym kształtowaniu przestrzeni na obszarach wiejskich (*The role of geodetic works in the modern shaping of rural space*). In: J.M. Chmielewski (ed.). Urbanistyka w Gospodarowaniu Przestrzenią (*Urban Planning in Spatial Management*). Vol X. Oficyna Wydawnicza Politechniki Warszawskiej.

Cork 2.0 Declaration (2016). Lepsze życie na obszarach wiejskich (*Better life in rural areas*). Luksemburg: Urząd Publikacji Unii Europejskiej.

CSO (2017). Rocznik Statystyczny Rzeczypospolitej Polskiej (*Statistical Yearbook of the Republic of Poland 2017*). Warsaw.

CSO (2019). Departament Rolnictwa (*Department of Agriculture*), Statistics Poland, Agriculture in 2019. Warsaw.

CSO (2021). Powszechny Spis Rolny 2020, Raport z wyników (*National Agricultural Census 2020, Report on the results*). Warsaw.

Geoportal. https://www.geoportal.gov.pl/ [access: 09.06.2022].

Inteligentna Wieś, Forum Aktywizacji Obszarów Wiejskich na zlecenie: Centrum Doradztwa Rolniczego w Brwinowie, Oddział w Warszawie (*Smart Village, Forum for the Activation of Rural Areas, commissioned by: Agricultural Advisory Center in Brwinów, Branch in Warsaw*). Warsaw, Poland, November, 2019.

Krupowicz W., Czarnecka A., Grus M. (2020). Implementing crowdsourcing initiatives in land consolidation procedures in Poland. Land Use Policy, 99. Doi:10.1016/j.landusepol.2020.105015.

Ministry of Agriculture and Rural Development (Ministerstwo Rolnictwa i Rozwoju Wsi). http://beneficjenciwpr.minrol.gov.pl/ [access: 09.06.2022].

Regulation, 2021. Regulation of the Minister of Economic Development, Labour and Technology of 21 July 2021 on the register of land and buildings (Official Journal 2021, item 1390).

Sadowski A., Poczta W., Szuba-Barńska E., Bebal P. (2015). Modele gospodarstw rolnych w państwach unii europejskiej (*Models of farms in the European Union).* Wieś i Rolnictwo, 3 (168), pp. 43–62.

Siuta J., Żukowski B. (2018). Polskie dylematy scalania gruntów i urządzania terenów wiejskich Część 1. Scalanie gruntów *(Rural land consolidation and management – the Polish dilemmas. Part 1).* Ecological Engineering, 19 (3), pp. 1–16. Doi: 10.12912/23920629/91604.

Sobolewska-Mikulska K., Stańczuk-Gałwiaczek M. (2018). The assessment of the scope of implementation of the idea of multifunctional rural development in land consolidation projects in Poland. Journal of Agribusiness and Rural Development, 1 (47). Doi:10.17306/J.JARD.2018.00375.

Sulmicka M. (2013). Mierzenie ubóstwa i wykluczenia społecznego (*Measuring Poverty and Social Exclusion*). Prace i Materiały Instytutu Rozwoju Gospodarczego SGH – Polityka gospodarcza w poszukiwaniu nowego paradygmatu, 92, pp. 139–164.

The EU Action for Smart Villages (2017). European Commission, Brussels.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.39

Jerzy Stanik[1], Maciej Kiedrowicz[2]

RISK IN GIS SYSTEMS

Abstract: The development of information technologies, widespread access to the Internet, globalisation and the development of measurement technologies in geodesy, on the one hand, result in wide access to geographical, cartographic or geodetic data, and on the other hand, increase the level of risk of losing basic security attributes of these data. Risk management in GIS should be implemented at every stage of the GIS life cycle, which starts with the organising phase of a GIS and is expected to continue until the end of its life – decommissioning. It is important to remember that it is not enough to have a good analysis and assessment of adverse events and their consequences without precise, pre-developed methods of measuring and responding to risks in the form of various response plans. This article is an attempt to answer the questions: what should be understood by risk in GIS systems, how to measure it and how to proceed to manage it effectively and efficiently. The models and instruments presented, which have been developed on the basis of available literature and own research, point the way to effective risk management in GIS class systems.

Keywords: spatial information system, risk, information security, risk management system, security configuration, Statement of Applicability (SoA)

Received: 13 June 2022; accepted: 30 June 2022

[1] Military University of Technology, Faculty of Cybernetics, Institute of Computer and Information Systems, Warsaw, Poland, ORCI ID: 0000-0002-0162-2579, email: jerzy.stanik@wat.edu.pl
[2] Military University of Technology, Faculty of Cybernetics, Institute of Computer and Information Systems, Warsaw, Poland, ORCI ID: 0000-0002-4389-0774, email: maciej.kiedrowicz@wat.edu.pl

Introduction

Modern geographic information systems (GIS) have, on the one hand, become very powerful technologies because they allow geographers to integrate their data and methods in ways that support traditional forms of geographic analysis as well as new types of analysis and modelling that go beyond the capabilities of manual methods, while on the other hand they have become more vulnerable to various cyber attacks. The consequences of cyber attacks most often manifest themselves in the leakage of sensitive data. The actions of criminals can also affect the stability of GIS systems and even cause them to lose business continuity or suffer long-term damage. This negatively affects all procedures, regardless of GIS class.

The effective operation of cyber security in a GIS environment involves implementing and coordinating appropriate solutions across the information system. Cyber security activities include providing security in areas such as networks and applications, endpoint protection, geodata, identity management, databases and infrastructure, cloud data, disaster recovery, technical security of the company network, system and server architecture, remote connection to the company server.

The ever-changing nature of threats is recognised as one of the more difficult challenges in GIS cyber security. Traditionally, actors focus most of their cyber security resources on protecting only their most important system components, in order to defend against known threats (Wróblewski, 2015). Today, this approach is insufficient as GIS threats are advancing and changing faster than organisations can keep up. As a result of the above, more proactive and adaptive approaches to cyber security and risk management in GIS cyber security should be promoted. Most people involved in cyber security recommend a move towards continuous monitoring and real-time threat assessments, to an approach based on elements of good practice and a data-driven approach to cyber security, as opposed to the traditional model.

Cyber security today requires a new approach to risk management, based on understanding the strengths and weaknesses of an entity of operation, e.g.: a GIS system, and based on this, developing effective cyber defence methods. Conscious management of the security area, bearing in mind limited and hard-to-reach resources, requires risk analysis and prioritisation of threats.

Risk management in GIS is a complex, interdisciplinary field (related to computer science, mathematics, statistics, finance and management). In general, risk management in GIS class systems increases the value of the GIS, and by increasing the value of the many components of the GIS system, there is ultimately an increase in value – added value – for the entire entity of operation that operates the system. The current trend is to manage both GIS information systems risk and GIS itself simultaneously, as one integrated GIS management process. There are many levels of integration, but this integrated measurement is the key point of this article. This is a difficult problem due to the variety of types and measures of risk of the underlying GIS components.

The multifaceted nature of the issue of GIS cyber security means that the issue is increasingly being considered not only in the area of protecting key information systems

and elements of the GIS technical architecture, but also from the perspective of the impact of the adopted GIS security model and risk management system lifecycle model on the choice of risk management strategy.

The aim of this paper is to present two models: a GIS security model and a risk management system lifecycle model for GIS. In the opinion of the authors, these models can help in a good effective method of risk estimation and handling strategy. The results obtained from the implementation of the risk estimation and handling strategy process provide a strong basis for the development of the Statement of Applicability document and then how to map the service strategies provided in ISO 27001 to the controls of ISO 27001 – Annex A. The Statement of Applicability is a basic requirement for ISO 27001 certification. This is a statement explaining which security controls in Annex A do or do not apply to the information security management system in GIS class systems.

GIS security system

GIS is one of the many information technologies that have changed the way geographers conduct research and contribute to the information society. GIS is (Aranoff, 1989 and Peggion et al., 2008) "an organized set of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information".

System security management is an integral part of system management and is related to rationalisation of the selection of measures (methods, technologies) to ensure safe (as intended) operation of the system in a hazardous environment (environment). If there are no external threats, then system security management can be reduced to the problem of managing the reliability of the system: the choice should be made of such a reliability strategy for which the value of the reliability assessment criterion (system reliability function) assumes a maximum value under the condition that the costs of increasing reliability (or maintaining reliability at the desired level) do not exceed the limit (acceptable) – Figure 1. However, if there is a threat to the security of the system, then the problem of safety management can be reduced to the selection of such a safety strategy (measures to protect the system against threats) from a set of acceptable strategies, for which, for example, the expected value of the effects (losses) of threats assumes the minimum value under the condition that the costs of the strategy (implementation of protective measures) do not exceed the limit (acceptable) value. It should be noted that both the problem of reliability management and the problem of system security management can be reduced to the problem of: (1) minimisation of the risk function provided that the value of the effects (utility) obtained thanks to the functioning of the system is not less than the limit (desired) value or (2) maximisation of the system efficiency function provided that the risk function does not exceed the permissible ("safe") value.

In the system security analysis it was assumed that the effectiveness of the GIS system is influenced by (Sienkiewicz, 2005 and 2013):

- System reliability, i.e. the ability to function efficiently (without damage, failure, errors, etc.) under specific conditions, e.g. time:
- Cyber security of the system, i.e. the ability to effectively protect against the effects of cyber threats;
- Business continuity, i.e. the ability to anticipate and respond to incidents and disruptions related to operations so that operations can continue at an acceptable level.

A diagram illustrating the relationship between risk management, security barriers, reliability, and business continuity of a GIS system, for a reasonable level of risk, is shown in Figure 1.

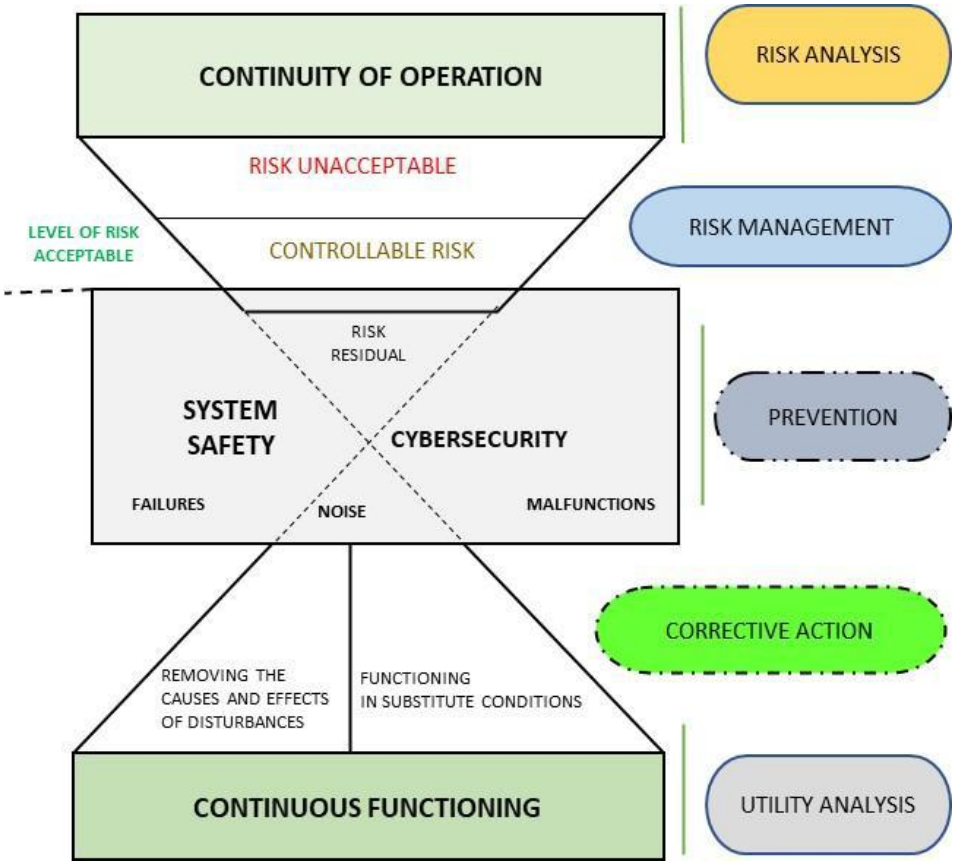


Fig. 1. Relationship between risk management, security barriers, reliability, and business continuity of the GIS for a reasonable level of risk
Source: The author's own elaboration

Keeping in mind the principles of good practice, we can assume that the best practice from the point of view of GIS information security is multiple layers of protection (Fig. 2). Caution: A high level of protection should not be expected from only one layer of defence.

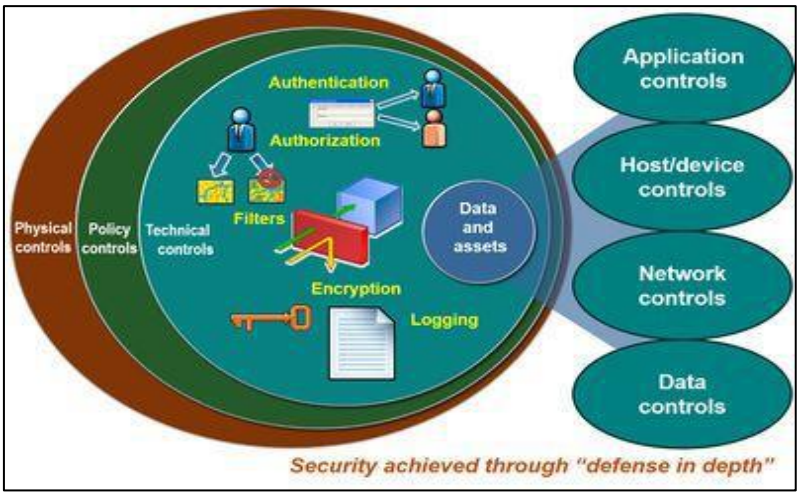


Fig. 2. Several security levels are required to ensure the protection of GIS business operations
Source: http://wiki.gis.com/wiki/index.php/Information_Security

The general security and risk management model of the GIS system is presented in Figure 3.

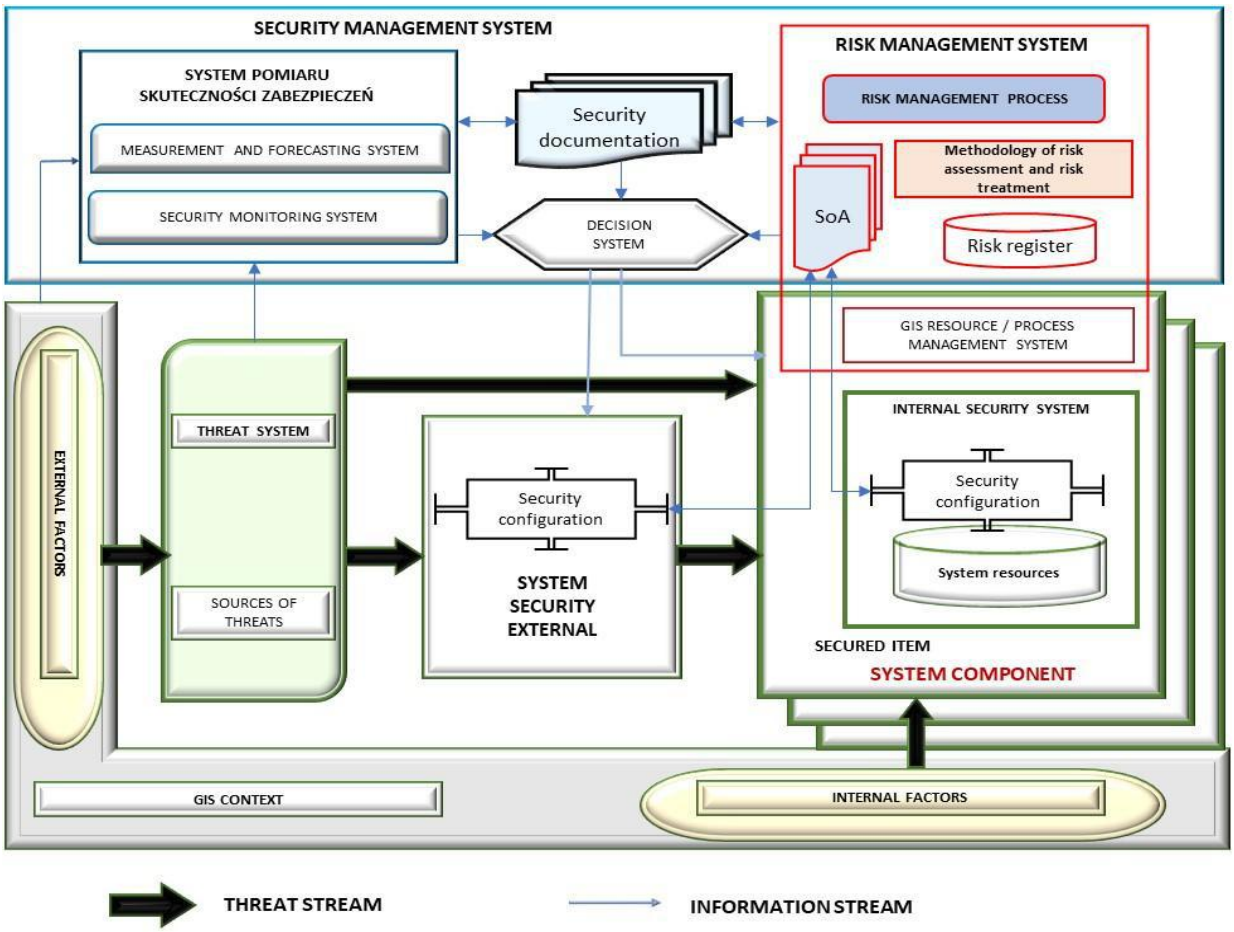


Fig. 3. General security and risk management model of the GIS system
Source: The author's own elaboration

GIS security is a property characterising the resistance to the emergence of hazardous situations, i.e. those in which the need arises to protect the internal values of the GIS system from external threats or threat factors. It was assumed that the general model of the GIS security system consists of components such as:

- The GIS context which is the set of all internal and external factors that affect the operation of the GIS and the effectiveness of achieving the objectives adopted by it. The external context includes the following factors: relations with external entities of GIS operation; external environment affecting GIS objectives: legal, financial, economic, technological. Internal context factors include: the configuration of the GIS, the resources at the disposal of the GIS (including information resources, financial resources, personnel resources, IT facilities and buildings), and the organisational chart with the division of responsibilities and roles in the GIS.
- The threat system (a set of threat sources and relationships between them) which is a specific threat generator.
- A system being secured (a threat object) having system resources of a certain value, protected by an internal protection system (a set of technical and organisational protections and relations between them).
- Security management system ensuring control of the external (superior) security system.
- Risk management system – GIS providing the GIS platform assets with an independent and cost-effective solution for all their information security and risk management requirements; the GIS risk management system can also be considered as a tool for addressing specific aspects of risk management.

A schematic illustration of the technical architecture of the GIS platform is shown in Figure 4.

There are currently several examples of integrated risk management applications, such as Risk-GIS. Developing a fusion between security, risk management philosophy and the power of GIS as a decision support tool has obvious practical applications and advantages. The purpose of Risk-GIS is to assist in decision making and problem solving in areas that affect the security and sustainability of communities. As such, it is an analytical 'engine' that drives the operational risk assessment process. It also provides a stronger form of risk communication through the ability to visually represent the risk situation.

There are many levels of integration of the Risk System with the GIS, but it is the comprehensive risk system model and integrated measurement that is the key point of this paper. This is a difficult problem due to the variety of types of risk system models and risk measures.

The security management process with the risk system can be considered as the relationship between the threat source, threats, security features, vulnerabilities and the threat objects of the technical architecture of the GIS platform with their vulnerabilities. Each local GIS subsystem informs the superordinate management system about the state of its security and forecasted threats.

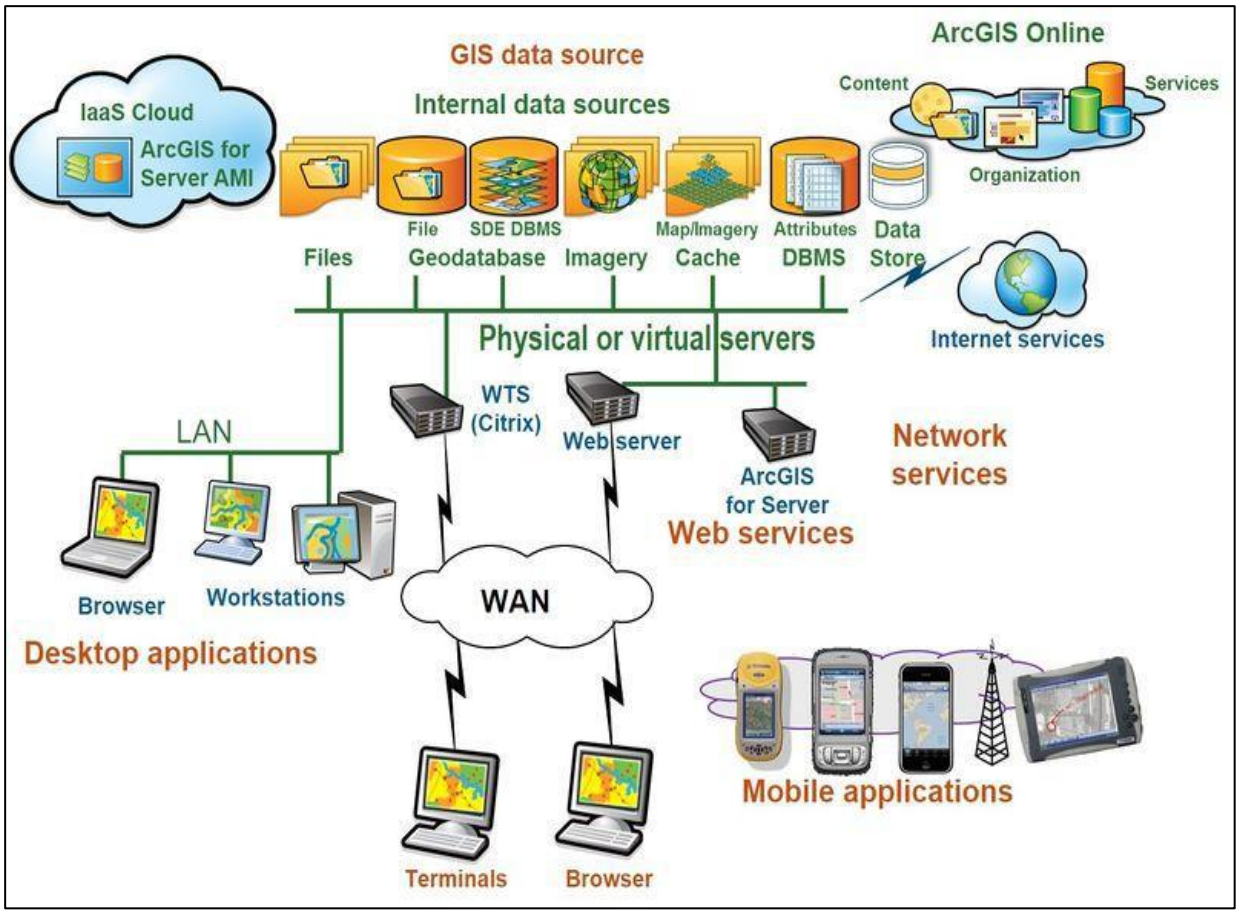


Fig. 4. Illustration of the technical architecture of the GIS platform.
Source: http://wiki.gis.com/wiki/index.php/Information_Security

The master system, on the basis of information about the state of the threat system and information about the local states of the GIS subsystems, plans a set of necessary security mechanisms of the external security system that can ensure effective protection of the resources of the GIS technical architecture.

In order to implement undertakings to ensure the required security level of GIS subsystems within the framework of an acceptable GIS security strategy, the master system should include the following subsystems:

- Decision-making system: allocates appropriate security configurations for the protection of local systems within an acceptable information security risk management strategy;
- Monitoring system: collects current information about the state of the GIS security system and identifies threat symptoms;
- Security level measurement and forecasting system: provides a basis for action planning;
- Risk management system: provides risk assessment and plans risk treatment and risk minimisation measures, which forms the basis for determining acceptable security strategies.

In the context of the above generalised model, the value of risk depends on threats, vulnerability (immunity) to threats, security gaps and the severity of the effects of threats. If threats have been identified, then a condition of system security is that the system is equipped with a certain defensive potential (resilience). In particular, it may be expressed by a specific, usually layered, system of protection against threats.

Standard approach to security risk management in GIS

Risk management as well as quality, resilience, business continuity and security management of GIS should be regular and continuous (Gregoriou et al., 2010), it should take place in a certain cycle consisting of phases, stages, processes and activities. Taking the number of distinguished stages in the life cycle of a risk management system as a criterion, we can distinguish many different models of risk management in GIS security, e.g. four-phase models, five-stage models, six-stage models, etc.

A common criterion for the subdivision/classification of security risk management models is the way in which security risk management is approached and/or the risk assessment methodology and strategy for dealing with risks. Standard approaches to security risk management are shown in Figure 5.

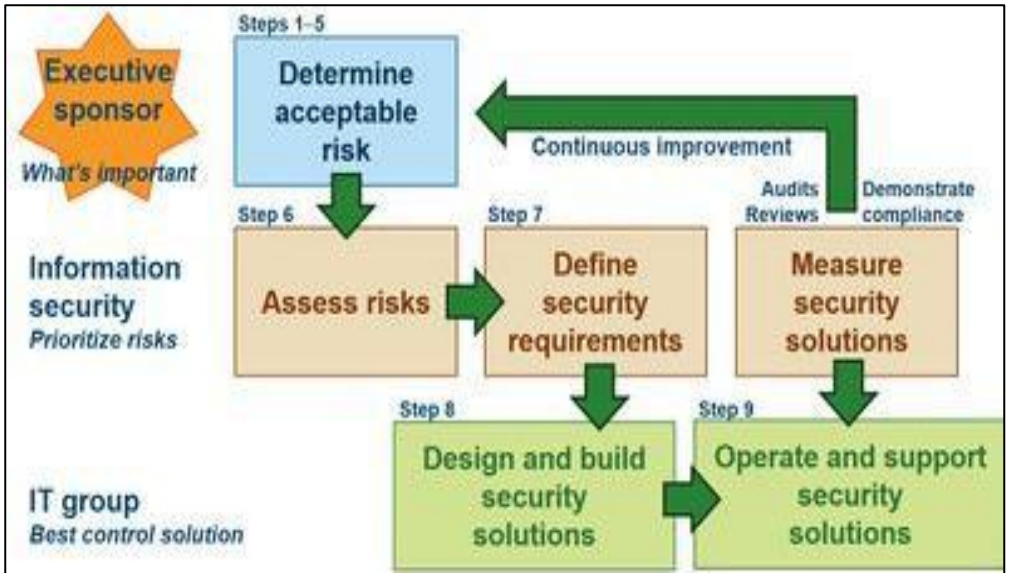


Fig. 5. Diagram of the security risk management process
Source: http://wiki.gis.com/wiki/index.php/Information_Security

Standard approaches to security risk management are well established and should be followed to ensure compliance (IEC/ISO 31010: 2009; He & Gong, 2009; Neves et al., 2015). The basic pillars of this approach with respect to GIS are in Figure 6.

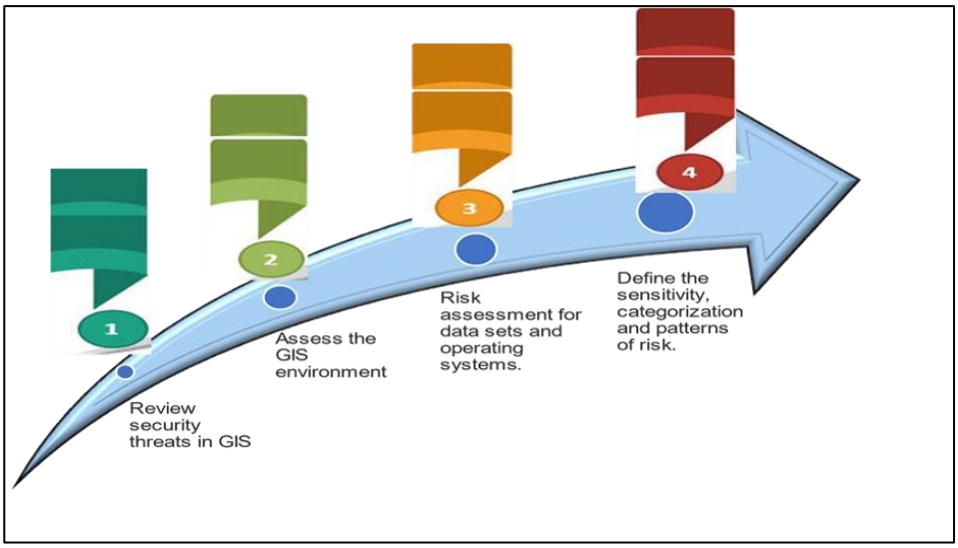


Fig. 6. Basic pillars of the standard approach
Source: The author's own elaboration

The key steps towards effective GIS information security are described in Table 1.

Table 1. Key steps towards effective GIS information security

Step name	Description
1. Legislation	Review regulations related to your industry. Security regulations can dictate compliance standards and security implementation frameworks; failure to comply can have negative business consequences.
2. Benefits	Identify any potential benefits to be gained from security compliance and operational savings attributable to the proposed security programme. This may be helpful in justifying the expenditure on the security programme.
3. Objectives	Set out the objectives of the SMART Information Security Programme. The objectives should be specific, measurable, achievable, relevant and time-bound.
4. Framework	Identify the information security management approach and methodology that will deliver results. Information security frameworks can be GIS-specific and share best practices that meet GIS business needs.
5. Approved planning	Establish a security risk assessment plan. You will need management authorisation for the required resources, support and financing.
6. Risk assessment and risk mitigation	Complete a risk assessment security needs analysis, identifying potential threats and associated mitigation strategies (Landquist et al., 2013).
7. Security features	Identify security procedures (rules) and technology (tools) to be implemented to meet identified security needs.
8. Training and awareness	Design and build validated security solutions. Implement training and awareness programmes to implement and enforce identified security practices.
9. Implementation	Operate and support security solutions. Monitor protection levels and measure compliance.

Source: The author's own elaboration

Risk management system model for GIS

For the purpose of this paper, the following definition of Risk Management System for GIS is adopted: "GIS Risk Management System (RMS) – a set of rules, principles, policies, processes, good practices, human resources and other measures relating to the risk analysis and review processes in GIS".

The GIS risk management system cannot be a creation detached from corporate reality, but must be an integral part of the organisation's management system (Kole et al., 2007). The basic components of a risk management system are:

- the strategy, which, together with the policy contained therein, sets the objectives, basic rules and a set of guidelines for risk management; it provides the basis for the development of detailed regulations and procedures;
- policy rules for risk management;
- internal regulations, rules and procedures that define the risk management process;
- the risk management structure that defines the levels of governance and the competencies and responsibilities of those involved in the risk management process;
- employees/personal resources involved in the risk management process (their qualifications);
- technical resources and IT support to the risk management process;
- management documentation;
- reporting documentation/system audit records;

In light of the above definition, an ordered five was adopted as the risk system model for controlling and maintaining an acceptable level of risk of the key elements of the technical architecture of the GIS platform:

$$\mathrm{SR} \equiv < C, SOO, \mathrm{OOO}, \mathrm{STR}, \mathrm{LCM}, \mathrm{FSC}, \mathrm{RF} > \quad (1)$$

where:

C – objective of the operation of the RMS defined on the subject of the action,

SOO – the subject of the operation of the EMS, which is the set of functional persons that make up the organisation's security service,

OOO – the object of operation of the GMS, which are the GIS objects in relation to which the required security level must be maintained,

STR – structure and attributes of a risk management system

LCM – life cycle model of risk management system

FSC – family of acceptable security configurations for the GIS technical infrastructure;

RF – reconfiguration function; this representation is determined at the IT design stage so that this representation can ensure that an acceptable level of risk is obtained. An acceptable level of risk can be achieved by generating an

appropriate functional configuration of GIS and security of GIS technical infrastructure from a set of acceptable solutions.

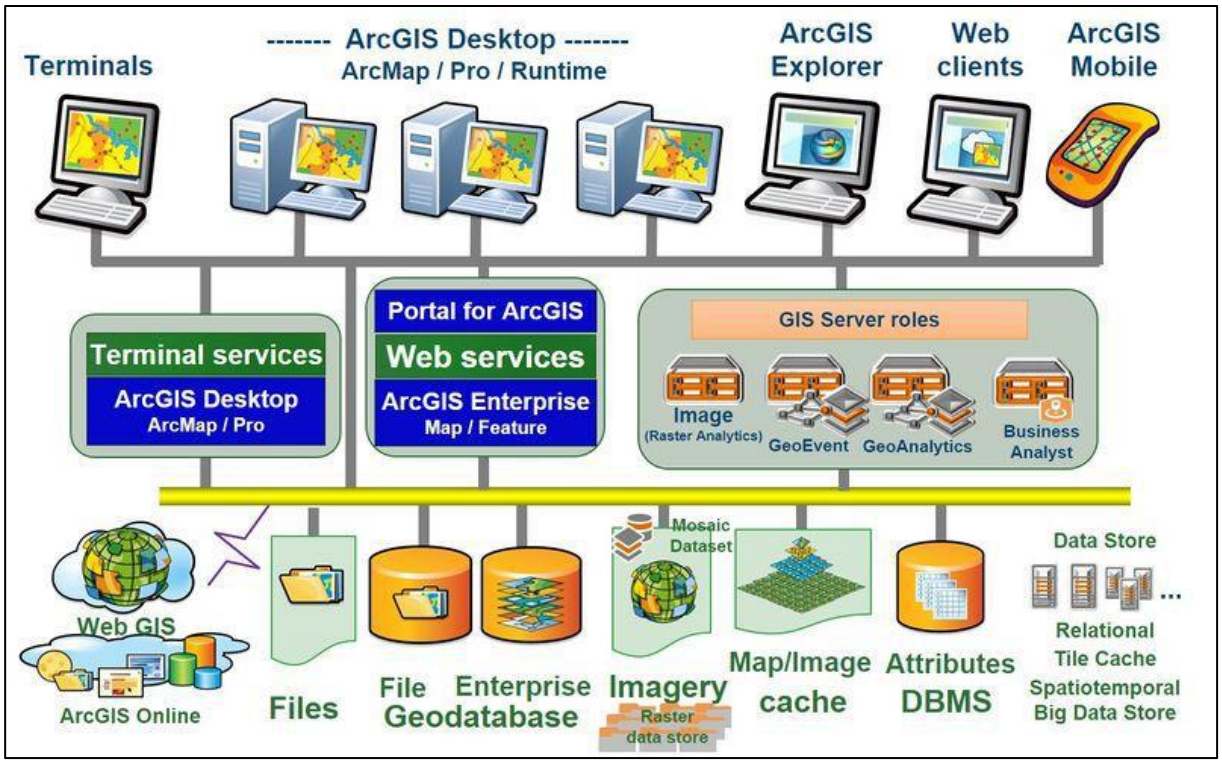


Fig. 7. Technical architecture of the GIS platform
Source: http://wiki.gis.com/wiki/index.php/Information_Security

The above elements shall be considered in the subsequent subchapters of this paper.

Subject of the operation. From the point of view of controlling the current level of information security, the subject of the operation may be:

- element of automatic development of control decisions, e.g. automatic security control system (ASCS),
- the set of functional persons, appointed within the project team and the security structure of an organisation's IT security management system (ITSMS), hereinafter referred to as the decision-maker.

Let`s introduce the following designations:

SF – set of ordered triples: $sf_p =< O_p, P_p, PO_p, MB_p > \in \Theta \times 2^P \times 2^{PO} \times 2^{MB}$, hereafter referred to as workstations; given the set of relations $\{R_i; i \in I\}$ defined on the set of SF, we can distinguish different functional structures of the GIS security service,

where:

Θ – the set of functional persons that may be nominated within the security service structure of the GIS; the set of these persons shall be defined at the stage of designing the GIS,

P – a set of protected resources owned by functional persons and for which they should maintain the required level of GIS security,

PO – a set of protective processes using appropriate protective methods and techniques of a technical or organisational nature, owned by functional persons of particular workstations; protective processes support processes of processing GIS information in the field of security and influence the continuity of business processes of the organisation.

MB – a set of security mechanisms at the disposal of functional persons and constituting

A set of controllable protective processes or protected facilities, or security mechanisms, or workstations shall specify the $\propto^{SB}$ purpose of the security service.

Object of the operation. From the point of view of controlling the current level of information security, GIS is the object of the operation of a set of such elements $e_j \in E^{GIS}$, GIS system, whose desired state may be determined by the decision-making entity (Stanik et al., 2018). The elements of the set E^{GIS} may be:

- Business processes or services;
- Organisational units;
- People;
- Locations;
- GIS IT infrastructure;
- GIS software and databases;
- Other documents and data (in electronic and other form).

Each resource of the GIS system shall be identified by a number $p \in P^{GIS}$ and described by a set of characteristics C_p^{GIS} names. If all different sets of features C_p^{GIS}, such as individual elements of the set E^{GIS}, are numbered with a variable $b = \overline{1,B}$ (which we call GIS resource type - object), then two objects are of the same type (e.g. 'b') when describing identical sets of characteristics. Sets of distinctive Q_p^{GIS} numbers describing the object $p \in P^{GIS}$ and the corresponding sets of distinctive names shall C_p^{GIS} not be empty for any person $p \in P^{GIS}$, where P^{GIS} it is a set of distinctive GIS resources numbers. We assume that for each feature $q \in Q^{GIS}$ a set A_q^{GIS} of possible performances a_q of the feature is defined.

Objective of operation of the risk management system. The operation of a risk management system can be defined:

1) with respect to the control of the security properties of GIS assets as an ordered pair:

$$DZ^{SIO} = <\propto^{SIO}, Z^{SIO}>, \tag{2}$$

where:

$\propto^{SIO}$ – the purpose of GIS in the context of information security,

Z^{SIO} – set of tasks for the secure processing of GIS information sets ensuring the achievement of the objective $\propto^{SIO}$.

2) with respect to the control of the performance features of the IT GIS infrastructure as an ordered pair:

$$DZ^{IT} = <\propto^{IT}, Z^{IT}>, \tag{3}$$

where:

$\propto^{IT}$ – the purpose of the GIS IT infrastructure,

Z^{IT} – the set of tasks (controls) of an IT administrator ensuring the achievement of a goal $\propto^{IT}$.

Structure and attributes of the risk management system. The Schematic illustration of the structure of the risk management system are shown in Figure 8.

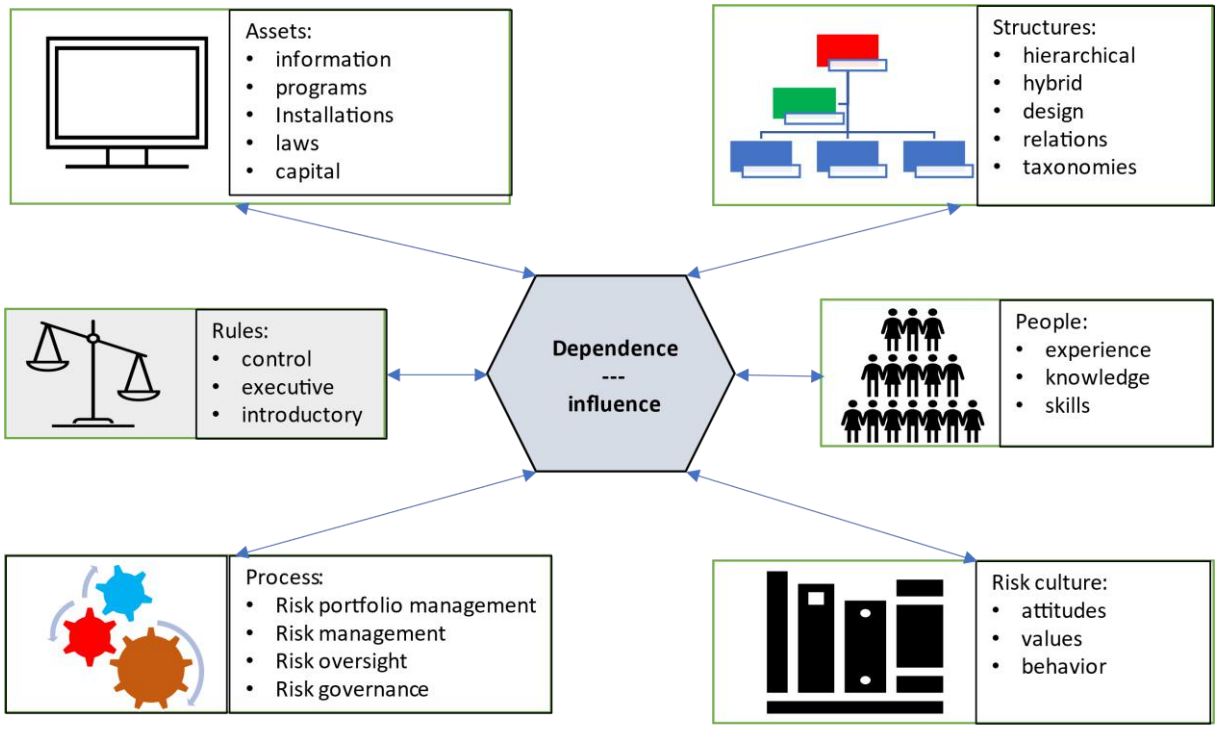


Fig. 8. Basic categories of risk management system components and their attributes
Source: The author's own elaboration

Each of these components is important for proper and effective risk management. The importance of any of these elements cannot be overlooked. The elements (components) identified in this way remain among themselves in specific relationships and system dependencies, which enables them to fulfil the common mission for which the RMS was created:

$$RMS = < \mathrm{E}^{RMS}, R^{RMS} \subseteq \mathrm{E}^{RMS} \times E^{RMS} > \rightarrow \boldsymbol{U}^{RMS} \tag{4}$$

where:

RMS – Risk Management System,

E^{RMS} – the set of elements of a risk management system,

R^{RMS} – set of system relations,

$\boldsymbol{U}^{RMS}$ – the usability of a risk management system.

Risk management systems must be characterised by specific performance characteristics that determine, inter alia, attributes such as objectives, functions, purpose, scope, boundaries, environment, structure, maturity, functionality, reliability, innovation and continuity of operation, under specific environmental conditions. We assume that usability, as an imperative feature of a risk management system, is a composite function of individual usability attributes:

$$\boldsymbol{U}^{RMS} = f(w_i^{RMS} \in \mathbb{W}^{\mathrm{RMS}}; \mathrm{i} \in \mathbb{I}^{\mathrm{RMS}}) \tag{5}$$

where:

$\mathbb{W}^{\mathrm{RMS}}$ – a set of distinguished usefulness attributes of the risk management system,

w_i^{RMS} – i-th attribute of usefulness of the risk management system,

$\mathbb{I}^{\mathrm{RMS}}$ – a set of numbers of distinguished attributes of the risk management system.

Life cycle of risk management system. In the relevant literature it is very difficult to find a definition or concept of a life cycle model of risk management. Very often this term is associated with the concept of risk management in information security (Jajuga & Kuziak, 2006; Bhattacharya, 2015; Escanciano & Olmo, 2007).

The concept of the system life cycle should be understood as a specific concept of the distribution of stages, phases or activities over time. ISO 31000 includes specific regulations for the different stages of the life cycle of the risk management process**,** such as:

1. Communication and consultation as part of risk management;
2. Determining the internal and external context and the context of risk management;
3. Defining risk criteria;
4. Risk estimation, i.e. identification and analysis of threats and risk assessment;
5. Determining a risk management strategy taking into account the different degrees of effectiveness of these strategies;
6. Preparation and implementation of risk management plans;
7. Monitoring and reviewing;
8. Documenting the risk management process.

In this paper, with reference to GIS class systems, the authors propose the following phases of the risk management system life cycle (Fig. 9).

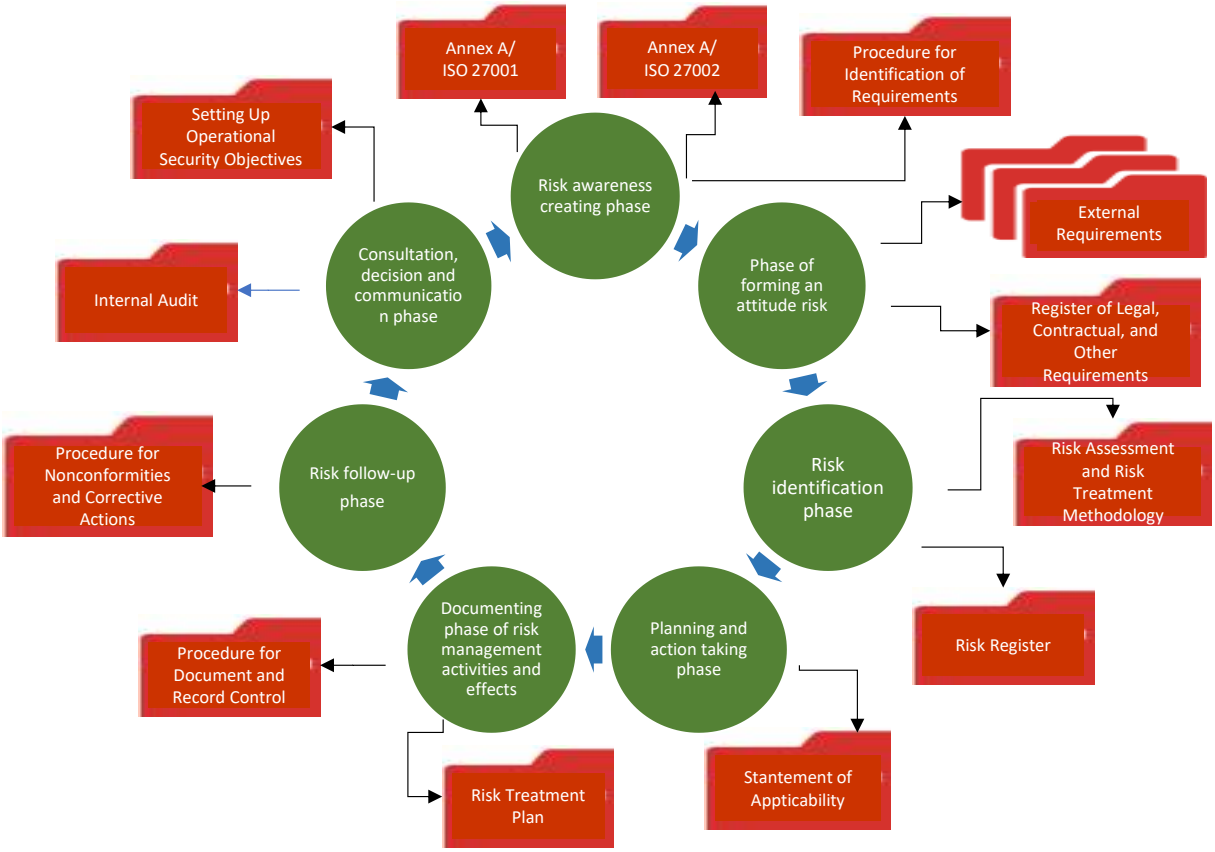


Fig. 9. Life cycle model of risk management system
Source: The author's own elaboration

Family of acceptable GIS infrastructure security configurations. Let's introduce the following notation of any security configuration:

$$KB_{kl} = \langle OB^{kl}, O^{k},\ MB^{l} \rangle \tag{6}$$

where:

- OB^{kl} – a set of information resources of the organisation's information system which such resources are protected by the security configuration,
- O^{k} – a set of functional persons involved in ensuring the security of information resources belonging to the set OB^{kl},
- MB^{l} – the set of security mechanisms of a technical or organisational nature that constitute the security configuration.

Knowledge of the security configuration KB_{kl} makes it possible to assign to each set OB^{kl}, with a fixed set MB^{l} of security mechanisms (organisational and technical safeguards), the corresponding set O^{k}. The security configuration KB_{kl} is feasible if and only if the set OB^{kl} with the fixed elements of the set MB^{l} can be assigned such *set* O^{k}, that will ensure that the required security level is maintained for the set of information resources OB^{kl}.

It is assumed that the GIS security team is equipped with a visualisation subsystem, an automatic security control subsystem and a control and diagnostic team capable of

identifying all types of GIS emergencies (security loss situations). The concept of an emergency situation $a \in A$ of type u shall $\in U$ be understood as the sets OB_n, O_m, MB_s remaining after the occurrence of an emergency situation with number u $\in U$.

The set of acceptable functional configurations after the occurrence of an emergency situation of number is determined based on knowledge (Stanik, 2019):

- OB^p – a set of GIS assets for which the required security level must be maintained,
- O^p – the set of human resources (functional persons) available after an emergency with the number u $\in U$,
- $MB^p \in$ MP – the set of deployable security configurations based on the sets of operable technical and organisational security safeguards remaining after a security loss of u $\in U$,

based on the following rule:

$$KB_{dop}^{u} = \begin{cases} \{KB_{kl} = \langle OB^{kl}, O^{k}, MB^{l} \rangle \in \Theta B_p \times \Theta_p \times MP_p : \\ OB^{kl} \supset OB^{p}\}, \ if \ \bigvee_{\langle k,l \rangle \in K^u \times L^u} (OB^{kl} \supseteq OB^{p}) . \\ \Phi \ \ in\ the\ opposite\ case\ -\ an\ empty\ set. \end{cases}$$

The above means that the set of KB_{dop}^{u} acceptable security configurations, after a loss of the ability to provide the required level of security to the GIS assets, includes all security configurations, built for different variants of personal sets and a set of safeguards of a technical or organisational nature, remaining after the occurrence of an emergency situation, which ensure that the required level of security is maintained for the current set of information assets $OB\ (t) \in \Theta\mathrm{B}(t)$. Each security configuration from the set KB_{dop}^{u} ensures that an acceptable level of security is maintained for the information resources from the set OB^{kl}.

FR mapping shall be determined at the design stage of the control system at the current level of security or at the establishment stage of the protection system, as an essential element of the SMS, to ensure that the desired objectives of the operation of the Security Service and of the information processing subsystem are achieved during their operation, despite an emergency situation. After an emergency situation – i.e. loss of the required level of security in order to effectively continue the process of safe processing of information in GIS, it is necessary to generate acceptable or optimal security configuration. Generation of the optimal or suboptimal security configuration, from among sets of permissible solutions is implemented on the basis of detailed reconfiguration function Q, which from the point of view of their essence is the criterion function.

Conclusion

Enterprise GIS environments cover a broad spectrum of technology integration. Most environments now include a variety of hardware vendor technologies, including database servers, storage area networks, Windows terminal servers, Web servers, map servers and desktop clients – all connected by a wide range of local area networks, wide

area networks and Internet communications. All these technologies must function properly to support a sustainable calculation environment and to ensure the effective functioning of cybersecurity in the GIS environment. Global cybersecurity of GIS is the accident of distinguished types of cybersecurity in the field – related to the distinguished categories of resources of information systems, types of cyber threats and elements of the technical architecture of GIS platform. Risk identification is a key step in the risk management process. The main contribution of these studies is to fill the research gap related to the lack of a proposal for a methodical, comprehensive approach to the development of an adequate GIS security model and risk management life cycle model for ISO 27001 certification. The additional value of this article is to use elements of good practice in dealing with risks that can enrich the process of drawing up the Application Declaration Document (SoA) – to make it more accurate.

This article shows that it is possible to create "good enough" GIS security models and a risk management system for GIS. The following conclusions arise from the considerations set out in this paper:

1. In order to eliminate the consequences of failure – maintaining the required level of reliability of the technical architecture of the GIS platform, security of IT resources and an acceptable level of risk, it is reasonable to clearly specify the following steps in the life cycle of the risk management system:
   - preparation of the Application Declaration Document (SoA),
   - determination on the basis of the SoA of a set of acceptable functional configurations in a given emergency situation,
   - determination of a set of acceptable protection configurations for a given emergency,
   - carry out the reconfiguration process in a given emergency.
2. The proposed way of controlling the current performance of the GIS platform technical architecture and the GIS security configuration should be an integral part of the risk management system.
3. Using the results of this work, it is advisable to conduct and develop further research in the following directions:
   - improvement of the GIS security model taking into account the guidelines of standards in the areas of reliability, security, cyber security and risk,
   - increase the precision of the proposed risk management system life cycle model by including more detailed parameters and variables.

This paper is not a ready-made recipe for comprehensive risk management in GIS class systems. This should only be regarded as a proposal by the authors for a partial solution to the problem.

References

Aranoff S. (1989). Geographic Information Systems: A Management Perspective, WDL Publications, Ottawa.

Bhattacharya J. (2015). Quality Risk Management – Understanding and control the risk in pharmaceutical manufacturing industry, International Journal of Pharmaceutical Science Invention, vol. 4 (1), pp. 29–4.

Escanciano J.C., Olmo J. (2007). Estimation Risk Effects on Backtesting for Parametric Value-at-Risk Models, Working Paper, http://papers.ssrn.com/sol3/papers.

Gregoriou G.N., Hoppe C.H, Wehn C.S. (2010). The Risk Modeling Evaluation Handbook: Rethinking Financial Risk Management Methodologies in the Global Capital Markets, McGraw-Hill, New York.

He X., Gong P. (2009). Measuring the coupled risk: A copula-based CVaR model, Journal of Computational and Applied Mathematics, vol. 223, pp. 1066–1080.

IEC/ISO 31010: 2009. Risk management – Risk assessment techniques, Geneva, ISO.

Jajuga K., Kuziak K. (2006). Model Risk Measurement – General Concept and Particular Models. In: Mathematical, Econometrical and Computational Methods in Finance and Insurance, ed. P. Chrzan, Wydawnictwo AE w Katowicach, Katowice, pp. 107–116.

Kole E., Koedijk K., Verbeek M. (2007). Selecting copula for risk management, Journal of Banking & Finance, vol. 31, pp. 2405–2423.

Landquist H., Hassellöv I.-M., Rosén L., Lindgren J.F., Dahllöf, I. (2013). Evaluating the needs of risk assessment methods of potentially polluting shipwrecks. Journal of Environmental Management, vol. 119, pp. 85–92.

Neves A.A.S., Pinardi N., Martins F., Janeiro J., Samaras A., Zodiatis G., De Dominicis M. (2015). Towards a common oil spill risk assessment framework – Adapting ISO 31000 and addressing uncertaintie.

Peggion M., Bernardini A., Masera M. (2008). Geographic information systems and risk assessment. Luxembourg: Office for Official Publications of the European Communities.

Sienkiewicz P. (2005). Teoria inżynierii bezpieczeństwa systemów, Monografia nr 3 (*Systems security engineering theory, Monograph No. 3*), Kraków, AGH.

Sienkiewicz P. (2013). Teoria efektywności systemów (*Systems efficiency theory*). Ossolineum, Wrocław.

Stanik J., Kiedrowicz M., Waszkowski R. (2018). Security and Risk as a Primary Feature of the Production Process, ISPEM 2018 (The Second International Conference on Intelligent Systems in Production Engineering and Maintenance).

Stanik J. (2019). The risk model of an it system that processes Spatial data in SIP/GIS. 26th Geographic Information Systems Conference and Exhibition GIS ODYSSEY 2019.

Wróblewski D. (ed.) (2015). Zarządzanie ryzykiem – przegląd wybranych metodyk (*Risk management – review of selected methodologies*), Józefów, Wydawnictwo CNBOP-PIB.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.57

Małgorzata Renigier-Biłozor[1], Artur Janowski[2], Marek Walacik[3], Aneta Chmielewska[4]

FEATURE ENGINEERING IN PROPERTY MARKETS HOMOGENOUS AREAS DETERMINATION PROCEDURES

Abstract: Real estate is one of the most important aspect of our life and play significant role in global economy. Sooner or later, everyone has contact with properties that are place for life, work, investment, relax. That is why properties are part of many decision-making systems related to valuation, taxes, land planning and sustainable development of the areas. Analysis related to property market are based on many assumptions such as property homogeneity determination. The following paper presents proposal of utilization of automated solutions based on robust geo-estimation that enables high efficacy of property submarkets identification. The study is to propose the optimal solutions for initial part of the homogenous market analyses such as feature engineering, that enables unbiassed identification of the homogenous areas (zones). In this case the following methods based on robust geo-estimation/geoprocessing will be used: Gauss filter, geocoding and reverse geocoding, tessellation model and entropy theory.

Keywords: homogeneous areas, property market analyses, robust geo-estimation, feature engineering

Received: 16 June 2022; accepted: 21 July 2022

[1] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Department of Spatial Analysis and Real Estate Market, Olsztyn, Poland, ORCID ID: http://orcid.org/0000-0002-4630-7564, email: malgorzata.renigier@uwm.edu.pl

[2] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Department of Geodesy, Olsztyn, Poland, ORCID ID: http://orcid.org/0000-0002-5535-408X, email: artur.janowski@uwm.edu.pl

[3] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Department of Spatial Analysis and Real Estate Market, Olsztyn, Poland, ORCID ID: http://orcid.org/0000-0003-1904-476X, email: marek.walacik@uwm.edu.pl

[4] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Department of Spatial Analysis and Real Estate Market, Olsztyn, Poland, ORCID ID: http://orcid.org/0000-0001-5888-5874, email: aneta.chmielewska@uwm.edu.pl.

Introduction

Identification of comparable market areas seems to be the most neuralgic though substantial step in property analyses or valuation procedures. The one of the common interpretations of the markets states that these are, as similar to each other as possible, in the given local, conditions and types of real estates, taking into account physical-legal (endogenous) and location-economic (exogenous) aspects. The empirical problem in homogeneous markets elaboration is related to the reconciliation of two intrinsically heterogeneous phenomes: property describing factors and the properties themselves described by physical and legal characteristics. Another crucial aspect is the comparable market areas determination is the optimal way of analysis conduction.

In every property market analyses the feature selection and definition is very important, therefore their proper measurement and coding that enable their real impact reflection seems to be additional challenge in this topic.

The selection of homogeneous markets should be based on a strictly defined procedure in terms of its main stages, but as flexible as possible to ensure proper and real adaptation to the analyzed market area. An in-depth analysis of the literature on this topic was presented in the previous authors' publication entitled "Modern challenges of property market analysis-homogeneous areas" (Renigier-Biłozor et al., 2022). General stages of feature model preparation for homogenous areas determination were presented below (Fig. 1).

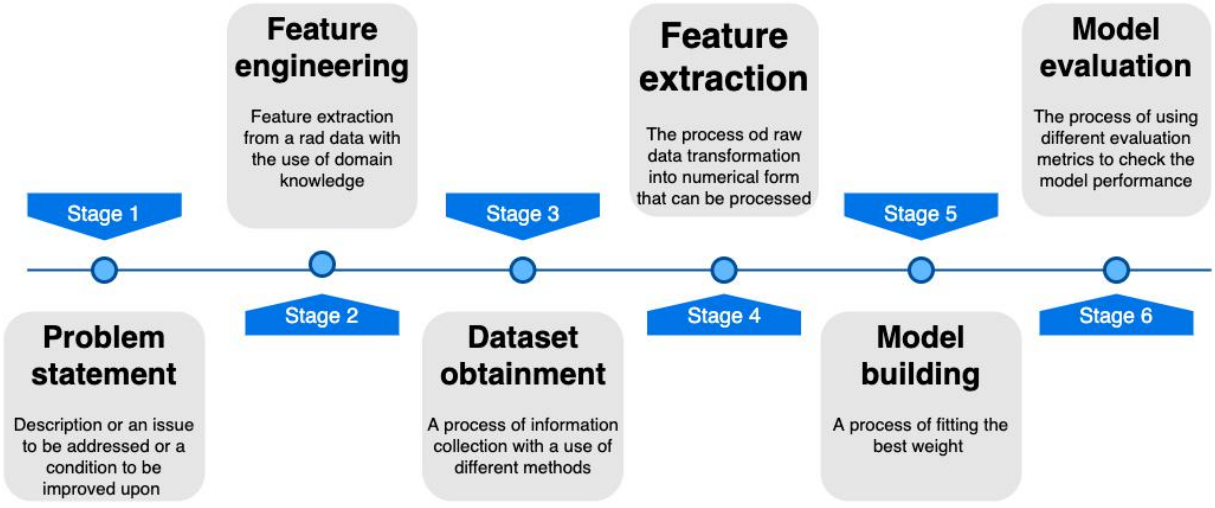


Fig. 1. Stages of feature model preparation for homogenous areas determination
Source: Own elaboration

The objective of the study is to propose the optimal solutions for initial part of the homogenous market analyses – feature engineering, that enables unbiassed identification of the homogenous areas (zones) with the use of following methods based on robust geo-estimation/geoprocessing: Gauss filter, geocoding and reverse geocoding, tessellation model and entropy theory.

Literature review and research issues

An important and indispensable stage of most market analyzes is the grouping / classification of objects into similar ones as a certain model depicting a complex / multi-dimensional phenomenon. While the details of this classification in relation to specific features or selected quantities are the domain of a given field of research, its general assumptions have (or should have) certain utilitarian schemes, stages or conditions incorporated into the technology or method used for this purpose.

When analyzing the real estate market, it should be considered that the dependencies occurring on it may be purely random, and an additional difficulty is their dynamically changing nature. Along with the growing awareness of the difficulties in getting to know the details of the processes taking place in the real estate market and reducing it "artificially" to a strictly deterministic and, in fact, perfect phenomenon, the need to look for approximate, blurred, indistinct, fuzzy solutions that can provide optimal, more satisfying results than these so-called “categorical”. The importance of the following scientific problem is underlined in the current state of art e.g. Del Giudice & De Paola (2017); Goodman & Thibodeau (1998); Manganelli et al. (2016); Morano et al. (2017); Morano & Tajani (2016); Tajani et al. (2016); Borst (2012).

In property taxation the homogeneity of the property market definition is indispensable. Usually, a taxation zone is an area in which a certain number of properties, being subject to an appraisal, demonstrate the same impact of the location on their value. According to Gnat (2019a) all the properties located in a given elementary area (a taxation zone) formally do not differ in terms of their locality. Many research work underlines the issue that indication of the zones constitutes one of the key problems that have significant impact on the accuracy of the achieved appraisal results (Cellmer & Kuryj, 2011; Manganelli et al., 2014; Morano & Manganelli, 2014; Rae, 2015; Renigier-Bilozor et al., 2019; Sawiłow, 2009; Wu and Sharma, 2012; Wu et al., 2020).

On the other hand, it is worrying that many researchers “do not understand the implication of the market segments they use in their studies and choose areas arbitrarily and ones that are too large for a meaningful evaluation of the benefit of market segmentation” and “neighborhood delineation (…) does not depend on apriori definitions such as administrative units, census tracts, ward boundaries“ (Borst, 2007). The aforementioned methods of submarkets are frequently criticized and treated as unscientific by people preferring markets classification based on empirical data (Calka, 2019; Chen et al., 2009; Mach, 2014; Salvati et al., 2019; Usman et al., 2020; Wu et al., 2018). Very interesting definition of the homogeneous areas was provided by the Eremeev et al. (2017) who claimed that objects that are not even explicitly connected and include similar objects, such as buildings, parks etc., as a rule, make up structures.

Another important issue in this topic is the determination of the size of homogeneous areas, which usually depends on the adopted assumptions. According to Manganelli at al. (2014) “the size of a homogeneous market area depends on structural factors and this value reflects the perception of market operators about location,

neighborhood, area where the property is located and inhabitants' characteristics, in practice place identity". According to Borst (2007) similarity of location is a fundamental assumption of division the universe of properties into subgroups. Numerous features of properties demand market segmentation through distinct property components consideration (Gabrielli et al., 2017; Islam & Asami, 2009; Keskin & Watkins, 2017; Warren et al., 2017).

Homogeneous areas elaboration has useful implications in terms of the property valuation, taxation, planning territorial transformations and verifying ongoing or ex post decision making. What underline Royuela and Duque after Jenkins (Jenkins, 1978; Royuela & Duque, 2013) the use of homogeneous geographic regions to define the applicability and scope of a policy or marketing strategy increase the probability of achieving the intended effects and of better predicting the unintended effects.

There is not both universal procedure and methods dedicated to homogeneous areas indication in property market analyses.

Methodology of feature engineering in homogenous areas determination

The methodology of the homogeneous property markets features engineering will be based on the several main stages. The proposed methodology is a universal and flexible solution that can be implemented in this form in other types of analyzes, aiming at homogeneous selection according to the predetermined ambiguous level of indiscernibility. In order to ensure that the analysis procedure follows the essential criteria presented in the proceeding chapters, the authors assumed the following conditions:

- the object's influence in space is not limited to a given space projection, but also includes buffers reflecting the strength of its impact,
- the division of space into optimal figures using the methodology of analytical geometry algorithms, eliminating the so-called "information dead points" at the interface of the designated area division grid (figures / units),
- "homogeneous" transactions are not strict (crisp) but a rough set with the assumed definition of similarity,
- homogeneous transactions do not have to be located only in the nearest neighborhood, the measurement of factors should be consistent with their real meaning and impact (e.g. city center travel time, sea – view, public transport accessibility etc.),
- minimizing the of the so-called behavioral simplification in the selection, quantification, and analysis of data through, inter alia, sensitivity analysis,
- classification of the attribute's significance by measuring capacity of information in data – there is no final and time-stable set of features for each type of market property.

Division of the area into optimal units.

The initial point for every spatial analysis based on vector datasets is the description of data categories that is why analytical geometry algorithms can be used for that purpose according to the following stages:

a) a rectangular node grid production at a fixed distance a.

b) creation of regular units of circles based on the node grid (that forms the circles centers).

Analysis of continuous and non-discrete impact of spatial factors for individual units according to the two simultaneous solution enables:

- provision of covering parts of neighboring circles (at assumed radius derived from analysis, with fulfilled condition that r < a), thus preliminary continuity of impact of spatial features without specified delimiting concrete skeletal lines,
- neighboring units attribute values influence increase.

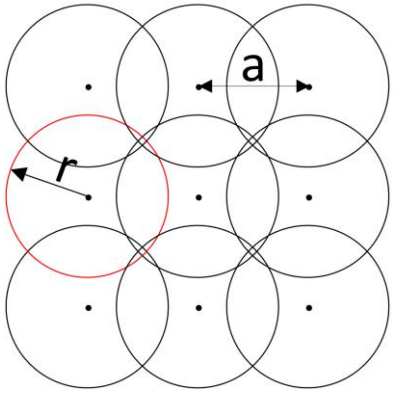


Fig. 2. Example of distances between the grid nodes and the radius of tessellation unit
Source: Own elaboration

Provided nodes grid with assigned features enable to conduct the sensitive analyses. The grid should be assumed based on the quantity of the established homogeneous groups. The nodes do not have to have strictly assigned attribute magnitude and their determination should be based on methods depending on the nature and spatial impact of the attribute. Additionally, it is worth to underline, that tessellation by means of tangent figures does not naturally consider the spatial characteristics of the neighboring units. A possible solution is to consider 4 or 8-neighborhoods, however, such a solution does not take into account the influence of units in a linearly dependent manner.

Indication and collection scope of the information about market.

In order to describe the analyzed market, the extensive literature review is usually conducted:

- **proximity and accessibility of facilities/services** is one of the factors mentioned most frequently in the literature dealing with market analysis and property valuation. The facilities include education institutions (e.g. primary schools, kindergartens etc.), health care institutions (e.g. hospitals), shopping centers (e.g.

convenience, bakeries etc.). The reason for their significance is usually connected with suitability of the neighborhood, the need and frequency of their use and time required for it. (Rabiei-Dastjerdi et al., 2021; Zheng et al., 2016);
- **environment conditions** are other characteristic indicated in the literature. Water, air or noise pollution and the accessibility of green spaces or natural hazards occurrence (e.g. floods) are the elements that seem to have the biggest influence on the residential property purchase decision. (Czembrowski & Kronenberg, 2016; Źróbek et al., 2015);
- **property communication** is another factor taken into consideration in residential property purchase decision making. The feature is usually interpreted accessibility to public transport (buts, stops, rail, metro) or distance from central business districts or public facilities (measured with time of cost of travel) (Guo et al., 2016; Hendricks, 2016; Shen & Karimi, 2017);
- **neighborhood aesthetics and social and economic background** seems to be the last predominate location characteristics described in the literature. Even though the factors might seem completely different they are usually strongly corelated. The dominating ethnicity, language, religion, family size, education level etc. usually influences the surrounding aesthetics (Bin et al., 2017; Mei et al., 2020; Pangallo et al., 2019; Xiao, 2017).

Creation of database model based on the ETL solution

Data acquisition and building a database model can be based on the classic ETL solution (Extract, Transform, Load).

Extraction

Data extraction and model determination should use of geoprocessing activities based on circle units. In order to fulfill the assumed requirements the following tasks should be conducted:
- **2D objects description** (e.g. green areas, surface area etc.), with special respect to zonal influence of individual spatial characteristics avoidance omitting – area size overlapping data layers (representing particular features);
- relevant city objects (e.g. airport or other points of interest) **distance** (e.g. euclidean) measurement for the proximity assessment of factors where the propagation or nuisance of their impact is a linear dependence on the distance or its derivative;
- **the pgRouting** use for factors proximity assessment where the propagation or nuisance of their impact is a nonlinear dependence on the distance or its derivative, distances to significant city life facilities measured along communication tracts;
- most of the data used to build the description of spatially homogeneous groups can be provided directly or indirectly form OSM (Geofabrik). OSM layers should be grouped thematically and in terms of vector representation.

Data application possibility can be analyzed, and spatial-semantic extraction performed with the use of (PostgreSQL/PostGIS/pgRouting) – Fig. 3.

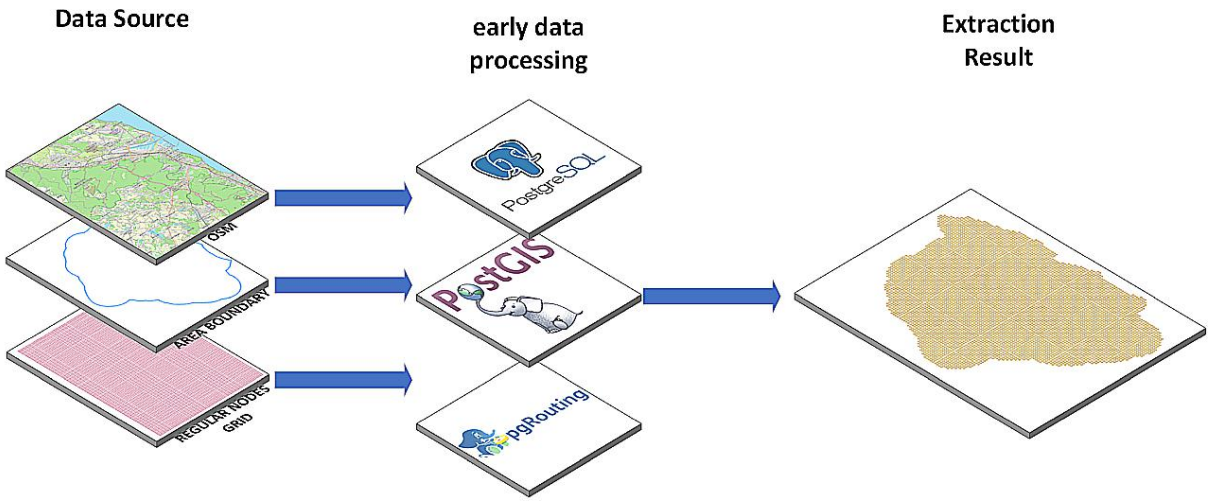


Fig. 3. Extraction process and components diagram
Source: Renigier-Biłozor et al. (2022)

As a result of the extraction and transformation of the values of all attributes, the actions taken should lead to the construction of a database whose entity-relationship diagram (ERD) example was presented below (Fig. 4).

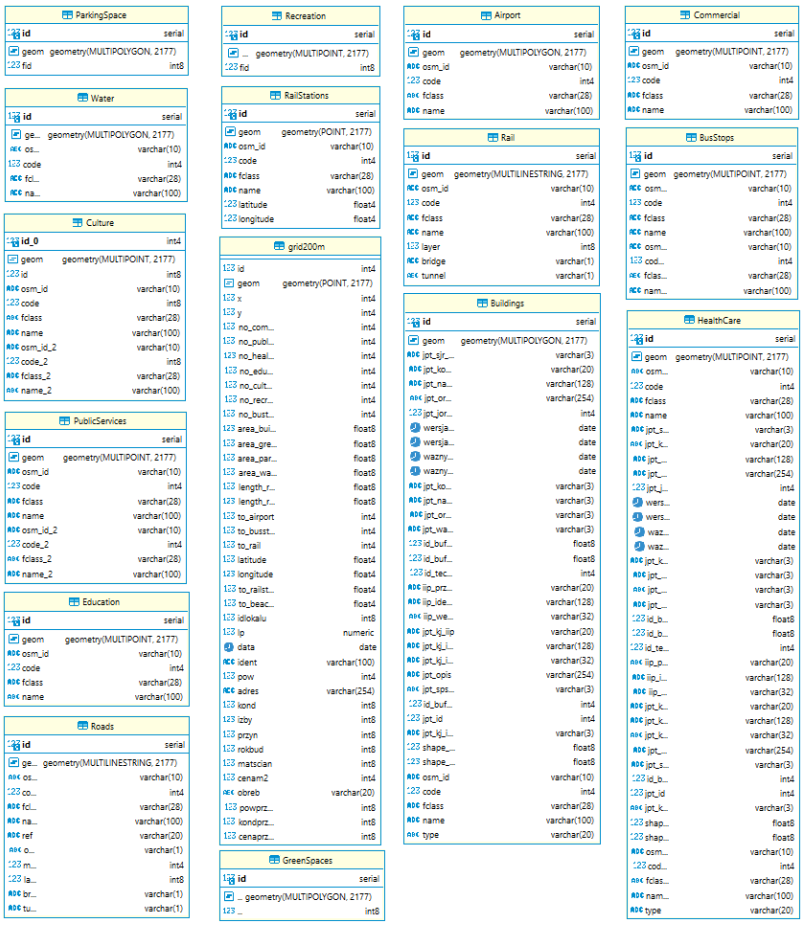


Fig. 4. Working ERD Diagram
Source: Own elaboration

Spatial extraction consisted in defining the spatial research area can be increased by a fixed buffer. Area boundary should be selected from the entire vast spatial data set only. Area boundary also makes it possible to define a tessellation layer of circular units, which in further stages of the study can have assigned quantified values of attributes describing space based on distance (Euclidean/pgRouting) to selected types of objects, their quantity or surface areas occupied by individual objects in units.

Transformation

Because of the fact that different attributes can have different characters (area, distances etc.) and type and format for storing that are not compatible – it is difficult to compare a description of numeric features, a greater unification can be indispensable. It can be processed with multiple and different types of sources data extraction and unification and smoothing. In individual units it can be obtained by the use of the entropy and Gaussian function for blurring unit tessellation.

The entropy theory allows consider simultaneously information's diversity, merit and usefulness. In the presented spin of entropy, a measure of 'disorder, chaos and randomness of certain information' (Shannon & Weaver, 1964), was used as a distinguishing factor. Entropy as a measure of homogeneity has been used in a regional analysis (Doszyń, 2008; Gnat, 2019b) as the useful measure of urban sprawl (Cabral et al., 2013), road connection order/disorder (Boeing, 2019).

Even though different theories, perceive entropy in a different way one can approach a number of equations describing it. Commonly, entropy is a logarithmic measure of the number of states with significant probability. In property market analysis the analyzed data is usually presented in the continuous form where the common formulas are inadequate. Due to this fact the following Formula 1. (Frigg and Werndl, 2011; Klein, 1970) was used for the data that consider the specificity of the geo-market information:

$$E_j = -K \sum_{i=1}^{m} n_{i,j} ln n_{i,j};\ K = 1/lnm;\ i = 1,\ldots,m;\ j = 1,\ldots,n, \qquad (1)$$

where:
Ej– entropy,
K – constant,
m – number of states in particular features,
n – expected (possible) states of feature.

Increasing the blur, stretching, mutual penetration of influence on average units can be obtained with the use of Gauss filter (especially used during blurring image data in computer vision applications and spatial data filtration (Tysiąc, 2020)) (Formula 2):

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}, \qquad (2)$$

Its discrete form of formula application for specificity of property market information is useful and efficient. Its discreet form with standard deviation σ= 1 and the size of 5×5 kernel was shown on the example below in Fig. 5.

$$G(x,y) = \frac{1}{16}$$

Fig. 5. The weights of individual neighboring units in Gauss filter discrete form for 3x3 kernel size and standard deviation equals 1
Source: Own elaboration on the OSM background

The received result data can occur to be of discrete character, which contradicts the concept of space continuity, also in terms of the real estate market. Therefore, in order to mitigate the locally high polarization of the descriptive attributes values that may occur in groups of neighboring units, Gaussian function can be used (Fig. 6).

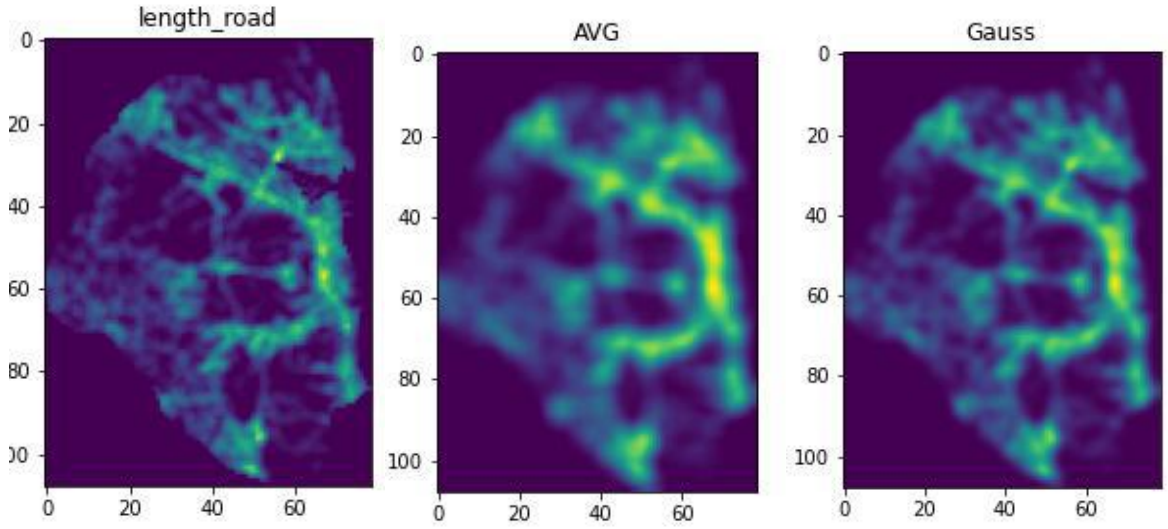


Fig. 6. Visualization of the Gauss filter attribute intensity mitigation (here: length road) with AVG calculated as arithmetic mean
Source: Own elaboration

Loading

Prepared data sets (into comparable form and assumed database) can be collected in the relational database PostgreSQL with PostGIS (spatial database extender for PostgreSQL). This gives the opportunity to:

- increase the efficiency of geometric and spatial processes with the use of spatial queries,

- automate the analyzed thematic layers geolocation of OSM, circle units and their mutual spatial relationships visualization in GIS tools (eg. QGIS, ArcGIS),
- integrate data and its portability,
- integrate data that provides compliance of the form of their storage and analysis with the objectives set up,
- multiple computing scripts (which are important in parallel way) to achieve optimal results in relation to the spatial polarization of unit's clusters.

Geo-features significance

Having removed the information redundancy an integral description of the space can be obtained within the database server – each clearly defined unit can have assigned strictly defined sets of values describing individual attributes.

For the purposes of properly features diversification in terms of their relevance and importance the entropy method can be used. This phase can be complex due to the lack of a decision factor (dependent features), to which the significance can be determined. It can be assumed, for the analysis purposes, that the relevance of variables is determined on the basis of weight of features fixed using the measures of entropy.

In this stage, a measure of entropy can be calculated for particular features according to the following Formula 3:

$$w_j = \frac{1-E_j}{\sum_{i=1}^{n}(1-E_i)}, \qquad (3)$$

where:

w_j – weight for particular feature j,

E_j – entropy calculated for particular feature j.

It must be underlined that the smaller the value of entropy and smaller variation in the analyzed information, the greater the weight of a given factor and consequently the greater the significance of the impact of the information on the outcome of the homogeneity classification/analyses. Realization of this stage enables indication of the minimum weight that should be considered in the analyses. In this stage it is possible to remove some particular data with marginal weight (under assumed significance threshold).

Conclusions

Subjectivity in property market analysis or property valuation seems to be the biggest disadvantage of the procedures and source of many misunderstandings. Therefore, while estimating property values or assessing its' investment potential, it is substantial to make the data collection and selection of homogenous groups of properties and market areas as objective and unbiased as possible. Proper comprehension of the complex real estate market dependencies requires the identification of relevant reference for analysis – submarkets. The challenge here is to determine appropriate criteria for distinguishing these submarkets and define the way of determining the similarity of the real estate market areas. The procedure of submarkets selection is multistage and involve:

- comparable area unit definition,
- particular attributes definition,
- methodology elaboration and appropriate methods selection,
- results verification.

The most troublesome, from analytical point of view, are the questions: how to combine two heterogeneous aspects - the property (physical and legal features describing it) and location (spatial features), and how to choose the size of the comparison unit?

Modern approaches to this problem are seeking for methods that allow to minimize the impact of information noise, errors or gaps in information or subjectivity in data processing and allow the processes large databases to the highest degree of raw data. Particular advantages of the presented solutions enable do diminish the following common simplifications in this area of the research:

- no need of a priori precise markets boundary definition,
- no limitations in either area or number of transaction feature description,
- no need of a priori features weights/significance definition,
- interpretation of area as contiguity phenomena described by the features elaborated in the buffer mode,
- indication of homogeneous areas as the indiscernibility areas that take into account specificity of the properties and markets related to their fundamental differentiation,
- high flexibility, scalability of the algorithm related to the boundary conditions of the model (entropy weight).

Acknowledgements

This work was supported by the National Science Centre [grant number 2019/33/B/HS4/00072, 2019/03/X/HS4/01035].

References

Bin O., Czajkowski J., Li J., Villarini G. (2017). Housing Market Fluctuations and the Implicit Price of Water Quality: Empirical Evidence from a South Florida Housing Market. Environmental and Resource Economics, vol. 68, pp. 319–341. https://doi.org/10.1007/s10640-016-0020-8.

Boeing G. (2019). Urban spatial order: street network orientation, configuration, and entropy. Applied Network Science, vol. 4, pp. 1–19. https://doi.org/10.1007/s41109-019-0189-1.

Borst R.A. (2007). Discovering and applying location influence patterns in the mass valuation of domestic real property. Doctoral thesis, Ulster: University of Ulster.

Borst R. (2012). A space-time model for computer assisted mass appraisal. Aestimum, pp. 535–545. https://doi.org/10.13128/Aestimum-13160.

Cabral P., Augusto G., Tewolde M., Araya, Y. (2013). Entropy in urban systems. Entropy, vol. 15, no. 12, pp. 5223–5236, https://doi.org/10.3390/e15125223.

Calka B. (2019). Estimating residential property values on the basis of clustering and geostatistics. Geosciences, vol. 9, pp. 1–14. https://doi.org/10.3390/geosciences9030143.

Cellmer R., Kuryj J. (2011). Określanie stref o podobnej cenności gruntów z wykorzystaniem metod geostatystycznych (*Defining the Land Value Zones with Use of Geostatistical Methods*). Studia i Materiały Towarzystwa Naukowego Nieruchomości, vol. 19, pp. 7–19.

Chen Z., Cho S.H., Poudyal N., Roberts R.K. (2009). Forecasting housing prices under different market segmentation assumptions. Urban Studies, vol. 46, pp. 167–187. https://doi.org/10.1177/0042098008098641.

Czembrowski P., Kronenberg J. (2016). Hedonic pricing and different urban green space types and sizes: Insights into the discussion on valuing ecosystem services. Landscape and Urban Planning, vol. 146, pp. 11–19. https://doi.org/10.1016/j.landurbplan.2015.10.005.

Del Giudice V., De Paola P. (2017). Spatial analysis of residential real estate rental market with geoadditive models, in: Studies in Systems, Decision and Control. Springer International Publishing, pp. 155–162. https://doi.org/10.1007/978-3-319-49746-4_8.

Doszyń M. (2008). Statystyczno-ekonometryczna analiza skłonności ludzkich (*Statistical-Econometric Analysis of Human Propensities*). Rozprawy i Studia / Uniwersytet Szczeciński, no. 707, 151 pp.

Eremeev S.V., Kuptsov K.V., Seltsova E.A. (2017). Algorithm for selecting homogeneous regions from a set of spatial objects, in: Proceedings of 2017 20th IEEE International Conference on Soft Computing and Measurements, SCM 2017. Institute of Electrical and Electronics Engineers Inc., pp. 109–112. https://doi.org/10.1109/SCM.2017.7970511.

Frigg R., Werndl C. (2011). Entropy: Aguide for the Perplexed. In: C. Beisbart, S. Hartmann (ed.), Probabilities in Physics. Oxford University Press, Oxford. https://doi.org/10.1093/acprof:oso/9780199577439.003.0005.

Gabrielli L., Giuffrida S., Trovato M.R. (2017). Gaps and Overlaps of Urban Housing Sub-market: Hard Clustering and Fuzzy Clustering Approaches. In: S. Stanghellini, P. Morano, M. Bottero, A. Oppio (ed.), Appraisal: From Theory to Practice. Green Energy and Technology. Springer, Cham. https://doi.org/10.1007/978-3-319-49676-4_15.

Gnat S. (2019a). Measurement of entropy in the assessment of homogeneity of areas valued with the Szczecin Algorithm of Real Estate Mass Appraisal. Journal of Economics & Management / University of Economics in Katowice, vol. 38, pp. 89–106. https://doi.org/10.22367/jem.2019.38.05.

Gnat S. (2019b). The Impact of the Training Set Size on the Classification of Real Estate with an Increased Fiscal Burden. Real Estate Management and Valuation, vol. 27, pp. 53–62. https://doi.org/10.2478/remav-2019-0015.

Goodman A.C., Thibodeau T.G. (1998). Housing Market Segmentation. Journal of Housing Economics, vol. 7, pp. 121–143. https://doi.org/10.1006/jhec.1998.0229.

Guo Y., Agrawal S., Peeta S., Somenahalli S. (2016). Impacts of property accessibility and neighborhood built environment on single-unit and multiunit residential property values. Transportation Research Record: Journal of the Transportation Research Board, vol. 2568, pp. 103–112. https://doi.org/10.3141/2568-15.

Hendricks A. (2016). Christchurch, New Zealand: Proceedings. Copenhagen: International Federation of Surveyors (FIG) https://www.fig.net/resources/proceedings/fig_proceedings/index.asp (access: 05.09.2021).

Islam K.S., Asami Y. (2009). Housing market segmentation: A review of Urban and Regional Development Studies, vol. 21, pp. 93–109. https://doi.org/10.1111/j.1467-940X.2009.00161.x.

Jenkins W. (1978). Policy Analysis: A Political and Organizational Perspective. Martin Robertson, London.

Keskin B., Watkins C. (2017). Defining spatial housing submarkets: Exploring the case for expert delineated boundaries. Urban Studies, vol. 54, pp. 1446–1462. https://doi.org/10.1177/0042098015620351.

Klein M. (1970). Ludwig Boltzmann, Encyclopedia.

Mach Ł. (2014). Próba budowy homogenicznych grup województw w obszarze lokalnych rynków nieruchomości mieszkaniowych (*The attempt to create homogeneous groups of provinces in the residential real estate market*). Metody Ilościowe w Badaniach Ekonomicznych, vol. 15, pp. 219–227.

Manganelli B., De Paola P., Del Giudice V. (2016). Linear programming in a multi-criteria model for real estate appraisal, in: Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). Springer Verlag, pp. 182–192. https://doi.org/10.1007/978-3-319-42085-1_14.

Manganelli B., Pontrandolfi P., Azzato A., Murgante B. (2014). Using geographically weighted regression for housing market segmentation. International Journal of Business Intelligence and Data Mining, vol. 9, pp. 161–177. https://doi.org/10.1504/IJBIDM.2014.065100.

Mei Y., Gao L., Zhang J., Wang J. (2020). Valuing urban air quality: a hedonic price analysis in Beijing, China. Environmental Science and Pollution Research, vol. 27, pp. 1373–1385. https://doi.org/10.1007/s11356-019-06874-5.

Morano P., Manganelli B. (2014). Estimating the market value of the building sites for homogeneous areas. Advanced Materials Research, vol. 869–870, pp. 14–19. https://doi.org/10.4028/www.scientific.net/AMR.869-870.14.

Morano P., Tajani F. (2016). Bare ownership of residential properties: Insights on two segments of the Italian market. International Journal of Housing Markets and Analysis, vol. 9, pp. 376–399. https://doi.org/10.1108/IJHMA-07-2015-0037.

Morano P., Tajani F., Locurcio M. (2017). GIS application and econometric analysis for the verification of the financial feasibility of roof-top wind turbines in the city of Bari (Italy). Renewable and Sustainable Energy Reviews, vol. 70, pp. 999–1010. https://doi.org/10.1016/j.rser.2016.12.005.

Pangallo M., Nadal J.P., Vignes A. (2019). Residential income segregation: A behavioral model of the housing market. Journal of Economic Behavior & Organization, vol. 159, pp. 15–35. https://doi.org/10.1016/j.jebo.2019.01.010.

Rabiei-Dastjerdi H., McArdle G., Matthews S.A., Keenan P. (2021). Gap analysis in decision support systems for real-estate in the era of the digital earth. International Journal of Digital Earth, vol. 14, pp. 121–138. https://doi.org/10.1080/17538947.2020.1808719.

Rae A. (2015). Online Housing Search and the Geography of Submarkets. Housing Studies, vol. 30, pp. 453–472. https://doi.org/10.1080/02673037.2014.974142.

Renigier-Bilozor M., Janowski A., Walacik M. (2019). Geoscience methods in real estate market analyses subjectivity decrease. Geosciences, vol. 9, pp. 1–20. https://doi.org/10.3390/geosciences9030130.

Renigier-Biłozor M., Janowski A., Walacik M., Chmielewska A. (2022). Modern challenges of property market analysis-homogeneous areas determination. Land Use Policy, vol. 119, pp. 106209. https://doi.org/10.1016/j.landusepol.2022.106209.

Royuela V., Duque J.C. (2013). HouSI: Heuristic for delimitation of housing submarkets and price homogeneous areas. Computers, Environment and Urban Systems, vol. 37, pp. 59–69. https://doi.org/10.1016/j.compenvurbsys.2012.04.005.

Salvati L., Ciommi M.T., Serra P., Chelli F.M. (2019). Exploring the spatial structure of housing prices under economic expansion and stagnation: The role of socio-demographic factors in metropolitan Rome, Italy. Land use policy, vol. 81, pp. 143–152. https://doi.org/10.1016/j.landusepol.2018.10.030.

Sawiłow E. (2009). Analiza wybranych metod modelowania wartości katastralnych nieruchomości (Analysis of selected methods of fixing cadastral value). Acta Scientiarum Polonorum. Geodesia et Descriptio Terrarum, vol.8, no. 2, pp. 27-38.

Shannon C.E., Weaver W. (1964). The mathematical theory of communication. The Iniversity of Illinois Press, Urbana.

Shen Y., Karimi K. (2017). The economic value of streets: mix-scale spatio-functional interaction and housing price patterns. Applied Geography, vol. 79, pp. 187–202. https://doi.org/10.1016/j.apgeog.2016.12.012.

Tajani F., Morano P., Locurcio M., Torre C.M. (2016). Data-driven techniques for mass appraisals. Applications to the residential market of the city of Bari (Italy). International Journal of Business Intelligence and Data Mining, vol. 11, pp. 109–129. https://doi.org/10.1504/IJBIDM.2016.081604.

Tysiąc P. (2020). Bringing bathymetry lidar to coastal zone assessment: A case study in the southern baltic. Remote Sensing, vol. 12, pp. 1–27. https://doi.org/10.3390/rs12223740.

Usman H., Lizam M., Adekunle M.U. (2020). Property price modelling, market segmentation and submarket classifications: A review. Real Estate Management and Valuation, vol. 28, no. 3, pp. 24-35. https://doi.org/10.1515/remav-2020-0021.

Warren C.M.J., Elliott P., Staines J. (2017). The impacts of historic districts on residential property land values in Australia. International Journal of Housing Markets and Analysis, vol. 10, pp. 66–80. https://doi.org/10.1108/IJHMA-02-2016-0015.

Wu C., Sharma R. (2012). Housing submarket classification: The role of spatial contiguity. Applied Geography, vol. 32, pp. 746–756. https://doi.org/10.1016/j.apgeog.2011.08.011.

Wu C., Ye X., Ren F., Du Q. (2018). Modified Data-Driven Framework for Housing Market Segmentation. Journal of Urban Planning and Development, vol. 144, no. 4, pp. 04018036. https://doi.org/10.1061/(asce)up.1943-5444.0000473.

Wu Y., Wei Y.D., Li H. (2020). Analyzing Spatial Heterogeneity of Housing Prices Using Large Datasets. Applied Spatial Analysis and Policy, vol. 13, pp. 223–256. https://doi.org/10.1007/s12061-019-09301-x.

Xiao Y. (2017). Hedonic Housing Price Theory Review, in: Springer Geography. Springer, pp. 11–40. https://doi.org/10.1007/978-981-10-2762-8_2.

Zheng S., Hu W., Wang R. (2016). How Much is a Good School Worth in Beijing? Identifying Price Premium with Paired Resale and Rental Data. The Journal of Real Estate Finance and Economics, vol. 53, pp. 184–199. https://doi.org/10.1007/s11146-015-9513-4.

Źróbek S., Trojanek M., Źróbek-Sokolnik A., Trojanek R. (2015). The influence of environmental factors on property buyers' choice of residential location in Poland. Journal of International Studies, vol. 7, no. 3, pp. 163–173. https://doi.org/10.14254/2071-8330.2015/8-3/13.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.73

Ryszard Źróbek[1], Sabina Źróbek[2]

SPECIFICITY OF MANAGING PUBLIC REAL ESTATE RESOURCES BASED ON THE EXAMPLE OF THE POLISH EXPERIENCE

Abstract: Real estate, due to its specificity and the role it plays in the economic, social and environmental area, requires an economically effective but also sustainable approach to its use. There is a need to protect both public and private interests through rational real estate management with the use of modern decision support tools. The changing socio-economic environment in a given country, as well as international cooperation, require modernization of the rules and procedures of real estate management, especially those that make up the public real estate stock. This article presents the basic premises and goals of the existence of public real estate resources. Features and conditions specific to the management system of such a resource are also given. A list of strengths and weaknesses was made using the literature and the results of the authors' own research on such a system functioning in Poland. It was emphasized that, at present, a key element in the decision-making process regarding spatial development and real estate management is having high-quality information. The article was written on the basis of selected literature, Polish law and the authors' experience in property management and appraisal.

Keywords: management system, public real estate resources, spatial development

Received: 7 June 2022; accepted: 15 July 2022

[1]University of Warmia and Mazury in Olsztyn, Department of Real Estate Management and GIS, Poland, ORCID ID: https://orcid.org/0000-0002-9760-1747, e-mail: rzrobek@uwm.edu.pl
[2] University of Warmia and Mazury in Olsztyn, Department of Spatial Analysis and Real Estate Market, Poland, ORCID ID: https://orcid.org/0000-0001-9481-7262, e-mail: zrobek@uwm.edu.pl

Introduction

Public space management is a large and important element of urban planning and design. The importance of this issue stems from the fact that the challenges of adapting to climate change, transforming energy sources and increasing mobility require significant changes in public spaces – both physical and social. The importance of the problem is also heightened by the fact that public space management involves large national and local budgets. More integral and strategic management of public space brings with it enormous potential, so far overlooked in the academic debate on public space in general and cities in particular (Źróbek, 2012; Duivenvoorden et al., 2021; Leclercq & Pojani, 2021; Lee, 2022). Pressure on urban areas is stronger than on rural areas and is increasing faster due to demographic changes.

Today, there is no need to argue that public spaces are necessary for the functioning and quality of life of residents of not only specific cities but also regions. They perform the much-needed function of infrastructure providers (roads, sewage systems, energy, telecommunications, green areas). Apart from this technical function, public spaces also perform social functions, contributing to the provision of health conditions, interpersonal relations, cohesion and biodiversity (UN Habitat, 2017; Maring, 2018).

Analysis and practical operation should take into account the assumption that public real estate (especially land) should be subject not only to long-term planning but also to systemic monitoring. These activities, therefore, require public involvement in decision-making and should serve many communities. Sustainable development is the dominant paradigm of development not only in the international arena but also at all levels of governance in many countries. This concept is embodied by the "think globally, act locally" slogan, which indicates that sustainable development principles should be developed and implemented first at the local level. Territorial governments play a special role in planning sustainable development and management of space and real estate (Źróbek-Sokolnik et al., 2021).

Real estate management can be understood as the process of taking action in the real and legal spheres by (public and private) entities in relation to real estate, aimed at selecting the most advantageous solution from the options considered from the point of view of the set goals (Grover & Grover, 2011; Molen, 2015; Trojanek, 2019).

The main goal of managing real estate owned by the commune is the effective use of communal real estate in the process of implementing public tasks, i.e. meeting the collective needs of the community by providing local public goods. The specific real estate management goals differ depending on the functions performed by the property. Municipal properties can serve many purposes, including:

- fulfilling the statutory obligations of the commune (functions of an administrative and public utility nature);
- generating one-off or periodic streams of revenues (sales), e.g. from rent, lease or loan; or
- implement investment projects or accumulate a reserve for the implementation of development goals in the future.

Activities related to real estate located within the commune and owned by another entity are another area of real estate management in a commune. The commune's activities in this respect are indirect, as opposed to the management of real estate owned by the commune.

The role of public real estate resources in area development

There is no uniform, universally binding definition of public real estate resources. In the specialist literature, one can find a fairly consistent view that land owned by the state and other public entities (e.g. local government units) can be treated as public property (Zimmerman, 2007; Grover, 2009; Źróbek et al., 2020). It should be noted that not all countries have a strict dividing line between state real estate and other units managing public land, such as rural communities, tribal organizations, mixed state-tribal structures, etc., to a distributed (local) system.

In many countries of the world, the role of state property in the implementation of state tasks in the economy is often highlighted. In the international arena, including Poland, the term "property" most often means both property and other property rights vested in the State Treasury (ST) and other state legal persons. This applies to both countries with a developed market economy and countries in transition (Survey …, 2016). Vietnam is an example where all land is owned by the state. In this country, land may only be transferred to other people (Do Thi Tuyet et al., 2022). Some countries still have a problem with the transition from a centrally planned economy to a market economy, including property re-privatization and the restoration of private property in the real estate sector.

The reasons for the prevalence of state ownership in many countries are considered both in economic theory and in the social and political spheres. A fairly unequivocal justification for the existence of state property (including property rights) was presented, among others, by Kwiatkowski (2016), who distinguished three basic types of functions assigned to the State, namely:

1. Allocation function - the existence of natural monopolies:
   - the existence of externalities,
   - the existence of public goods,
   - capital market failure (reluctance to finance projects with long lead times and high-risk rates).
2. Stabilization function – counteracting fluctuations in the level of employment and investments related to the business cycle.
3. Redistributive function – providing the so-called socially desired goods at prices below the market – ensuring universal access to goods considered as basic.

Stiglitz (2004) points out that sometimes the redistributive function is included among the other justifications for the state's function in managing public resources.

In Poland, the state real estate sector still covers over 30% of the area of all real estate (approximately 10.4 million ha) and, for example, in New Zealand, the state owns over 45% of the country's area, which is approximately 15 million ha. However, the structure of functions related to real estate in this sector is different than in Poland. The structure of public real estate resources is also different in Great Britain and the USA. In many publications related to the management of public real estate resources (Bovaird & Loeffler, 2009; Ingram & Hong, 2009; Gross & Źróbek, 2013 and 2015; UN Habitat, 2017; Źróbek-Sokolnik et al., 2021) points to the important role of state property related to, *inter alia*, reducing poverty in society, sustainable protection of the natural environment and providing housing to citizens. This matter is also mentioned in many publications issued by the F.A.O (2007) and the World Bank (2011). The national economy includes, *inter alia*, spatial management, including real estate management. It should be assumed that the management of public real estate resources constitutes a significant part of the spatial, legal, financial and technical dimensions of spatial

development. This sphere of the economy should essentially be viewed as a process of regulating development, optimizing use and conserving resources. This also applies to obtaining revenues from the disposal of real estate and the elimination or limitation of conflicts regarding land rights and the principles of their development, now and in the future. An important element of this economy is, among others, the use of the potential inherent in real estate, taking into account the principles of sustainable development in the use of space. The remainder of the work focuses on the principles and procedures of managing public real estate resources in Poland based on the solutions used in selected countries of the world. Recommendations developed by various international organizations such as the World Bank, the F.A.O. and the International Federation of Surveyors (F.I.G.) have also been included.

It is commonly accepted (Williamson et al., 2010; World Bank, 2011; Zevenbergen et al., 2013 and 2015; Źróbek-Różańska & Zadworny, 2016) that the goals of real estate management concern, among others:

1) creating conditions conducive to the implementation of the objectives of the spatial policy,
2) acquiring land necessary for the implementation of area development programs,
3) creating legal conditions and administrative procedures for the use of real estate resources and the implementation of public tasks and goals,
4) counteracting the use of the property inconsistently with its intended use contained in local plans and other detailed studies,
5) ensuring income from resource management and optimization of costs related to the management and administration of resources.

Attention should be paid to the place where decisions related to the strategy and day-to-day management of real estate resources are made. An important component of this process is the provision of timely and adequate information about resources. A significant role should be assigned to spatial information systems used in the management process, and attention should be paid to the decision-making system concerning management strategies. Their proper functioning, depending on the decision-making level, is a condition leading to the sustainable development of areas.

The development and implementation of the basic principles of real estate management at the national or regional level should concern:

- real estate management (administration),
- maintaining and developing the structure of administering real estate resources at various levels of management,
- creating a policy for the use of real estate resources and their protection,
- development of legal regulations taking into account the specificity of the country (law, society, environment),
- maintenance and updating of real estate information systems.

In the management of public real estate resources, the following features can be distinguished in the manner of management and administration:

- introduction to the public sector of professional principles related to the concept of "new public management" and "good governance",
- adopting many principles proven over the years in the practice of private sector real estate management and management,
- improvement and adaptation of standards of conduct and modernization of the principles of measuring the effects in the management of public property (economic and social effects),

- increasing emphasis on an efficient system of controlling the state of managing public property by various entities and making the results of these inspections public,
- improving the system of accounting records and other (spatial and non-spatial) information systems about real estate,
- increasing discipline in managing public property and applying the principles of saving expenses related to this management,
- reducing, as far as possible, the role of state and local administration in resource management and introducing changes to market regulation mechanisms,
- optimizing the process of privatization of public real estate,
- introduction of competition rules in public entities dealing with management and competition with private entities.

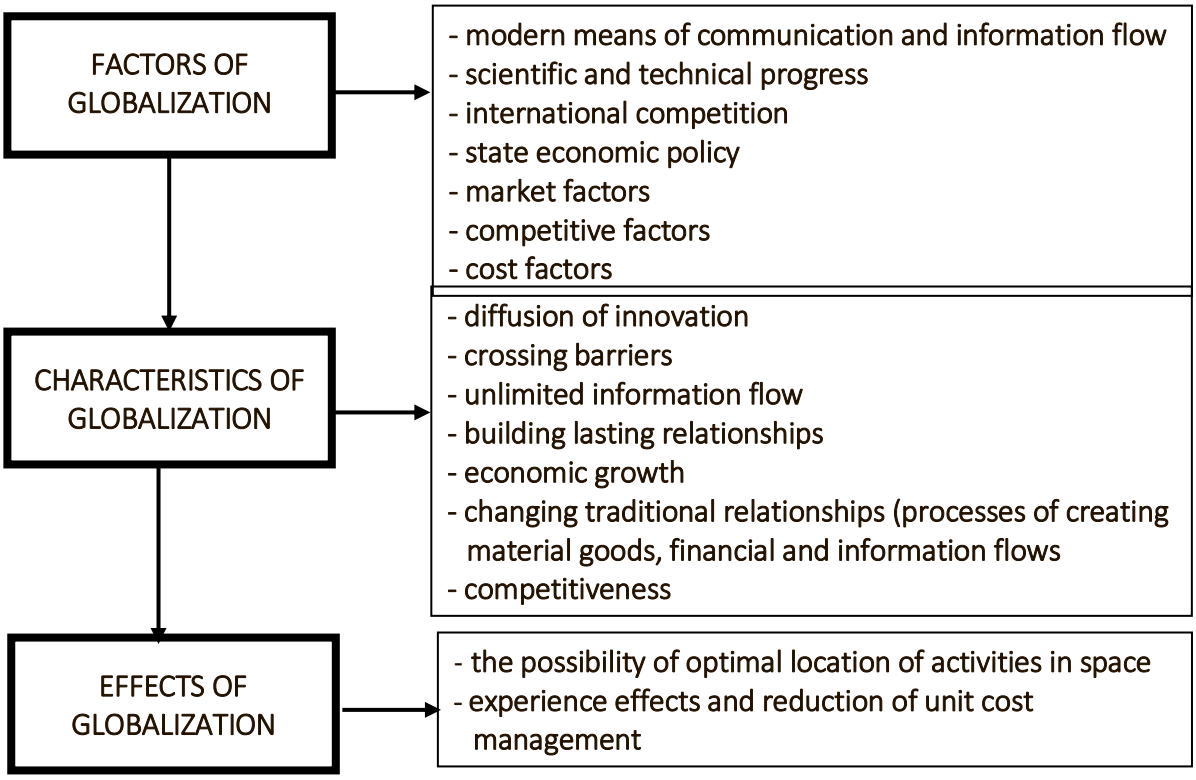


Fig. 1. Spatial management and development in the globalization context
Source: Own study

In real estate management, the recently noted and increasing impact of globalization on the spatial development of individual countries and regions cannot be overestimated. This economy develops spatial management and allows for the implementation of spatial plans and area development strategies, also taking into account various forms of international and cross-border cooperation. Figure 1 shows selected factors, features and effects of globalization related to the possibilities of information flow, overcoming various barriers (including political and administrative) and the need to optimize the location in a specific space. Modern means of information flow and forms of its presentation are essential in this process.

It is also important to get decision-makers accustomed to the solutions from the previous period, as well as mental and social fears of introducing new rules to the

management system, such as public-private partnerships or the multidimensional nature of the privatization of public property. This also applies to the use of passive forms of management in practice, despite the creation of formal foundations for active management and possible obstacles in the implementation of various detailed procedures.

The starting point for management activities is the identification of the processes taking place in the management of real estate resources. It is also important to pay attention to the specificity of the public sector and its complexity and susceptibility to external influences. Rational resource management additionally requires the assessment of alternative scenarios and making effective choices.

Attention should also be paid to the difficulties that may arise after the transformation of a centrally controlled economy into a market economy. At the same time, this process is subject to adaptation to changing market conditions, both on a global and local scale.

The specificity and principles of management in the public resources sector

The specificity of managing resources that are the responsibility of the public sector should be clearly noted. This is manifested, *inter alia*, by such problems as:

- the environment of these resources usually has opposite goals and expects different results,
- the public is different, and the expectations towards the private sector are different,
- there is little tolerance for failures in the implementation of public projects,
- detailed measures of the management process related to the mission and the results obtained (e.g. social effectiveness) are difficult to identify,
- resource management is carried out within imposed constraints (predefined processes and procedures),
- the implementation of tasks usually occurs within the existing human resources,
- there is a possibility of developing professional experience (relative stabilization) as well as raising qualifications and developing a training system,
- the environment for the performance of tasks may also contain elements of clashes between various political options,
- goals imposed from the outside are achieved (significant limitation of independence in actions and detailed proceedings),
- high social and political pressure in the decision-making process related to spatial development.

Efficient management in the public real estate sector requires good information at various levels and stages of decision-making related to the development of space, treated as a non-renewable resource (information support for the decision-making process related to space). In the real estate sector, activities are related to:

- ensuring the safety of trading,
- efficient and effective management and management of resources,
- assessment of the effects of planned projects,
- improving the quality of information used in decision-making processes.

Information, especially information about the area, is one of the important factors in the functioning of spatial management, contributing to the improvement of area development processes. Real estate management, treated as a system, is both a "consumer" and a "producer" of information about the area. This applies to both

geometric data and descriptive data – related to the subject of management and managing entities.

In the conditions of the development of the resource management system, it seems possible to formulate the three main principles of public resource management, taking into account the general guidelines of economics and basic legal regulations:

1. Satisfying and protecting public interests;
2. Reducing possible conflicts resulting from development;
3. Real estate market balancing.

Overall assessment of the property management system in Poland

In Poland, there are three types of public real estate resources: the State Treasury, municipalities, poviats and provinces, which were established under the Real Estate Management Act (Ustawa 1997). On its basis, the following groups of mutual relations between real estate management entities can be distinguished:

- the State Treasury and local government units;
- relations between individual local government units (commune, poviat and voivodship);
- the State Treasury, local government units and private entities;
- indirect influence of public entities on private property owners;
- special relations between the State Treasury, local government units and their organizational units without legal personality (permanent management);
- relations included in the contract for putting land in perpetual usufruct: (owner – ST or local government unit and perpetual usufructuary).

An analysis of the principles of real estate management in the public sector shows that this system has both strengths and, unfortunately, also weaknesses (Gross & Źróbek 2013; Marona, 2018; NIK, 2018; Trojanek, 2019; Źróbek, 2012; Źróbek et al., 2020).

Strengths include:

- a relatively well-designed real estate information system (Real Estate Cadaster, Integrated Real Estate Information System),
- most real estate held in public resources was entered into a Land Registry (it is covered by the state-guaranteed registration system),
- experience in managing state real estate in the previous socio-economic system and the possibility of using it in a market economy,
- a relatively efficient decision-making system,
- the relatively good skills of the management staff,
- transparency of procedures and the possibility of lodging appeals against decisions and orders,
- transparency in making decisions (social responsibility),
- principles of public-private partnership developed,
- public sector innovation,
- resource management plans as the basis for making decisions,
- real estate professional activity system, including public real estate appraisal.

The main factors that impede the proper functioning of the system are its weaknesses:

- no current updating of some of the data covered by information systems about real estate,
- no land and mortgage registers for some real estate included in public resources,
- excess and detail of legal regulations (including various interpretations and ambiguities in basic concepts),
- frequent changes in regulations related to the management of real estate resources (the Real Estate Management Act of 1997 has been amended many times),
- different interpretations of administrative courts in similar cases,
- inconsistency in implementing rules,
- the lack of a uniform and obligatory system of lifelong learning for people dealing with real estate management,
- relatively low economic efficiency of managing public real estate resources,
- lack of comprehensive real estate resource management programs taking into account the specificity of the resource and directional goals.

Key elements of an effective public real estate management system

The theory and practice of property management show that there is no universal management model. Indications for constant changes in the approach to property management result, in particular, from the need to rationalize the cost of maintaining the asset, constant changes in the size and structure of the asset, or the need to increase the cost of property maintenance. In order to ensure optimal operation in the area of real estate management services, knowledge in various fields is necessary: law, financial and insurance sciences, economics, and technical sciences (Marona, 2018).

Figure 2 presents some trends and directions of the development of the public real estate management system. It should be remembered that effective action does not always mean that it is effective from an economic point of view. In managing public property, the so-called social efficiency is no less important, which is usually related to the implementation of public goals.

Systemic implementation of the activities presented in the diagram could make the management of real estate in general and real estate as a public resource, in particular, more effective. However, it requires first having an appropriate legal and administrative system and carrying out significant preparatory and design work so that it can be implemented in practice and then consistently applied.

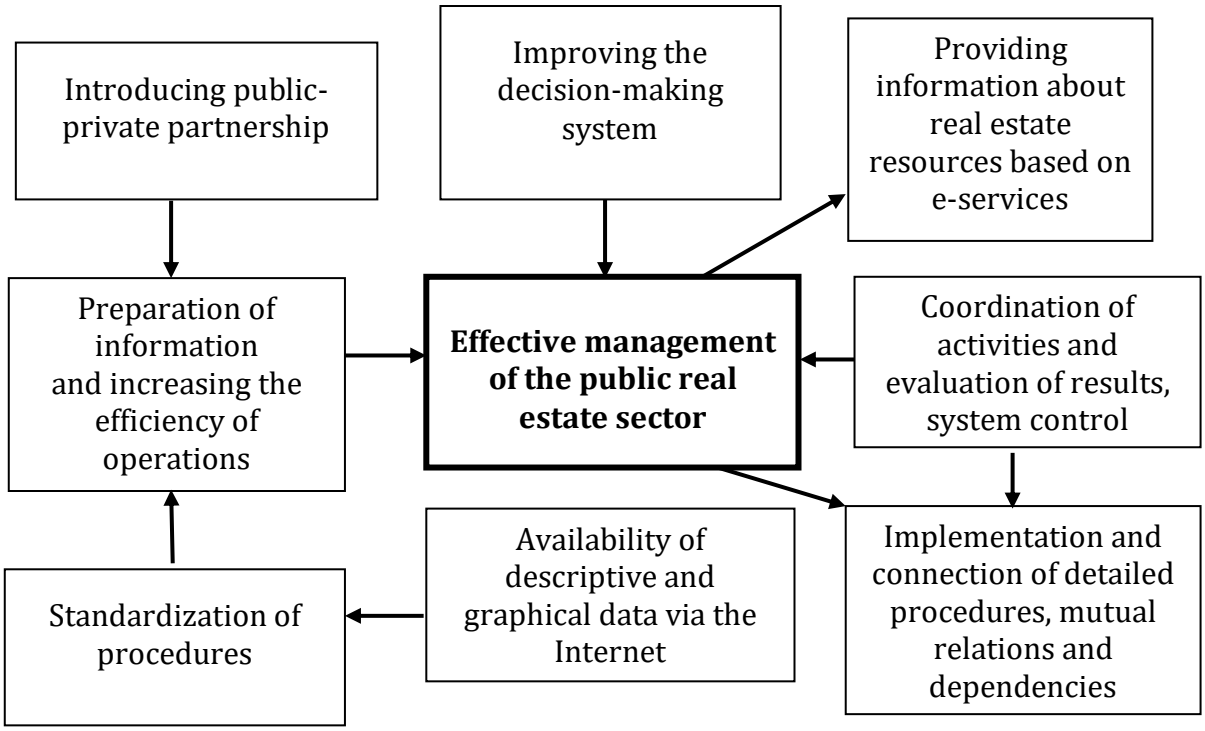


Fig. 2. Key activities and conditions for an effective system of managing public real estate resources
Source: Own study based on Williamson et al., 2010

Final remarks and recommendations

This article analyses some of the problems related to the management of public real estate resources. The presented considerations show that the management of the public real estate sector has many goals to be achieved, both in the economic and social spheres. Meeting these expectations requires comprehensive and systematic actions taken in the legal (legislative) sphere and at various levels of administration. The success of these activities largely depends on having good information about real estate (as a subject of management, but also about the legal and economic environment in which the areas and individual properties are used) at various levels and stages of the decision-making process. It also requires up-to-date specialist knowledge from those who develop resource management plans as well as those from the public administration sector issuing specific decisions. Proper management of real estate resources should also ensure the security of real estate transactions (also increasingly with the participation of foreign entities) and the possibility of access to financing public investments. It is also noticeable that the scope and volume of public services are being extended as well as the relationships between the office and economic and physical entities. The changes are also visible in the new approach to educating specialists in the field of real estate services (e.g. in Poland, there is an obligation to certify property appraisers). The functioning of an efficient quality control system for the effects of public real estate management is also important (e.g. in Poland, they are systematically performed by the Supreme Chamber of Control – NIK).

To sum up, based on the presented observations, it is possible to formulate several key recommendations as to the main directions of the development of the real estate management system: a) register the rights to all real estates, as well as: improve the flow of information through computerization of the system in conjunction with other real estate information systems; b) simplify and reduce the number of regulations, integrate real estate regulations with each other, develop a so-called "real estate code"; c) improve the quality of human resources and services, including through an appropriate policy of employing specialists with skills acquired during education, improving their qualifications (postgraduate studies, courses improving knowledge and skills). In an era of ever closer international cooperation, also in the real estate market sector, the need for greater integration of the principles of managing public real estate resources in the international arena, especially within the European Union, has become essential. It is required by the idea of sustainable development of areas, which should be effectively and consistently implemented in a given country and in international relations.

References

Bovaird T., Loeffler E. (ed.) (2016). Public Management and Governance. ROUTLEDGE, Third Edition, p. 68.

Do Thi Tuyet M., Źróbek-Różańska A., Źróbek R. (2022). The experience of the Polish real estate market as a guide to transition of real estate sector in Vietnam. Acta Scientiarum Polonorum Administratio Locorum, 21(2), pp. 185–195.

Duivenvoorden E., Hartmann T., Brinkhuijsen M., Hesselmans T. (2021). Managing public space – A blind spot of urban planning and design. Cities, vol. 109, 103032, https://doi.org/10.1016/j.cities.2020.103032, p. 3 [access: 01.06.2022].

F.A.O. (2007). Good governance in land tenure and administration. FAO Land Tenure Studies. no. 9. Rome, p. 68.

Gross M., Źróbek R. (2013). Public real estate management in post socialist countries. 2014/4. In: REMV, vol. 21, no. 4, pp. 11–16.

Gross M., Źróbek R. (2015). Good Governance in Some Public Real Estate Systems. Land Use Policy, vol.49, pp. 352–364.

Grover R. (2009). State and public land management. In: Journal of Land Reform 2009/1. FAO, pp. 58–68.

Grover R., Grover Ch. (2011). Modeling Indicators of Land Governance. FIG, paper 4999. Marrakech, p. 23.

Ingram G., Hong Y-H. (ed.) (2009). Property Rights and Land Policies. Lincoln Institute of Land Policy, Cambridge, Massachusetts, p. 31.

Kwiatkowski G. (2016). Własność państwowa a rola państwa we współczesnej gospodarce (*State ownership and the role of the State in modern economy*). www.ue.katowice.pl/fileadm, [access: 03.06.2022], pp. 228–237.

Leclercq E., Pojani D., (2021). Public space privatisation are users concerned? Journal of Urbanism: International Research on Placemaking and Urban Sustainability 2021, AHEAD-OF-PRINT, 1–18, https://doi.org/10.1080/17549175.2021.1933572, p. 18.

Lee D. (2022). Public Space in Transition Co-production and Co-management of Privately Owned Public Space in Seoul and Berlin. Trascript Verlag, p. 202.

Maring L., Maaike B. (2018). Asset management to support urban land and subsurface management. Science of The Total Environment, vol. 615, pp. 390–397.

Marona B. (2018). Zarządzanie nieruchomościami gmin jako obszar teoretycznych rozważań i badań empirycznych w ramach zarządzania publicznego. (Municipal Real Estate Management as an Area of Theoretical Deliberations and Empirical Research in Public Management). Zeszyty Naukowe / Uniwersytet Ekonomiczny w Krakowie. Seria Specjalna, Monografie, nr 258, p. 225.

Molen Van der P. (2015). Property and administration: comparative observations on property rights and spatial planning with some cases from the Netherlands. Administration & society, 47.2, pp. 171–196.

NIK (2018). Wykorzystanie nieruchomosci gminnych na podstawie umów najmu, dzierżawy, użyczenia. Informacja o wynikach kontroli (*Use of communal real estate on the basis of rental, lease and lending contracts. Information on the inspection results*). www.nik.gov.pl, [accessed: 07.08.2022].

Stiglitz J. (2004). Ekonomia sektora publicznego, WN PWN, Warszawa, p. 483.

Survey on Status of Public Land Management in Kenya (2016). Full rapport, Land Development and Governance Institute 2/24/2016, Nairobi.

Trojanek M. (2019). Strategiczny wymiar gospodarowania komunalnym zasobem nieruchomości (*Strategic Dimension of Municipal Real Estate Stock Administration*). Acta Universitatis Lodziensis. Folia Oeconomica, vol. 3, t. 342, pp. 45–59.

UN Habitat (2017). Global public space programme UN-Habitat, Nairobi.

Ustawa o gospodarce nieruchomościami 1997 (*Real Estate Management Act 1997*). Dz.U. (Journal of Laws) 1997, no. 115, item 741.

Williamson I., Enemark S., Wallace J., Rajabifard A. (2010). Land Administration Systems for Sustainable Development. https://www.fig.net/resources/proceedings/fig_proceedings/fig2010/papers/ts03a/ts03a_williamson_enemark_et_al_4103.pdf [access: 01.06.2022].

World Bank (2011). Land Governance Assessment Framework. Washington D.C. Available at: http://www.wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/11/24/000386194_20111124011109/Rendered/PDF/657430PUBOEPI1065724B09780821387580.pdf.

Zevenbergen J., Augustinus C., Antonio D., Bennett R. (2013). Pro-poor land administration: Principles for recording the land rights of the underrepresented. In: Land Use Policy, no. 31, pp. 595–604.

Zevenbergen J., De Vries W., Bennett R. (ed.) (2015). Advances in Responsible Land Administration. CRS Press, Taylor & Francis Group. Available at: https://www.crcpress.com/Advancrs-in-Responsible-LandAdministration/Zevenbergen-Vries-Bennett/9781498719599

Zimmerman W. (2007). Good governance in public land management. In: Journal of Land Reform, Land Settlements and Cooperatives 2007/2 FAO, pp. 30–40.

Źróbek R. (2012). Current issues of real estate management Case study. In: D. Kereković, R. Źróbek (ed.). GIS for Geoscientists. Croatian Information Technology Association – GIS Forum, University of Silesia, Zagreb, pp. 18–33.

Źróbek R., Źróbek S., Źróbek-Różańska A., Źróbek-Sokolnik A., Dynowski P. (2020) Podstawy i Procedury Gospodarowania Publicznymi Zasobami Nieruchomości: Teoria i Praktyka (*Fundamentals and Procedures of Managing Public Real Estate Resources: Theory and practice*). Olsztyn: UWM in Olsztyn, Poland, p. 335.

Źróbek-Sokolnik A.; Dynowski P.; Źróbek S. (2021). Preservation and Restoration of Roadside Tree Alleys in Line with Sustainable Development Principles – Mission (Im)possible? Sustainability, 13(17), 9635. https://doi.org/10.3390/su13179635, p. 17.

Źróbek-Różańska A., Zadworny D. (2016). Can urban sprawl lead to urban people governing rural areas? Evidence from the Dywity Commune, Poland. Cities, vol. 59:57-65, DOI:10.1016/j.cities.2016.06.003.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.85

Sanja Šamanović[1], Danko Markovinović[2], Vlado Cetl[3], Bojan Đurin[4]

COMPARISON OF DEPRESSION REMOVAL METHODS IMPLEMENTED IN OPEN-SOURCE SOFTWARE

Abstract: Modern tools for hydrological analysis are based on data derived from DEM. Hydrological methods that create a stream network by overland flow simulation require to remove depression (pit or sink) on DEM first. Depression occurs when a cell or group of cells is surrounded by adjacent cells at higher altitudes. Even though their removal creates an incorrect DEM, it is common practice to remove all topographic depressions (real, artificial, or combined) not to interrupt the creation of stream networks. There are two basic methods of depression removal: the filling method and the carving or breaching. Combined methods contain good characteristics of both procedures. GIS software includes a depression removal algorithm within its hydrological analysis module. The paper investigates which methods are implemented within individual open-source software SAGA and GRASS. A comparison of DEM before and after depression removal for each method is given. The methods were tested on a DEM, resolution 5x5 meter for a hilly area intersected by a significant number of watercourses.

Keywords: DEM, depression removal, open-source software, stream network, filling method, carving method

Received: 16 June 2022; accepted: 19 July 2022

[1] University North, Department of Geodesy and Geomatics, Croatia, ORCID ID: https://orcid.org/0000-0003-1212-5583, email: sanja.samanovic@unin.hr
[2] University North, Department of Geodesy and Geomatics, Croatia, ORCID ID: https://orcid.org/0000-0001-6435-9790, email: danko.markovinovic@unin.hr
[3] University North, Department of Geodesy and Geomatics, Croatia, ORCID ID: https://orcid.org/0000-0003-1835-5777, email: vcetl@unin.hr
[4] University North, Department of Civil Engineering, Croatia, ORCID ID: https://orcid.org/0000-0002-2361-8036, email: bdjurinv@unin.hr

Introduction

The concept of the Digital Terrain Model (DTM) in Croatia (DMR) includes original and derived DTM (URL1). Since the data for the paper were collected by interpolation from the original DTM, the paper uses the term the Digital Elevation Model (DEM). DEM was created from the original DTM with the regular raster elevation data structures stored in the derived DEM. The digital elevation model is the base of all the geomorphometric and hydrologic analyses and is the basis for spatial analysis and data modeling. For the needs of hydrological analysis, such as Catchment area, Drainage area, Stream network and Flow direction a digital model with depressions (pit, sink) removed is necessary.

In geomorphometry, a depression is a landform sunken or depressed below the surrounding area. Surface depressions on the landscape vary greatly in size, ranging from relatively small, unmanaged water storage systems to large, regularly managed water bodies such as lakes and reservoirs. Small surface depressions include wetlands embedded within uplands or those along river corridors, ponds, and other similar small waterbodies (Biggs et al., 2017).

For hydrological analysis to be carried out, GIS software contain modules for depression removal within their hydrological modules. Depression removal alters the geomorphometry of the DEM. Depression removal affects the relief related parameters, so the choice of depression removal method is an important step in hydrological analyses to obtain a morphometrically minimally altered model after depression removal.

GIS technology has improved and accelerated the possibilities of manipulation, analysis, and visualization of local and global spatial data, but the prerequisite for quality and resilient results are correct input data, created by methods optimal for geomorphometry of the area. Geodesy and geomatics, as interdisciplinary professions, can provide guidelines for the application of certain methods within this phase of data preparation (Šamanović, 2014).

Research area and methodology

In this paper we used data obtained by collecting a raster of height points by interpolation at a resolution of 5x5 meters for the area of Papuk (Fig. 1).

The Papuk mountain, located on the northern and northwestern border of the Požega valley in the eastern part of Croatia, was chosen for the research area. The general characteristics of the basin channels are the water torrents channels that form on the steep slopes of the mountains. Stream channels are unstable. Stream channels are unstable. Due to heavy rains, water overflow and frequent changes in watercourses occur.

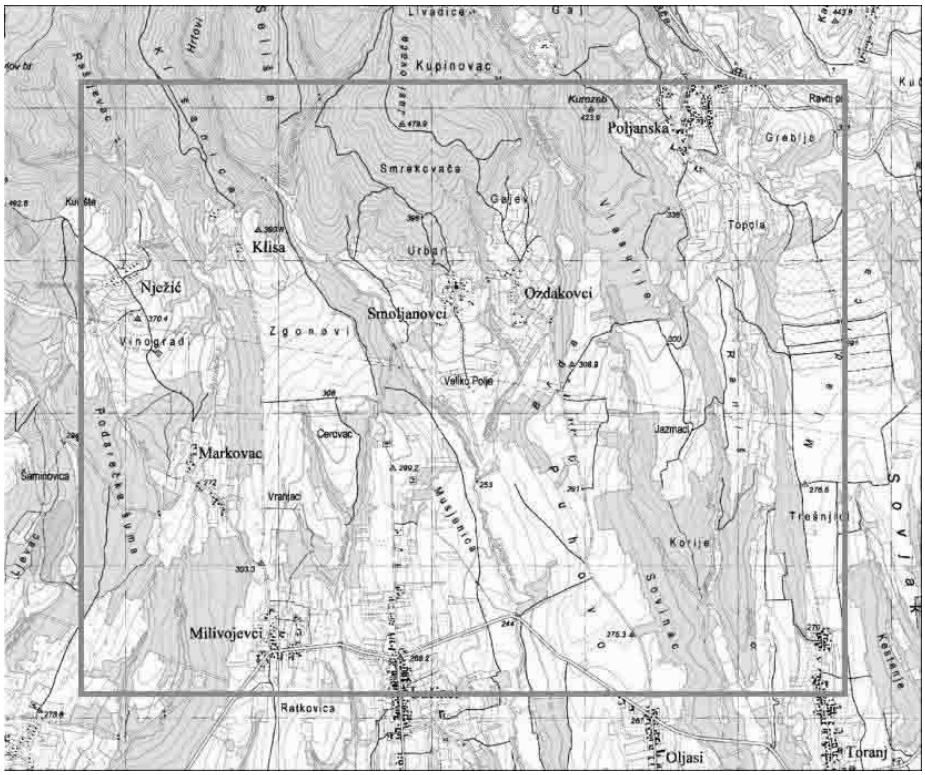


Fig. 1. Research area Papuk
Source: Šamanović, 2013

Altitude points grids (digital elevation models) that were used in subsequent analyses were obtained by interpolation. The data obtained with the parameters listed in Table 1 were loaded into the GIS software and the results are DEM shown in Figure 2. Interpolation is a procedure in the scope of which the value of a function is determined based on two known values (Frančula & Lapaine, 2008). The data are gathered by combining three interpolation methods: linear method, least-squares method, and finite element method. The basic idea behind the linear interpolation method is to use several first-degree polynomials instead of a single higher degree polynomial (Bosner, 2013).

Table 1. Area borders in meters and resolution in cells for test area

max x	6 468 540.00	max y	5 033 360.00
min x	6 463 740.00	min y	5 030 160.00
Δx	4 800.00	Δy	3 200.00
columns	960	rows	640

Source: own elaboration

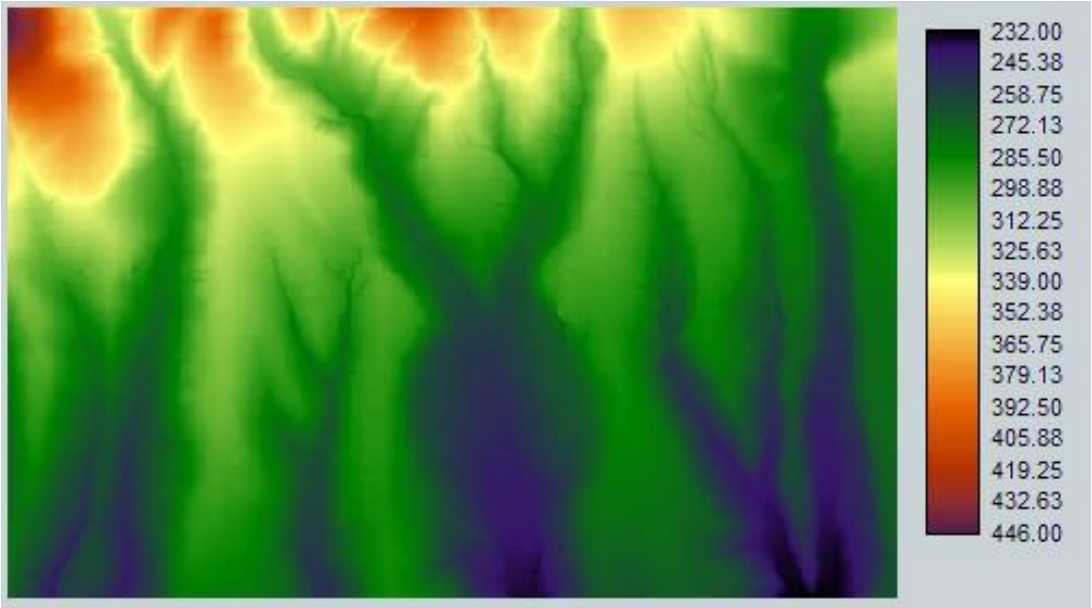


Fig. 2. DEM of Papuk area (elevation are in meters)
Source: Šamanović, 2013

Hydrological methods that create stream networks and drainage areas based on overland flow simulation require removal of depression first. Pits in the DEM are depressions or local minimum (Planchona & Darboux, 2001) and occur when a cell or group of cells is surrounded by adjacent cells of higher elevation. Depressions may consist of flat surfaces and smaller nested depressions within pre-existing ones. Regardless of the way DEM is created, depressions occupy 5% of the total DEM area (Tarboton et al., 1991). The existence of depressions in the DEM will interrupt the creation of a stream network as well as the modeling of other spatial hydrological processes.

Topographic depressions can be real, artificial, or combined. Natural depressions are areas of natural accumulation or natural soil change. Artificial depressions are often the result of errors during sampling (misclassified input data) or interpolation, generalization, rounding of the interpolated value to lower accuracy, smoothing of cells within the area, or smoothing because of resampling. Observing DEM makes it difficult to determine whether depression is natural or artificial. Although techniques are being developed today to distinguish between natural and artificial depressions, the only safe method is field research (Lindsay & Creed, 2005).

As no technique aimed at differentiating natural from artificial depressions (except on-site surveys) can provide fully reliable results, and as the procedures are also quite complex, the depression removal algorithms operate in an unselective manner in all GIS software. Most natural depressions finally overflow into the downstream discretization cell, and, despite unselective removal of depressions, such a corrected model can in fact be accurate (Šamanović et al., 2015).

There are two basic methods of depression removal (Fig. 3.): the filling method and the carving or breaching method. A simpler and more commonly used method is the method of filling depressions (DEM). The method raises the DEM cell to the altitude of the lowest neighboring cell and continues with the process until the cell is filled.

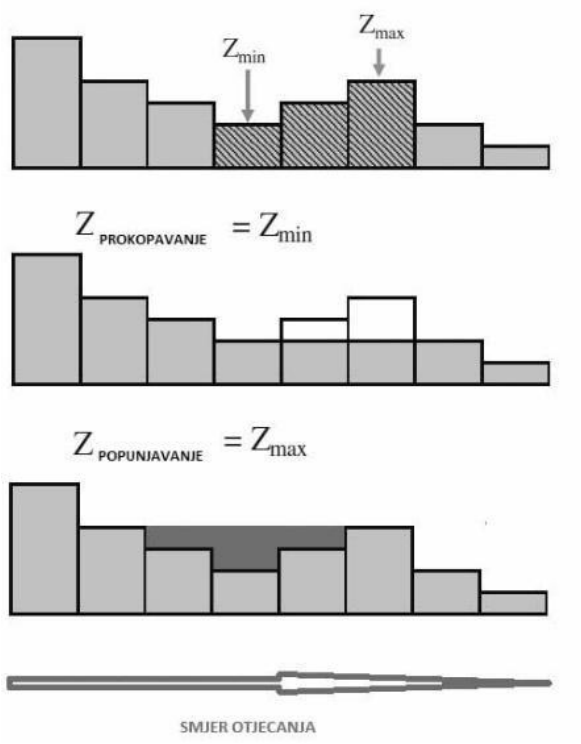


Fig. 3. Examples of depression removal method
Source: Šamanović et al., 2017

The filling method is the most widespread method, primarily due to its simplicity, and to date, several algorithms have been developed to fill the depression. Most GIS software within the hydrological analysis module contains a procedure-based depression removal module which raises the height of the depression until the level reaches the height of the points from which competition is possible (Grimaldi et al., 2007). The fill grows to the overflow point, and the result are cells whose value is always the same or higher than the DEM. The procedure is repeated until all the depressions are overfilled or more correctly until all the cells are associated with the runoff path.

The carving method solves the problem of depression by creating lines of water runoff and lowers the elevated cells in the DEM by carving channels. Algorithms create a way from depression by finding the lowest adjacent cell, and in the case of multiple cells of the same height, the shortest path is considered. Cells that are in depression are brought to the nearest cell of the lowest height or to the edge of the model.

This paper compares five depression removal methods implemented in open-source GIS software SAGA and GRASS. Methods developed by Planchon and Darboux, Conrad and two algorithms developed by Wang and Lie implemented in SAGA GIS and methods developed by Jenson and Domingue implemented in Grass are discussed. The methods developed by Planchon and Darboux and Jenson and Domingue remove depressions by the filling method, the method developed by Conrad fills depression by the carving method, while Wang and Liu developed two methods that combine the two basic methods.

Overview of depression removal methods

The following case is a theoretical overview of the five depression removal methods used in this paper.

The Planchon and Darboux algorithm replace depression with a strictly horizontal surface but is also used to create a drainage network where the depression is replaced by a slightly sloping surface. The Planchon and Darboux process can be divided into two phases (Planchona & Darboux, 2001): flooding the entire DEM with water and draining water surplus. The algorithm first floods the surface by increasing of the water level at all cells and then iteratively drains water surplus from each cell. In the final phase, the water from the depression is drained at the level of the highest overflow points and creates a flow path to the DEM boundary resulting in a model with depressions removed.

Olaf Conrad developed a method that, based on a DEM uses a runoff pathway to form a modified digital model. Depression removal is based on the cell value lowering to find an exit from the depression, and it consists of two steps (Brenning, 2017). In the first step, the algorithm recognizes the route of the concentrated runoff line and, at that, the area without depression is marked with zero, and then the values ranging from 0 and 8 are attributed to the depression, depending on the route by which evacuation from the depression will be operated. The second step involves depression removal using the concentrated runoff calculation line (Šamanović, 2014). The direction of water runoff is determined starting from the depression, over the minimum cell elevation that is lower than the depression point, considering eight adjacent cells (O'Callaghan & Mark, 1984).

The Jenson and Domingue algorithm gives satisfactory results for fewer data sets. The problem occurs with a large data set, where smaller depressions are nested in larger ones (Fig. 4), so the search of the entire data set must be performed multiple times to find a nested depression. The algorithm is quite complex and difficult to implement.

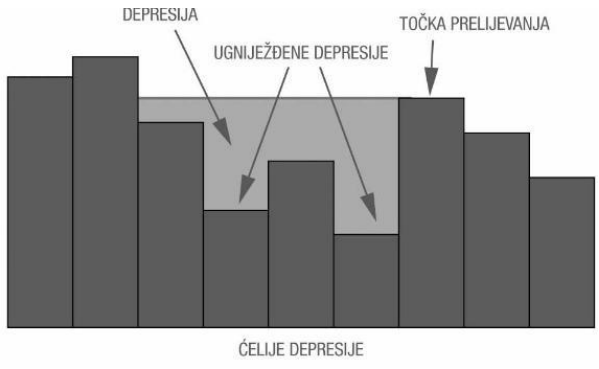


Fig. 4. Nested depressions
Source: Šamanović, 2013

Wang and Liu introduced a new concept of overflow from depressions and a progressive method of optimal overflow pathway, based on the structure of priority

order data and analysis of the optimal outflow pathway. They have proposed a new efficient depression filling method that can simultaneously determine runoff direction and spatial distribution of drainage areas, all this in a single step (Wang, 2006). If the elevation is sufficient to establish the downstream direction of the flow to the second basin, the cell does not need to be elevated, and its overflow elevation is the same as its elevation on the original DEM. If the cell is not high enough to establish runoff, we need to raise it to its runoff elevation. In one step, the method creates a depression-free DEM and identifies places and depths of depression, using a priority data structure, avoiding the eight-way search used by Planchon and Darboux.

Modul XXL Wang Liu uses an algorithm proposed to identify and fill surface depressions in digital elevation models. The method was enhanced not only to fill the depressions but also to preserve a downward slope along the flow path. This is accomplished by preserving a minimum slope gradient between cells. This version of the module is designed to work on large data sets e.g., LIDAR data (URL2).

As already mentioned, these algorithms are embedded in Grass GIS and SAGA GIS and are the subject of this paper. There are many different algorithms implemented in open-source software. Below are descriptions of some of them.

The open-source GIS Whitebox GAT use breaching method develop on Lindsay and Dhun (Lindsay, 2016). Lindsay and Dhun proposed a method based on identifying depression cells, and after that algorithm create breaching channel. GIS Whitebox GAT also have implemented fill depression developed by Wang and Liu. Fill depression algorithm base on the computationally efficient approach of examining each cell based on its spill elevation, starting from the edge cells, and visiting cells from lowest order using a priority queue (UTL3).

Integrated Land and Water Information System (ILWIS) offers a range of simple procedures to reduce spurious sink that might not perform equal successful in all areas (Hengl, 2009). Process depends on number of pixels in depression. When a depression of a single pixel is encountered the height value of this pixel will be increased to the smallest value of its 8 neighbor's pixels. When a depression of multiple pixels is encountered the height values of this depression will be increased to the smallest value of a pixel that is both adjacent to the outlet for the depression, and that would discharge into the initial depression.

MATLAB-based software for topographic analysis TopoToolbox has implemented process of filling pit using replacing negative values and zeros with 'NaN' values. Then algorithm computed flow direction on the filled DEM (Pastor, 2017).

Result and discussion

Input data for analysis is DEM of Papuk area where depressions were not removed. Table 2 provides a statistical analysis of each method to see a comparison to the model without depressions removed. From the table that the three methods do not change the height range of the DEM, while the method developed by Conrad and Jonson and Domingue lowers the terrain elevation.

Table 2. Statistical parameters DEM with depression and DEM on which depressions were removed

METHOD	CELLS NUMBER	CELL SIZE	MEAN	MIN	MAX	VAR	ST DEV	STD DEVLO	STD DEVHI
DEM with depression	614400	5	289.7005	0	445.06	1595.4649	39.9433	249.7572	329.6437
Planchon_and Darboux	614400	5	289.7014	0	445.06	1595.4280	39.7585	249.7585	329.6442
Conrad (QM)	614400	5	290.2473	-0.96	445.06	1472.3950	38.3718	251.8755	328.6191
Wang and Liu	614400	5	289,7014	0	445.06	1595.4264	39.9428	249.7586	329.6441
XXL and Wang_Liu	614400	5	289,7014	0	445.06	1595.4264	39.9428	249.7586	329.6441
Jenson and Domingue	614400	5	290.2497	-0,10	444,96	1471.8475	38.3647	251.8850	328.6144

Source: own elaboration

Since the removal of depressions affects the creation of the surface runoff line, surface runoff networks have been created. Figure 5 shows the model in which the depressions were not removed. The stream network was interrupted.

To compare five methods of depression removal, on the DEM Papuk, depressions were removed in two software (SAGA and GRASS) with five described methods. Figures 5, 6 and 7 show the same areas after the depression was removed. In selected circles shown the areas where differences between individual methods of depression removal are visible. From figure 6 and 7 can see that by applying four methods of depression removing obtained results deviate lesser extent from each other. The method developed by Jenson and Domingue (Figure 8) gives a significantly different stream network created. Apart from the complexity of the algorithm, the reason lies in the large range of data for which the module is not suitable.

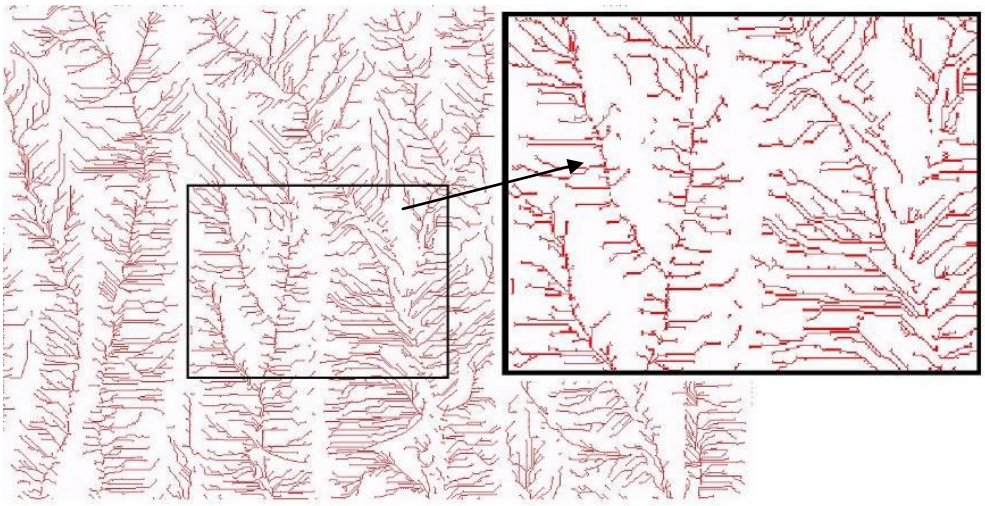


Fig. 5. A network of runoff network without depressions removed
Source: own elaboration

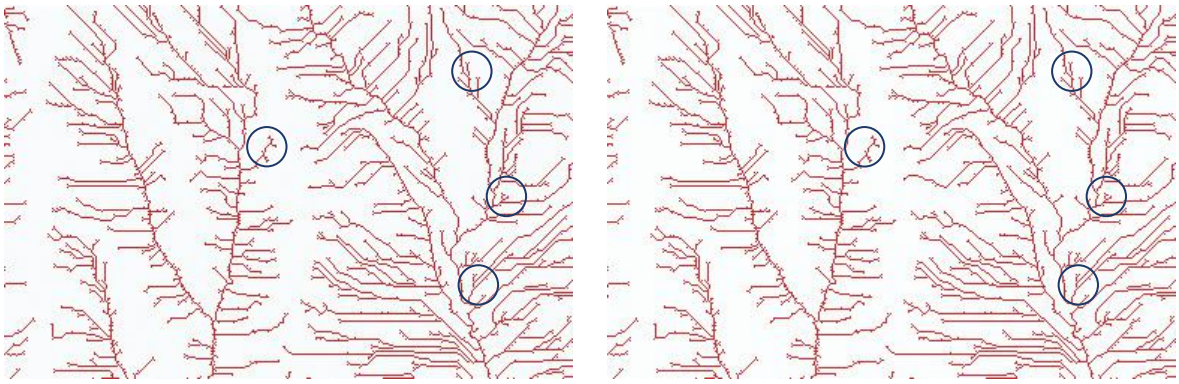


Fig. 6. Enlarged view of part of the area with depressions removed with Planchon and Darboux method (left) and Conrad method (right)
Source: own elaboration

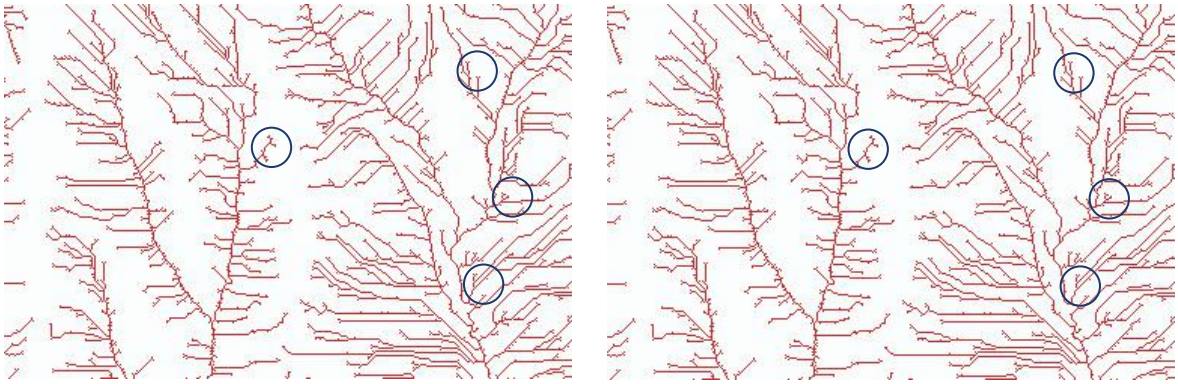


Fig. 7. Enlarged view of part of the area with depressions removed with Wang and Liu method (left) and XXL Wang and Liu (right)
Source: own elaboration

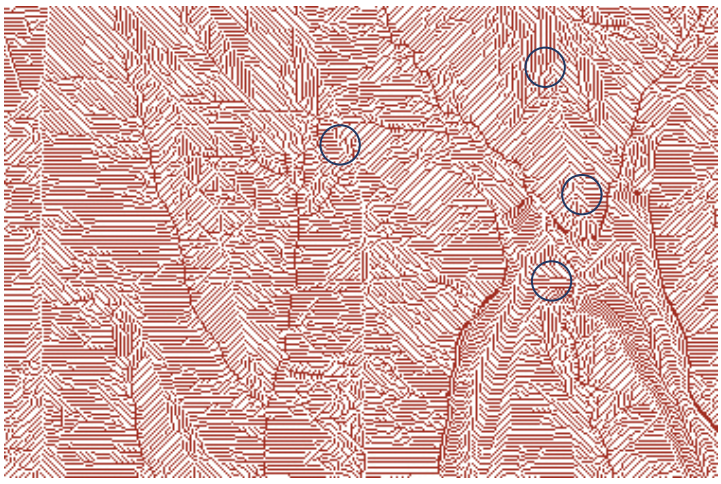


Fig. 8. Enlarged view of part of the area with depressions removed with Jenson and Domingue
Source: own elaboration

To notice the differences in the connection of broken stream network, representations were created in which blue lines represent connected stream network and red existing networks created from DEM data without depressions removed (Figures 9, 10 and 11).

Table 3 shows the number of changed cells for all applied methods. The three methods implemented in SAGA which remove depressions by the method of filling change the creation of a stream network in almost equal influences. The method developed by Conrad washes the stream network to a slightly greater extent, while the method developed by Jenson and Domingue significantly affects the change in the stream network. As the XXL module was adapted to Lidar data that we did not use, two modules developed by Wang and Lie behaved the same.

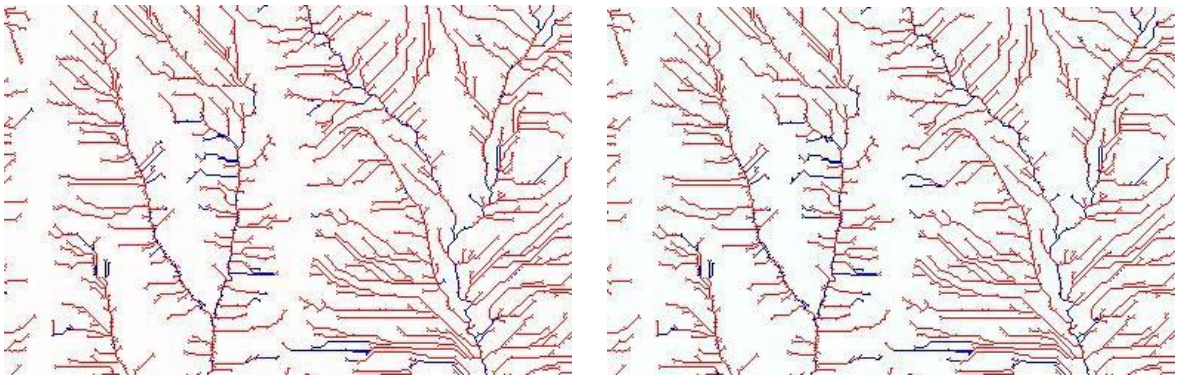


Fig. 9. Stream network after filling the depression with the Planchon and Darboux method (left) and Conrad method (right)
Source: own elaboration

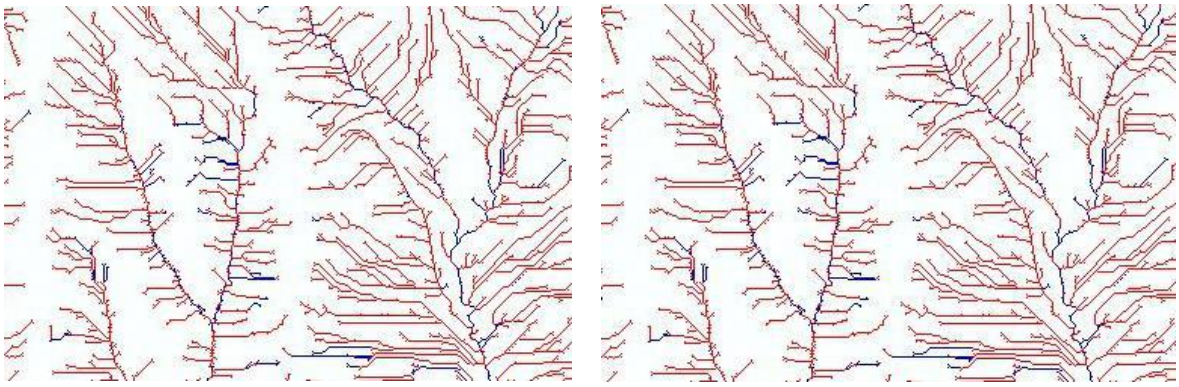


Fig. 10. Stream network after filling the depression with the Wan and Liu method (left) and XXL Wang and Liu method (right)
Source: own elaboration

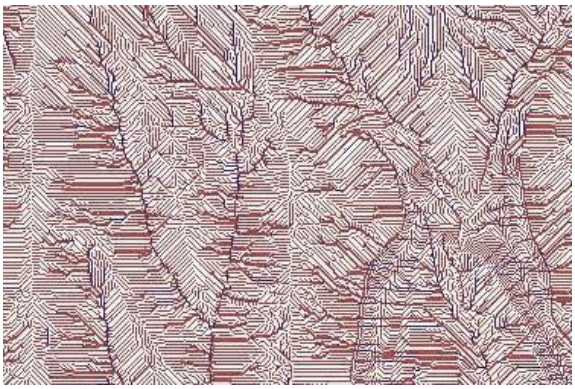


Fig. 11. Stream network after filling the depression with
the Jenson and Dominique method
Source: own elaboration

Table 3. Amount of changed and unchanged cells after the depression filling

Method	**Number of no data cells**	**Number of changed cells**	**Number of unchanged calls**
Planchon and Darboux	556170	7318	50912
Conrad (QM)	556084	7508	50808
Wang and Lie	556152	7354	50894
XXL Wang and Lie	556152	7354	50894
Jenson and Domingue	348028	251917	14455

Source: own elaboration

Conclusion

Automatic surface runoff calculation from DEM has become increasingly popular over the last 20 years, due to the availability and bigger DEM resolutions. Algorithms for determining the direction of stream network are used to check cells watercourses on the DEM as well as the movement of water to lower points in the field. Basically, runoff algorithms define the path by which surface runoff will move from a given cell to one or more adjacent lower cells (Šamanović, 2014). Such provides a quality base for modeling the movement of the surface water flows. To create the surface runoff, it's necessary to identify and remove depression on the DEM, whether it's the real depression or depression created as an artifact during the DEM creation. The depression removal process' disadvantage is the DEM's cell elevation change.

Depression removal creates new altitude areas, leading to inaccurate calculations of runoff directions and basins. The five methods compared in this paper are used within open-source software. Although the two methods (Planchon and Darboux and Jenson and Dominigue) remove depression by the filling method, the number of cells with altered heights is significantly different due to the inadequacy of the Jenson and

Domingue algorithm to a large range of data and geomorphometric relief characteristics. The carving method in the area intersected by numerous watercourses and all terrain slope to the south, gives results slightly better compared to the two mentioned methods, but also the combined methods developed by Wang and Liu.

New methods for the choice depression removal algorithms need to adapt to the terrain's geomorphometric characteristics, the area's size and the number of watercourses. The recognition of depressions should be semi-automatic to distinguish real depressions from errors during the DEM creation. In addition to the above, the partial application of certain methods to the DEM would enable the creation of a more accurate DEM as a basis for calculating stream network and catchment areas.

Acknowledgements

The APC was funded by the scientific project 3D geoinformation for the purpose of irrigation canal modelling of the University North with PhD Sanja Šamanović as a project lead.

References

Biggs J.,von Fumetti S., Kelly-Quinn M. (2017). The importance of small waterbodies for biodiversity and ecosystem services: Implications for policy makers. Hydrobiologia, 793(1), pp. 3–39.

Bosner N. (2013). Interpolacija i aproksimacija splajnovima, Interna skripta. (*Interpolation and approximation with splines, Internal script*). Department of Mathematics, PMF, Zagreb, http://web.math.pmf.unizg.hr/~nela/nmfmpredavanja/nmfm_splajnovi.pdf [access: 05.11.2013].

Brenning A. (2017). SAGA Geoprocessing and Terrain Analysis in RSAGA. https://cran.r-project.org/web/packages/RSAGA/vignettes/ RSAGA-landslides.pdf [access: 29.01.2017].

Frančula N., Lapaine M. (2008): Geodetsko-geoinformatički rječnik (*Geodetic-geoinformatics dictionary*). State Geodetic Administration of the Republic of Croatia, Zagreb.

Grimaldi S., Nardi F., Di Benedetto F., Istanbulluoglu E., Bras R.L. (2007). A physically-based method for removing pits in digital elevation models. Advances in Water Resources, vol. 30, no. 10, pp. 2151–2158.

Hengl T., Hannes I.R. (2009). Geomorphometry: Conepts, Softvare, Applications. Elsevier, Oxford.

Lindsay J.B., Creed I.F. (2005). Removal of artifact depressions from digital elevation models: towards a minimum impact approach. Hydrological Processes, no. 19, pp. 3113–3126.

Lindsay J.B. (2016): Efficient hybrid breaching-filling sink removal methods for flow path enforcement in digital elevation models, Hydrological Processes, 30(6), pp. 846–857.

O'Callaghan J.F., Mark D.M. (1984). The extraction of drainage networks from digital elevation data. Computer Vision, Graphics, and Image Processing, vol. 28, no. 3, pp. 323–344.

Pastor-Martín C., Antón L., C., Fernández-González C. (2017). Matlab-based tool for drainage network ordering by horton and hack hierarchies, Primer Congreso en Ingeniería Geomática. Valencia, pp. 162–170.

Planchona O., Darboux F. (2001). A fast, simple and versatile algorithm to fill the depressions of digital elevation models. Catena, no. 46, pp. 159–176.

Šamanović S., Medak D., Kunštek D. (2017). Influence of pit removal algorithms on surface runoff simulation. Građevinar, no. 69, 183–198.

Šamanović S. (2013). The influence of algorithms for pit removal on the reliability of a digital elevation model. Doctoral thesis. Faculty of Geodesy, Zagreb.

Tarboton D.G., Bras R.L., Rodriguez Iturbe I. (1991). On the extraction of channel networks from digital elevation data. Hydrological Processes, vol. 5, no. 1, pp. 81–100.

URL1: https://dgu.gov.hr/proizvodi-i-usluge/podaci-topografske-izmjere/digitalni-model-reljefa/180 [access: 09.06.2022].

URL2: https://saga-gis.sourceforge.io/saga_tool_doc/2.2.3/ta_preprocessor_5.html [access: 09.06.2022].

URL3: https://www.whiteboxgeo.com/ [access: 16.07.2022].

Wang L., Liu H. (2006). An efficient method for identifying and filling surface depressions indigital elevation models for hydrologic analysis and modelling. International Journal of Geographical Information Science, vol 20, no. 2, pp. 193–213.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.99

Ewelina Wójciak[1], Agnieszka Cienciała[2]

SELECTED METHODS AND FACTORS IN THE RELIABLE APPRAISAL OF AGRICULTURALLY USED REAL ESTATES

Abstract: Effective management of land resources requires implementing suitable policies and tools enabling a sustainable approach towards the improvement of the structure of farms, the acquisition of agricultural properties, their subdivision, as well as other procedures concerning the use and turnover of agricultural land. Proper analytical basis for managerial decisions includes procedures concerning estimation of land value..

The estimation of agricultural real estate in Poland generally takes place using a comparative approach, however, an alternative to the valuation process is allowed - the land valuation index method, which falls under the mixed approach. The purpose of the following paper is to verify the effectiveness of the land valuation index method in the context of the changing prices of agricultural real estates in Poland over the years.

Moreover, there is widespread recognition that the estimation indices depend on the data of the real estate cadastre, as well as on the location of the real estate differentiated by its affiliation to a given tax district. As emhasised in the literature, the validity of the cadastral data is sometimes problematic and the state disclosed in the cadastre very often differs from the actual state. For the purposes of the following publication, examples of situations occurring in practice and affecting the reliability of the cadastral data on the basis of which the determination of the value of real estate is carried out were also indicated.

Keywords: appraisal of real estate, agricultural real estates, valuation methods, cadastral data in valuation

Received: 22 June 2022; accepted: 18 July 2022

[1]Kielce University of Technology, Faculty of Environmental, Geomatic and Energy Engineering, Kielce, Poland, email: biuro@esw24.pl

[2]Kielce University of Technology, Faculty of Environmental, Geomatic and Energy Engineering, Kielce, Poland, ORCID ID: http://orcid.org/0000-0001-5123-4147, email: acienciala@tu.kielce.pl, corresponding author.

Introduction

As indicated in available climate scenarios, the demand for food will increase permanently on a global scale during the next 3–4 decades due to the growing population and the increasing gross domestic product of countries (Atzberger, 2013). As numerous factors that negatively impact the efficiency of agricultural production can be observed nowadays, the aim should be to provide tools that enable a sustainable and effective use of agricultural land and its management. As emphasised by Ostapchuk et al. (2021) land resources constitute an essential part of the enterprise potential providing, among others, the spatial and territorial basis for economic activities, as well as being used as production means in agriculture, alternative energies, etc. The authors indicate that effective management of land resources is crucial to providing the efficient functioning of the enterprise as a whole. According to Kassie et al. (2017), the possibility of securing land ownership and long-term renting influences the economic growth. Many activities have already been implemented around the world to support agricultural production. Rząsa et al. (2019) claim that sustainable rural development is also one of the basic objectives of the rural areas policy in Poland. To improve the structure of farms, the regulations governing the acquisition of agricultural properties have been sharpened, resulting in restrictions on trade in and a decrease in prices. As highlighted by Źróbek-Różańska (2019), the radical act of 2016 stopped the sale of Treasury resources and brought strong limitations of sales on the private market, but the provisions of the Act of April 2019 have alleviated the restrictions on agricultural real estate trade. According to the data of the Central Statistical Office, in 2020 a total of more than 137 thousand agricultural real estate sale transactions were finalized, of which 130 thousand were concluded on the free market. The total volume of trade reached almost PLN 16 billion, with a total area of agricultural land of 104 thousand hectares.

Apart from the above-mentioned turnover, agricultural properties can also be subject to, among others, inheritance proceedings, expropriation, land consolidation, and all of such processes bring demand for proper land management policies. Proper management, conditioning analytical basis for managerial decisions, includes procedures concerning estimation of land value. For the needs of the following paper, authors have concentrated on the activity related to reliable appraisal of agricultural properties. To begin with, the estimation of agricultural real estate in Poland generally takes place using a comparative approach. This is due to the fact that the considered market segment is relatively well developed throughout the country. However, the legislator allows an alternative to the valuation process in the comparative approach. This is the land valuation index method, which falls under the mixed approach.

The purpose of the following paper is to verify the effectiveness of the land valuation index method in the context of the changing prices of agricultural real estates in Poland over the years. In principle, the above-mentioned method leads to market value determination, however, there are doubts whether in fact the results obtained by means of land appraisal index method can be treated as representative for the current state of

agricultural real estate market. Furthermore, the question of the influence of the reliability of the cadastral data on the reliability of the appraisal reports was analyzed.

Literature review

The literature review is divided into two sections. The first provides an overview of the literature thematically related to the analysis of the principles of valuation of agricultural properties in Poland and other selected countries. In the second section, the authors analysed the influence of the reliability of cadastral data on the property appraisal process.

Valuation of agricultural properties in Poland and other selected countries

Along with the development of an economic society, it is necessary to develop a reliable and effective approach to determining the market value of real estate (Chen et al. 2017). As emphasised by Bieda (2018) real estate valuation is carried out properly if all the conditions occurring on a given market at the time of its performance are taken into consideration. The author indicates that the proper determination of the land use class of the valued property is one of the important determinants of correct appraisal. According to Ostapchuk et al. (2021), the value of land resources depends on several factors including, among others, land allocation, zoning, productivity, properties of soils, land use planning, environmental regulations, infrastructure development, value-added premium, relationship between demand and supply in the market, surrounding area, inflation, benchmark land price, etc. Kovalova et al. (2020) emphasizes the characteristics of the resources, such as the size of the plot, the landscape, the distance to the product sales places, the infrastructure, the transport system, etc. should be taken into consideration. According to Kocur-Bera (2016), in Poland, two groups of factors can be listed that influence the prices of agricultural properties: natural factors, as well as spatial and organizational issues. The author adds that they can be divided into exogenous, relatively permanent factors (for example demographic relationships, urban development, transport and retail networks, etc.), as well as endogenous, anthropogenic ones (including the size and shape of plots, location, land-use, etc.). The research conducted by Kocur-Bera (2016) showed that the prices of agricultural properties located up to 2 km from compact rural settlements are higher than those of plots located at a distance of more than 6 km (because of the higher cost and the longer time of transport to farmland) and that high quality soils also drive up prices. As emphasised by Sobolewska-Mikulska et al. (2014), there are many features that are unique and specific only for agricultural real estates, for example, the value of soil evaluation, the quality of the access road, the shape of the parcel, the relationship of water, etc. Meanwhile, as indicated by Matko (2008) in Slovenia, there are three factors determining the value of agricultural land, value per m2 of a norm object (depending on the location), bonita factor (the quality of land), as well as size of a plot. An impact of location on the market value of the land can be observed that is expressed by value zones and constitutes the most important factor for models of mass apraisal. In the Primorje region for speculative

reasons, land is sold at relatively high prices (the maximum average value of agricultural land), irrespective of its quality. Also Helbing et al. (2017) in Germany claim that estimation of location values involves a variety of attributes and variables, such as plot size, soil quality, land use systems, or distance to cities. The authors emphasise that in Germany on average less than one percent of the agricultural land is sold every year, as there are only a few or even no land transactions within a particular subdistrict (Gemarkung). As a result, estimating location values entails including weighted observations from other subdistricts and if the assumption of equal location value is violated, considerable bias may be incurred. Moreover, the authors find variations in agricultural product prices, technological alteration and changes in legislation as a source of changes of the value of land. As described by Kharitonov et al. (2020) in the Russian Federation at present all the conditions have been created for performing high-quality appraisal works. However, when determining the value of agricultural land, environmental factors, such as the content of pollutants, are not taken into account. The authors propose a technology for complement the cadastral value calculation algorithm with an environmental indicator reflecting the ecological condition of land plots, which will allow taking into account not only future revenues but also future potential costs that directly depend on the anthropogenic factor. Kharitonov et al. (2020) indicate that there are several drawbacks of such solution, among others, the lack of data on the qualitative and environmental condition of lands in the cadastre and the perspective of a significant increase in the cost of appraisal works.

As mentioned above, the appraisal of agricultural real estate in Poland is generally carried out using the comparative approach, but there is also an alternative method of land valuation indices, which falls under the mixed approach. According to § 18 of the Regulation of the Council of Ministers on Real Estate Valuation and Development of the Valuation Report (Regulation, 2004), the land valuation index method is applied in the process of estimating the value of real estate intended for agricultural or forestry purposes only in the absence of market transactions. The application of this method can be formally difficult, especially from the point of view of already mentioned good condition of agricultural land segment, as well as from the point of view of possibility to extend the area of market monitoring from local level to regional or even supra-regional market. The idea of using the method of land estimation indices in the context of agricultural real estate is related to the production potential of land of a given classification class, expressed in a hypothetical number of decitons of rye grain that it is possible to obtain from 1 ha of the surface. The title "estimation indexes", depending on bonitification class shown in the real estate cadastre and tax district adopted according to the provisions on agricultural tax (Law, 1984), are defined in the annex to the decree (Decree, 2004). Paragraph 18 Subparagraph 3 of the Ordinance (Ordinance, 2004) states, in turn, that the price for rye grain must be taken from the local market, leaving it to the property appraiser to obtain the relevant data. The data sources that could be used were not indicated. It is important to note that the prices for rye grain are characterized by a significantly higher annual variability than the prices for agricultural real estate on the free market.

The last element of the land valuation method are the correction coefficients, which, with reference to § 19 of the Regulation (Regulation, 2004), should take into account such characteristics of the land as location in relation to main roads, quality of access roads, danger of erosion, difficulty of cultivation, agricultural culture, structure of land use or presence of infrastructure hindering agrotechnics, among others. Current legal regulations do not indicate how the indicated characteristics should be taken into account in the valuation process or what adjustment dimension may actually be applied. In the commentary to the professional standard V.6 – "Determination of the value of forest and wooded and bushland property", only exemplary numerical values of correction factors for forest land were proposed. However, such an elaborate document is not available for agricultural land. Regardless of that, it is worth re-calling that the professional standards of real estate appraisal do not have the value of currently binding legal regulations. Taking into account the above, the value of agricultural real estate estimated in the mixed approach, using the method of land estimation indexes, will be burdened with a large measure of subjectivity. The entire calculation procedure can be reduced to the following formula:

$$W_{GR} = \left[\sum_{i=1}^{n}(W_{SRi} \times P_{Ri})\right] \times C_z \times (1 + v_{R1} + v_{R2} + \ldots + v_{Rm})$$

where:
W_{GR} – market value of agricultural real estate;
W_{SRi} – an assessment rate expressed in decitons of rye grain for 1 acre of agricultural land of a given class located in the appropriate tax district;
P_{Ri} – an area of agricultural land of a given quality class (expressed in hectares);
C_z – price of 1 deciton of rye grain from the local market;
v_R – correction factors.

The market value determined in this way does not reflect the real development potential of the property, understood as the possibility of using agricultural land in a different way in the long run. Unfortunately, this aspect was also omitted from the catalog of features compiled in § 19 of the Regulation (Regulation, 2004).

Influnce of the reliability of the cadastral data on the process of property valuation

As has been mentioned, the estimation indices specified in the annex to the decree (Decree, 2004) depend on the data revealed in the cadastre, including the field of the cadastral parcel area, land use and bonitification classes. The legislator has provided different dimensions of estimation indices for arable land and meadows and pastures. For example, for arable land of class II located in tax district I, it is assumed that 132 decitons of rye grain can be produced and for meadows and pastures of similar parameters, 118 decitons of rye grain. Several adjustments have also been made for other types of land, such as orchards or land under ponds. Therefore, the estimation indices depend only on the data of the real estate cadastre, as well as on the location of the real estate differentiated by its affiliation to a given tax district. However, in

numerous publications the authors point out the fact that the validity of the above-mentioned data is sometimes problematic (Cienciała, 2017; Cienciała et al., 2021; Kocur-Bera & Frąszczak, 2021; Benduch & Pęska, 2016; Benduch, 2017; Benduch, 2019; Benduch et al., 2019; Felcenloben, 2009; Hanus et al., 2021; Konieczna, 2012). As a rule, Polish legal regulations define rules of the maintenance and update of the cadastral record, registering cadastral data concerning plots. The data inscribed in the cadastre are revised through the introduction of documented changes, displaying new cadastral information, or excluding incorrect information. The aim is to keep the record up-to-date and consistent with the source materials and documentation accessible to the authority. In the process of cadastre modernization and its current updating, outdated or erroneous data is corrected. The sources of discrepancies between the cadastre and the actual state are various, including, among others, lack of updating the land and building cadastre after the changes in the actual state, lack of reliability of the archival documentation, which is the basis for revealing the changes in the cadastre, etc. Attention is also drawn to the lack of updating the land use designation after a change in the regulations, deliberate avoidance of land use updates, or changes in accuracy requirements and technological progress guaranteeing more and more precise measurement results. In her publication, Kocur-Bera (2019) examined 3273 cases of differences between the documented situation and factual circumstances. The analysis revealed that the discrepancies were mainly affected by the quality of the source data and the terrain conditions.

The necessity of effective verification of the credibility of cadastral data and their regular update has been repeatedly emphasised in the literature (Lisec et al., 2013; Mika, 2017; Hycner, 2006; Kuznetsov et al., 2022), however, in many countries of the world, just like in Poland, there is currently no obligation for top-down, systematic control of the content of evidential data by the authorities. As indicated by Bieda (2018) one of the crucial determinants of correct valuation is the proper determination of the land use class of the valued property. Periodic verification of cadastral data concerning land use based on widely available surveying and photogrammetric materials, including orthophotomaps, would be advisable. For the registration of cadastral objects – the boundaries of land parcels and the outlines of buildings – very high-resolution aerial photographs can be used (Kurczyński et al., 2016), but also, due to the achieved quality of data, the terrestrial laser scanning (TLS) method can be applied. They obtained an accuracy of photogrammetric works (0.05m) sufficient to ensure a measurement accuracy of 0.10 m sufficient to measure the cadastral boundary on the orthophotomap. Their research showed that the most important issue was related to the ability to interpret the measured features depending on the geometric and radiometric quality of the images and the observer's experience. Also, according to Sedighkia & Datta (2022) traditional methods of surveying in case of quick update of data concerning land use might be expensive and arduous, whereas novel methods have been highlighted in recent decades. The authors highlight remote sensing data processing as one of the efficient methods to update the land use map.

Methodology

In order to verify the efficiency of the land valuation index method in the context of changing prices of agricultural real estates in Poland in the course of years, the market value of hypothetical agricultural real estates with an area of 1 ha, located in the 2nd tax district, designated in the cadastre as arable land (R) of classes I to VIz, was determined. The calculations were based on the average prices of 1 dt of rye grain in the years 2005-2021. At the same time, the average market characteristics of the estimated real estates were assumed, which means that an additional correction of the obtained results with correction coefficients was omitted. It was analyzed whether the results obtained using the land estimation index method can be treated as representative of the current state of the agricultural real estate market. In addition, the question of the influence of the reliability of cadastral data on the credibility of agricultural real estate valuation was analyzed. The research was conducted on the basis of selected cadastral data and orthophotomaps gathered in the national geodetic and cartographic resource.

Results

The table 1 shows the results of estimating the market value of 1 ha of arable land of a given class in the 2nd tax district for the years 2005–2021.

Table 1. Market value of 1 ha of arable land of a given class in tax district 2 over the years

Year	Rye grain price [zł/dt]	Bonitification class								
		I	II	IIIa	IIIb	IVa	IVb	V	VI	VIz
2021	61,48	7746	7070	6332	5287	4304	3197	1844	738	307
2020	58,55	7377	6733	6031	5035	4099	3045	1757	703	293
2019	58,46	7366	6723	6021	5028	4092	3040	1754	702	292
2018	54,36	6849	6251	5599	4675	3805	2827	1631	652	272
2017	52,49	6614	6036	5406	4514	3674	2729	1575	630	262
2016	52,44	6607	6031	5401	4510	3671	2727	1573	629	262
2015	53,75	6773	6181	5536	4623	3763	2795	1613	645	269
2014	61,37	7733	7058	6321	5278	4296	3191	1841	736	307
2013	69,28	8729	7967	7136	5958	4850	3603	2078	831	346
2012	75,86	9558	8724	7814	6524	5310	3945	2276	910	379
2011	74,18	9347	8531	7641	6379	5193	3857	2225	890	371
2010	37,64	4743	4329	3877	3237	2635	1957	1129	452	188
2009	34,10	4297	3922	3512	2933	2387	1773	1023	409	171
2008	55,80	7031	6417	5747	4799	3906	2902	1674	670	279
2007	58,29	7345	6703	6004	5013	4080	3031	1749	699	291
2006	35,52	4476	4085	3659	3055	2486	1847	1066	426	178
2005	27,88	3513	3206	2872	2398	1952	1450	836	335	139

Source: Central Statistical Office

The above mentioned researches confirm that the variability of rye grain prices year-to-year significantly influences the fluctuations of the valuation results made with the use of the land valuation index method, which can be clearly seen especially in the years 2006–2007, 2008–2009 and 2010–2011. In the last case, the price of rye doubled year-to-year, which directly translated into the doubled increase of the market value of the real estate.

It is also evident that, in the case of weaker classes of bonitations, the estimated value of real estates decreases very rapidly, reaching in practice a dimension that is inadequate to the market realities. Referring to the indicated problem, it should also be noted that the results obtained differ significantly from even the average transaction prices of agricultural land published by GUS. The figure below presents the variation of average transaction prices of agricultural real estate in Poland in the perspective of the last 30 years.

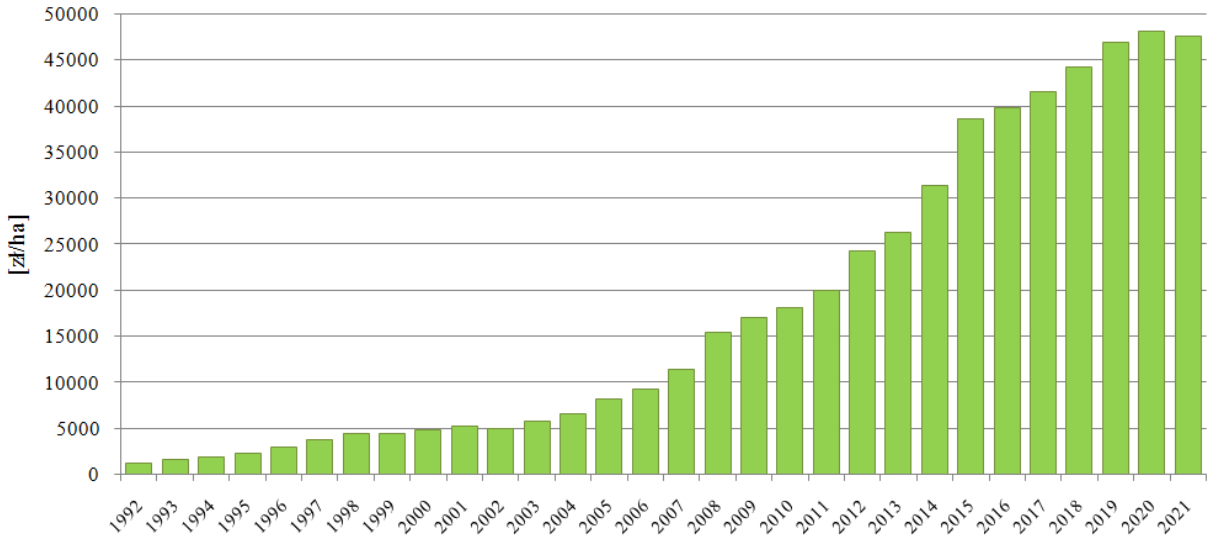


Fig. 1. Average prices of agricultural land in Poland in 1992–2021
Source: own elaboration based on CSO data

The above diagram confirms that the degree of the market value underestimation using the land valuation index method is significant, even being 10 times lower. This means that the prices of rye grain increase at a slower rate than the prices of agricultural land, which makes the method ineffective and leads to an underestimation of the market value. It is also connected with the fact that the algorithm of land estimation index method does not allow taking into consideration the development perspectives of agricultural land. More and more often, especially near larger urban centers, agricultural land is purchased for speculative purposes. The purchasers decide to buy an agricultural property located near existing buildings and the technical infrastructure network of the area, characterized by convenient access, and then take actions to change the land's designation for nonagricultural purposes. In such a case, the issue of land use and land quality class is of secondary importance. These are increasingly common free market mechanisms, especially in light of the desire to protect capital from rising inflation.

It should be emphasized that this kind of behavior is currently limited to some extent by the provisions of the Act of April 11, 2003 on shaping of the agricultural system (the Act, 2003), although it mainly concerns agricultural properties of the area exceeding 1 ha.

It is worth noticing that in the moment of coming into force of the Regulation on real estate valuation and making the appraisal report (Regulation, 2004), the average prices of agricultural land oscillated around 6000 zloty/ha (Fig. 1). At that time, the results obtained using the method of land estimation indexes appeared to be close to the actual state of the market. Poland's accession to the European Union and launch of the direct payments system for farmers caused a rapid increase of agricultural real estate prices, which finally separated this method from market reality.

In case of valuation, reliable information regarding the cadastral area of the plot is essential, whereas the area disclosed in the cadastral register is not always consistent with the geodetic (actual) area. Examining the quality and reliability of the materials of the state surveying and cartographic resource, one may conclude that especially plots within rural areas are exposed to significant, deviating from acceptable, differences between the registered data and the actual state. This is mainly due to the fact that in those areas until recently lower accuracy requirements were imposed on the surveying grid, to which the measurements of boundaries were attached, which influenced the accuracy of determination of coordinates of boundary points and the discrepancies in the location of boundary points obtained today. Before preparing the appraisal report, there is no obligation to update the cadastral data, and the activities associated with it would significantly increase the time of execution of the order. Consequently, the surveyor bases only on theoretical, outdated data, and, as practice shows, sometimes even dating back to the 1970s, when the land register (cadastre) was being established and the plot area was recorded with the precision of up to 1 acre. Underneath an example of such a case has been shown (Fig. 2). According to the entry in the land register and the graphical part – the cadastral map – the southern part of the plot of land No. 8 is designated as land use S (orchard), which is not consistent with the actual state in the field. Similarly, the southern part of the plot of land No. 8 is built up, while according to cadastral map it is arable land.

The size of the area of the land plot and individual land classes within it, disclosed in the currently binding unit - ha with the accuracy of 1 ara – shows that the area data are not geodetic data, but refer to the once rounded off area, given in acres. According to currently binding standards, the area of a cadastral parcel is calculated on the basis of coordinates of boundary points of the cadastral parcel, taking into account the value of the mapping correction, and is shown in hectares with the recording precision of up to 0.0001 ha. As a rule, for those parcels for which the area since the establishment of the registration has not been calculated with a precision of 0.0001 ha, it is permissible to record the area with a precision of 0.01 ha.

Fig. 2. Example of a discrepancy between the actual state of the plot no. 8 [shown on the orthophotomap (right)] and the data registered on the cadastral map (left); the descriptive part of the cadastre (bottom)
Source: own elaboration based on https://mapy.geoportal.gov.pl/, data from the state geodetic and cartographic resource

Updating the cadastre may in some cases show changes in legal status that have occurred over the years. Below (Fig. 3) is a situation of a change of the shoreline. There is widespread recognition that such situation may result in acquisition of the property right by the owner of the flowing water, which in this case is the State Treasury. This is because, according to Article 223. 1. of the Act of 20 July 2017 on water law. If inland flowing waters or waters of the territorial sea or internal sea waters occupy permanently, in a natural way, the land not being the property of the owner of the waters, this land at the moment of occupation becomes by law the property of the owner of the waters. In the case in question (Fig. 3) the northern fragment of the cadastral plots no. 94/29 and 94/31 is permanently occupied by inland flowing water; thus, it is necessary to conduct a demarcation and to regulate the legal status of the property.

3	2	94/29	WŁ	1/1	Ps	Ps	VI	0.2451	0.3430
					N			0.0979	
4	2	94/31	WŁ	1/1	Ps	Ps	VI	0.2270	1.3116
			DZ	1/1	Tr			0.1169	

Fig. 3. Example of plots of land that have been permanently occupied by flowing water and cadastral data describing an outdated state
Source: https://mapy.geoportal.gov.pl/, data from the state geodetic and cartographic resource

Summary

The main disadvantages of using the land estimation index method include:
1) High degree of correlation of the results obtained with the prices of rye grain in the local market, which are characterized by periodic variability;
2) Problematic determination of the spread and dimension of the correction coefficients;
3) Inability to reflect the real development potential of the property;
4) Low efficiency of the method – generally provides results lower than those obtained when using the comparative approach (underestimated market value);
5) Relatively well-developed agricultural real estate market - the availability of market data on real estate sales transactions in the sector in question is a factor that limits the validity of the land valuation method.
The above indicates that for valuation of agricultural real estate should be used primarily a comparative approach. The regulations resulting from the assumptions of the land valuation index method are outdated and inadequate to the current market

realities. Taking into account the fact that the valuation of agricultural real estate is an important issue affecting a number of real estate management processes, we should consider changing the assumptions of the discussed method or even its removal from the catalog of legally permitted methods of property valuation applied in Poland.

As has been mentioned, the estimation indices, specified in the annex to the decree (Decree, 2004) depend on the data revealed in the cadastre, including the field of the cadastral parcel area, land use and bonitification classes. Meanwhile, the validity and reliability of cadastral data is sometimes problematic, and the state disclosed in the cadastre very often differs from the actual state. Often, the property appraiser works on the basis of theoretical data and the appraisal report does not refer to the actual geodetic area and the actual state of usage. There is no requirement to update the cadastral data before proceeding to prepare the valuation of the property, and such a rule would cause considerable difficulty and increase the time of execution of the order. However, it would be reasonable to implement standards and requirements for verification of cadastral data by the authorities that maintain the cadastre. Verification of the reliability of source materials – their unambiguity and compliance with the actual state on the ground would be the guarantee of the effectively conducted real estate valuation.

References

Atzberger C. (2013). Advances in Remote Sensing of Agriculture: Context Description, Existing Operational Monitoring Systems and Major Information Needs. Remote Sensing, vol. 5, no. 2, pp. 949–981.

Benduch P., Pęska A. (2016). The Influence of the Cadastre Modernization on the Real Estate Tax Base Assessment. Infrastruktura i Ekologia Terenów Wiejskich, vol. III, no. 1, pp. 787-800.

Benduch P. (2017). Selected problems of law determining the extent and types of land uses. Infrastruktura i Ekologia Terenów Wiejskich, vol. III, no. 1, pp. 999–1015.

Benduch P. (2019). The study of dependency between land-use coverage and parcel boundaries. In E3S Web of Conferences, vol. 86, p. 00006. EDP Sciences.

Benduch P., Pęska-Siwik A., Hanus P. (2019). Problematic aspects of registering ecological land-use in the Real Estate Cadastre. In E3S Web of Conferences, vol. 86, p. 00007. EDP Sciences.

Bieda A., Bydłosz J., Warchoł A., Balawejder M. (2020). Historical Underground Structures as 3D Cadastral Objects. Remote Sensing, vol. 12, 1547.

Bieda A. (2018). Conditional Model of Real Estate Valuation for Land Located in Different Land UseZones, Real Estate Management and Valuation, vol. 26, no. 1, pp. 122–130.

Chen Z., Hu Y., Zhang C. J., Liu Y. (2017). An Optimal Rubrics-Based Approach to Real Estate Appraisal,Sustainability, vol. 9, no. 6, pp. 1–19.

Cienciała A. (2017). The Issue of the Legal and Surveying Division of Agricultural Land on Selected Examples in Poland and on the International Stage. Geographic Information Systems Conference and Exhibition "GIS ODYSSEY 2017", 4th to 8th of September 2017, Trento – Vattaro, Italy Conference proceedings.

Cienciała A., Sobolewska-Mikulska K., Sobura S. (2021). Credibility of the cadastral data

on land use and the methodology for their verification and update. Land Use Policy, vol. 102, 105204.
Felcenloben D. (2009). Wyłączenie gruntów z produkcji rolnej w kontekście aktualizacji ewidencji gruntów i budynków (*Exclusion of land from agricultural production in the context of updating the land and building register*). Samorząd Terytorialny, vol. 4, pp. 61-68.
Hanus P., Benduch P., Pęska-Siwik A., Szewczyk R. (2021). Three-stage assessment of parcel area quality Three-stage assessment of parcel area quality. Area, vol. 53, no. 1, pp. 161–174.
Helbing G., Shen Z., Odening M., Humboldt M.R. (2017). Estimating Location Values of Agricultural Land. SFB 649 Discussion Paper 2017–002.
Hycner R. (2006). Ewidencja gruntów i budynków w Polsce jako kataster (*Registration of land and buildings in Poland as a cadastre*). Acta Scientifica Academiae Ostroviensis, vol. 23, pp. 19–43.
Kassie G.W., Kim S., Fellizar F.P. (2017). Determinant factors of livelihood diversification: Evidence from Ethiopia. Cogent Social Sciences, vol. 3, no. 1.
Kharitonov A.A., Vikin S.S., Ershova N.V. (2020). Improving the Technology of Cadastral Appraisal of Agricultural Lands with the Account of Environmental Factors. IOP Conference Series: Earth and Environmental Science, vol. 459, 022019.
Kocur-Bera K., Frąszczak H. (2021). Coherence of Cadastral Data in Land Management – A Case Study of Rural Areas in Poland. Land, vol. 10, 399.
Kocur-Bera K., Stachelek M. (2019). Geo-Analysis of Compatibility Determinants for Data in the Land and Property Register (LPR). Geosciences, vol. *9*, no. 7, 303.
Kocur-Bera K. (2016). Determinants of agricultural land price in Poland – a case study covering a part of the Euroregion Baltic. Cahiers Agricultures, vol. 25, no. 2.
Konieczna J. (2012). Użytki gruntowe i ich aktualizacja podstawą prac kształtujących strukturę przestrzenną obszarów wiejskich (Land use and its updating as a basis for works shaping the spatial structure of rural areas). Infrastruktura i Ekologia Terenów Wiejskich, no. 1/II, pp. 197–206.
Kuznetsov A.D., Rada A.O., Timofee A.E., Nikitina O.I., Osintseva M.A. (2022). Features of the choice of information technologies for the development of agriculture. IOP Conference Series: Earth and Environmental Science, vol. 981, 032019.
Matko V. (2008). Mass appraisal of agricultural land. Geodetski Vestnik, vol. 52, no. 3, pp. 520–529.
Ostapchuk T., Orlova K., Biriuchenko S., Dankevych A., Marchuk G. (2021). Defuzzification in the process of managerial estimating the value of agricultural lands. Agricultural and Resource Economics: International Scientific E-Journal, vol. 7, no. 4.
Rozporządzenie Rady Ministrów z dnia 21 września 2004 r. w sprawie wyceny nieruchomości i sporządzania operatu szacunkowego (*Decree of the Council of Ministers of 21 September 2004 on real estate valuation and the preparation of valuation reports*). Dz.U. 2004 nr 207 poz. 2109 z późn. zm.
Rząsa K., Ogryzek M., Źróbek R. (2019). The Land Transfer from The State Treasury to Local Government Units as a Factor of Social Development of Rural Areas in Poland.

Land, vol. 8, no. 11, 170.
Sobolewska-Mikulska K., Krupowicz W., Sajnóg N. (2014). Methodology of validation of agricultural real properties in Poland with the use of geographic information system tools. Geodesy and Mine Surveying, 14th International Multidisciplinary Scientific GeoConference SGEM 2014.
Ustawa z dnia 15 listopada 1984 r. o podatku rolnym (Law of 15 November 1984 on Agricultural Tax). Dz.U. 1984 nr 52 poz. 268 z późn. zm.
Ustawa z dnia 11 kwietnia 2003 r. o kształtowaniu ustroju rolnego (Act of 11 April 2003 on the formation of the agricultural system). Dz.U. 2003 nr 64 poz. 592 z późn. zm.
Źróbek-Różańska A; Zielińska-Szczepkowska J (2019). National Land Use Policy against the Misuse of the Agricultural Land – Causes and Effects. Evidence from Poland. Sustainability, vol. 11, no. 22, 6403.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.113

Mirosław Bełej[1]

THE SPATIAL HETEROGENEITY OF THE DIFFERENT TYPES OF ACCOMMODATION WITH THE USE OF POI DATA

Abstract: This study investigates the geographical dimension of tourist accommodation in Slovenia, Croatia, and Bosnia and Herzegovina and attempts to synthesize its spatial structure. The countries were chosen for the study due to their undoubted tourism qualities, their proximity in terms of location and, at the same time, the fundamental diversity of country size, population and access to the sea. The basis of this research was the use of point of interest (POIs), an open-source data, to analyse the spatial heterogeneity of the different types of accommodation. Kernel Density Estimation and Empirical Bayesian Kriging were used in the research.

Keywords: tourism, accommodation, points-of-interest, spatial heterogeneity

Received: 12 June 2022; accepted: 8 August 2022

[1] University of Warmia and Mazury in Olsztyn, Faculty of Geoengineering, Institute of Spatial Economy and Geography, Department of Spatial Analysis and Real Estate Market, Olsztyn, Poland, ORCID ID: https://orcid.org/0000-0001-8650-6990, email: miroslaw.belej@uwm.edu.pl

Introduction

Geography focuses on place, space, and environment as its central concerns. A recent area of proper development for applied geographical research has been GIS, which enables geographers to play a problem-solving role in tourism (Hall & Page, 2009). According to Williams and Shaw (Williams & Shaw, 2015), tourism geography is a broad research area that studies the interactions between geography's space, place, and environmental dimensions. Tourism contributes to the growth of regional economies, providing a source of income for both resident households and local firms (Carrascal Incera & Fernández, 2015). Tourism is the mobility of society in geographical space, conditioned by the search for natural and anthropological tourist attractions (Bełej, 2021; Lengyel, 2016; Silviu-Florin, 2014). Tourism means moving from one point (home) to another, which is a place intended to give a feeling of relaxation. As a result, tourism combines spatial, environmental, infrastructural (forms of transport), economic, cultural, religious, or health aspects. Tourism is performed in the tourist space, which is the area of tourist services provision. Tourist services include, among others:

- transport services – transport by air, rail, coach, ship, or individual vehicle traffic,
- leisure and sports services – infrastructure for active recreation,
- tour guiding services – allows, under the guidance of a guide, to acquire knowledge related to cultural or environmental tourism,
- organisation and agency services – facilitate purchasing processes for, e.g. catering, leisure, insurance, accommodation services,
- commercial services – providing the opportunity to purchase local products, tourist equipment or souvenirs,
- cultural and entertainment services – providing access to cultural events such as museums, theatres, philharmonics, or cinemas,
- catering services – providing catering during tourist stays,
- accommodation services – providing temporary accommodation away from the usual place of residence.

In a brief analysis of the services presented above, we know their high complementarity. Each of these services strengthens tourist traffic and ensures the demand for other services. One of the basic human needs is a sense of security, provided by a roof over one's head. In the place of permanent residence, a person fulfils this need in his/her dwelling or house, while the tourist must have access to temporary rental accommodation. From the catalogue of services presented above, this is an essential service, which may be a reason for choosing or abandoning specific tourist destinations due to its high economic dimension. Generally, establishments are divided into (Han & Song, 2020; Lee et al., 2020; Navrátil et al., 2012; Rodríguez Rangel et al., 2020; Suárez-Vega & Hernández, 2020): hotels, motels, hostels, boutique hotels, guest houses, tour houses, hostels, youth hostels, bungalows, campsites and agritourism.

This study investigates the geographical dimension of tourist accommodation in Slovenia, Croatia, and Bosnia and Herzegovina and attempts a general synthesis of its spatial structure. This study assumes that the spatial distribution of the accommodation

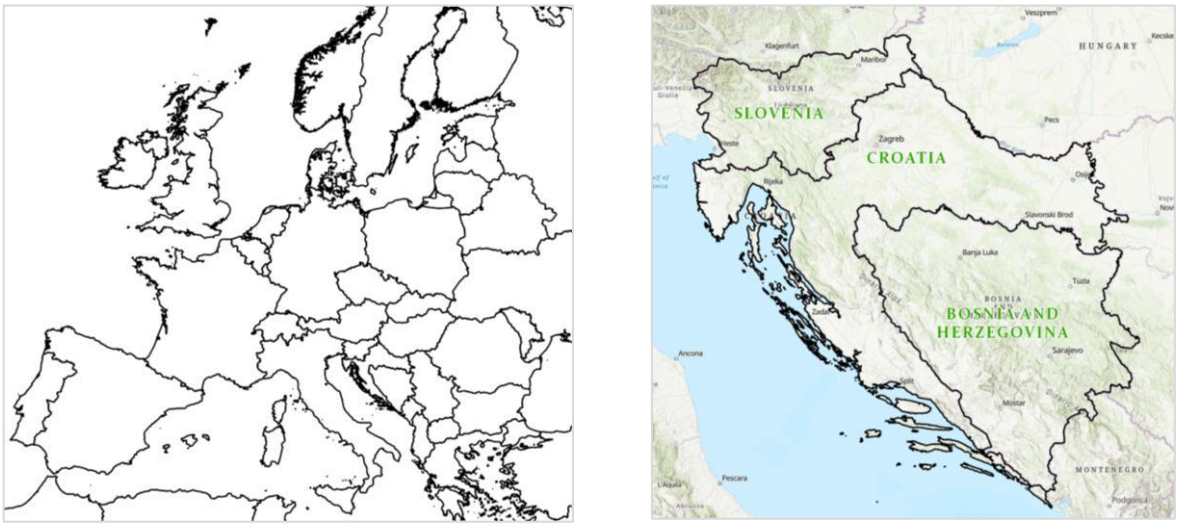
facilities allows evaluation of the potential popularity of different areas in each country. When a country is not well identified in terms of tourist attractiveness, the number of different accommodation establishments accumulated in specific destinations may suggest the high tourist value of these destinations. The analysis of the spatial distribution of accommodation facilities requires geolocalisation data on these facilities. The acquisition of such data is not always quick and free of charge. Often, data on the location of accommodation facilities are based solely on administrative address data. As a result, geographical coordinates are missing, and a sometimes cumbersome procedure for obtaining such coordinates is necessary. This research proposes to use open-type data provided by OpenStreetMap. These data are the so-called Point-of-Interest (POI), which contain information on geographic coordinates and the type of, e.g. fire station, post office, library, prison, courthouse, university, school, kindergarten, hospital, theatre, night club, cinema, park, swimming pool, tennis court, restaurant, pub, bakery, shop, bank, castle, tourist information and of course many types of accommodations. In conclusion, the research is based on the use of POI points concerning tourist accommodation facilities in Slovenia, Croatia, Bosnia and Herzegovina using a GIS tool: Kernel Density Estimation and Empirical Bayesian Kriging.

Points-of-Interest is cartographically mapped in geographical space and is uniquely associated with different aspects of human life (Liu et al., 2020; Wu et al., 2021). According to (Milias & Psyllidis, 2021), Points of Interest are available from several internet sources, for example Twitter and Instagram (geo-positioned social media), OpenStreetMap and Google Maps (map applications), Airbnb and Tripadvisor (applications for booking accommodation and positioning tourist attractions). There is a broad literature available on the geographic application of GIS tools and POI points (Cai et al., 2021; Jia et al., 2018; Liu et al., 2020; Lu et al., 2020; Milias & Psyllidis, 2021; Vestal et al., 2021; Wu et al., 2021; Yu and Ai, 2014).

Materials and methods

Study area. The spatial coverage of the presented study is limited to the borders of three countries; Slovenia, Croatia, Bosnia, and Herzegovina, which are located in South Europe. These countries were part of Yugoslavia (before 1991), so they have a shared history, but today they are developing independently, with Slovenia and Croatia being members of the European Union and Bosnia and Herzegovina not being. The reasons for choosing these countries were, on the one hand, territorial proximity (these countries border each other) and access to the Adriatic Sea (as a fundamental factor for the development of tourism services). On the other hand, these countries are fundamentally different in terms of surface area, population, and, above all, unequal access to the sea. Both Slovenia and Bosnia and Herzegovina have very little access to the Adriatic Sea, which for the most part forms Croatia's southern border; hence, the country relies heavily on tourism. In the context of the spatial distribution of accommodation analysis, such a definite difference between countries may give interesting and fundamentally

different results. It seems natural that it will be substantially different for Bosnia and Herzegovina and Slovenia, which have limited access to the sea (Fig. 1.)



a) b)

Fig. 1. Study area: (a) Location in Europe; (b) Slovenia, Croatia, Bosnia, and Herzegovina
Source: Own study

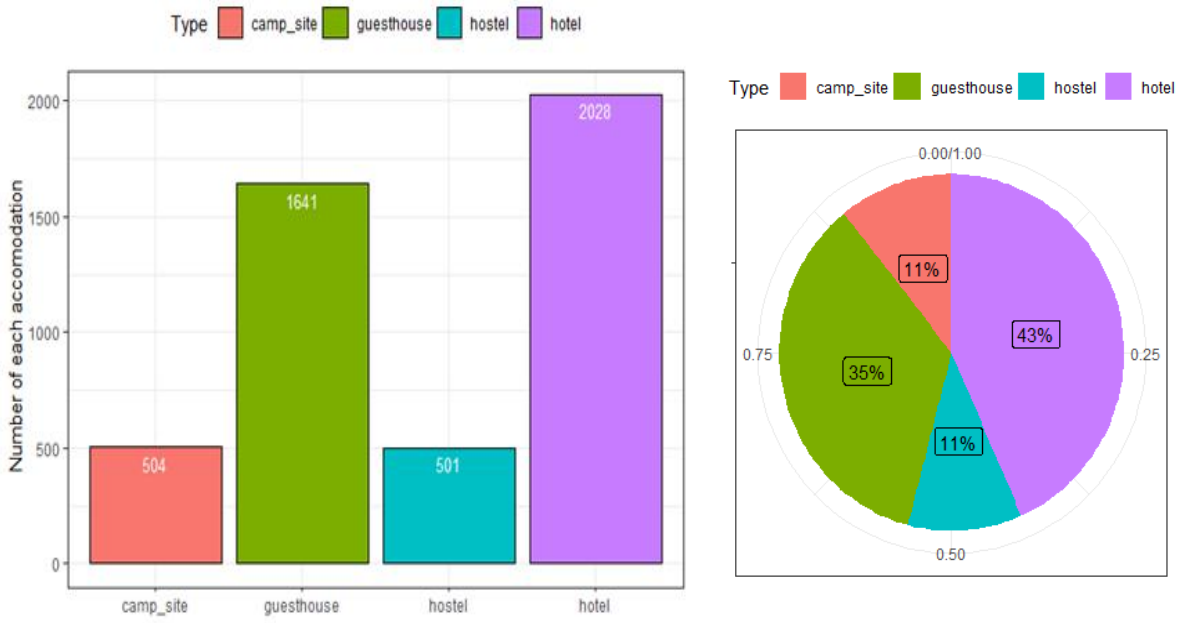
Data description and preliminary analysis. One of the study's primary objectives is to demonstrate that Point-of-Interest (POI) is a cheap (in principle free), fast, and reliable data source on the spatial heterogeneity of accommodation facilities in different countries. POI data were collected from OpenStreetMap (OSM) through the Geofabrik portal. According to Geofabrik (Geofabrik, 2022), free data encourage creativity and innovation and allow many people to contribute their ideas. However, for daily use, free data has tangible and pragmatic benefits: where data, format specifications, and software are open to everyone, where worldwide communities work with the same data, many problems that one encounters have already been solved by someone else, and the solution can be found. The data was downloaded on 31 March 2022. OpenStreetMap divides POIs, relating tourist accommodation into hotels, motels, bed and breakfast, guesthouses, hostels, chalets, hostels, camping, mountain hut, and camping site. Table 1 shows the accommodation facilities used in this study and their description.

4674 POIs related to tourist accommodation were downloaded from OpenStreetMap for Slovenia, Croatia, and Bosnia and Herzegovina. The details of the data collected, together with its visualisation, are shown in Figure 2. Most are hotels (2028), followed by guesthouses (1641) and a similar number of hostels (501) and campsites (504) (see Fig.2.a). Hotels were found to be 43%, guest houses 35%, and hostels and campsites 11% each. The level of diversification of different accommodation facilities in each surveyed country is shown in Figure 3.

Table 1. Description of variables

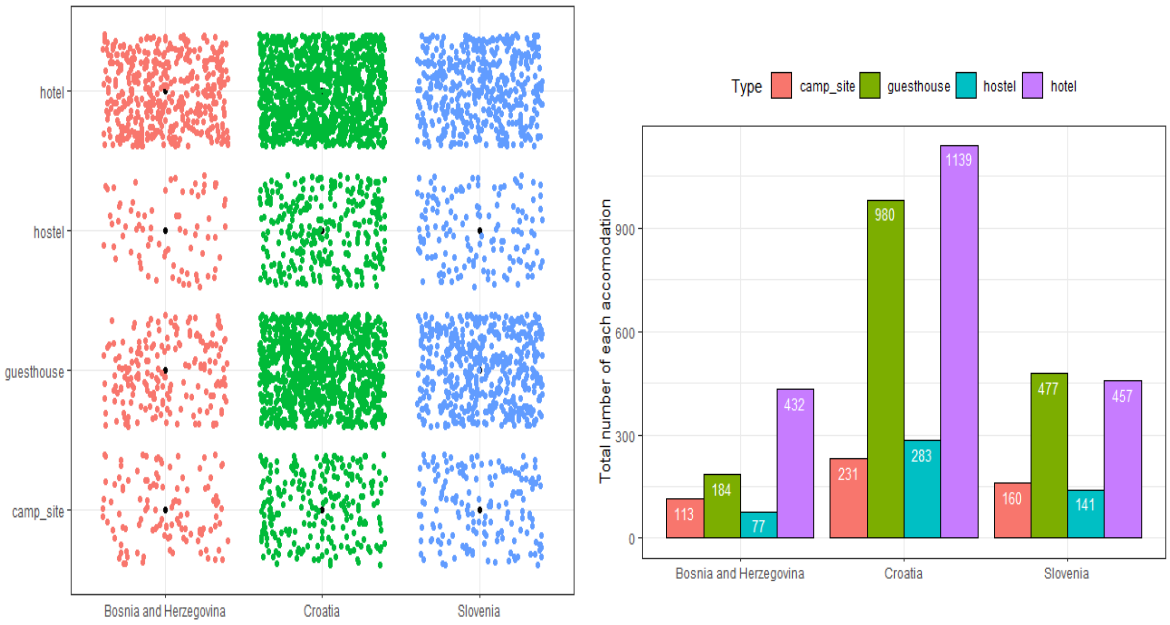
POI Types	POI Description
Hotel	Buildings with at least ten rooms, with most places in single and double rooms, provide a wide range of services related to customers' stay.
Hostel	It is cheaper than a hotel and differs in the number of beds in rooms, bunk beds and sharing (e.g. kitchen, bathroom).
Guesthouse	Rooms in dwellings and houses (excluding collective accommodation facilities) and adapted farm buildings owned by farmers, rented out for overnight stays for a fee.
Campsite	Guarded sites provide accommodation in tents, camper vans and caravans, preparing meals, parking cars, and providing services related to clients' stay; these sites may also provide accommodation in tourist cabins or other permanent facilities.

Source: Own study



(a) (b)

Fig. 2. Touristic accommodation in Croatia, Slovenia, and Bosnia and Herzegovina:
(a) Total number of each accommodation type;
(b) Percentage of each accommodation type
Source: Own study



(a) (b)

Fig. 3. Touristic accommodation in Slovenia, Croatia and Bosnia and Herzegovina: (a) Visualization of the volume of different types of accommodation in each country; (b) Total number of each type of accommodation type in each country
Source: Own study

Figura 2 (a) shows the volume visualisation of different types of touristic accommodation in Slovenia, Croatia and Bosnia and Herzegovina. This type of graph provides a good visual representation of the differences in numbers for each country and each type of accommodation establishment (without specifying their numbers). Bosnia and Herzegovina bases the vast majority of its accommodation services on hotels; the number of others is low. The structure of hotel facilities in this country is probably due to the limited access to the sea. Therefore, there are no distinctive seaside hotels, which are very different from typical business hotels. Croatia and Slovenia are dominated by seaside hotels and guesthouses, while the number of hostels and camping sites is much smaller. According to Figura 2 (b), Croatia has the highest number of hotels (1139) and guesthouses (980). Although the number of hostels and campsites is almost twice as high as in Slovenia and Bosnia and Herzegovina, they represent a small proportion of accommodation. Surprisingly, in Slovenia, we have more guesthouses than hotels. Bosnia and Herzegovina has only 77 hostels, although it is almost twice as large as Slovenia.

The data analysis (POI point) verified the assumption of the random spatial distribution of accommodation facilities in each country analysed. The Average Nearest-Neighbor method (Table 2) and Spatial Autocorrelation with Moran's Global Statistic I (Table 3) were applied.

Table 2. Average Nearest-Neighbor

	Slovenia	Croatia	Bosnia and Herzegovina
Observed Mean Distance (metres)	2221,1989	951,9488	1766,1387
Expected Mean Distance (metres)	9149,2042	5425,9938	6941,7250
Nearest Neighbor Ratio	0,242775	0,175442	0,254424
z-score	-50,908377	-80,942641	-40,493989
p-value	0,000	0,000000	0,000000

Source: Own study

Table 3. Spatial autocorrelation with Moran's I global statistic

	Slovenia	Croatia	Bosnia and Herzegovina
Moran's Index	0,118536	0,132821	0,153844
Expected Index	-0,000810	-0,000380	-0,001242
Variance	0,000127	0,000043	0,000222
z-score	10,599161	20,387262	10,397824
p-value	0,000000	0,000000	0,000000

Source: Own study

Given the z-score (Table 2), it is a less than 1% likelihood that this cluster pattern accommodation in chosen countries could result from random chance. The results of spatial autocorrelation presented in Table 3 allow us to check the dispersion of facilities in individual countries and verify the hypothesis of clusters of attribute values. Obtained from OpenStreetMap, the dataset does not value the different types of accommodation. In order to apply Moran's global statistic I, the code value of a particular type of accommodation facility from OpenStreetMaps was used. It was also confirmed that the z-score value means there is a less than 1% likelihood that this clustered pattern accommodation in chosen countries could result from random chance.

Methods

The Kernel Density Estimation (KDE) and Empirical Bayesian Kriging (EBK) were used to visualise spatial heterogeneity of accommodation in Slovenia, Croatia, Bosnia, and Herzegovina.

KDE aims to generate a smooth density surface of point events over space by computing the event intensity as density estimation and further discovering the spatial heterogeneity or inconsistency of the geographical process (Yu and Ai, 2014). Using the kernel density method, an arbitrary spatial unit of analysis can be defined that is homogeneous for the entire area, making comparison and classification possible. KDE involves placing a symmetrical surface over each point, evaluating the distance from the point to a reference location based on a mathematical function, and then summing the

value for all surface points for that reference location (Jia et al., 2018). The density estimate (KDE) can be calculated using the formula at an (x, y) location to predict the density (ArcGis, 2021):

$$Density = \frac{1}{(radius)^2}\sum_{i=1}^{n}\left[\frac{3}{\pi}\cdot pop_i\left(1-\left(\frac{dist_i}{radius}\right)^2\right)^2\right] \quad (1)$$

$$\text{For } dist_i < radius$$

where:

- i = 1,…,n are the input points. Only include points in the sum if they are within the radius distance of the (x,y) location
- pop_i is the population field value of point i, which is an optional parameter
- $dist_i$ is the distance between point i and the location (x, y)

Empirical Bayesian Kriging, is one of the kriging techniques which assumes that at least some of the spatial variability observed in natural, social or economic phenomena can be modelled by random processes with spatial autocorrelation, and requires explicit modelling of spatial autocorrelation. The basic assumptions of kriging: spatial continuity, spatial autocorrelation, stationarity, normal distribution, no global trends, spatial clustering.

Kriging uses a semivariogram, a function of the distance and direction that separate two locations, to quantify the spatial dependence in the data. A semivariogram is constructed by calculating half the average squared difference of the values of all pairs of measurements at locations separated by a given distance h. The semi-variogram is plotted on the y axis against the separation distance h (Krivoruchko, 2012). EBK differs from classical kriging methods by accounting for the error introduced by estimating the semivariogram model. This is done by estimating and then using many semivariogram models rather than a single semivariogram. This process entails the following steps (Krivoruchko, 2012):

- A semivariogram model is estimated from the data.
- Using this semivariogram, a new value is simulated at each input data location.
- A new semivariogram model is estimated from the simulated data.

The weight for this semivariogram is then calculated using the Bayes rule, which shows how likely the observed data can be generated from the semivariogram. For a given distance h, empirical Bayesian kriging supports the following semivariograms:

- Power $\gamma(h) = \text{Nugget} + b|h|^{\alpha}$ (2)
- Linear $\gamma(h) = \text{Nugget} + b|h|$ (3)
- Thin Plate Spline $\gamma(h) = \text{Nugget} + b|h^2|*ln(|h|)$ (4)

Empirical Bayesian Kriging (EBK) models do not require specification of the prior distributions for the model parameters; allow moderate local and large global data non-stationarity; locally transform data to Gaussian distribution, if needed; allow for varying measurement error; use covariates, and work reasonably fast and produce reliable outputs with default parameters (Krivoruchko & Gribov, 2019). Empirical Bayesian Kriging is a conglomerate of two geostatistical models: the intrinsic

random function kriging and the linear mixed model (Gupta et al., 2017; Oliver & Webster, 1990).

Results and Discussion

Figure 4 shows collected POIs from OpenStreetMap to visualise the spatial heterogeneity of their distribution across countries. At this stage, individual types of accommodation facilities have not yet been analysed. Figure 4 shows the most homogeneously distributed accommodation facilities in Slovenia. Of course, some clusters are visible; however, the number of areas where none of the selected 4 types of accommodation is identified is low. On the other hand, Croatia is characterised by a linear distribution of accommodation facilities accumulated along the coastline. It is clear that the further away from the sea, the density of accommodation facilities decreases significantly. We have a much lower density of analyzed POIs than Slovenia in the rest of the country. Bosnia and Herzegovina is characterised by a small number of accommodation facilities concentrated in a few essential locations.

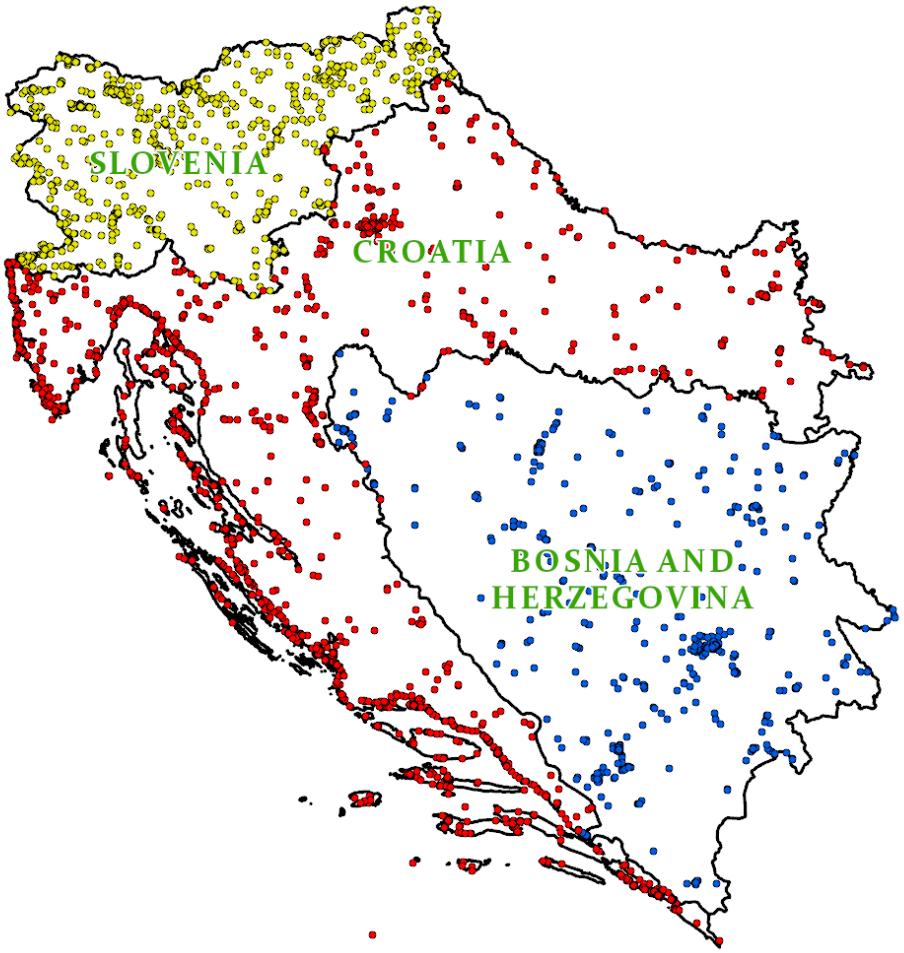


Fig. 4. Spatial heterogeneity of all POIs (all types of accommodation)
Source: Own study

This study assumes that the spatial distribution of POIs, which identify different types of accommodation, informs us about the potential tourist popularity of different areas in a country. In this sense, Croatia and Bosnia and Herzegovina have highly concentrated tourist attraction sites, with a significant part of their area providing practically little in the way of accommodation services. As a result, it is possible to focus on such underinvested accommodation facilities to determine whether the reasons are anthropogenic or environmental (terrain) in nature. This article does not address this issue. Slovenia, having the most even spatial distribution of POIs, shows that its tourism potential is not only based on leisure tourism associated with proximity to the sea.

Further modelling of tourist accommodation facilities was using ArcGIS Pro. In this next stage of the study, the kernel density analysis method (KDE) was applied to all points. This stage aims to explain in more detail the spatial confinement of accommodation facilities (without categorising them). Figure 5 shows the kernel density estimation for all analysed accommodation facilities in Slovenia, Croatia and Bosnia and Herzegovina.

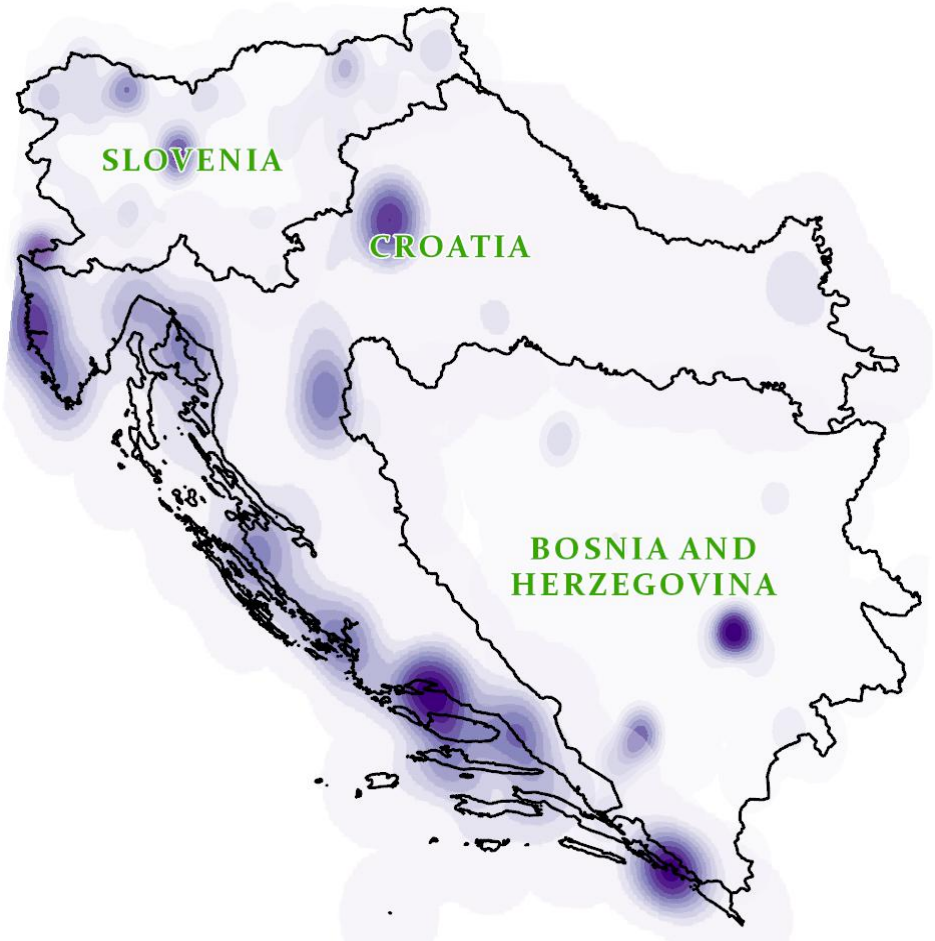


Fig. 5. Estimation of kernel density for all analysed accommodation facilities in Slovenia, Croatia and Bosnia and Herzegovina
Source: Own Study

In Croatia, areas of density of tourist accommodation are visible from the west of the coast, from the town of Poreč, through Rovinj to the southern edge of the Istrian peninsula and the town of Pula. A medium-density tourist accommodation can be seen around Rijeka, Zadar, and Sibenik. In Croatia, the highest density of tourist accommodation is in two places. The first of these can be found around Split (the heart of Dalmatia) and on the surrounding islands of Brač, Korčula and Hvar. The second is the Dubrovnik area. In Bosnia and Herzegovina, only two clusters of tourist accommodation density are visible: the capital Sarajevo and the capital of the Herzegovinian-Nereto canton, the city of Mostar. There are several areas of density in Slovenia, e.g. the area around Maribor, Radovijica, Tolmin, Postojna or the capital Ljubljana. The largest concentration of accommodation facilities is located in the coastal area of Slovenia, which is quite obvious.

So far the analysis has been based on all types of accommodation facilities. Further research considers differences in the spatial distribution of different accommodation facilities. Four types were selected: hotel, hostel, guesthouse and camp site (Data description chapter). The research was carried out using Empirical Bayesian Kriging modelling. The model used required the adoption of different weights for different accommodation establishments. To minimise subjective selection of weights, weights were set based on the percentage abundance of all types of accommodation establishments in all countries. The results of the analysis are presented in Table 2.

Table 4. Determination of weights for various touristic accommodation types

	Total numbers	Percentage	Weights
Hotel	2028	43%	43
Guesthouse	1641	35%	35
Hostel	501	11%	11
Camp site	504	11%	11

Source: Own study

The procedure of Empirical Bayesian Kriging was carried out for Slovenia (Fig. 6), Croatia (Fig. 7) and Bosnia and Herzegovina (Fig. 8).

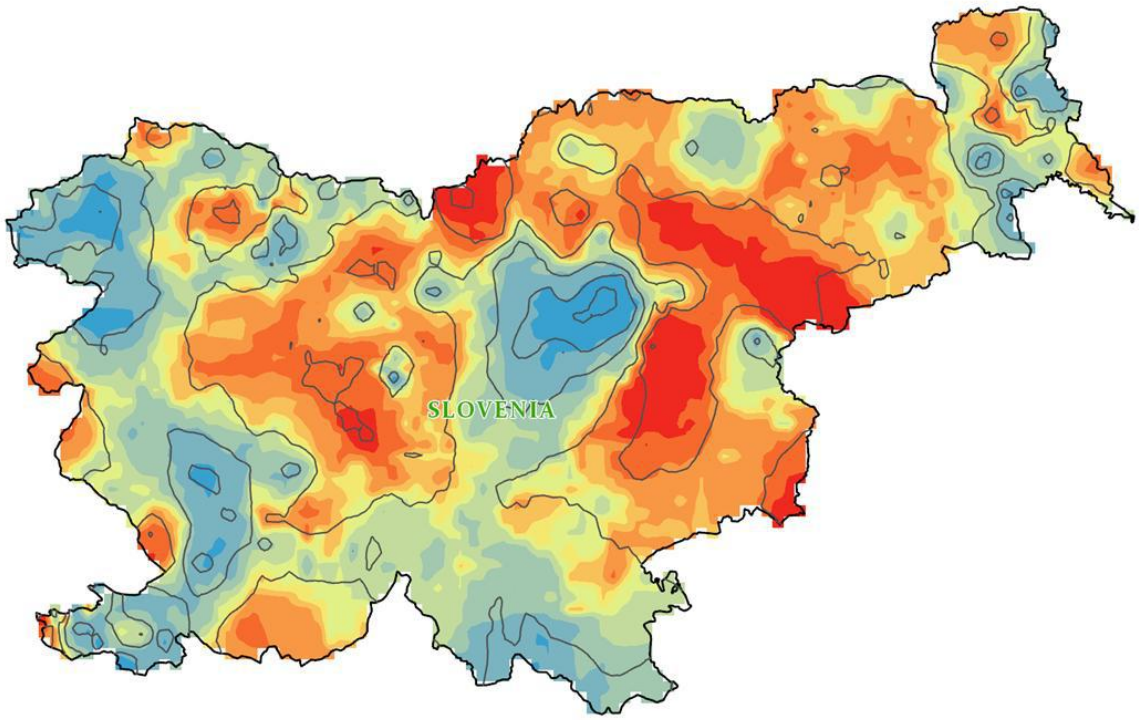


Fig. 6. Empirical Bayesian Kriging of accommodation in Slovenia
Source: Own Study

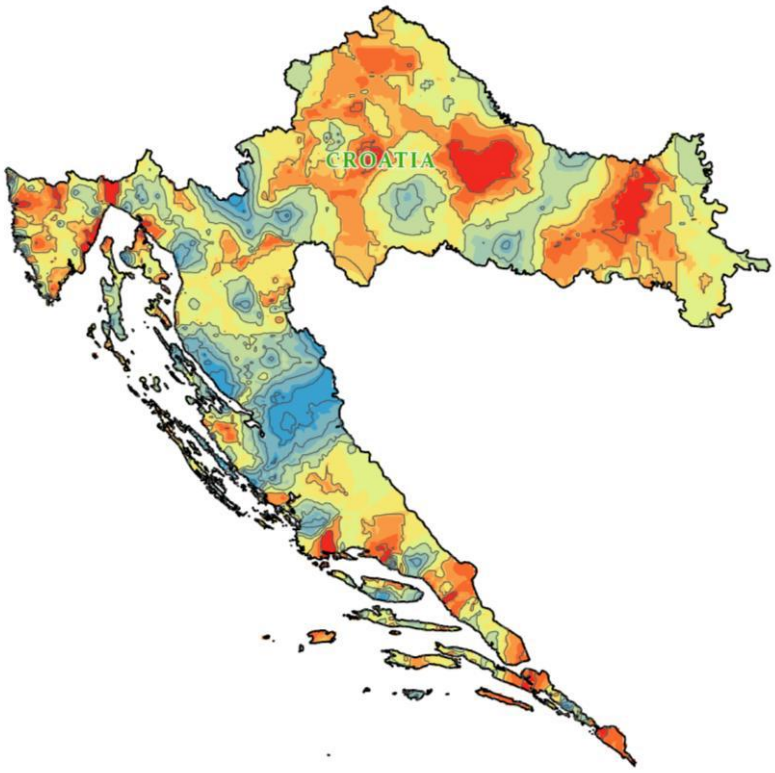


Fig. 7. Empirical Bayesian Kriging of accommodation in Croatia
Source: Own Study

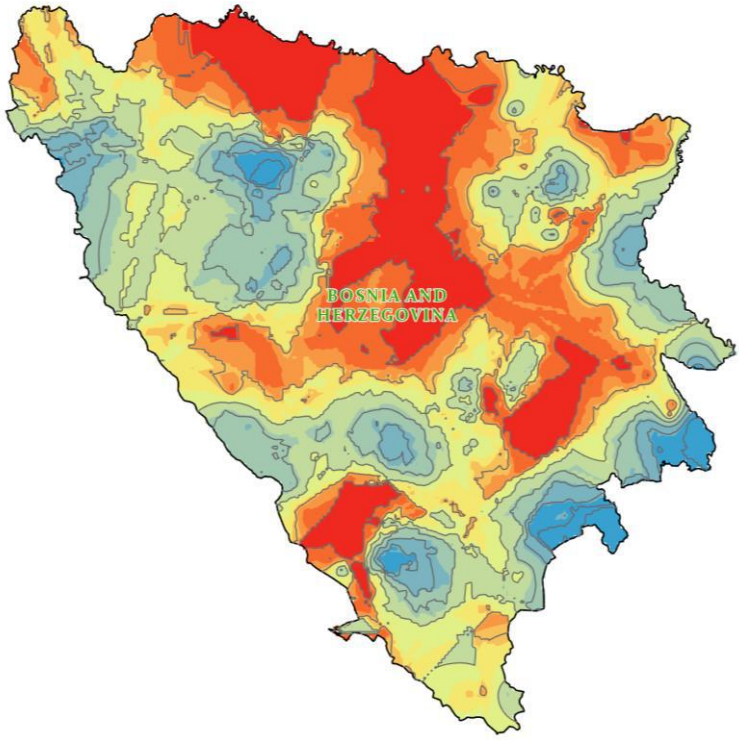


Fig. 8. Empirical Bayesian Kriging of accommodation in Bosnia and Herzegovina
Source: Own Study

Graphical interpretation of the obtained results in Fig. 6, Fig. 7 and Fig. 8 results from the adopted weighting system (Table 4). In each of the analysed countries, red and orange colours symbolise hotels and guesthouses respectively, while light green and blue indicate areas of the dominance of hostels and campsites. Modelling using different accommodation facilities and Empirical Bayesian Kriging is a more accurate method than Kernel Density Estimation. The use of POI as a fast and accessible source of data on accommodation facilities allows a simplified spatial analysis of the heterogeneity of accommodation facilities in a fast and cost-effective way. A detailed analysis taking into account the type of tourist attractions (cultural, natural, or business) is not the purpose of this study.

Conclusions

Tourism is an important bridge between economics and the environment in socio-economic geography. In general, tourism is associated with the possibility of contact with nature and the culture and history of a given society. It seems that an increase in the intensity of accommodation in particular areas of the studied region or country is closely correlated with the tourist attractiveness of that place. If the research is conducted by someone familiar with the region's specifics, the spatial distribution of accommodation facilities and the differences in this distribution are obvious. On the other hand, if the research is conducted in an environment that has not been autopsied, there are limited possibilities for accurate and quick analysis. The proposed

combination of points of interest (POI point) with basic GIS analysis models (Kernel Density Estimation and Empirical Bayesian Kriging) provides a fast and cheap procedure. The presented research represents the initial phase of the analysis of tourist accommodation services in Slovenia, Croatia, and Bosnia and Herzegovina. The analysis constructed in this way may be the beginning of more detailed studies taking into account the historical, political, cultural, and environmental specificities of the selected countries.

References

ArcGis (2021) How Kernel Density works – ArcGIS Pro | Documentation. Available at: https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/how-kernel-density-works.htm.

Bełej M. (2021). Analysis of spatial distribution of touristic accommodation in Poland with the kernel density estimation of POIs. Acta Scientiarum Polonorum. Administratio Locorum, 20(3), pp. 159–171. DOI: 10.31648/aspal.6818.

Cai L., Wen W., Wu B., Yang X. (2021). A coarse-to-fine user preferences prediction method for point-of-interest recommendation. Neurocomputing, 422, pp. 1–11. DOI: 10.1016/j.neucom.2020.09.034.

Carrascal Incera A., Fernández M.F. (2015). Tourism and income distribution: Evidence from a developed regional economy. Tourism Management, 48, pp. 11–20. DOI: 10.1016/j.tourman.2014.10.016.

Geofabrik (2022). Available at: http://download.geofabrik.de/ [access: 4.06.2022].

Gupta A., Kamble T. and Machiwal D. (2017). Comparison of ordinary and Bayesian kriging techniques in depicting rainfall variability in arid and semi-arid regions of north-west India. Environmental Earth Sciences, 76(15). Springer, pp. 1–16.

Hall C.M., Page S.J. (2009). Progress in Tourism Management: From the geography of tourism to geographies of tourism – A review. Tourism Management 30(1), pp. 3–16. DOI: 10.1016/j.tourman.2008.05.014.

Han Z., Song W. (2020). Identification and Geographic Distribution of Accommodation and Catering Centers. ISPRS International Journal of Geo-Information, 9(9): 546. DOI: 10.3390/ijgi9090546.

Jia R., Khadka A., Kim I. (2018). Traffic crash analysis with point-of-interest spatial clustering. Accident Analysis & Prevention, vol. 121, pp. 223–230. DOI: 10.1016/j.aap.2018.09.018.

Krivoruchko K. (2012). Empirical Bayesian Kriging Implemented in ArcGIS Geostatistical Analyst. Available at: https://www.esri.com/news/arcuser/1012/files/ebk.pdf [access: 4.06.2022].

Krivoruchko K. Gribov A. (2019). Evaluation of empirical Bayesian kriging. Spatial Statistics, 32. Elsevier: 100368. DOI: 10.1016/J.SPASTA.2019.100368.

Lee Y-JA., Jang S. and Kim J. (2020). Tourism clusters and peer-to-peer accommodation. Annals of Tourism Research, 83: 102960. DOI: 10.1016/j.annals.2020.102960.

Lengyel A. (2016). Tourism, meditation, sustainability. ABSTRACT: Applied Studies in Agribusiness and Commerce, 10(1033-2016–84303): 81–92.

Liu T., Liao J., Wu Z., Wang Y., Wang J. (2020). Exploiting geographical-temporal awareness attention for next point-of-interest recommendation. Neurocomputing 400: 227–237. DOI: 10.1016/j.neucom.2019.12.122.

Lu Ch., Pang M., Zhang Y., Li H., Lu Ch., Tang X., Cheng W. (2020). Mapping Urban Spatial Structure Based on POI (Point of Interest) Data: A Case Study of the Central City of Lanzhou, China. ISPRS International Journal of Geo-Information, 9(2): 92. DOI: 10.3390/ijgi9020092.

Milias V., Psyllidis A. (2021). Assessing the influence of point-of-interest features on the classification of place categories. Computers, Environment and Urban Systems, 86: 101597. DOI: 10.1016/j.compenvurbsys.2021.101597.

Navrátil J., Švec R., Pícha K. (2012). The Location of Tourist Accommodation Facilities: A Case Studyof the Sumava Mts. and South Bohemia Tourist Regions (Czech Republic). *Moravian Geographical Reports* 3(20): 50–63. Available at: https://www.researchgate.net/profile/Josef-Navratil/publication/283509021_The_Location_of_Tourist_Accommodation_Facilities_A_Case_Study_of_the_Sumava_Mts_and_South_Bohemia_Tourist_Regions_Czech_Republic/links/563c6e7208ae405111a909b4/The-Location-of-Touri.

Oliver M.A., Webster R. (1990). Kriging: a method of interpolation for geographical information systems. International Journal of Geographical Information System, 4(3). Taylor & Francis: pp. 313–332.

Rodríguez Rangel M.C., Sánchez Rivero M., Ramajo Hernández J. (2020). A Spatial Analysis of Intensity in Tourism Accommodation: An Application for Extremadura (Spain). Economies 8(2): 28. DOI: 10.3390/economies8020028.

Silviu-Florin S. (2014) What is Tourism Geography? Geography Realm. Available at: https://www.geographyrealm.com/tourism-geography/.

Suárez-Vega R., Hernández J.M. (2020). Selecting Prices Determinants and Including Spatial Effects in Peer-to-Peer Accommodation. ISPRS International Journal of Geo-Information, 9(4): 259. DOI: 10.3390/ijgi9040259.

Vestal B.E., Carlson N.E., Ghosh D. (2021). Filtering spatial point patterns using kernel densities. Spatial Statistics, 41: 100487. DOI: 10.1016/j.spasta.2020.100487.

Williams A.M., Shaw G. (2015). Tourism, Geography of. In: J.D. Wright (ed.) International Encyclopedia of the Social & Behavioral Sciences (Second Edition). Oxford: Elsevier, pp. 469–473. Available at: https://www.sciencedirect.com/science/article/pii/B9780080970868720824.

Wu R., Wang J., Zhang D., Wang S. (2021). Identifying different types of urban land use dynamics using Point-of-interest (POI) and Random Forest algorithm: The case of Huizhou, China. Cities, 114: 103202. DOI: 10.1016/j.cities.2021.103202.

Yu W., Ai T. (2014). The visualization and analysis of urban facility pois using network kernel density estimation constrained by multi-factors. Boletim de Ciências Geodésicas, 20(4). Available at: https://revistas.ufpr.br/bcg/article/view/38958.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.129

Katarzyna Roszewska[1]

SOURCES OF GEOGRAPHIC INFORMATION SYSTEMS IN LAW VS. ACCESSIBILITY FOR PERSONS WITH DISABILITIES IN THE EU AND IN POLAND

Abstract: The meaning of space for persons with disabilities is a research area in geography, urban planning, spatial planning and architecture, also in sociology and public policy. Accessibility has become a focus of interdisciplinary research. The development of accessibility standards and new technologies also presents challenges for legal science.

GIS provides data for planning and implementation decisions by policy makers, and then evaluate the implementation. It also serves to enhance the effectiveness of the rights of persons with disabilities. Inadequate spatial planning means that the rights of persons with disabilities are not exercised despite being declared in the law.

The use of GIS is growing ever more widespread, and their strengthened role in disability studies allows to enhance the autonomy of persons with disabilities and foster their integration into society. One of the key issue for the development of GIS in this area undoubtedly comes from the regulations that guarantee access to the physical environment, transport, other facilities, information and communication and public services.

While the sources of legal regulation of accessibility standards and how to ensure accessibility in the traditional sense are known, the basics of GIS for people with disabilities are still insufficiently analyzed.

However, it is also worth looking at the legal basis for the functioning of GIS itself. This article aims to examine the sources of law for the functioning of GIS and its application for people with disabilities in EU and Polish law.

Keywords: GIS, new technologies, persons with disabilities, accessibility

Received: 9 June 2022; accepted: 25 August 2022

[1] Cardinal Stefan Wyszyński University in Warsaw, Faculty of Law and Administration, Warsaw, Poland, ORCID ID: 0000-0002-1452-2497, email: k.roszewska@uksw.edu.pl

Introduction

It is commonly believed that social and legal norms in a specific society shape the perception of and the reactions to disability. They can limit or – quite the opposite – develop and support the rights of persons with disabilities. Another key factor apart from social and legal conditions is space. Disability, similarly to unemployment and poverty, depends to a considerable degree on spatial conditions (Bird, 2019). Geographical structures can be the source of spatial traps in the life of persons with disabilities. They cover not only the lie of the land, but also its demography, infrastructure, social and economic resources, distance from centres of economic and social activity, and presence of public services. Structural injustice can be compensated by tools and technological solutions introduced thanks to geographic information systems (GIS).

GIS provide more than just information and data used to plan, implement, evaluate and change solutions with regard to space. They make it possible to analyse the placement of (natural and artificial, permanent and mobile) objects in space, but also specific natural phenomena, climate-related events, epidemiological and terrorist threats, historical and cultural elements, and finally economic and social phenomena (see subject literature mentioned in Bachad et al., 2012; Roszewska, 2018). The mutual effect of information technologies and space research serves human development. It even serves to redefine fundamental rights (Kocaman & Ozdemir, 2020). A greater role of GIS in studies on disability could increase their dissemination in practice, thus increasing the effectiveness of the realisation of the rights of persons with disabilities, their autonomy and their integration into society.

The progress of accessibility standards and new technologies likewise constitutes a challenge for the legal studies. The main focus of the present publication is to identify the sources of law that regulate the operation of GIS for the purpose of ensuring accessibility to persons with disabilities, as well as their place in the legal system. While the sources of legal regulations of accessibility standards and the ways of ensuring accessibility are identified, albeit not without difficulty, the foundations of GIS for persons with disabilities remain insufficiently analysed. It is worth examining the legal basis for the functioning of GIS in EU and Polish law and the extent to which they affect the legal framework for the functioning of GIS in order to apply it to the full realisation of the rights of persons with disabilities.

The concepts of GIS and accessibility

The starting point is the proper understanding of the concepts of GIS and accessibility. GIS has no legal definition, although it does incidentally appear in EU regulations (for recent instances, see: Article 65(3)(e) of Regulation (EU) 2021/2116). The concept of GIS is explicated chiefly in the doctrine. They are defined as systems for acquiring, collecting, processing, analysing, and sharing data containing spatial information as well as the accompanying descriptive information about objects distinguished in the section of geographic space covered by the system. In other words,

they are understood as systems for the flow and use of information using technological tools (Gaździcki, 1990; Bielecka, 2006 and the subject literature cited therein). The component parts of these systems – as it is sometimes added – are also their users and support staff (Kistowski & Iwańska 1997; Bielecka, 2006).

Accessibility, in turn, is a technical as well as normative category. In the first case, it serves to indicate and meet various measurable parameters and requirements that affect human functioning in the environment; it is a function of compliance with regulations or criteria that define a certain minimum level of solutions necessary to fully benefit people with disabilities (Salmen, 2001; Iwarsson & Ståhl, 2003). Accessibility describes the degree to which an environment, service, or product allows access by as many people as possible, in particular people with disabilities. And an accessibility standard is a level of quality accepted as the norm (WHO, 2011). Accessibility appeared as a universal normative category in the UN Convention on the Rights of Persons with Disabilities. The Convention does not provide a definition of accessibility. It does, however, list accessibility as one of the general principles underlying the Convention (Article 3(f)) and provides a description of the purpose of accessibility, its scope, the means of achieving it and its addressees (Article 9).

GIS are used to serve numerous functions and can be considered in different contexts even for the needs of people with disabilities. For example, it is possible to analyse the incidence of disability in space (Roszewska, 2018) and to use GIS tools to identify social needs as well as plan and coordinate public services (Roszewska, 2019). Accessibility in terms of spatial factors, on the other hand, is a matter not so much of the availability of a particular facility or service, but rather of its functional distribution in a given area. It is not only the distance that separates people from an object – a place where products are offered or services provided. What also matters are the waiting time, which depends on the accessibility of transport, the type and choice of offers in a given area, the quality in relation to services provided in another area, etc.

Legal regulations of accessibility

We undoubtedly consider the UN CRPD to be the primary source of regulation of accessibility for persons with disabilities. Although the prevailing view is that the CRPD does not create new rights, but only operationalises pre-existing human rights taking into account the new disability paradigm, in the case of accessibility one can be convinced that we are dealing with the emergence of a new right – the right to access (Roszewska, 2021).

The CRPD has been adopted by the EU, as well. A number of pieces of legislation in Union law that regulated the rights of persons with disabilities, including made some kind of reference to accessibility for persons with disabilities prior to the signing of the Convention, were included in the appendix to Annex II to the Council Decision of 26 November 2009 concerning the conclusion, by the European Community, of the United Nations Convention on the Rights of Persons with Disabilities (2010/48/EC). Since its entry into force, the UN Convention has been an integral part of EU law. While

the validity of the earlier equality directives in the light of the CRPD cannot be questioned, they should, as far as possible, be interpreted in line with the Convention (CJ judgments in Joined Cases C-335/11 and C-337/11 and Cases C-363/12 and C406/15).

The mutual relations between Union law and the Convention, however, are more complex than that (Pohjankoski, 2017). Even the UN Committee on Persons with Disabilities itself expressed concerns about the implementation of Article 9 of the CRPD (Committee on the Right of Persons with Disabilities, 2015); the concerns remain valid. A step towards the implementation of the accessibility principle under the Convention was supposed to be Directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services (OJ L 151, 07/06/2019, pp. 70–115) called the European Accessibility Act (EAA). Its objective is to approximate the laws of the Member States with regard to the accessibility requirements for certain products and services, in particular by eliminating and preventing barriers to the free movement of certain accessible products and services that result from divergent accessibility requirements in the Member States. The Directive refers to the understanding of accessibility in the CRPD and indicates that accessibility and universal design should be interpreted in accordance with General comment No. 2 (2014) – Article 9: Accessibility, drawn up by the Committee on the Rights of Persons with Disabilities (Recital 50). Unfortunately, the EAA does not fully implement Article 9 of the CRPD with regard to accessibility due to the very narrow material scope of the regulation.

The EEA was going to be transposed into national legislation by 28/06/2022 and enter into force on 28/06/2025, with a transitional period until 28/06/2030, and in some cases even later (Articles 31 and 32 of the EEA). In order to implement it in Poland, a draft law on the accessibility of certain products and services was prepared (draft No UC 119).

While the EAA was still in the making, the Act of 19 July 2019 on ensuring accessibility to persons with specific needs was adopted in Poland. It sets out measures to ensure accessibility to such persons and the obligations of public entities in this regard. The Polish act was not the first to refer to an 'accessibility law'. However, the drafters assumed that accessibility should be a horizontal principle underlying the implementation of all public policies. One of the instruments for implementing this principle was supposed to be the above-mentioned law of a systemic character, broadly defining measures to ensure various aspects of accessibility for persons with special needs and the obligations of public entities in this respect (Explanatory memorandum, pp. 2 and 4).

The law undoubtedly has a horizontal character and will contribute to the gradual improvement of accessibility of public institutions. However, the objective to render its scope systemic has not been achieved. Already Article 1(2) makes a reference in the area of digital accessibility to the Act of 4 April 2019 on digital accessibility of websites and mobile applications of public institutions. It covers three areas of accessibility only. The legislature has not brought order to the legislation in the area of accessibility law. The national provisions in this field are still dispersed. Only to a narrow extent does the law

apply to non-governmental actors. Specific obligations concerning accessibility result from many other provisions assigned to specific areas of accessibility (architectural accessibility, digital accessibility, communication accessibility, transport accessibility) or specific categories of rights, goods and services, such as education, work, health, transport, tourism, postal services, commercial services, cultural goods, and natural goods (Roszewska, 2021). The proposed law on the accessibility of certain products and services likewise has a narrow scope of impact, with the EU being largely responsible for that fact. After all, the law implements directive (EU) 2019/882 of the European Parliament and of the Council of 17 April 2019 on the accessibility requirements for products and services (European Accessibility Act).

Legal regulations of GIS

GIS are faced with a similar dispersion of legal sources. There is not even a legal act that would attempt to cover horizontally all the functions performed by GIS. In the EU, the leading source of law for GIS is Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). However, its objective was to set the legal, conceptual and organisational framework for the construction of spatial infrastructure in the Member States (Bielecka, 2011). The standardisation of spatial data infrastructure was supposed to facilitate the collection, retrieval, use and sharing of data.

Considering its main objectives (building an infrastructure for spatial information), the INSPIRE directive refers primarily to the information function of GIS. However, the creation of spatial information infrastructure, in addition to providing faster access to spatial data, was also intended to help more effectively execute tasks in the fields of, among others, spatial and economic planning, implementation of construction projects, crisis management, and many others. This can be achieved thanks to the possibilities offered by GIS in the compilation and analysis of multiple data using an automated process of their visualisation and spatial data analysis (Felchner & Jankowska, 2013).

The specific spatial data themes covered by the directive have been assigned various priorities, taking into account priority Community policies and progress already made in the Member States (Recital 14). The directive placed a strong emphasis on environmental policies and policies that affect the environment, such as transport, agriculture, energy, spatial planning, regional development, etc. (Recital 5, Article 1). In addition, it set out several specific objectives, including establishing a legal framework for the use of spatial data in the EU, creating coordination structures in the Member States and the EU, and identifying the spatial data needed. At a later stage, online services were going to be established.

Gathering in one act the issues covering the spatial information infrastructure and the obligation to implement these solutions into Polish law was a step towards coherence of resources and facilitation of their search and sharing, as well as effective use of data provided by public institutions. On the basis of the INSPIRE directive, a wide range of spatial data concerning the environment, geography, society and economy is

collected. A legal framework for sharing spatial data and services has been created. However, the INSPIRE directive and the Polish law did not specifically address all potential functions of GIS and their application for public policies. This was not the purpose of these regulations. The directive did, however, require Member States to characterise the current and planned functional dimension and land use, e.g. residential, industrial, commercial, agricultural, forestry, or recreational (Annex III). These include, for example, the geographical distribution of dominance of specific pathologies and information indicating the effect on health (biomarkers, decline of fertility, epidemics) or well-being of humans (fatigue, stress, etc.) linked directly (air pollution, chemicals, depletion of the ozone layer, noise, etc.) or indirectly (food, genetically modified organisms, etc.) to the quality of the environment. It is further required to label utility facilities, administrative and social governmental services, and public services (including civil protection sites, schools and hospitals). The administrative and social governmental services referred to in Annex III to the INSPIRE directive include specialist services for the benefit of persons with disabilities (INSPIRE Thematic Working Group Utility and Government Services, 2013). Thus, although the directive does not treat accessibility as a key issue, the requirement to take into account the functional dimension should contribute to its implementation. Accessibility as a set of standards and a legal obligation is not sufficiently taken into account in functional spatial planning. It is to be expected that this process should progress more smoothly.

Access to spatial information at the European level is regulated by other provisions, as well. They concern access to information, re-use of public sector information, protection of information, and personal data processing. In national law, there are additional legal regulations that underpin the creation and operation of databases for the use of a specific sector of public administration, as in the case of education or health (see the list in Felchner & Jankowska, 2013). People with disabilities benefit from such infrastructure common to all citizens. Still, further work on the model of spatial infrastructure regulation is needed (Szpor, 2011). The changes that have taken place since the adoption of the INSPIRE directive take too little account of its usability for people with disabilities.

Juridisation of GIS vs. accessibility

The right to information is only a part of the area that should be subject to juridisation in the context of GIS. Space monitoring was supposed not only to serve informational purposes, but also to be an instrument of rational management. In addition to maintaining a continuously updated information database, GIS was meant to enable analysis of the current spatial status and forecasting of spatial development processes. In the first years, significant diversity of the developing local information systems was observed (various systems were created without any clear legal basis), along with small resources of data important for the decision-makers in various areas of administration and poor use of the data that had already been collected (Szpor, 1998). The initial work of the government was oriented mainly towards the needs of geodesy, especially to replace paper maps. In turn, the development of legal regulations and the

interest of science focused strongly on the right to and the protection of information, including secrecies subject to legal protection (Szpor, 1998). Yet a common model for the juridisation of information issues was called for already at the end of the 1990s. Even some dangers related to the legislative empowerment of information systems were pointed out. However their establishment was undoubtedly in the public interest. Already at the end of the 1990s, it was proposed to establish a central spatial information system (or metainformation, as it was even then defined) and to base it on statutory provisions harmonising inter-ministry information networks (Szpor, 1998).

The link between spatial information and spatial planning law has its historical roots. It was for the purposes of spatial planning that the regulation of the spatial information system was called for. The Act on spatial information infrastructure has become the basis for regulating the emerging right to geoinformation in Poland, which, as a part of the widely understood right to information, has been recognised as a separate legal category and is subject to a separate legal regulation. The right to geoinformation has been defined as a new subjective right of the individual, embedded in the doctrine of the information society, which imposes on us new standards of behaviour and creates new expectations and opportunities (Dobrowolski, 2006). Yet the legislation was heavily influenced by the areas of regulation at the EU level. These required namely implementation in national law, thus setting the priorities of legal regulations. There was a logical reason behind that. Functional planning and use of space required an interoperable spatial information infrastructure.

The functioning of GIS is not standardised in a comprehensive way. It is even less standardised for the purpose of ensuring accessibility to persons with disabilities. Determining the legal basis for the functioning of GIS vs. accessibility is further complicated by the fact that it is not clearly assigned to a specific field of science as a research area or to a specific branch of law as an area of legal regulation. Spatial information is regulated in land use planning law. Many aspects related to access to information using GIS are governed by other legal acts. In particular, industry-specific information systems relating to data in space are standardised in the provisions concerning the relevant law branch. GIS is a subject of information law research, too. It continues to be a young field of law in Poland, yet the extent of standardisation has already been outlined. Ever more often, it is a separate subject of teaching. The situation is different in terms of the rights of persons with disabilities. This field is usually studied as part of human rights and social law. However, research on accessibility for people with disabilities is scarce. Accessibility law as a certain complex of legal regulations is only just entering a period of intensive progress. It has not yet been widely recognised or accepted (Greco, 216; Broderick, 2020; Roszewska, 2021). Accessibility law regulations are not in the mainstream of legal considerations, despite the fact that they concern a wider group of people than just persons with disabilities. They affect, to varying degrees, also elderly people, people with temporary impairments caused by injury or illness, parents with young children, and pregnant women.

Conclusions

The relationship between GIS and accessibility is undisputed. Juridisation of GIS in the area of accessibility seems to be necessary for the purpose of comprehensive standardisation of various tasks related to spatial governance. Regulations should strengthen the effectiveness of the application of new technologies in social and economic relations (Szpor, 2017). The lack of a legal basis for the full implementation of the social functions of GIS precludes their harmonious development. There is still little recognition in subject literature of the wide application of GIS and the need for its fuller regulation. There is not even a discussion in which field the functions of GIS for accessibility law could be regulated – whether they should be developed within information law, or more narrowly within spatial information law, or exclusively within accessibility law.

Regulatory fragmentation, gaps, lack of coherence and stability, and even chaos in the definitions are typical for newly emerging areas of law. In this case, we are dealing with an exceptionally complicated situation, entailing the constantly developing law of information technology, intersectional applications of GIS, and access law, which is only slowly being identified. In this situation, it is easier to notice the shortcomings and dangers of the current legal status quo than to present a coherent vision of juridisation of the mutual relations between GIS and accessibility.

The subject of regulation is certainly one of those in which the law follows social changes caused by technical development. Moreover, the area is highly internationalised. Technical civilisation and the nature of new technologies force the internationalisation of law and the search for new forms of protection of civil liberties and rights (Szpor, 2017; Chauvin et al., 2021). Undoubtedly, fundamental human rights can be redefined with the progress of science and technology (Kocaman & Ozdemir, 2020). In this context, it is a positive phenomenon that also accessibility for persons with disabilities is perceived as one of the binding international human rights standards.

The UN Convention on the Rights of Persons with Disabilities requires the legal standardisation of accessibility at the national level. In the view of the Committee on the Rights of Persons with Disabilities, states parties to the CRPD are obliged to adopt and monitor national accessibility standards. And the first step is to adopt an appropriate legal framework. To this end, states should undertake a comprehensive review of accessibility legislation in order to identify, monitor and address gaps in legislation and its implementation (General comment No. 2).

It is not optimal to build an entirely new legal environment for the functionality of spatial information systems for the purpose of implementing the right of access. It seems more desirable to include general legal solutions for information technology in the area of information technology law. The scope of legal regulations that standardise and guarantee the use of GIS for accessibility purposes needs to be agreed. The starting point should certainly be terminological consistency, an agreed list of principles, and a legal framework that takes into account the constant and rapid technological development,

providing for minimum standard solutions where full legislative regulation is impossible or impractical due to the pace of change and the level of specialised solutions in practice.

References

Bachad E.W., Majid Z., Setan H., Chong A.K., Sulaiman N.S. (2012). GIS application and geodatabase for archaeological site documentation system: Bujang, Valley, Malaysia. In: A.A. Rahman, P. Bogusławski, C. Gold, M.N. Said, Developments in Multidimetional Spatial Data Models, Universiti Technologi Malaysia, pp. 173–189.

Bielecka E. (2006). Systemy informacji geograficznej. Teoria i zastosowania (*Geographic information systems. Theory and applications*). Warszawa, pp. 1–2.

Bielecka E. (2011). Implementacja dyrektywy INSPIRE w Polsce. Ustawa o infrastrukturze informacji przestrzennej (*Implementation of the INSPIRE directive in Poland. Act on spatial information infrastructure*). In: INSPIRE i Krajowa Infrastruktura Informacji Przestrzennej. Podstawy teoretyczne i aspekty praktyczne (*INSPIRE and the Polish Spatial Information Infrastructure. Theoretical foundations and practical aspects*). Warszawa, p. 87.

Bielecka E., Maj K. (2009). Systemy informacji przestrzennej. Podstawy teoretyczne (*Geographic information systems. A theoretical background*). Warszawa, p. 13.

Bird K. (2019). Addressing Spatial Poverty Traps, Chronic Poverty Advisory Network, London, p. 2.

Broderick A. (2020). Of rights and obligations: the birth of accessibility. The International Journal of Human Rights, vol. 24, no. 4, pp. 398–407.

Chauvin T., Stawecki T., Winczorek P. (2021). Wstęp do prawoznawstwa (*Introduction into legal theory*). Warszawa, C.H. Beck, p. 155.

Committee on the Right of Persons with Disabilities (2015) Concluding observations on the initial report of the European Union, 2 October 2015, CRPD/C/EU/CO/1, para 18–19, 28.

Council Decision of 26 November 2009 concerning the conclusion, by the European Community, of the United Nations Convention on the Rights of Persons with Disabilities (2010/48/EC), OJ L 23, 27.1.2010, p. 35–61.

Directive 2007/2/EC of The European Parliament and of The Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). OJ L 108, 25.4.2007, p. 1–14.

Dobrowolski Z. (2006). Społeczeństwo informacyjne i społeczeństwo wiedzy w świetle krytycznej teorii modernizacji Urlicha Becka (*Information society and knowledge society in light of Urlich Beck's critical theory of modernzation*). In: B. Sosińska-Kaleta, E. Chuchro, W. Daszewski (ed.), Informacja w sieci. Problemy, metody, technologie (*Information on the Web. Problems, methods, technologies*). Warszawa, p. 26.

Felchner K., Jankowska M. (2013). Ustawa o infrastrukturze informacji przestrzennej. Komentarz (*Act on spatial information infrastructure*). LEX/el., commentary to Article 1. [access: 10.05.2022].

Gaździcki J. (1990). Systemy informacji przestrzennej (Geographic information systems) Warszawa-Wrocław, p. 9.

General comment No. 2 (2014). Article 9: Accessibility, Committee on the Rights of Persons with Disabilities CRPD/C/GC/2, para 28.

Greco G.M. (2016). On Accessibility as a Human Right, with an Application to Media Accessibility. In: A. Matamala, P. Orero, Researching Audio Description. New Approaches, series: Palgrave Studies in Translating and Interpreting, Barcelona, p. 21.

INSPIRE Thematic Working Group Utility and Government Services (2013) D2.8.III.6 Data Specification on Utility and Government Services – Technical Guidelines, European Commision Joint Research Centre, p. 15, https://inspire.ec.europa.eu/id/document/tg/us [access: 20.05.2022].

Iwarsson S., Ståhl A. (2003). Accessibility, usability and universal design – positioning and definition of concepts describing person-environment relationships. Disability and Rehabilitation, vol. 25, no. 2, pp. 57–66.

Janowski J. (2011). Informatyka prawa. Zadania i znaczenie w związku z kształtowaniem się elektronicznego obrotu prawnego (*Legal informatics. Objectives and significance in connection with the emergence of electronic legal legal transactions*). Lublin, pp. 240–258.

Judgment of the Court (Grand Chamber) 18 March 2014, C-363/12, EU:C:2014:159.

Judgment of the Court (Second Chamber) 11 April 2013 – HK Danmark, acting on behalf of Jette Ring v. Dansk almennyttigt Boligselskab (C-335/11) and HK Danmark, acting on behalf of Lone Skouboe Werge v. Dansk Arbejdsgiverforening, acting on behalf of Pro Display A/S, in liquidation (C-337/11), ECLI:EU:C:2013:222.

Judgment of the Court (Second Chamber) 9 March 2017, C-406/15, ECLI:EU:C:2017:198.

Kistowski M., Iwańska M. (1997). Systemy informacji geograficznej. Podstawy techniczne i metodyczne. Przegląd pakietów oprogramowania i zastosowań w badaniach środowiska przyrodniczego (*Geographic information systems. Technical and methodological foundations. A review of software packages and applications in natural environment studies*). Poznań, p. 9.

Kocaman S., Ozdemir N. (2020). Improvement of Disability Rights via Geographic Information Science. Sustainability, no. 12, p. 1, 3, 12.

Pohjankoski P. (2017). UN Disability Convention through the prism of EU law: boosting human rights but blurring responsibilities? Anti Discrimination Law Review, no. 2, pp. 28–43.

Projekt z 24 marca 2022 ustawy o dostępności niektórych produktów i usług (*Draft of 24 March 2022 of an act on the accessibility of certain products and services*), no UC 119, https://legislacja.gov.pl/docs//2/12358257/12865990/12865991/dokument549122.pdf [access: 22.05.2022].

Regulation (EU) 2021/2116 of the European Parliament and of the Council of 2 December 2021 on the financing, management and monitoring of the common agricultural policy and repealing Regulation (EU) No 1306/2013, OJ L 435, 6.12.2021, pp. 187–261.

Roszewska K. (2018). Application of GIS in the area of Social Security. 25th Anniversary Conference Geographic Information Systems Conference and Exhibition GIS Odyssey 2018, Conference proceedings, 10th to 14th of September 2018, Perugia, Italy, pp. 420–426.

Roszewska K. (2019). The concept of an active social services platform, conference proceeding 26th Geographic Information Systems Conference and Exhibition GIS Odyssey 2019, pp. 249–255.

Roszewska K. (2021). Accessibility – One of the Human Rights or the Means of Their Implementation. Prawo i Więź, no. 3, vol. 37, pp. 158–176.

Salmen J.P.S. (2001). U.S. Accessibility Codes and Standards: Challenges for Universal Design. In: W.F.E. Preiser, K.H. Smith, Universal Design. Handbook, para 6.2, ebook.

Szpor G. (1998). Prawnoustrojowe uwarunkowania rozwoju systemów informacji przestrzennej (*Legal and organisational conditions of spatial information systems development*). In: Przetwarzanie i ochrona danych (*Data processing and protection*), Katowice, pp. 174, 178–182.

Szpor G. (2017). Jawność i jej ograniczenia. Idee i pojęcia (*Transparency and its limitations. Ideas and concepts*), vol. 1. Beck, wyd. elektr. Legalis, ch. 1, § 2.IV and § 4.IV.C; ch. 2, § 5.V [access: 14.05.2022].

Szpor G. (ed.) (2011). Restrukturyzacja regulacji infrastruktury informacyjnej (*Restructuring of information infrastructure regulation*). In: Internet. Ochrona wolności, własności i bezpieczeństwa (*The Internet. Protection of freedom, property and security*). Warszawa, p. 223.

Szpor G. (2012). Information in the land use planning process as an element of administrative legislation. In: D. Kereković, R. Źróbek, (ed.). GIS for Geoscientists. Croatian Information Technology Association – GIS Forum, University of Silesia, Zagreb, pp. 231–236.

URL:https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2019/03/Spatial-poverty-traps-policy-responses-2019.pdf [access: 22.05.2022].

World Report on Disability (2011). WHO, WB, Geneva, p. 170, 301, https://www.who.int/teams/noncommunicable-diseases/disability-and-rehabilitation/world-report-on-disability [access: 20.05.2022].

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.141

Grażyna Szpor[1], Agnieszka Gryszczyńska[2]

HACKING IN THE (CYBER)SPACE

Abstract: The article analyzes the concept of hacking, taking into account its evolution from a neutral term that means going beyond specific schemes of action to a negative context in which the concept is often equated with a cyber-security breach or cyber-crime. A study of the understanding of the concept of space and cyberspace, as well as selected cyber threats, shows the impact of the development of modern technologies on the blurring of the boundaries between real and virtual space. Based on selected cases in the field of cybercrime, the specific features of actions in cyberspace and their effects in the real world are indicated. New methods of cybercriminals open up new areas of criminological research on the geography of crime. The paper points out the involvement of State-Actors in cyber attacks, which makes it challenging to eliminate safe harbors for cyber criminals and reduces the effectiveness of instruments of international cooperation in criminal cases.

Keywords: hacking, cybersecurity, cybercrime, spatial data, cyberspace, incident

Received: 25 August 2022; accepted: 2 September 2022

[1] Cardinal Stefan Wyszyński University in Warsaw, Faculty of Law and Administration, Department of Informatics Law, ORCID: 0000-0002-3264-9360, g.szpor@uksw.edu.pl.
[2]Cardinal Stefan Wyszyński University in Warsaw, Faculty of Law and Administration, Department of Informatics Law, ORCID: 0000-0003-3004-5253, a.gryszczynska@uksw.edu.pl.

Introduction

The term "hacking" is interpreted in different ways. Most broadly, it is understood as breaking security measures. It is mainly related to cyberspace and is subject to regulations in this context. Technological progress, especially the expansion of the Internet of Things, is resulting in increasingly strong and complex interconnections between virtual and real space. Spatial data, which may constitute personal data or legally protected secrets, are also targets of attacks, affecting the principles of their protection, causing the negative consequences of their breach, and leading to potential criminal liability. An analysis of these issues is needed to answer whether the legal regulation of hacking should change due to the fusion of cyber and real space.

The evolution of the concept of hacking

The term "hacking", which has been in use since the mid-20th century, was initially associated mainly with specific "intellectual experiments". Its negative connotation began to emerge in the 1980s (Britannica). However, it did not become exclusive, not least because of public authorities' legitimate use of hacking techniques (Legal Frameworks for Hacking by Law Enforcement, 2017).

In a broader perspective, the verb 'to hack' has numerous meanings and is considered the moment's word. Its technological connotations have been evaluated in both scope and presence. It derives from a verb meaning "to cut or chop with repeated and irregular blows" (The American Heritage Dictionary of the English Language, 2022). In 1955 at the Massachusetts Institute of Technology, the word "hack" first came to mean fussing with machines. According to Jessie Sheidlower, president of the American Dialect Society, the terms early references to machines "share a relatively benign sense of 'working on' a tech problem in a different, presumably more creative way than what's outlined in an instruction manual" (Yagoda, 2014). In the 1960s, the terms' hack' and 'hacker' were incorporated into the vocabulary of computer enthusiasts, but they had positive connotations. Predominant definitions were that a hacker is a person who enjoys exploring the details of programmable systems and stretching their capabilities, as opposed to most users, who prefer to learn only the minimum necessary. Hacking was characterized as 'an appropriate application of ingenuity' (more: The Jargon File; RFC 1392). The word "hack" is also defined as "to manage to deal successfully with something" or "a good solution or piece of advice" (Cambridge Dictionary). Also increasingly popular as a method of finding creative solutions to specific problems are hackathons, defined not only as an event in which a large number of people meet to engage in collaborative computer programming but also as a form of civic innovation in which participants represent citizens can point out existing problems or social needs and propose a solution (Nikiforova, 2022).

Despite those benign definitions, over time, most individuals have come to understand the term "hack" to mean malicious meddling (Eckart, 2019), and the word quickly became synonymous with "digital trespasser".

In the legal literature, the term "hacking" appears in a broad or narrow sense. There is a distinction between "hacking sensu stricto", i.e. behavior of gaining unauthorized access to an information system or computer data, and "hacking sensu largo", i.e. any attack on the security of information systems and data, including, for example, the disruption of the operation of an information system, the modification or destruction of computer data (Radoniewicz, 2016).

The Convention on Cybercrime (2001) imposes an obligation on state parties in Article 2 to adopt such legislative and other measures that may be necessary to establish intentional access to the whole or any part of a computer system without right. as criminal offences under its domestic law. A state party may require that the offence be committed by infringing security measures, with the intent of obtaining computer data or other dishonest intent, or in relation to a computer system that is connected to another computer system. Ratification of the Convention required individual states to ensure that their domestic law complied with its norms.

Defining cybercrime and, more narrowly, hacking may also be influenced by the ongoing work of the Ad Hoc Committee to Elaborate a Comprehensive International Convention on Countering the Use of Information and Communications Technologies for Criminal Purposes, established by Resolution 74/247 (2019) of the General Assembly. In the course of work on the new UN Convention, the most contentious issue is determining the material scope of the new instrument. It is undisputed that the Convention should cover cyber-dependent crimes, i.e. crimes against the confidentiality, integrity and availability of computer systems, networks and data as well as the misuse of such systems, networks and data. Some states parties indicate that the Convention should also cover narrowly defined cyber-enabled crimes (as defined in the Convention on Cybercrime (2001), including offences related to child pornography). Several states parties, however, have a much broader approach, seeking to extend the new Convention to cover all crimes committed using information and communications technologies. Regardless of the final decision on the exact material scope of the Convention, the regulation will indisputably cover the conduct defined in Article 2 of the Convention on Cybercrime (2001) and Article 267 of the Polish Criminal Code.

The Polish Criminal Code (CC) criminalizes illegal access to information in Article 267. This article introduces punishment of a fine, community sentence or imprisonment for a maximum term of 2 years to anyone who:

- without being authorized to do so, acquires information not intended for him or her, by opening a sealed letter, or connecting to a telecommunications network or by breaching or bypassing electronic, magnetic, informatic or other special protection for such information (§ 1);
- gains access to an entire computer system or any part thereof without authorization (§ 2);
- installs or uses any wire-tapping, visual or other special equipment for the purpose of obtaining unauthorized access to information (§ 3);
- divulges to another person the information obtained in the manner specified in §§ 1 to 3 (§ 4).

The prosecution of the above offence, referred to in legal doctrine as the crime of hacking (The Great Encyclopedia of Law, 2021), is carried out at the aggrieved party's motion (§ 5.).

The word hacking is used to describe a crime and in the broader context of Internet security threats (Madej & Terlikowski, 2009). Frequently distinguished forms of ICT threats are "hacking, hacktivism, cybercrime, cyberterrorism, cyberespionage, the use of cyberspace as a fifth theatre of military operations, or the effects of uncontrolled use of the Internet in the social and psychological sphere" (Banasiński, 2018). Illegal hacking is considered a cyber security incident.

The legal doctrine also distinguishes the 'political hacking' category, outlining its evolution from hacktivism to cyber-terrorism and "info wars" (Corcoran, 2020; Szpor,

2016; Filipkowski, 2015). An example may serve Russian investments in IT systems related to social media.

According to a press release from 2012, Russia's foreign intelligence service announced three tenders, worth more than $1 million, to build a system for controlling mass consciousness through social networks. The first stage covered by the tenders was to create the Dysput system for monitoring the blogosphere and determining factors influencing the popularity and spread of information. The next one was to make the "Monitor-3" system based on developing methods for organizing and directing a virtual community of experts on the Internet and receiving answers from them on assigned topics. The third stage was the "Storm-12" system uploading messages approved by Russian intelligence to the network (Szpor, 2016).

In 2022, Scott has characterized four elements of Ukraine's digital tactics: 1. Controlling the narrative 2. Splitting the internet 3. Data processing in cooperation with companies advanced in big data and artificial intelligence applications. 4. IT Army of hackers. About this last element, Scott pointed out that Mykhailo Fedorov, Ukraine's digital minister, called for volunteers, both in and outside the country, to create an "IT Army" of hackers to target Russia with predominantly unsophisticated cyber attacks in response to the invasion. "During six months, hundreds of thousands of would-be hacktivists took down scores of Russian websites, attacked the country's state media and leaked mass of sensitive data onto the Internet – much to the embarrassment of the Kremlin. In this cyber battle, Russia's own digital troops still far outgun Ukraine's volunteer squad" by Kremlin-linked groups have repeatedly attacked its Western neighbor with malware and hacking campaigns, and, most recently, tried to bring down the country's electricity network in April (CERT-UA registered 1123 attacks in the period six months of the war). According to Ukrainian officials, hackers with ties to Belarus, a close Moscow ally, also successfully targeted Ukrainian government websites earlier in the year. By crowdsourcing its hacking efforts, Kyiv is borrowing from Russia's years-long strategy to unleash rogue cybersecurity specialists if it plays to its geopolitical favor" (Scott, 2022).

The broadest meaning of the term "hacking" is used by Yuval Harari, who points out that the growth of biological knowledge, computing power and data resources adds up to the ability to 'hack people', their body, brain and life. This means an AI-based system that understands humans better than they understand, can predict and manipulate their feelings and decisions, and ultimately can make human decisions. The use of AI could lead to job losses and the creation of a class of 'expendable people', relegating many countries to the category of 'data colonies' and, at the same time, the creation of 'digital dictatorships' that will control everyone at all times (Harari, 2020).

Space and cyberspace

Hacking is classified as a negative phenomenon in cyberspace (Morańska, 2015). An element of this compound term is the word space [space], which was known in ancient times.

Space (Latin: spatium; English: space; French: espace; nm: Raum) as a philosophical category has been the subject of many definitions. "Absolute space" (imaginary space) is an extensible, unbounded receptacle that contains all bodies (the Universe) to the exclusion of themselves. As the Encyclopedia Britannica defines space as a boundless, three-dimensional extent to which objects and events occur and have relative position and direction. In classical physics, physical space is often conceived in three linear dimensions. However, with time, modern physicists usually consider it to be part of a

boundless four-dimensional continuum known as spacetime. The concept of space is considered to be of fundamental importance to an understanding of the physical Universe. However, philosophers disagree over whether it is an entity, a relationship between entities, or part of a conceptual framework (Podsiad, 2001; Britannica, 2022; Wikipedia, 2022).

In the economy context, geographic space (land, water, and air) is defined as a scarce good, i.e., one that cannot be significantly expanded in the production process. The way to expand space relatively is to substitute it with inputs of labor and capital, allowing higher outputs from the same "pieces of space," leading to a reduction in the space necessary for humans to live. Information technology is considered to consume fewer material resources, and its products can save energy and materials to meet human needs. At the same time, the space over which man has control (allowing for the self-satisfaction of life's needs) is shrinking, and the space available is expanding, thanks to the development of communications. An essential measure of the distance between objects – beyond the meter or mile – is becoming the time or cost of covering it. There is talk of political, economic, cultural, sociological, psychological, and organizational spaces (and relative distances). Virtual space or cyberspace is emerging as a new category of relative spaces (Szpor, 2016).

The origin and evolution of the term "cyberspace" have already been extensively analyzed in scientific papers (Wasilewski, 2013; Worona, 2021). The computer science literature points out that in the computer science the term "cyberspace" is explained as "a network of interconnected computer systems through which electromagnetic impulses flow with coded signals controlling the operation of digital multimedia devices", "an IT-generated virtual reality with network access", and in other approaches cyberspace is called "a field of consciousness, a sphere of activity, a living environment, a decision environment, a plane of unification, a control architecture, a method of influence, a horizon of expansion, a means of virtualization, a place of movement, a network of connections, an information resource, and an activator of the senses." It is "a world of interconnected computer networks creating an information space with the possibility of exploring it, and feeling it with the help of senses stimulated by computer-assisted devices" (Janowski, 2012) or an immaterial emanation of the Internet, a new space in which social life takes place in a specific way – a combination of two components: technical and social (Dobrzeniecki 2004). Following the current view, the technical infrastructure of cyberspace is mainly owned by global IT companies. Therefore, the law should effectively protect the infrastructure from attacks so that it doesn't come to the point where multinational corporations are the ones starting wars. A Comparative Study of Domestic Laws Constraining Private Sector Active Defense Measures in Cyberspace shows that current regulations are inadequate (Corkoran, 2020).

According to the Polish legal definition, cyberspace is the space for processing and exchanging information created by information and communication systems, along with the links between them and relationships with users. Such a definition is contained in the Act of 29.08.2002 on martial law and the competencies of the Supreme Commander of the Armed Forces, and the principles of his subordination to the constitutional bodies of the Republic of Poland in Article 2(1b) (unified text: Dz. U. of 2017, item 1932), the Law of 21.06.2002 on the state of emergency in Article 2, paragraph 1a (unified text: Dz. U. of 2017, item 1928), and the Law of 18.04.2002 on the state of natural disaster in Article 3, paragraph 4 (unified text: Dz. U. of 2017, item 1897). To these three acts of law, the definition of cyberspace was introduced by a single act: the Act of 30.08.2011 on

amending the Act on martial law and on the competencies of the Commander-in-Chief of the Armed Forces and the principles of his subordination to the constitutional bodies of the Republic of Poland, and some other acts (Dz.U. item 1323). The laws on states of emergency allow for the introduction of: 1) in the event of an external threat to the state caused by actions in cyberspace; 2) in the event of a specific threat to the constitutional system of the state, the security of citizens or public order caused by actions in cyberspace; 3) to prevent the consequences of natural disasters or technical failures bearing the hallmarks of a natural disaster caused by events in cyberspace, and to remove them.

In the "Cybersecurity Strategy of the European Union: an open, secure and protected cyberspace" of 2013, cybersecurity refers to safeguards and actions that can be used to protect the "cyber domain," both civilian and military, from those threats that affect its interdependent networks and information infrastructure and that can damage those networks and that infrastructure. The 2015 cybersecurity doctrine of the Republic of Poland, referring to this EU strategy, defines cyberspace as "the space of information processing and exchange created by information and communication systems (ensembles of cooperating IT devices and software that provide for the processing, storage, as well as the sending and receiving of data over telecommunications networks by means of a telecommunications terminal device appropriate for the type of network intended to connect directly or indirectly to network terminations), together with the links between them and the relationships with users". The term cyberspace appears 34 times in the current Republic of Poland's Cyber Security Strategy for 2019–2024. The term cyberspace also appears, without definition, in the preamble to the 2016 NIS Directive (Szpor, 2016; Great Encyclopedia of Law, 2021).

The evolution of threats in (cyber)space

At present, electronic communication is used by several billion users. Global growth is being observed in the number of Internet users – in January 2022, they accounted for about 62.5% of the population, cell phone users, accounting for 67.1% of the population, or social media users, 58.4%. The amount of time spent online is also growing, which among Internet users aged 16 to 64 was already 6 h 58 m per day at the beginning of 2022 (DataReportal, Digital, 2022). Global trends show a significant increase in the popularity of e-commerce, which, boosted by the COVID-19 pandemic, shows no signs of slowing down once some restrictions are lifted. Therefore, it should not be surprising that criminals are also becoming more active online.

Depending on the definition of hacking adopted, most of the crimes committed in cyberspace can be classified as hacking. Since representatives of the doctrine of criminal law in Poland understand hacking as a criminal act involving unauthorized access to information by breaking or bypassing security measures, the broader concept of cybercrime will be used for the general characterization of cyber threats caused by humans.

The hacking problem in the (cyber)space can be analyzed in several dimensions.

New opportunities for the exploration and use of space data make such data an object of interest on the part of criminal groups – both as a primary target for perpetrators and as a necessary means to prepare for other cyber attacks, including geographically targeted disinformation operations. Thus, focusing on the object of protection, it is possible to analyze attacks on spatial data and examine the perpetrators' criminal liability, taking into account the nature of the acquired data. At this point, however, it should be noted that spatial data are not subject to specific protection under

Polish law. They are subject to protection on general principles as information, while if they are processed in electronic form – they will be protected as computer data. If they constitute personal data or are a component of a legally protected secret, they will also be subject to specific regulations (Gryszczyńska, 2019).

Hacking can also be analyzed considering the problem of crime mapping and geographic profiling. The idea of crime mapping has its roots in the theoretical assumptions of environmental criminology, which seeks relations between crime and its environmental and geographic determinants. Crime maps enable us to seek the reasons for the concentration of criminal activity in the area. Geographic profiling allows for establishing the most likely estimated place of residence of serial offenders (based on information concerning crime location and places of significance to the incident). The problem of uneven distribution of crime in time and space is one of the most essential and inspiring phenomena of modern criminology. When studying the movement of crime to cyberspace, it is also important to see the impact of this phenomenon on criminological studies on the spatial distribution of crime (Goldschneider, 2010). The typical and most common methods identified in criminology studies must be revisited. For example, studies on crime scene locations are related mainly to hot spots, places where more criminal incidents than the average are reported. However, it should be taken into account that hacking, or more broadly, cybercrime, has transitioned previously geographically located crimes (e.g., fraud, theft) to a space without borders (Chang & Whitehead, 2022). By its very nature, cybercrime is characterized by global reach (the perpetrators' actions are not limited to a specific place or geographic area), anonymity (it is difficult to locate the source of the attack, where the perpetrator acted, make attribution or establish the perpetrator's identity) or, finally, ease of asymmetric effect (thanks to simple and cheap access to information resources and data processing systems, it is possible to cause significant damage with relatively small forces and resources). This makes it possible for a criminal with a single action to simultaneously bring about the effects observed in many places (e.g., infecting many victims with malware). Victims of such an act will file crime reports with many different law enforcement units (e.g., police stations). What's more, actions in cybersecurity usually have a cross-border nature – their adverse effects are observed in many countries, and the perpetrators also use infrastructure from many providers around the world. An example is a case involving Korean military hacking units, known by multiple names in the cybersecurity community, including Lazarus Group and Advanced Persistent Threat 38 (APT38). According to the indictment, the perpetrators launched attacks on numerous financial institutions worldwide. Around October 2016, the hackers gained unauthorized access to the Polish Financial Supervision Authority's computer network and turned its website into a watering hole (Indictment, 2020 a). The same group is responsible for the WannaCry ransomware attack (Criminal Complaint, 2018), which was estimated to have affected more than 200,000 computers across 150 countries, with total damages ranging from hundreds of millions to billions of dollars. Examining the locations of concentrated crime notifications in space will therefore not always be a good indicator. Using anonymizing network traffic tools (VPN, PROXY, TOR) by perpetrators also makes it unreliable to determine the perpetrator's physical location based on IP addresses.

However, a caveat should be made that some attacks are geographically targeted (at a specific facility, a business entity, or a specific country), and attack attribution can also be carried out on this basis. For example, in 2020, a federal grand jury in Pittsburgh returned an indictment charging six computer hackers, all residents and nationals of the

Russian Federation and GRU officers. These hackers and their co-conspirators engaged in computer intrusions and attacks intended to support Russian government efforts to undermine, retaliate against, or otherwise destabilize Ukraine; Georgia; elections in France and the 2018 PyeongChang Winter Olympic Games after Russian athletes were banned from participating under their nation's flag, as a consequence of Russian government-sponsored doping effort (Indictment, 2020 b).

However, attacks that target a particular geographic location sometimes have global implications. The NotPetya malware, for example, spread worldwide, damaged computers used in critical infrastructure, and caused enormous financial losses. The target of the attack was Ukraine (about 80% of affected companies were from Ukraine). Still, the malware also spread to several companies in other geolocations due to those businesses having offices in Ukraine and networking around the globe (for example, Mondelez International, APM Terminals, FedEx, Saint Gobain, Heritage Valley Health System of Pittsburgh, law firm DLA Piper, pharmaceutical company Merck & Co). The NotPetya malware, among others, impaired Heritage Valley's provision of critical medical services to citizens of the Western District of Pennsylvania through its two hospitals, 60 offices, and 18 community satellite facilities. The attack caused the unavailability of patient lists, patient history, physical examination files, and laboratory records, thereby causing a threat to public health and safety (Indictment, 2020 b).

The example mentioned above shows that when investigating the hacking phenomenon, it is also necessary to assess the impact of the perpetrators' actions on real and virtual space – in particular, taking into account the intertwining of these two dimensions and the kinetic effect of attacks initiated in cyberspace. Given the pandemic's status and significant risks to patients' lives and well-being, the cyberattack on Brno University Hospital was considered an attack on critical infrastructure (Europol, 2020). In contrast, due to a patient's death in connection with a ransomware attack, German authorities are investigating the perpetrators on suspicion of negligent manslaughter (Wired, 2020). Analysis of incident reports, popular studies and press reports indicate the use of information operations. Gathering information on the location of selected individuals or objects in space results not only in the ability to identify the location of military bases (e.g. based on data from the Strava app) but also in classic kinetic attacks using conventional weapons – for example, in 2015, US troops bombed one of ISIS's command centres after one of the militants posted on social media a selfie taken a right in front of it (Castillo, 2015).

With the development of smart cars, autonomous drones, smart medical devices and the Internet of Things, our physical world is becoming even more intertwined with the virtual one. A disruption of Internet services and other information infrastructure can paralyze a whole country. Increasingly, attacks initiated in cyberspace have a kinetic effect. This creates additional incentives for hacking activities. As a direct consequence, we observe the emergence of new categories of hackers: state-sponsored hackers, spy hackers or even cyber-terrorists. In parallel, new concepts such as cyber-war, cyber-defence and cyber-peace have emerged as a response to cyber perpetrators' actions (Jaquet-Chiffelle & Loi, 2020). Cyberspace can also be used as a fifth theatre of war. Alongside land, water, air and outer space, the progressive militarization of the Internet, manifested by the emergence of specialized military units, is prompting a redefinition of terms such as security or national sovereignty. Military operations in cyberspace aim to facilitate or replace conventional military operations in other locations. One of the most advanced and, at the same time, most dangerous forms of threats are cyber-attacks that

will affect the course of events in outer space, leading to the descent of satellites from designated orbits around the earth (Lakomy, 2015).

Conclusions

With the development of advanced technologies, the physical world is increasingly intertwined with the virtual one, and it is ever more challenging to draw a line between space and cyberspace.

Today's bank robbers use keyboards rather than guns and steal digital wallets of cryptocurrency instead of sacks of cash. By operating in cyberspace, they do not have to devise a plan for a spectacular bank escape from law enforcement. Thanks to the abuse of the anonymity provided by the services available online, they remain unpunished. Cyber attacks attributable to state actors show that cyberspace is also an area for cyber-operation or cyber-warfare.

The development of cybercrime, including hacking, leads to the revision of current legal regulations, the development of instruments of international cooperation in cybercrime cases or the identification of new areas of criminological research. The examples given show that attacks carried out in cyberspace cause kinetic effects in real space, and thanks to the asymmetry effect, the damage caused by cybercriminals exceeds that caused by conventional perpetrators. Changes in substantive and procedural law must follow changes in the threat landscape. Unfortunately, the involvement of some countries in cyber operations and their support of cybercrime groups brings into question the effectiveness of international cooperation instruments in cybercrime cases, which are necessary due to their cross-border nature.

References

Banasiński C. (ed.). (2018). Cyberbezpieczeństwo (*Cybersecurity*). Warszawa 2018, p. 23.

Britannica. https://www.britannica.com/topic/cybercrime/Hacking [access: 14.08.2022].

Cambridge Dictionary. https://dictionary.cambridge.org/pl/dictionary/english/hack [access: 14.08.2022].

Castillo W. (2015). Air Force intel uses ISIS 'moron' post to track fighters, CNN, 5.06.2015. https://edition.cnn.com/2015/06/05/politics/air-force-isis-moron-twitter/index.html [access: 14.08.2022].

Chang L.YC., Whitehead J. (2022). What the Hack: Reconsidering Responses to Hacking. Asian J Criminol, 17, pp. 113–126. https://doi.org/10.1007/s11417-021-09356-1.

Corcoran B. (2020). A Comparative Study of Domestic Laws Constraining Private Sector Active Defense Measures in Cyberspace. Harvard National Security Journal, 11, no. 1, 1-ix.

Criminal Code of June 6, 1997 (Journal of Laws of 2020, item 1444, as amended).

Criminal Complaint. 2018. United States District Court for the Central District of California, Case No. MJ 18 – 1479. https://www.justice.gov/opa/press-release/file/1092091/download [access: 15.08.2022].

DataReportal, Digital 2022. Global Overview Report, https://datareportal.com/reports/digital-2022-global-overview-report [access: 14.08.2022].

Dobrzeniecki K. (2004). Prawo a etos cyberprzestrzeni (*Law and the ethos of cyberspace*). Toruń, p. 10.

Eckart J.P. (2019). The Department of Justice Versus Apple Inc. – The Great Encryption Debate Between Privacy and National Security, 27 Cath. U. J. L. & Tech 1. https://scholarship.law.edu/jlt/vol27/iss2/3 [access: 14.08.2022].

Europol, 2020. Pandemic profiteering: how criminals exploit the COVID-19 crisis. Europol. https://www.europol.europa.eu/publications-documents/pandemic-profiteering-how-criminals-exploit-covid-19-crisis [access: 14.08.2022].

Glossary of key cybersecurity terms (*Słownik kluczowych pojęć z zakresu cyberbezpieczeństwa*) NSC 7298 1.0 01/09/2021 https://www.gov.pl/web/baza-wiedzy/narodowe-standardy-cyber [access: 26.08.2022].

Goldschneider M. (2010). Geography of crime. Remarks on spatial analyses of crime with the use of digital technologies (*Geografia przestępczości. Uwagi na temat przestrzennych analiz przestępczości przy wykorzystaniu technik cyfrowych*), Archiwum Kryminologii, XXXII (2010), p. 23–43, DOI 10.7420/AK2010B.

Great Encyclopedia of Law, T. XXII, Information Technology Law (*Wielka Encyklopedia Prawa, T. XXII, Prawo informatyczne*), Warsaw 2021, pp. 149–150.

Gryszczyńska A. (2019). Handling incidents involving spatial data breaches. In: I. Basista, P. Cichociński, E. Dębińska, M. Gajos-Grzetić (ed.), 26th Geographic Information Systems Conference and Exhibition "GIS Odyssey 2019". Zagreb, Croatian Information Technology Society – GIS Forum, pp. 81–90, http://www.gis.us.edu.pl/index.php/past-gis-conferences/26-gis-odyssey-2019/1081-10-handling-incidents-involving-spatial-data-breaches [access: 14.08.2022].

Harari Y. Rich elites and exploited "data colonies", https://businessdialog.pl/artykuly/bogate-elity-i-wyzyskiwane?xg_source=linkedin [access: 26.08.2022].

Indictment. 2020 a. United States District Court for the Central District of California, CR 2:20-cr-00614-DMG 2020. https://www.justice.gov/opa/press-release/file/1367701/download [access: 15.08.2022].

Indictment. 2020 b. United States District Court Western District of Pennsylvania, Criminal No. 20 316. 2020. https://www.justice.gov/opa/press-release/file/1328521/download [access: 15.08.2022].

Janowski J., 2012. Cyberkultura prawa. Współczesne problemy filozofii i informatyki prawa (*Cyberculture of Law. Contemporary problems of the philosophy and computer science of law*). Warsaw, p. 38.

Jaquet-Chiffelle D.O., Loi M. 2020. Ethical and Unethical Hacking. In: M. Christen, B. Gordijn, M. Loi (ed.), The Ethics of Cybersecurity. The International Library of Ethics, Law and Technology, vol 21. Springer, Cham. https://doi.org/10.1007/978-3-030-29053-5_9.

Lakomy M. (2015). Cyberprzestrzeń jako nowy wymiar rywalizacji i współpracy państw (*Cyberspace as a new dimension of competition and cooperation among states*). Katowice, pp. 168–172.

Legal Frameworks for Hacking by Law Enforcement: Identification, Evaluation and Comparison of Practices (2017). Directorate General For Internal Policies Policy Department C: Citizens' Rights And Constitutional Affairs. https://www.europarl.europa.eu/RegData/etudes/STUD/2017/583137/IPOL_STU(2017)583137_EN.pdf [access: 14.08.2022].

Madej M., Terlikowski M. (ed.) (2009). Bezpieczeństwo teleinformatyczne państwa (*State ICT security*). Warszawa, pp. 96–97.

Morańska D. (2015). Patologie w cyberprzestrzeni. Profilaktyka zagrożeń medialnych (Pathologies in cyberspace. Prevention of media threats). Dąbrowa Górnicza.

Nikiforova A. (2022). Open data hackathon as a tool for increased engagement of Generation Z: to hack or not to hack? Electronic Governance with Emerging Technologies Conference, Springer. Forthcoming, Available from: https://www.researchgate.net/publication/362229959_Open_data_hackathon_as_a_tool_for_increased_engagement_of_Generation_Z_to_hack_or_not_to_hack [access: 14.08.2022].

Radoniewicz F. (2016). Odpowiedzialność karna za hacking i inne przestępstwa przeciwko danym komputerowym i systemom informatycznym (*Criminal liability for hacking and other crimes against computer data and information systems*). Warsaw.

Resolution 74/247. 2019. Resolution adopted by the General Assembly on 27 December 2019, A/RES/74/247; https://documents-dds-ny.un.org/doc/UNDOC/GEN/N19/440/28/PDF/N1944028.pdf?OpenElement [access: 14.08.2022].

RFC1392. 1993. Malkin G., LaQuey Parker T., Internet Users' Glossary, RFC 1392, Interop, Inc., January 1993, https://www.rfc-editor.org/rfc/rfc1392 [access: 14.08.2022].

Scott M. (2022). How Ukraine used Russia's digital playbook against the Kremlin. From hacktivists to info wars, Kyiv is mastering digital warfare in ways previously associated with the Kremlin. 24.08.2022. https://www.politico.eu/article/ukraine-russia-digital-playbook-war [access: 25.08.2022].

Szpor G. (2016). Jawność i jej ograniczenia. Idee i pojęcia (*Openness and its limitation. Ideas and concepts*). Warsaw 2016.

The American Heritage Dictionary of the English Language (2022). Fifth Edition, https://www.ahdictionary.com/word/search.html?q=hacking [access: 14.08.2022].

The Convention on Cybercrime of the Council of Europe (CETS No.185) (2001). https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/185 [access: 14.08.2022].

The Jargon File, version 4.4.7, http://catb.org/jargon/html/H/hack.html [access: 14.08.2022].

Wasilewski J. (2013). Zarys definicyjny cyberprzestrzeni (*A definitional outline of cyberspace*). Przegląd Bezpieczeństwa Wewnętrznego, no. 9, p. 226.

Wired (2020). A Patient Dies After a Ransomware Attack Hits a Hospital. 19.09.2020. https://www.wired.com/story/a-patient-dies-after-a-ransomware-attack-hits-a-hospital/ [access: 14.08.2022].

Worona J. (2020). Cyberprzestrzeń a prawo międzynarodowe. Status quo i perspektywy (*Cyberspace and International Law. Status quo and perspectives*). Warsaw, p. 56.

Yagoda B. (2014). A Short History of Hack. The New Yorker. https://www.newyorker.com/tech/annals-of-technology/a-short-history-of-hack [access: 14.08.2022].

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.153

Małgorzata Krajewska[1], Kinga Szopińska[2], Ewa Siemińska[3], Ivo Kostov[4]

REVITALIZATION AS AN ACTION IN SPACE – CASE STUDY OF LARGE CITIES IN POLAND AND BULGARIA

Abstract: The main goal of revitalization is to improve the spatial condition of the city, which improves its image and increases the value of space. Any revitalization process requires the acquisition of geolocation data. This data can help visualize the spatial changes that were the goal of revitalization efforts. Acquiring such data is not always easy and requires the use of multiple sources of GIS information. The purpose of this paper is a spatial presentation of the analyzed areas with their identification before and after the revitalization process using spatial data made available in an open resource on Google Maps map application. Data is presented for two cities: Bydgoszcz (Poland), Varna (Bulgaria), characterized by a similar population. The paper uses current and archival orthophotos of the revitalized areas, Street View panoramic views from street level and own photographic documentation. The results of the analysis show that regardless of the stage of revitalization, the use of spatial data is essential in the designation of a degraded area, as well as later in its design, monitoring and management.

Keywords: revitalization, public space, open-source data, Poland, Bulgaria

Received: 22 August 2022; accepted: 13 September 2022

[1] Bydgoszcz University of Science and Technology, Faculty of Civil and Environmental Engineering and Architecture, Department of Geodesy, Spatial Management and Real Estate, Bydgoszcz, Poland, ORCID ID: https://orcid.org/0000-0002-8541-2295, email: m.krajewska@pbs.edu.pl

[2] Bydgoszcz University of Science and Technology, Faculty of Civil and Environmental Engineering and Architecture, Department of Geodesy, Spatial Management and Real Estate, Bydgoszcz, Poland, ORCID ID: https://orcid.org/0000-0002-2702-936X, email: k.szopinska@pbs.edu.pl, corresponding author

[3] Nicolaus Copernicus University in Toruń, Faculty of Economic Sciences and Management, Department of Investment and Real Estate, Toruń, Poland, ORCID ID: https://orcid.org/0000-0002-8885-0338, email: ewahsiem@umk.pl

[4] University of Economics – Varna, Faculty of Economics, Department of Business, Investment, Real Estate, Varna, Bulgaria, ORCID ID: https://orcid.org/0000-0001-5623-471X, email: i.kostov@ue-varna.bg

Introduction

Revitalization is an interdisciplinary concept, the definition of which has been undertaken by many researchers, including (Belniak, 2009; Bryx, 2012; Leary & McCarty, 2013; Bieda, 2017; Palicki, 2020; Palicki & Rącka 2016). In addition, legal regulations on revitalization can be found in the Law on Revitalization of October 9, 2015, defining revitalization as "the process of bringing degraded areas out of crisis, carried out in a comprehensive manner, through integrated actions for the benefit of the local community, space and economy, concentrated territorially, carried out by revitalization stakeholders on the basis of a municipal revitalization program".

The comprehensive and integrated nature of revitalization influences the renewal of degraded areas in various aspects of the city, including social, spatial and environmental (Kobylarczyk et al., 2020). These areas not infrequently have great development potential through their great historical or architectural value or convenient location. Revitalization is an opportunity to revitalize these places and restore them to their former functions or adapt them to perform new ones. Nowadays, when human interference with the environment is increasing, e.g. through massive cutting down of trees for the sake of new developments, the revitalization process is even more important. It influences an increase in the quality of existing urban space, resulting in an increase in the urban and aesthetic qualities of the city. Revitalization is mainly associated with the implementation of brownfield projects, i.e. using already existing real estate resources, whose utility functions are adapted to the current needs of various groups of urban space stakeholders. Thus, the concept of revitalization in urban space is in line with the current policy of the European Union regarding the need to implement the idea of urban ecology and sustainable development. It is important that such projects directly affect not only the improvement of environmental quality, but also promote the improvement of the quality of life of the community (European Green Deal, 2019). In addition, the city becomes more attractive to investors and tourists and helps maintain social balance (Bieda, 2017).

Revitalization thus has several goals, as described by Domański (2000) and Palicki (2020), among others. One is economic, related to revitalizing the economy by promoting entrepreneurship, investing in tourism and commercialization. Another is social, related to increasing the quality of life of residents and developing public services. Revitalization, moreover, promotes the reduction of divisions among the population, the prevention of pathologies, and stimulates in the community a sense of belonging and a feeling of security. The environmental goal of revitalization is related to the elimination of the negative effects of former industrial sites and increasing the amount of green areas in the city. These activities contribute to improving the environment as a result of reducing air and noise emissions (Kwiecień & Szopińska, 2013). As indicated by Jaszczak et al. (2021) the cultural and historical sphere is given the least importance in revitalization. Undoubtedly, however, the overriding goal of revitalization is to improve the spatial condition of the city, influencing the proper shaping of the urban fabric and reducing degraded areas, which improves the image of the city and increases the value of space (Bieda, 2017). The realization of the above goals involves urban-architectural and

technical measures, as noted by Lorens (2006). All of the above goals are interrelated and have an integral effect on the positive outcome of the revitalization process. Thus, in order to restore the development capacity of a degraded area or region, it is necessary to carry out revitalization in various spheres (Kopeć, 2011). The success of the revitalization process is also associated with the undertaking of comprehensive planning and design (defining the structure of the project, developing an action plan and strategy), organizational and financial (defining the organizational structure of the project and providing financial resources), and promotional and informational (defining the needs and goals through cooperation with the local community). Entities influencing the development of the revitalization program should be guided by the needs of the local community (Palicki, 2020). In addition, their task is to interest the largest possible group of people outside the revitalized area as well. Agglomeration renewal is not only an enrichment of the urban fabric, but also actively influences economic development (Bryx, 2012; Hajduga, 2020).

What's more, revitalization influences the current and future life of the local community, which ultimately increases the competitiveness of the city. A perfect example of the above phenomenon is Bydgoszcz (a city in the northern part of Poland), where numerous revitalization projects have been undertaken in recent years (Kufel, 2022) and Varna (a city in the eastern part of Bulgaria, located on the Black Sea) – cities with a similar population. Therefore, the purpose of this work is a spatial presentation of the analyzed areas with their identification before and after the revitalization process using spatial data made available in an open resource on Google Maps map application. All revitalization processes involve activities in space and their management requires the acquisition of geolocation data. This data can help visualize the spatial changes that were the target of revitalization activities. Acquiring such data is not always easy and requires the use of many sources of GIS information, which are successively made available to the public on Internet portals. The study used geospatial data for the city of Bydgoszcz and Varna in the open resource, current and archival orthophotos of revitalized areas, Street View panoramic views from street level and own photographic documentation. In addition, Geomedia Professional software was used for data visualization.

Revitalization process model

The basis for effective management of revitalization processes is the revitalization model (Palicki, 2020). It is a general scheme of conduct and a set of tools dedicated to authorized persons. It helps to identify the participants and strategies for action. It provides an opportunity to look at activities at each phase of the revitalization process and provides an important underpinning for the development of revitalization programs. The success of revitalization requires solving many difficulties on legal, organizational and financial grounds (Janas & Jarczewski, 2010).

In the literature, revitalization has been divided into several major stages. Ptaszycka-Jackowska (2000) distinguishes between six key stages of proceeding through the revitalization process, including: designating a degraded area, preparing a development

vision, creating an action plan, securing sources of funding, implementing a project, and operating, monitoring and evaluating the program. According to Janas and Jarczewski (2010), the revitalization process should be divided into five stages (initiating stage, scoping stage, planning stage, implementation stage and finalization stage).

Regardless of the methodological approach, in the first stage of revitalization, the problem of urban degradation and deprivation is noticed, which is the main need for revitalization of the area. The originator of this process can be the city government, local associations, media and private companies, as well as residents. Residents are the first to notice the need to repair certain areas that they interact with on a daily basis. The final verification and assessment of needs rests with the city government, which can use a number of research tools. In this regard, an urban audit performed in multiple iterations works well, which, by analyzing social and urban problems, will indicate directions for possible changes in a given area. In revitalization, survey research can be successfully used, as confirmed by Palicki (2020), among others, in his research. A very important element of the revitalization process is the coherence of the project obtained, among other things, through agreement among all stakeholders on the desire to achieve benefits and a common goal. Before the revitalization area is selected, residents should be informed about the planned activities. The media, the Public Information Bulletin and other means of communication serve this purpose. City authorities must also communicate with councilors and local government officials, who have a decision-making voice in connection with the adoption of a resolution to proceed with revitalization. This is a formal document that concludes the initiating phase of the revitalization process. The draft resolution is drawn up by the mayor and includes, among other things, the identification of crisis areas, a description of the reasons for undertaking revitalization activities, the scope and timing of revitalization program activities, the scope of community participation in decision-making, the method of appointing a social revitalization council and the rules for organizing activities by the project team, including the appointment of a revitalization operator.

The second stage of the revitalization process is to determine the scope of revitalization, i.e. the areas that will be covered by the revitalization program. After the resolution is adopted, a project team is appointed to identify the area and prepare the revitalization program. It acts as a revitalization operator who oversees the entire process. The operator can act within the office or through an external company. The project team should be composed of people holding different positions, representing different fields (i.e.: planners, architects, landscape architects, economists, builders, surveyors, scientists specializing in revitalization). The first task of the project team is to identify conditions and opportunities for revitalization programs. Due to financial constraints, the team must decide which areas will be included in the revitalization process first. Next, the possibilities of the crisis areas are identified, as well as the identified barriers and possible risks occurring during project implementation. The results of surveys of residents' attitudes and expectations will be helpful in assessing revitalization opportunities and conditions. All this information, along with the rationale, should be included in one document, which is submitted for pricing. After the comments

are submitted, the project team makes the appropriate corrections. The final decision on the selection and order of the areas to be subjected to the revitalization program rests with the mayor. The selection of areas for revitalization is followed by work on refreshing the stage of conditions and directions of spatial development and local development plans, which are part of the revitalization area.

Stage three (the planning stage) includes a complex of activities that are to result in a local revitalization program. The first activity is a detailed analysis of the causes of degradation and characterization of crisis phenomena. The next activity is the identification of partners and stakeholders. After conducting an urban audit, identifying the causes of degradation, while having the result of a survey of attitudes and expectations of residents, it is possible to formulate revitalization goals and priorities. At this time, the project team again activates the local community enabling them to submit a project proposal. During these activities it is necessary to identify sources of funding for the project. The next step is the establishment of a community council, representing the citizens of the city, taking an active role in advising the project team. Then the evaluation, prioritization and selection of projects from among the proposals takes place. During the evaluation, the following are taken into account: the existing barriers to the implementation of the projects, their compatibility with the goals set earlier, the financial and organizational possibilities and the originality of the procedure. Once the projects are selected, it remains to combine them and create a methodical program, i.e. a document that contains a hierarchical list of tasks and projects with accepted goals grouped in such a way that their implementation carries the lowest possible cost. In addition, the program must identify various options for action and alternatives.

The penultimate stage of the revitalization process is program implementation. At this stage, work is also underway on a system for monitoring the progress of the adopted revitalization program. Once the financial capital is in place, work of a preparatory nature begins (including tenders, obtaining permits, concluding contracts, preparing land and developing infrastructure for a given investment project). In the finalization stage, the settlement of obligations between partners and the collection of documentation of the revitalization program takes place. This stage should also consider measures to sustain the current state of the revitalized areas. The final activity is the enactment of the completion of the revitalization program.

Study area

Revitalization projects are presented for two large cities, located in Poland and Bulgaria. Cities with similar populations in 2021 were adopted for analysis. The first is the city of Bydgoszcz, located in the northern part of Poland with a population of over 340,000, and the second is Varna, located in the eastern part of Bulgaria with a population of over 390,000.

Bydgoszcz is the capital of the Kuyavian-Pomeranian region. It is one of the largest cities in Poland. It is an industrial and commercial and service center. On the outskirts of the city there is one of the largest industrial and technological parks in Poland. The city's

economic development is also influenced by its favorable location with access to road (expressways S5, S10), rail and water transport. The city is located on two rivers. On the eastern side is a bend of the Vistula River, while the Brda cuts through Bydgoszcz along its entire length from the east, through the entire center, to the western areas. The Brda River significantly influences the development of the city, especially in the area of Bydgoszcz's Old Town, including Młyńska Island (Fig. 1a). For years, the riverfront areas have been revitalized, which has a direct impact on the good image of the city and its attractiveness. Riparian areas are used not only for recreation, but also for cultural events (e.g. the Bydgoszcz Water Festival "Ster na Bydgoszcz", the summer concert series "Rzeka Muzyki") and sports (e.g. the Bydgoszcz Thriathlon). The city also has other watercourses and artificial lagoons, i.e. Regatta Course, Smukalski Lagoon, Bydgoszcz Canal. The architecture of Bydgoszcz mainly represents 18th and 19th century buildings. The city is an important cultural and musical center, attracting tourists not only from Poland, but also from outside the country. The city is surrounded by forests on all sides. It also has numerous green areas (parks, squares and greens). Bydgoszcz is among the top cities in Poland with the largest number and area of parks. The size is estimated at 874 hectares. Among the largest areas is the Forest Park of Culture and Recreation called Myślęcinek. Besides it, there are 30 other parks, municipal and state forests.

Fig. 1. Location of the analyzed areas: a) Bydgoszcz, b) Varna
Source: own work

Varna – The First Civilization in Europe and the Oldest Gold in the World. Varna is the third-largest city in Bulgaria and the largest city and seaside resort on the Bulgarian Black Sea Coast and in the Northern Bulgaria Region (Fig. 1b). Situated strategically in the Gulf of Varna. Varna is an important centre for business, transportation, education, tourism, culture, entertainment and healthcare. Varna has some of the finest and oldest museums in Bulgaria. The city it developed as a festival centre of international standing. Varna is the administrative centre for Varna District. The city is referred to as the maritime capital of Bulgaria and has the headquarters of the Bulgarian Navy and merchant marine. In 2008,

Varna was designated as the seat of the Black Sea Euroregion by the Council of Europe. In 2014, Varna was awarded the title of European Youth Capital 2017. The city occupies 238 km2. The city has been surrounded by vineyards, orchards, and forests. Commercial shipping facilities are being relocated inland into the lakes and canals, while the bay remains a recreation area. All the waterfront of Varna is parkland. The urban area has in excess of 20 km of sand beaches and abounds in thermal mineral water sources. The city lies 470 km north-east of Sofia. Varna attracts 2 to 3 million tourists a year, as the holidaymakers may reach over 200,000 daily during the high season. Thus, there are about 600,000 people in the city in summer, and sometimes at peak moments in July and August, even around 1,000,000 people.

Research methodology and data

When conducting any activity in space, an important aspect is the use of GIS data. Places of interest are cartographically mapped in geographic space and are clearly related to various aspects of human life. According to (Liu et al., 2020; Wu et al., 2021; Milias & Psyllidis, 2021), Points of Interest (POI) are available from several online sources, for example, OpenStreetMap and Google Maps (map applications). The geographic application of GIS tools and POIs has also been extensively discussed by (Bełej, 2021; Lu et al., 2020; Yu & Ai, 2014), while Bieda et al. (2020) pointed out the validity of conducting 3D analysis in spatial planning based on data obtained from Airborne Laser Scanning (ALS). Spatial data are also being successfully used in the revitalization process. They are used at the initial stage in defining the revitalization area and its characteristics. Specialists analyze various spatial resources in order to recognize relationships between objects or identify areas that may generate spatial conflicts arising at the interface of areas with different functions. Another valuable resource is archival data (orthophotos, panoramic street images conducted as part of Street View, etc.), which can be used to visualize spatial changes over time. Which is very important in rationalizing the needs and creating revitalization goals for the area. As can be seen, regardless of the stage of revitalization, the use of spatial data is indispensable in the designation of a degraded area, as well as later in its design, monitoring and management.

The study used geospatial data for the city of Bydgoszcz and Varna, current and archival orthophotos of the analyzed areas made available in the open resource www.geoportal.gov.pl (Bydgoszcz), and panoramic views from street level (Street View function) made available at Google Maps (Bydgoszcz and Varna). In Poland, access to open geospatial data began in 2011 (Szopińska et al., 2022). Since then, the publicly available resource has been gradually expanded. Which makes it possible to widely use the data in the field of various scientific research. One of the most recent updates (July 31, 2020) involved the discontinuation of fees for sharing data on, among other things, orthophotos. For Poland, Street View street-level images have been available since 2012. Not all areas have the resource until 2021. For areas that have not been archived by Street View, archival images from various web portals and the company's own photographic documentation taken in July 2022 were used. A similar situation applies to sites located

in Varna. Geomedia Professional software was used to visualize the data. The individual steps of the methodology are presented in Figure 2 in the form of a diagram.

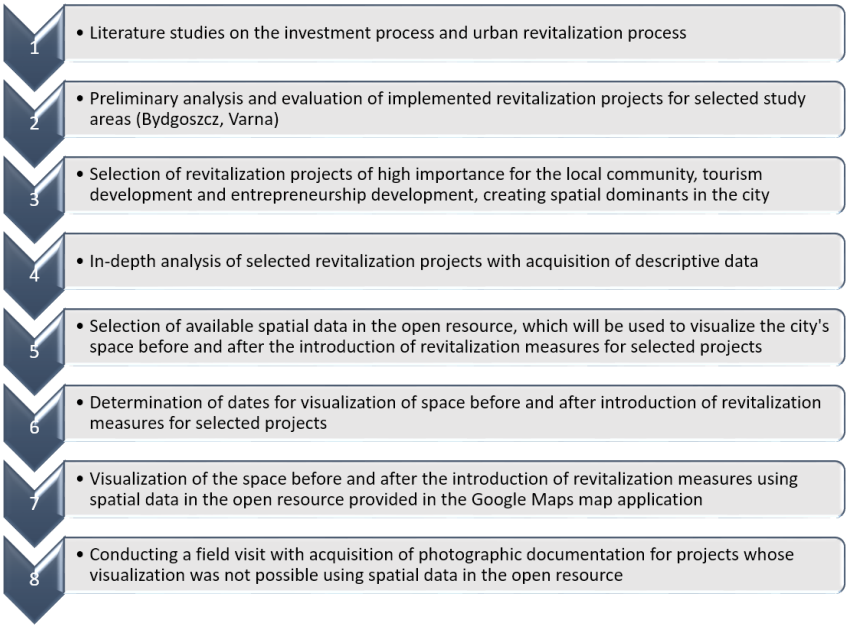


Fig. 2. The individual steps of the methodology
Source: own work

Examples of revitalization projects for the city of Bydgoszcz

The paper presents examples of completed revitalization projects for areas forming spatial dominants of great importance to the local community, tourism development and business development. All projects were implemented in the downtown zone (29 cadastral precincts with a total area of 542 hectares) (Fig. 3). Downtown is the central old-town district of Bydgoszcz. It is the historically shaped central part of the city, with compact buildings and a significant share of historically valuable buildings. It is an area of concentration of service and administrative functions of urban and regional importance (Rącka et al., 2017). Downtown Bydgoszcz (Śródmieście) is mostly formed by buildings from the second half of the 19th and early 20th centuries. The zone includes the Old Town area located along the Brda River, which has a medieval layout and many historic buildings. The second area is the New Town, which is commonly referred to as Śródmieście. All the buildings in this area were erected between 1865 and 1915, and relate in architecture to classicism and modernism. Many townhouses were built in the Art Nouveau style. Hence the area is called "Bydgoszcz Art Nouveau". The paper describes and spatially visualizes four revitalization projects, including: Młyńska Island, the Astoria swimming pool, the Focus shopping center and the Bydgoszcz Główna railroad station (Fig. 3).

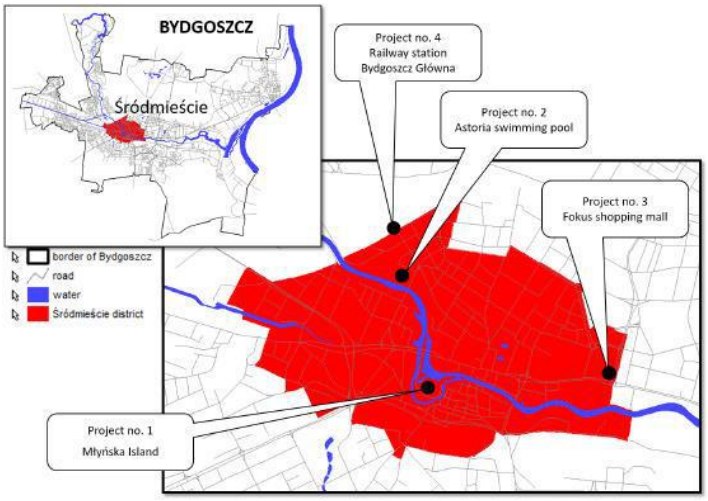


Fig. 3. Analyzed revitalization projects against the background of the city of Bydgoszcz and the Downtown area
Source: own work

Project No. 1 Młyńska Island. The Młyńska Island is an area of 6.5 hectares, located a few dozen meters from the Old Market Square. To the north it is surrounded by the Brda River, while to the south it is surrounded by the Brda Młyńska River, known as the "Młynówka", which is home to the picturesque Venice of Bydgoszcz. The verdant area is home to historic residential and industrial buildings (Fig. 4). Although Młyńska Island was once a place that drove the city's economic development, over the years, including through World War II and fires, the area has been largely degraded, losing its former significance and original functions. In 2004, city authorities decided to comprehensively renovate the post-industrial area. The total value of the revitalization of Młyńska Island until 2012 was about PLN 80 million (Euro 17 million), of which PLN 35 million came from EU funds. The work included the creation of paths for pedestrians and cyclists, the construction of a complex of park pools and three footbridges, as well as the strengthening of quays. In addition, an amphitheater, a playground, lighting and benches were built, and the area was landscaped with many plantings. A green leisure space was created in the middle of the island (Fig. 4b). However, the most important element of the comprehensive revitalization of Młyńska Island was the renovation of the buildings and adaptation to serve new functions (Table 1). The "Marina Bydgoszcz" complex was built on the site of the former sports club building. It houses a hotel, a restaurant, a teaching room, a wellness studio and a sports sphere with an exercise room, water equipment storage and a rental shop. Next to it is a pier for walkers and for mooring yachts.

Fig. 4. Młyńska Island: a) orthophotomap 2009; b) orthophotomap 2022
Source: www.geoportal.gov.pl

Table 1. Historic buildings located on Młyńska Island included in the 2006–2012 revitalization program (Street View – 2019)

Building
The White Granary (Fig. 3, object no. 1). The building from the 2nd half of the 18th century served as a grain warehouse. It was built on the foundations of a 15th-century granary. Since 1979 it served the purposes of the city's Leon Wyczółkowski District Museum, after eighteen years becoming the property of the institution. Since the 1990s, the building housed a history department. During the revitalization of Młyńska Island, this, as well as several other buildings, underwent restoration as part of the second stage of the project entitled "Renovation of Cultural Heritage Objects on Młyńska Island in Bydgoszcz." The Museum of Archeology was opened in it.
The Red Granary (Fig. 3, object no. 2). The current building was built in the 2nd half of the 19th century and served as a steam mill. It was handed over to the museum in 1979. The building was in a very poor state of repair, so it was only seasonally used as a venue for contemporary art exhibitions. Because of its brick façade, it is now known as the "Red Granary" and, following the revitalization of the Island, has housed the Modern Art Gallery since 2008.
The Młyńska Tavern (Fig. 3, object no. 3). The 1873 building served as a grain granary and later as a carriage house. During the second stage of the comprehensive revitalization work, the building was adapted into a restaurant with old-Polish cuisine, which still operates today and is very popular.
The European Money Center (Fig. 3, object no. 4). The structure was built on the site of one of the former 17th-century buildings of the Bydgoszcz Mint, then rebuilt in the late 18th century, and later served as a residential house for mill officials until 1996. In 2009, after numerous restoration works, the building was handed over to the museum for use, and it still houses the European Money Center.
The Miller's House (Fig. 3, object no. 5). It was built in the 18th century and served residential purposes for mill workers. In the late 1980s the building was used by the museum and in 1997 it was transferred to the ownership of the entity. During the comprehensive revitalization of Młyńska Island, the facility houses the Museum Information Center.
The Labor and Entrepreneurship Center (Fig. 3, object no. 6). Built at the turn of the 18th and 19th centuries, the building served as a residential house for mill officials. As part of the first stage of the project on the comprehensive revitalization of the Island "Revitalization of the Młyńska Island in Bydgoszcz for the purpose of entrepreneurship development", the Labor and Entrepreneurship Center was opened in the facility.
Wyczółkowski House (Fig. 3, object no. 7). The structure was built in 1899. It is located opposite the Rothera Mills and served as a residential house for members of the facility's management. Over the years it retained its function. In 1994 it was handed over to the museum and in 2009 the building was transformed into the Leon Wyczółkowski House in an old-fashioned style. There are paintings, prints and the painter's workshop.

Source: Street View (Google Maps)

In the middle of 2018, adaptation work began on the Rothera Mills building complex (Fig. 4, object No. 8). The industrial building dates back to the mid-19th century. It includes a mill and two granaries. The huge facility on Młyńska Island stood abandoned for many years undergoing increasing deterioration. In 2013 it became the property of the city (Fig. 5a). The revitalization of the edifice is an investment of about PLN 100 million (about €21 million). The city received funding of PLN 25 million from EU funds. The duration of the project covered the years 2017–2022. Currently (mid-2022) the Rothera Mills is already open and possible to visit, but the final finishing works will be completed in 2023 (Fig. 5b). Eventually, the complex will house restaurants, small food stands, a florist, conference and educational rooms, along with a coworking area. On the roof of the building there is an observation deck from which one can admire the panorama of Bydgoszcz, while outside there is a terrace with a fountain for leisure purposes. The entire complex has been adapted for people with disabilities. The undertaking to revitalize Młyńska Island and now Rother's Mills are among the city's most spectacular investments in recent years. With work on the Rothera Mills underway, vehicle traffic on Młyńska Island was blocked and parking lots were eliminated in order to increase safety and greater freedom for walkers.

Fig. 5. Rothera Mills: a) view of the building before revitalization – Street View 2017;
b) view of the building after revitalization – photographic documentation 2022,
by Kinga Szopińska
Source: own work and Street View (Google Maps)

Project No. 2 Astoria swimming pool. The Astoria swimming pool located at Królowej Jadwigi Street is currently the largest pool in the region. The facility was built on the site of the former Astoria Hall, built in 1962, at which time the hall served as a sports and entertainment venue. From 1962 to 2002 Astoria was the main venue for various events in Bydgoszcz. Both league matches and cultural events were held here. It

also housed an indoor swimming pool and an open-air swimming pool complex (Fig. 6a, 6b). After 2002, Astoria became a less popular venue due to the construction of a new sports and entertainment hall "Łuczniczka" on the opposite side of Downtown. In 2017, the Astoria hall was demolished and revitalization efforts began over the complex. Astoria's new swimming pool is of Olympic dimensions. Thanks to the modern solutions used, the functionality of the swimming hall has been increased. A movable platform divides the swimming pool into two arbitrarily smaller pools. Meanwhile, the movable bottom allows the depth of the pool to vary between 2.1 and 6 meters. This creates a wide range of possibilities for organizing activities. The place is designed for leisure activities of children, teenagers as well as adults. An additional attraction for the youngest is, among other things, a water obstacle course. There is also a hangar for kayaks in the complex. The four-story facility was built with ecological and natural building materials. From the outside, the effect blends perfectly with Astoria's waterfront location (Fig. 6c, 6d).

It took 2 years to build the larger and more modern Astoria. The rationale of the project was confirmed by public consultations held earlier. The investment totaled PLN 110 million (about €23 million). It was financed through a loan and funds from the city's budget and the national Physical Culture Development Funds. The complex was finally put into operation in October 2020. During the first year, despite the fact that it was a COVID-19 pandemic period, the facility was visited by as many as 235,000 people, 90% of whom were residents of the city of Bydgoszcz. The revitalized Astoria swimming pool was nominated for the "Top Municipal Investments 2021" competition.

Fig. 6. Astoria swimming pool: a) orthophotomap 2014; b) view of the building before revitalization – Street View 2014; c) orthophotomap 2022; d) view of the building after revitalization – photographic documentation 2022, by Kinga Szopińska
Source: own work, www.geoportal.gov.pl, Street View (Google Maps)

Project No. 3 Focus shopping center. Focus Shopping Center is located in the city center, on Jagiellońska Street. The 90,000 m^2 property has retail, service and entertainment functions. Focus Shopping Center was established in 2006 and was the first such large shopping mall in the city. The history of the area dates back to the 1890s, where

the land in question was located on the border between the city and the village of Schrötterdorf. At that time, commercial slaughter was banned in the Prussian state. The only places allowed for this were municipal slaughterhouses. Therefore, a large-scale meat plant was erected in Bydgoszcz, which was under German annexation at the time. Inside were abattoirs, processing halls, cold stores, while outside was a yard with pens for animals. The front buildings housed the administrative headquarters, a residential building, a market and a restaurant. The entire complex of buildings architecturally presented a very high standard. After several reconstructions and after World War II, the facility was given the status of the State Meat Plant in Bydgoszcz in 1950. The Bydgoszcz Meat Works operated until 2006 (Fig. 7a, 7c). Four front brick buildings have survived to this day. They have been restored. In one of them, the former administrative headquarters of the meat plant, the Stanislaw Horno-Poplawski Bydgoszcz Art Center was established (Fig. 7b, 7d). The cost of the investment amounted to PLN 250 million (about €53 million). The facility was put into operation on April 23, 2008. Projekt nr 3 Centrum handlowe Fokus.

Fig. 7. Fokus shopping center: a) orthophotomap 2010; b) orthophotomap 2017; c) view of buildings before revitalization; d) view of buildings after revitalization – Street View 2017

Source: www.geoportal.gov.pl, www.bydgoszcz.wyborcza.pl, Street View (Google Maps)

Project No. 4 Bydgoszcz Central Railroad Station. The current railroad station, located on Zygmunt August Street, is one of the most recognizable and distinctive properties in Bydgoszcz. The original railroad station building was constructed in 1851. Over more than a century of use, the building was rebuilt and expanded several times. The most recent remodeling took place in 1965 (Fig. 8a, 8c). In 2014, the renovation of the Main Station began, consisting of the restoration of the old historic island station (inner, inter-track), the creation of a brand-new main building, and the renovation of platforms and underpasses. The total cost of the project was PLN 197 million (about €41 million). The grand opening of the new station took place on October 10, 2015. The new building

has a very interesting architectural form. Directly above the first floor is a characteristic indentation that allows a view of the historic island station building, which is located behind the modern and glazed building. On level -1 there is a waiting room for travelers and ticket offices, along with an underground passage to the various platforms. On the first floor there is an exit to an observation deck and premises with retail and food services (Fig 8b, 8d). The historic building from the 19th century is located exactly between the third and fourth platforms. During the works, its roof was rebuilt, and the original shape of the window openings and stucco was restored. The island station mainly serves as a waiting room and a passage to the underground tunnels. Both facilities are adapted for people with disabilities.

The construction of the new main building and the renovation of the historic inner station building is one of the largest investments of the Polish railroad modernization program. The station's innovative design, functionality, use of high-quality materials and accuracy of workmanship have led to the facility being noticed and appreciated. In 2016, PKP S.A. received the "Crystal of Public Tenders" award. And in 2017, the Bydgoszcz Central Railway Station became a winner in a competition organized by Baumit. "Facade of the Year" in the "Building after renovation" category.

Fig. 8. Bydgoszcz Central Railroad Station: a) orthophotomap 2013; b) orthophotomap 2017; c) view of the building before revitalization – Street View 2013; d) view of the building after revitalization – Street View 2017.
Source: www.geoportal.gov.pl, Street View (Google Maps)

Examples of revitalization projects for the city of Varna

As in the case of the Polish city, revitalization projects of areas forming spatial dominants of great importance to the local community, tourism development and business development were selected. The paper describes and spatially visualizes three revitalization projects (see: https://varna.bg/en), including the modernization of public areas of the central part of Varna city, the modernization of residential public space and the construction of the Karantinata fishing port (Fig. 9).

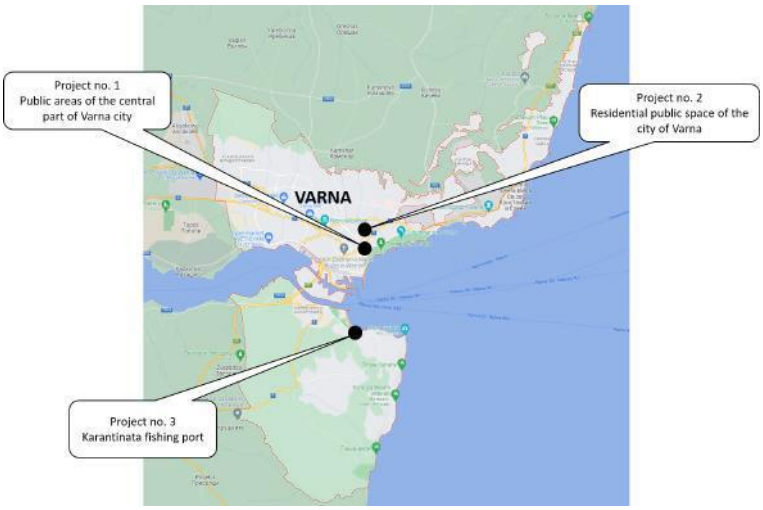


Fig. 9. Analyzed revitalization projects against the background of the city of Varna
Source: own work

Project No. 1 Public areas of the central part of the city of Varna. The overall objective of the revitalization project was to improve the quality of life in the urban center of Varna with the assurance of a sustainable and ecological urban environment and balanced socio-economic development. As part of the project, the aesthetics and modernization of the main pedestrian routes and public recreational areas in the central part of Varna were carried out. Accessibility to the city center was improved, including increased accessibility of the built environment for the disadvantaged. These activities influenced the integration of the Varna community and increased safety in the city. The project involved the complete reconstruction and modernization of pedestrian routes, including the design of sidewalks, bicycle paths or murals (Fig. 10d). In addition, elements of small architecture in the form of monuments or fountains were added (Fountain on Nezavisimost Square – Fig. 10b). The measures were guided by the idea of a green, sustainable city, so energy-efficient street lighting and a comprehensive irrigation system were designed. The revitalized area is located in the eastern part of the city, near the beach, and covers an area of about 10 hectares. Its scope includes Independence Square – "Knyaz Boris I" Blvd. – "Ruse" Sreet. The budget of the project was about BGN 11 million (about €6 million). Work began in May 2013 and was completed in mid-2016. The revitalized area is very popular with tourists and Varna residents. It has significantly improved the city's image and attractiveness.

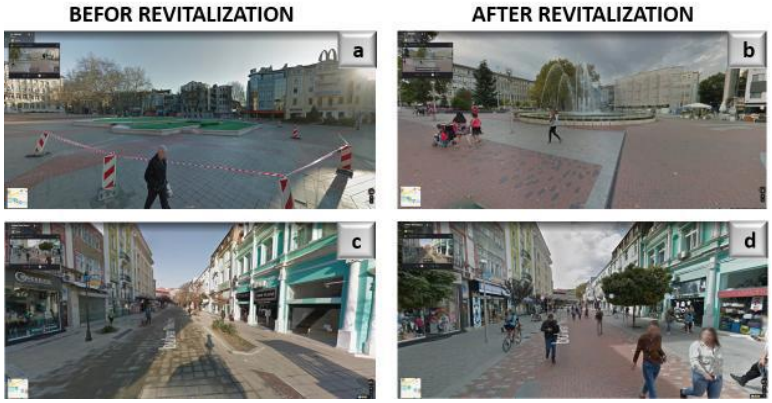


Fig. 10. Modernization of Varna city center (Street View): view of Fountain on Nezavisimost Square (2012 – a), (2019 – b); view of "Kniaz Boris I" Blvd. (2012 – c), (2019 – d)
Source: Street View (Google Maps)

Project No. 2 Settlement public spaces of the city of Varna. The main objective of the project was to improve living conditions in Varna through the construction and restoration of public recreational areas. This activity was aimed at improving the quality of life in the city and improving the environmental conditions of the settlement spaces by upgrading roads, building sports facilities and increasing the biodiversity of flora. As part of the project, part of the city's street network was repaired and reconstructed, including the reconstruction of the "General Kolev" Blvd. from "Chataldzha" Street to "Loza" Street, the reconstruction of the northern lane of "Tsarevets" Street – on the section from "Osmi Primorski Polk" Blvd. to "Vasil Levski" Blvd. and the improvement and development of the spaces between "Chataldzha" Street, "Tsar Asen", "Drava Cheh" Street, "General Kolev" Blvd. The target groups of the revitalization activities carried out were daily commuters along "General Kolev" Blvd. (pedestrians and drivers); daily users of the new parking spaces; and residents using the improved inter-block space, living in the immediate vicinity of the revitalized area. The project included the construction of three new sports fields, numerous playgrounds, climbing walls, and the planting of nearly 3,000 trees and shrubs (Fig. 11b).

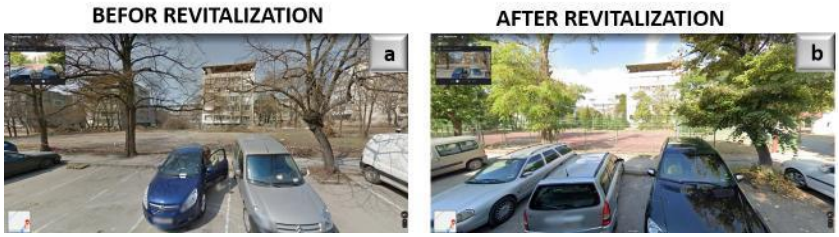


Fig. 11. Modernization of Varna's settlement space (Street View): a) 2012; b) 2019
Source: Street View (Google Maps)

The result of the work carried out was an improvement in urban traffic conditions with a reduction in automobile accidents involving pedestrians, as well as an improvement in

living conditions in the city, especially in neighborhood spaces. The project's budget was more than BGN 7 million (about €3.5 million). Work began in July 2010 and was completed after two years.

Project No. 3 Karantinata fishing port. Within the framework of the revitalization project, the fishing port located in the southern part of Varna (Karantinata Fishing Port, "Karantinata" Locality, "Asparuhovo" Area, City of Varna, Varna Municipality) was reconstructed and modernized. The main revitalization activities included the construction of hydrotechnical facilities with the necessary infrastructure and the construction of a modern and attractive mixed-use main building. The main objective of the project was to ensure the possibility of efficient, regulated, safe and hygienic unloading, storage, sale and forwarding of fish and aquatic fishing. The project is a classic solution for creating a shelter from waves, currents and marine sediment. The port has a bypass along the wharves with a width of 6 meters, which allows access and temporary stopping of sea transport. Pedestrian walkways of about 100 m in length have been provided along the facility's western quay. Two viewing platforms were also built as part of the project. The total capacity of the port is 116 watercraft (including 103 boats), 8 berths for vessels 18–24 m in length, and 5 berths for vessels over 24 m in length (Fig. 12b).

Fig. 12. Modernization of Karantinata fishing port: a) view of waterfront before revitalization – Street View 2012; b) view of waterfront after revitalization – Street View 2019; c) view of waterfront and building after revitalization 2022
Source: Street View (Google Maps) and https://varna.bg/en

The main building has a mixed function, with public, commercial and service spaces. The building consists of one underground and two above-ground floors. The most attractive part of the building is the roof. It is shaped like an amphitheater with a view of the sea and the city. A tower with a spiral staircase 18.26 meters high provides access to the restaurant, to the rooftop amphitheater and higher up to the viewing platform (Fig. 12c).

The project created a protected water area for safe mooring of fishing boats, which guarantees modern conditions for fishing. The project's budget was more than BGN 13 million (nearly €7 million). Work began in May 2018 and was completed in late 2020.

Conclusions

Revitalization is increasingly important in urban transformation. It is a complex process with a long time horizon, requiring detailed analysis and predictive planning. Its success is linked to the undertaking of comprehensive measures of a multidimensional and interdisciplinary nature, and it is necessary to cooperate and involve all stakeholders, both public and private sector entities. Undertaking appropriate projects fosters the concept of sustainable urban development, resulting in the rebalancing of degraded areas, equalizing existing disparities in the urban agglomeration. Thanks to EU funds, it is possible to undertake not only smaller revitalization projects such as comprehensive restoration of tenement houses, but also to implement larger innovative and unusual investments. Most often, degraded areas located in the central part of the city are monitored and revitalized. Then revitalization makes it possible to reduce the social problems that often occur in downtown districts, i.e. vandalism, unemployment or social marginalization, which are determined by the low level of education of the population living in these areas, the high density of people in the post-working age and their difficult financial situation.

Carrying out revitalization results in improving the quality of life and increasing the economic value of a given public space. As a result, the areas become attractive to investors. Based on analyses conducted by Bieda (2017), among others, it can be concluded that the value of land is related to urban revitalization. This is due to the fact that revitalization has a positive impact on such property characteristics as "standard," "environment" and "fashion." Research conducted by Rącka et al (2017) shows that downtown Bydgoszcz is very attractive to investors – nearly 25% of all secondary market transactions take place in this part of the city. In the wake of revitalization, there is also the phenomenon of gentrification, which is associated with the displacement of poorer segments of society from their former place of residence in favor of the settlement of these areas by middle- and upper-class people. The downtown location allows easy access to cultural and entertainment facilities and events, and has great architectural and natural advantages. Gentrification carries both positive and negative aspects. This process leads to an increase in the material value of a neighborhood through increased spatial qualities, but at the same time is associated with higher rental and maintenance costs. In addition, there is a turnover in the structure of the community and more people with higher education and higher social status appear. In addition, it is worth noting that many revitalization projects are associated with the application of the latest technological solutions for energy efficiency of buildings, in accordance with the concept of the European Green Deal (2019), (Gasiński et al., 2021).

The purpose of the work was the spatial presentation of the analyzed areas with their identification before and after the revitalization process using spatial data made available

in an open resource in the Google Maps map application. The purpose of the work was realized for two European cities, Bydgoszcz and Varna. For the selected projects, visualization and diagnosis were successfully carried out using the selected map application. The examples discussed show that many revitalization investments are successful. Fulfilling the assumptions about public participation has influenced the active participation of the public in creating the future appearance of the city (especially downtown areas). The participation of residents in the revitalization process has instilled a sense of pride and belonging to the place. The projects have significantly improved the quality of life of residents. The completely degraded space was restored to its former splendor, giving it a new socio-economic function. Historic buildings were adapted for museum purposes, which strengthened the historical value of the space (Gorgoń, 2016). Bydgoszcz and Varna, moreover, have gained a new tourist destination, which affects the higher attractiveness and competitiveness of these cities. In addition, Bydgoszcz has gained a new tourist destination, making the city more attractive and competitive. For example, the revitalized Mill Island in Bydgoszcz has become one of the most visited places by residents and tourists. It provides an opportunity to visit museums and has been used for years to organize events, concerts and community picnics. It is now a showcase of Bydgoszcz. In the city's development policy, it is important to use the potential of all natural resources, including water resources. The revitalization of waterfronts in Bydgoszcz, which has been going on for several years, contributes to the increased activity of residents and a desire to communicate by ecological means of transportation. A similar situation applies to Varna, a tourist city located on the Black Sea. The revitalization of the central part of the city and the construction of a modern fishing port, combining recreational and economic functions, has strongly improved the city's attractiveness. The revitalization of residential areas, which may contribute less to tourism, but greatly improve the quality of life in the city, is also very important for Varna authorities. As you can see, revitalization is a process that affects the economic, social, economic, environmental and cultural aspects of the city.

Current revitalization projects are a combination of the latest technologies with functionality, usability and originality. Due to their interdisciplinary nature, they require the involvement of various entities and specialists, using the latest developments in the IT sector, not excluding GIS technology and information. These technologies greatly facilitate research and project execution, while visualizations and study analyses can be useful for protecting the city skyline and revitalized areas, cleaning up the landscape, reducing visual chaos, and facilitating discussion and public participation in space planning. The examples presented from Bydgoszcz and Varna show that these spatial activities and GIS information processing capabilities do not depend on the location of revitalization activities and can be applied successfully in different European countries.

References

Bełej M. (2021). Analysis of spatial distribution of touristic accommodation in Poland with the kernel density estimation of POIs. Acta Scientiarum Polonorum. Administratio Locorum, vol. 20, no. 3, pp. 159–171.

Belniak S. (2009). Rewitalizacja nieruchomości w procesie odnowy miast (*Real estate revitalization in the process of urban renewal*), Uniwersytet Ekonomiczny w Krakowie.

Bieda A. (2017). Urban renewal and the value of real properties. Studia Regionalne i Lokalne, vol. 3, no. 69, pp. 5–28.

Bieda A., Bydłosz J., Parzych P., Pukanská K., Wójciak E. (2020). 3D technologies as the future of spatial planning: The example of Krakow. Geomatics and environmental engineering, vol. 14, no. 1, pp. 15–33.

Bryx M. (ed.) (2012). Rewitalizacja miast a przedsiębiorczość (*Urban renewal and entrepreneurship*), Oficyna Wydawnicza Szkoła Główna Handlowa w Warszawie.

Domański B. (2000). Restrukturyzacja terenów poprzemysłowych w miastach (*Restructuring of brownfield sites in cities*). In: Z. Ziobrowski, D. Ptaszycka-Jackowska, A. Rębowska, A. Geissler, Rewitalizalizacja, rehabilitacja, restruturyzacja. Odnowa miast (*Revitalisation, rehabilitation, restruturisation. Urban renewal*). Kraków: Instytut Gospodarki Przestrzennej i Komunalnej. Oddział w Krakowie.

European Green Deal, 2019, COMMUNICATION FROM THE COMMISSION, COM(2019) 640 final, EUROPEAN COMMISSION, Brussels, 11.12.2019; https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN [access: 27.07.2022].

Gasiński T., Krupa W., Boulez A. (2021). Dekarbonizacja nieruchomości: już czas działać (*Real estate decarbonization: it's time to act*). ESG Real Estate Insights, Deloitte, https://www2.deloitte.com/pl/pl/pages/real-estate0/articles/ESG-Real-Estate-Insights-2021/Dekarbonizacja-nieruchomosci-juz-czas-dzialac.html [access: 27.07.2022].

Gorgoń J. (2016). Revitalization processes of old industrialized region in the context of Functional Urban Areas. Studia Regionalia 47, pp. 87–94.

Hajduga P. (2020). A vital city and revitalization processes. Biblioteka Regionalisty. Regional Journal, vol. 20.

Janas K., Jarczewski W. (2010). Model procesu rewitalizacji – poziom lokalny (*Revitalization process model – local level*). In: K. Janas, W. Jarczewski, W. Wańkowicz, Model rewitalizacj miast (*The urban regeneration model*), vol. 10. Kraków: Instytut Rozwoju Miasta.

Jaszczak A., Kristianova K., Pochodyła E., Kazak J.K., Młynarczyk K. (2021). Revitalization of Public Spaces in Cittaslow Towns: Recent Urban Redevelopment in Central Europe. Sustainability, vol. 13, p. 2564.

Kobylarczyk J., Kuśnierz-Krupa D., Ivashko Y., Savelieva L. (2020). Methods of Revitalizing Historical Industrial Facilities–International Experience, Wiadomości Konserwatorskie – Journal of Heritage Conservation 2020, vol. 62, pp. 97–103.

Kopeć M. (2011). Finansowanie projektów rewitalizacji. Warszawa: Wydawnictwo C.H. Beck.

Kufel N. (2022). Rewitalizacja jako narzedzie rozwoju miasta (*Revitalization as a tool for city development*). Praca licencjacka (*Bachelor thesis*). Uniwersytet Mikołaja Kopernika w Toruniu, Wydział Nauk Ekonomiczbych i Zarządzania.

Kwiecień J., Szopińska K. (2013). Implementation of the EU Noise Directive in Process of Urban Planning in Poland. In: C. Ellul, S. Zlatanova, M. Rumor, R. Laurini, International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, vol. XL-4/W1, pp. 45–49. 29th Urban Data Management Symposium.

Leary M.E., McCarty J. (2013). Introduction. Urban regeneration, a global phenomenon. In: M.E. Leary i J.McCarthy (ed.), The Routledge companion to urban regeneration. London-New York: Routledge.

Liu T., Liao J., Wu Z., et al. (2020). Exploiting geographical-temporal awareness attention for next point-of-interest recommendation. Neurocomputing, vol. 400, pp. 227–237.

Lorens P. (2006). Rola kultury w procesie rewitalizacji miast (*The role of culture in the process of urban revitalization*). In: K. Grabowicz, Działania artystyczne w przestrzeni publicznej. Aspekty estetyczne i społeczne (*Aesthetic and social aspects*). Gdańsk: CSW "Łaźnia".

Lu Ch., Pang M., Zhang Y., Li H., Lu Ch., Tang X., Cheng W. (2020). Mapping Urban Spatial Structure Based on POI (Point of Interest) Data: A Case Study of the Central City of Lanzhou, China. ISPRS International Journal of Geo-Information, vol. 9, no. 2, p. 92.

Milias V., Psyllidis A. (2021). Assessing the influence of point-of-interest features on the classification of place categories. Computers, Environment and Urban Systems, vol. 86, p. 101597.

Palicki S. (2020). Rewitalizacja miast (*Urban renewal*). Wydawnictwo UEP Uniwersytet Ekonomiczny w Poznaniu. Poznań.

Palicki S., Rącka I. (2016). Influence of urban renewal on the assessment of housing market in the context of sustainable socioeconomic city development, Smart City 360°, Springer International Publishing, pp. 851–860.

Ptaszycka-Jackowska, D. (2000). Odnowa miast – zarys problem (*Urban renewal – outline of the problem*). In: Z. Ziobrowski, D. Ptaszycka-Jackowska, A. Rębowska, A. Geissler, Rewitalizacja, rehabilitacja, restrukturyzacja. Odnowa miast (*Revitalisation, rehabilitation, restruturisation. Urban renewal*). Kraków: Instytut Gospodarki Przestrzennej i Komunalnej. Oddział w Krakowie.

Rącka I., Palicki S., Krajewska M., Szopińska K., Kempa O. (2017). Changes on the Housing Market of the Downtown Area in selected Polish Cities, Real Estate Management and Valuation, vol. 24, no. 2, pp. 79–90.

Szopińska K., Balawejder M., Warchoł, A. (2022). National legal regulations and location of noise barriers along the Polish highway. Transportation Research Part D: Transport and Environment, vol. 109, p. 103359.

Wu R., Wang J., Zhang D., Wang S. (2021). Identifying different types of urban land use dynamics using Point-of-interest (POI) and Random Forest algorithm: The case of Huizhou, China. Cities, vol. 114, p. 103202.

Yu W., Ai T. (2014). The visualization and analysis of urban facility pois using network kernel density estimation constrained by multi-factors. Boletim de Ciências Geodésicas, vol. 20, no. 4.

GIS Odyssey Journal

2022 • Volume 2 • Number 1

https://doi.org/10.57599/gisoj.2022.2.1.175

Aleksandra Syryt[1]

GEOGRAPHIC INFORMATION SYSTEMS (GIS) AS A VITAL TOOL IN HUMAN RIGHTS WORK

Abstract: In the face of various local, regional, and global threats, the protection of human rights develops and increases its importance. National and international legal acts define catalogues of human rights and create institutional and procedural conditions for their protection. However, apart from that, it is also necessary to use other tools that will support activities for the protection of human rights in various dimensions while respecting the law. Undoubtedly, one of such tools can be GIS. The potential of GIS is in providing information and responding to a threat, and locating the place and extent of human rights violations, which allows for an ex-post response.

GIS can improve geographic literacy and improve our knowledge of where human rights violations are occurring. It can improve public awareness of human rights by placing them geographically. GIS can also support various projects aimed at the protection of human rights. Due to the topicality of the topic and the increase in phenomena affecting human beings and human rights, especially in the context of military operations, it is reasonable to deepen this issue and indicate the detailed scopes of GIS application in the service of human rights. The analysis will also identify the opportunities and risks associated with this tool in achieving human rights objectives.

Keywords: GIS, human rights, humanitarian law, human rights protection

Received: 13 June 2022; accepted: 14 September 2022

[1] Cardinal Stefan Wyszyński University in Warsaw, Faculty Law and Administration, Warsaw, Poland, ORCID ID: https://orcid.org/0000-0002-7501-0786, a.syryt@uksw.edu.pl.

Introduction

Global threats to humankind caused by various factors necessitate certain entities to take protective measures. The state and its agencies, as well as the international community, are of particular importance here, especially when the specific risks are wide ranging. In this context, relevant are specific legal instruments and mechanisms for the protection of human rights that are being formed both at the national and international levels. Leaving aside the assessment of the rationality and legitimacy of the current directions in the development of the concept of human rights, one cannot underestimate this particular sector, which emerged at the end of the twentieth century from public international law as a separate order and incorporated the law of national minorities and humanitarian law. Criticism of many of these directions is presented in detail by Muszyński (2022). It has also gained wide acceptance, institutionalization, as well as mechanisms for their enforcement. Human rights have become the essence of many legal systems, as well as the link between national and international law intended to harmonize these orders (Muszyński, 2022; Domingo, 2010). Changes in the approach to human rights cannot obscure the original intentions for which they were introduced into legal systems. This is because from the very beginning, human rights were unequivocally grounded axiologically on three fundamental constructs: dignity, personal freedom, and human equality (Muszyński, 2022). Any new trends should not distort this. For this reason, I will direct my reflections on the use of GIS for the purpose of serving human rights primarily to the classical view of human rights, the source of which is dignity.

National and international legal acts define catalogs of human rights and create institutional and procedural conditions for their protection. However, in addition to this, it is also necessary to use other tools that will support efforts to protect human rights in various aspects with respect for the law.

One such tool may be the Geographic Information System (GIS). The potential of GIS lies in providing information and responding to the threat as well as locating the place and extent of human rights violations, allowing for an ex-post response. GIS can improve geographical knowledge and expand our understanding of where human rights violations occur. It can also increase public awareness of human rights through the potential to monitor specific phenomena in geographical terms. GIS can also support various projects aimed at protecting human rights.

While there has been much discussion of the development of human rights and new phenomena in this area in the legal science literature to date, too little has been said so far about the use of specific extra-legal tools, including technology, in the implementation of human rights. Any research focuses primarily on the impact of artificial intelligence on human rights, or the formulation of quasi-human rights related to access to new technologies (e.g. the right to internet access) or the participation of an individual in cyberspace. They also address informational autonomy and the protection of privacy and personal data (Michalski & Syryt, 2018).

In light of this, it is reasonable to refer to GIS as a tool that can affect the implementation and protection of human rights.

Given the timeliness of the topic and the increase in phenomena affecting humans and human rights, especially in the context of military operations, it is warranted to take a deeper look at this issue. The purpose of this article is to indicate the scopes of application of GIS in relation to human rights. In addition, an attempt will be made to recognize the opportunities and threats associated with the use of GIS in achieving the goals in the area of human rights. The assumptions made require a general explanation of the essence of the concept of human rights, followed by an indication of how they can be implemented with the help of GIS tools. The main research method used to make relevant findings will be the analysis of literature and documents.

Transformations in the understanding of human rights

Human rights are one of the central issues in contemporary societies. Although there are differences as to the details of how they are framed, these rights are seen as a universal gauge of respect for human dignity and as a basis for the legitimacy of the social order accepted in pluralistic societies not only from a worldview perspective but also from an axiological one (Fel, 2007). Wiktor Osiatyński points out that "Human rights are universal moral rights of a fundamental nature, inherent to every individual in their relations with the state. The concept of human rights is based on three theses: first, that all authority has limits; second, that each individual has a sphere of autonomy to which no authority has access; and third, that each individual can justifiably demand that the state protect their rights" (Osiatyński, 2004).

The concept of human rights first appeared in an enactment in 1776, in the "Bill of Rights" of Virginia. It was based on the mindset of the Enlightenment period. At the time, they were understood as the rights of the individual primary in relation to the state and society. In that perspective, the starting point was the individual's freedom of action and their freedom to decide their own affairs. The state was seen as the greatest threat to human rights. The concept of the Enlightenment period arose from the opposition of the individual to the state. Today, it's different. It is the state that is seen as the guarantor of fundamental rights (Piechowiak, 2009).

In legal studies, the concept of human rights is understood in various ways (i.e. Michalska, 1982; Encyclopedia of Public International Law, 1985; Mik, 1994; Banaszak, 1995; Osiatyński, 1996; Kuźniar, 2000; Łopatka, 2002; Jabłoński & Jarosz-Żukowska, 2004; Gronowska et al., 2010; Marks, 2016; Malczyńska-Biały & Żarna, 2019).

The development of instruments for protection of human rights in international law was observed in the 19th century. However, during this period no coherent catalog of rights of the individual protected in international law emerged, nor did any instruments for comprehensive protection of the rights of the individual develop (Banaszak & Preisner, 2002).

After World War II, the foundation for the development of a universal and regional system for the protection of human rights was established under the United Nations

Charter. The codification process of the development of international human rights law began with the Universal Declaration of Human Rights.

Human rights after World War II as part of the regime of international law were intended to address the lack of reference to the law of nature in positivist law (Muszyński, 2022; Pietrzykowski, 2013). In practice, one can observe a far-reaching relativization of human rights, and their conceptualization is distant from that which stood at the origin of the formulation of human rights catalogs. Paradoxically, what was meant to emphasize the connection to the law of nature, namely the normativization of human rights, has the opposite effect. In fact, one can observe that the positivization of the idea of "natural human rights" has led to their transformation from "natural" privileges into positive law rights, granted by certain norms of international and national law. Thus, their link to the belief in the legal-naturalistic sources of their origin and their inherent character has been severed in a way (Pietrzykowski, 2013; Stępniak, 2019). This does not mean that it is the right direction. The separation of human rights from the human being and the focus on other contexts that are an expression of the implementation of specific policies is not a good thing, because it reinforces social divisions and, consequently, does not promote the implementation of the protection of the human being and their rights, but, on the contrary, can lead to even greater violations by causing secondary illegality of the actions of public authorities.

For this reason, I adopt an understanding of human rights that is equated with the basic, natural prerogatives to which every human being is entitled by virtue of their humanity. The fact that they have been expressed in normative acts is evidence that they constitute socially important values that should be subject to special protection by the authorities, and not because the legislator has created them, and if they were not regulated they would not exist.

The human privileges that are granted (rather than affirmed) by normative acts and that do not relate to human nature should not be called human rights. This is because they represent the adoption of a particular legislative policy and serve purposes other than the protection of human beings.

GIS and human rights

A Geographic Information System is a collection of spatial data (i.e. data with locations attached to it) and the tools required to work with the data (Reynolds, 1997). It is currently understood as a system of computer software, hardware, and data, personnel that enables the input, manipulation, analysis, and presentation of data and information related to location on the Earth's surface. This system consists of the software, hardware, data, and personnel that enable the input, manipulation, analysis, and presentation of information related to location on the Earth's surface (Ali, 2020).

Geographic information systems (GIS) are important tools for viewing broad-scale patterns of spatial data, organizing and integrating information about an area, and for analyzing this data in order to answer various research questions.

A Geographic Information System is more than just a tool for making pretty maps. GIS provides the user with the ability to store, edit, and display information about a region. What distinguishes GIS from simple mapping software is data that is geographically referenced, can come from multiple sources, and can be manipulated and analyzed in a variety of ways. As such, GIS allows for the exploration of more detailed spatial questions than would be possible with a map alone. Furthermore, along with the actual software, other important parts of a complete GIS are the people and resources required for support. Most people who work with GIS quickly realize that they rely on a computer system administrator (to help them keep the computer running), data that must be accurate for a particular application, and the many combined tools, people, and software that are all needed together to complete the project (Greenberg et al., 2017; Scholten & De Lepper, 1995).

At a wide range of scales, the map is becoming increasingly important as a legal document that supports policy or legislative decision making.

The use of GIS provides various types of information and data that, in relation to human rights, can serve to strengthen their implementation. This is because tools have a broader scope than just that of legislative regulation. Firstly, they can support the activities of specific actors in the increasing fulfilment of human rights. These are not only public entities, but also holders of these rights, who, based on specific spatial information, can realize, among other things, such rights as the right to protection of life and health, the right to mobility, but also the right to obtain information that may affect their decisions on certain ventures in the sphere of personal, private, or public life.

Secondly, GIS can support decision-making processes related to the development of appropriate legal mechanisms and political decision-making regarding the protection of human rights. It has to do with creating conditions for the protection of life and health (Świtała & Sikorski, 2021; Place Matters in the Helping Professions: GIS for Human and Social Services Organizations, An Esri White Paper, 2011), building a system that gives social security in view of various risks (Roszewska, 2021), combating threats that interfere with freedoms and rights. Third, GIS can assist in responding to specific human rights violations, including those related to violations of personal liberty, inhumane treatment, etc.

In view of this, GIS can be considered as being used for digital acquisition, mapping, collection, analysis, processing, including visualization of spatial data (Burrough & McDonnell, 1998). These systems allow data to be compared across time (map data relating to different time periods). Data can refer to physical, natural, political, social, ethnic, and cultural elements and can come from a variety of sources. GIS enable spatial coordination of resources from different systems (Enders & Brandt, 2007). GIS are faster and more accurate to use than paper maps, and data can be shared online. Overlaying different types of data can reveal not only the problem of interference with a particular human right, but also its source and cause (Roszewska, 2021).

In particular, GIS can be used to map phenomena related to human rights. Mapping is a technique used in many disciplines. In the context of social mapping processes, mapping can be defined as a participatory or collaborative technique through which

a problem or current issue is translated and presented in a visual illustration to facilitate an in-depth and systematic analysis (Maping for Human Rights).

Mapping can particularly address human rights violations and abuses. It can also be used to design social change. Factors that are mapped in relation to the human rights situations include, in particular:

1) violence (by state officials, criminal violence, domestic violence);
2) violations or abuses of human rights (e.g., in terms of restricting or prohibiting the exercise of freedom of assembly, or in relation to actions affecting the protection of life and health);
3) tendencies and patterns of human rights violations or abuses (both negative phenomena and positive trends);
4) participation of the individual in social, economic and cultural life;
5) authority structures, and control of information and resources.

The main objectives of mapping may include identifying the various dynamics of the situation regarding human rights and the key actors involved; developing a deeper understanding of the prevailing situation; conducting a critical analysis of the situation regarding human rights that can be used in decision-making processes; involving the local community in human rights activities; stimulating collective action against human rights violations; facilitating monitoring and evaluation of change.

Mapping of human rights covering specific violations and abuses aims to identify relevant factors, key actors and their interconnections in order to determine steps that can be taken to improve the state of respecting human rights.

From the perspective of the use of GIS in relation to human rights, the following should be pointed out in particular:

1) navigation, i.e. routing and planning. They facilitate the exercise of freedom of movement, but also information about migration. Given information can be useful, for example, in planning humanitarian corridors in relation to warfare;
2) obtaining information on threats to life and health such as natural disasters like earthquakes, volcanic eruptions, floods, tsunamis, landslides, etc.;
3) planning and development of the community. GIS allows data to be presented at macro and micro scales, allowing it to facilitate responses to global challenges. Knowledge gained from GIS tools allows geographic intelligence to be integrated into how we think and behave;
4) tracking and planning the use of energy resources that serve the fulfillment of an individual's needs and therefore provide them with a dignified life;
5) response to emergency situations, such as fires, explosions, hazardous material spills, and other unforeseen events;
6) monitoring access to water and food, the quality of the environment (especially in the context of its pollution) in order to protect the right to the protection of life and health;
7) population density analyses that affect living standards. They can influence undertaking projects to improve people's lives, etc.

In social research, GIS is used to analyze spatially changing population attributes such as income, crime, health, or housing quality. GIS also provides the opportunity to fully model public utility networks, such as ones that deliver water, energy, and telecommunications to large numbers of consumers, which affects the realization of social rights that are a derivative of the right to the protection of life.

An example of the practical use of GIS in human rights protection is the initiative of Ariel Low and Christoph Koettl, who created the Human Rights Mapping website, (https://humanrightsmapping.wordpress.com/), which presents and explains a variety of online mapping resources. Researchers, activists and others can use them to support human rights activities. They hypothesized that digital mapping is suitable for documenting human rights violations given that human rights violations are intrinsically linked to geographical context.

As part of the project, the maps were divided into several categories, i.e.:

1) social maps created based on information shared by users;
2) story maps – containing a story that is geographically linked to various contemporary pieces of history, as the viewer navigates the map along a predetermined path (e.g. Lee, 2022);
3) rapid response maps – quick and easy to execute in situations where information spreading requires an immediate response;
4) data visualizations typically available online that allow the user to explore the data at different zoom levels, at different time points, and with different attributes that can be turned on or off depending on the map settings;
5) static (non-interactive) maps that present data in a preset way that allows the person creating the map to choose which geographic areas and attributes the map focuses on (Low, 2015).

Similar tools are used to monitor specific violations. Thanks to partnerships with local communities and interactive platforms, data can be collected to help illustrate the situation (Brinkhurst, 2018).

Satellite imagery and geographic information systems (GIS) can be an important tool in the work for human rights, helping to provide evidence of human rights violations. This is confirmed by the practice and actions taken, also in terms of regulating certain issues. In 2020, Andrew Palmer, who leads the Early Warning and Information Support Unit at the U.N. Human Rights Office, confirmed that the U.N.'s partner organization, the UNITAR's Operational Satellite Applications Programme (UNOSAT), has signed an agreement with the Office to provide greater access to information and training in the use of technology. The goal of this outreach is to expand the use of satellite imagery and GIS maps at OHCHR and provide the knowledge and skills to fully realize its potential.

Since 2000, UNOSAT has provided UN agencies, member states and non-governmental organizations with access to satellite imagery and analysis. Through the development and delivery of Earth observation and geographic information systems (GIS), its information has helped areas as diverse as humanitarian relief, security, emergency management, and reconstruction.

The type of information that satellite imagery can show is both broad and targeted. Images have been used to provide information on possible mass graves, details regarding the destruction of civilian homes and infrastructure during a conflict or natural disaster, and the location of detention centers.

When OHCHR receives reports of allegations of human rights violations and abuses, immediate access to some locations may prove difficult or even impossible. Before initiating on-site monitoring activities, satellite imagery can greatly assist in confirming this information and help verify details (Emergency Live, 2020).

The above findings confirm that GIS can and does have a wide range of applications in the field of human rights, whether at the stage of their exercise or in the sphere of their preventive and subsequent protection. It seems that while the potential in this area is very high, it is necessary to raise awareness about the importance of given tools in the protection of human rights. It is particularly important to develop competencies in the handling and use of the tools in question, and not only among those working directly on human rights, but also among individuals in general. As the information presented above indicated, it is the human who, by submitting specific data on a platform using GIS, can contribute to speeding up the response to either a threat or a human rights violation.

Conclusions

The complexity of social relations, the emergence of new threats to the individual and its existence, both those arising from the work of nature and those caused by human activity, make it necessary to search for means and tools to support human welfare and dignity. Mere political declarations or even written guarantees contained in normative acts are not sufficient for this. Efforts for the implementation and protection of human rights, in addition to legal instruments, must also make use of other tools that will provide information and data allowing for appropriate decisions to be taken in the sphere of the protection of human rights or their limitation, both at the legislative level, in the process of applying the law, as well as within the framework of directional decisions on specific policies.

Undoubtedly, GIS is a tool that can fulfill the tasks indicated above. Firstly, the tools and data provided as part of it can serve individuals to better exercise their fundamental rights (e.g., right to mobility, right to health care access). Secondly, the tools in question can be used by entities responsible for ensuring and protecting human rights, which includes addressing threats and remediation. In the latter case, GIS provides data that can be used both for rapid response to threats, but also for analysis of staggered phenomena involving human rights such as humanitarian treatment, meeting welfare needs (including water, food or shelter), migration monitoring, population support during armed conflicts, etc. Such analyses, based on continuously updated data, can be used both to describe the current state of the observance of human rights and to forecast the future. At the same time, they can be used to devise activities that support the protection of human rights.

Possible risks that may arise while using GIS in relation to human rights are associated with the reliability of the data provided and its proper interpretation, with the timeliness of the data, and with the manner in which it is collected, stored, and processed, especially considering that it is not uncommon that the acquisition of such data will raise questions about compliance with human rights (e.g., the right to privacy). This, in turn, prompts the question of the extent to which the use of certain tools to protect one of the human rights may be in violation of another. This is an issue of proportionality and should also be considered when deciding to use GIS and when applying it.

Another risk is that certain data may be used for purposes other than intended, especially if access to certain platforms is widespread and public. In some cases, excessive availability of information may impede operational activities that serve human rights. For the above reasons, it would be appropriate to consider, at the international, EU but also national levels, systemic legal solutions on how to use GIS tools to enhance and protect human rights, respecting the principles of subsidiarity and proportionality.

The right to privacy and the protection of personal data must be respected. When considering the systemic use of GIS in protecting human rights, it would need to be reviewed whether the existing arrangements for data protection and the right to privacy are sufficient to use the tools in question. If there are deficits, appropriate legal solutions would need to be implemented. Human rights are a universal matter, so possible legislation should be broader than just at the national level; at least, individual countries' legal solutions should be harmonised. Otherwise, the usefulness of GIS tools in protecting human rights will be low.

However, the barriers identified above do not detract from the advantages of using GIS in protecting human rights. This is because the responsible use of mapping in the context of human rights provides a great opportunity to document and report on human rights violations occurring across the globe. As with any form of research on human rights, it is important to collect data with the utmost care, respecting legislation, including that on human rights, especially the right to privacy and the protection of informational autonomy. Education and the formation of appropriate competencies and attitudes are also important in this regard. It will then be possible to use the tools reliably and effectively and to apply them for the benefit of humankind.

References

Ali E. (2020). Geographic Information System (GIS): Definition, Development, Applications & Components. https://www.academia.edu/42329737/Geographic_Information_System_GIS_Definition_Development_Applications_and_Components [access: 05.05.2022].

Banaszak B. (1995). Prawa jednostki i systemy ich ochrony (*Individual rights and systems of their protection*). Wrocław.

Banaszak B., Preisner, A. (2002). Prawa i wolności obywatelskie w Konstytucji RP (*Civil rights and freedoms in the Polish Constitution*). Warsaw.

Brinkhurst M. (2018). Mapping human rights abuse, Mapbox, 28 June 2018. https://blog.mapbox.com/mapping-human-rights-abuse-cbdda8e3c68d) [access: 30.04.2022].

Burrough P.A., McDonnell R.A. (1998). Principles of Geographical Information Systems. Oxford University Press, Oxford.

Domingo R. (2010). The New Global Law. Oxford.

Emergency Live: GIS And Satellite Imagery to Assist Human Rights Work. https://www.emergency-live.com/news/more-satellite-images-to-assist-human-rights-work/, 28 August 2020 [access: 04.05.2022].

Bernhardt R. (ed.). Encyclopedia of Public International Law (1985), vol. 8. Amsterdam-New York-Oxford.

Enders A., Brandt Z. (2007). Using Geographic Information System Technology to Improve Emergency Management and Disaster Response for People with Disabilities. Journal of Disability Policy Studies, vol. 17 ,no. 4, pp. 223–229.

Fel S. (2007). Prawa człowieka – rozwój idei, podstawa, treść i ochrona (*Human rights - development of ideas, basis, content and protection*). In: S. Fel, J. Kupny (ed.). Katolicka nauka społeczna. Podstawowe zagadnienia z życia społecznego i politycznego (*Catholic Social Teaching. Basic issues in social and political life*), Katowice, pp. 57–75.

Greenberg J.D., Logsdon M.G., Franklin J.F. (2017). Introduction to Geographic Information Systems (GIS). In: S.E. Gergel, M.G. Turner (ed.), Learning Landscape Ecology. Springer, New York, pp. 17–31.

Gronowska E., Jasudowicz T., Balcerzak M., Lubiszewski M., Mizerski R. (2010). Prawa człowieka i ich ochrona (*Human rights and their protection*). Toruń.

Human Rights Mapping, https://humanrightsmapping.wordpress.com/ [access: 10.05.2022].

Jabłoński M., Jarosz-Żukowska S. (2004). Prawa człowieka i systemy ich ochrony. Zarys wykładu (*Human rights and systems of their protection. Lecture outline*). Wrocław.

Jurczyk T. (2009). Geneza rozwoju praw człowieka (*The origins of the development of human rights*). Homines Hominibus, no. 1, pp. 29–43.

Kuźniar R. (2000). Prawa człowieka. Prawo, instytucje, stosunki międzynarodowe (*Human Rights. Law, institutions, international relations*). Warsaw.

Lee N. (2022). Story Map: The use of GIS and Tracking Human Rights Abuses, 15 May 2022 https://storymaps.arcgis.com/stories/71cacfbd36084f47b580881dd7040433 [access: 15.09.2022].

Low A. (2015). Digital Mapping for Human Rights, FXB Center for Health & Human Rights at Harvard University, 10 April 2015. https://fxb.harvard.edu/2015/04/10/digital-mapping-for-human-rights/) [access: 25.04.2022].

Łopatka A. (2002). Jednostka, jej prawa człowieka (*The individual, his human rights*). Warsaw.

Malczyńska-Biały M., Żarna K. (ed.) (2019). Prawa człowieka i ich ochrona (*Human rights and their protection*). Rzeszów.

Maping for Human Rights, https://www.amnesty.nl/content/uploads/2017/01/mapping_for_human_rights.pdf?x56589, p. 2) [access: 9.05.2022].

Marks S.P. (2016.). Human Rights: A Brief Introduction. Harvard University.

Michalska A. (1982). Prawa człowieka w systemie norm międzynarodowych (*Human rights in the system of international norms*). Warszawa-Poznań.

Michalski M., Syryt A. (2018). Historical-Cultural and Legal Aspects of the Right to Privacy and Spatial Information. Challenges Related to the Development of Technology: Constitutional Standards (Polish Case). In: 25th Anniversary Conference Geographic Information Systems Conference and Exhibition "GIS Odyssey 2018", pp. 354–363.

Mik C. (1994). Koncepcja normatywna europejskiego prawa praw człowieka (*The normative concept of European human rights law*). Toruń.

Muszyński M. (2022). Siła. Norma. Idea. Prawo międzynarodowe w ujęciu historycznym (*Strength. Standard. Idea. International law in historical perspective*). Warsaw.

Osiatyński W. (1996). Wprowadzenie do pojęcia praw człowieka (*Introduction to the concept of human rights*). In: Szkoła Praw Człowieka. Teksty wykładów (*School of Human Rights. Lecture texts*). Warsaw.

Osiatyński W. (2004). Wprowadzenie do pojęcia praw człowieka (*Introduction to the concept of human rights*). Law through Experience, 116881-CP-1-2004-SK-GRUNDTVIG-G11. http://www.psep.pl/grundtvig/1/wprowadzenie_do_pojecia_praw_czlowieka.pdf [access: 02.05.2022].

Piechowiak M. (1997). Pojęcie praw człowieka (*The concept of human rights*). In: L. Wiśniewski (ed.), Podstawowe prawa jednostki i ich sądowa ochrona (*Basic individual rights and their judicial protection*). Warsaw, pp. 7–37.

Pietrzykowski T. (2013). Przeszłość i przyszłość filozoficznoprawnej idei praw człowieka (*The past and future of the philosophical and legal idea of human rights*). Filozofia Publiczna i Edukacja Demokratyczna, vol. II, no. 2, pp. 212–232.

Place Matters in the Helping Professions: GIS for Human and Social Services Organizations, An Esri White Paper, April 2011, https://www.esri.com/content/dam/esrisites/sitecore-archive/Files/Pdfs/library/whitepapers/pdfs/gis-for-human-svc-and-ssos.pdf). [access: 07.05.2022].

Reynolds H. (1997). An Introduction to Geographical Information Systems (GIS). https://badpets.net/IntroGIS/GIS_Intro.pdf [access: 07.05.2022].

Roszewska K. (2021). Geographic Information Systems and accessibility for persons with disabilities, GIS Odyssey Journal, vol. 1, no. 2, pp. 21–29.

Scholten H.J., De Lepper M.J.C. (1995). An Introduction to Geographical Information Systems. In: M.J.C. De Lepper, H.J. Scholten, R.M. Stern (ed.), The Added Value of Geographical Information Systems in Public and Environmental Health. The GeoJournal Library, vol 24. Springer, Dordrecht, pp. 53–70.

Stępniak K. (2019). Koncepcja jurydyzacji czwartej generacji praw człowieka w międzynarodowym systemie ochrony (*The concept of juridization of the fourth generation of human rights in the international protection system*). Przegląd Sejmowy, vol. 151, no. 2, pp. 97–121.

Świtała K. & Sikorski S. (2021). Use of GIS in Healthcare. GIS Odyssey Journal, vol. 1, no. 2, pp. 83–90.