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IDENTIFICATION OF DEVELOPMENT DETERMINANTS OF GREEN INFORMATION SYSTEMS FOR URBAN AREAS – POLISH CASE STUDY

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ABSTRACT

The green information systems (green IS) address the demand for information about green spaces in both urban and non-urbanized areas. This systems are part of green infrastructure (GI) and National Spatial Data Infrastructure (NSDI). GI are very important for the urban environment, and it improves the quality of life. There are various types of urban greenery. The green IS can support the management, maintenance, monitoring, protection and revitalization of urban greenery and all GI. This systems contribute to the sustainable development of urban areas, the development of smart and green cities and spatially enabled societies where community members are involved in local projects. In Poland, few cities have so far taken the effort to create a green IS due to the costs of starting and maintaining the system. Municipalities give up the creation of this system because it is not a good first necessity. However, green infrastructure is developing in Poland and there is a strong demand for green IS for easier GI management. Therefore, the aim of the research was to identify various determinants (factors) that may affect the development of green IS in Poland. Analysis of determinants is necessary and important from the point of view of knowledge of mechanisms affecting the development of green IS and may be useful to develop a strategy for further activities promoting the creation of green IS in all cities in Poland. The research results provided the basis for distinguishing groups of impact factors due to their specificity and showed which instruments are applied to them taking into account global and local initiatives.

Key words: green information system**,** green cadastre, urban greenery, green infrastructure, spatial data infrastructures

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INTRODUCTION

The literature review shows a multitude of studies on determining the significance of urban greenery or the green infrastructure for society (Molla 2015) and how important the green information systems (green IS) are for sustainable development (Dedrick 2010 Jenkin et al. 2011), however, there is still a lack of comprehensive research identifying the development determinants of green IS. Knowledge of the latter will allow us to understand what mechanisms affect the direction of development of these systems and discover specific expectations from green IS.

For the needs of this study, the green IS was defined as a system for recording and tracking urban green spaces in various cities around the world. Green areas are very important for the urban environment, and various types of urban greenery exist. The green IS supports the management, maintenance, monitoring, planning and protection of urban greenery (Lelova and Blikov 2012) – Figure 1.

The development of a green IS contributes to the expansion of urban green spaces, and it enables cities to be better prepared for natural disasters and climate change. A comprehensive register of parks and other green spaces containing information about plant species is required to improve planning and policy-making in cities. Green spaces have to be protected for environmental reasons and to improve the health of urban residents and their quality of life (UNDP 2016). Numerous information systems supporting the management of urban green spaces have been developed in recent years (GEO INFO Strategies 2018 Marian 2014 UNDP 2016). Those systems have been implemented to:

- develop a database for planning and monitoring the management of urban green spaces and the relevant resources,
- inventory the existing urban green spaces,
- minimize labour needs,
- facilitate planning and reporting of maintenance services in urban green spaces.

The developed systems account for the growing demand for urban green spaces and their role in the social, environmental and economic dimensions (Table 1).

Considering the above information the green IS should be developed not only with the involvement

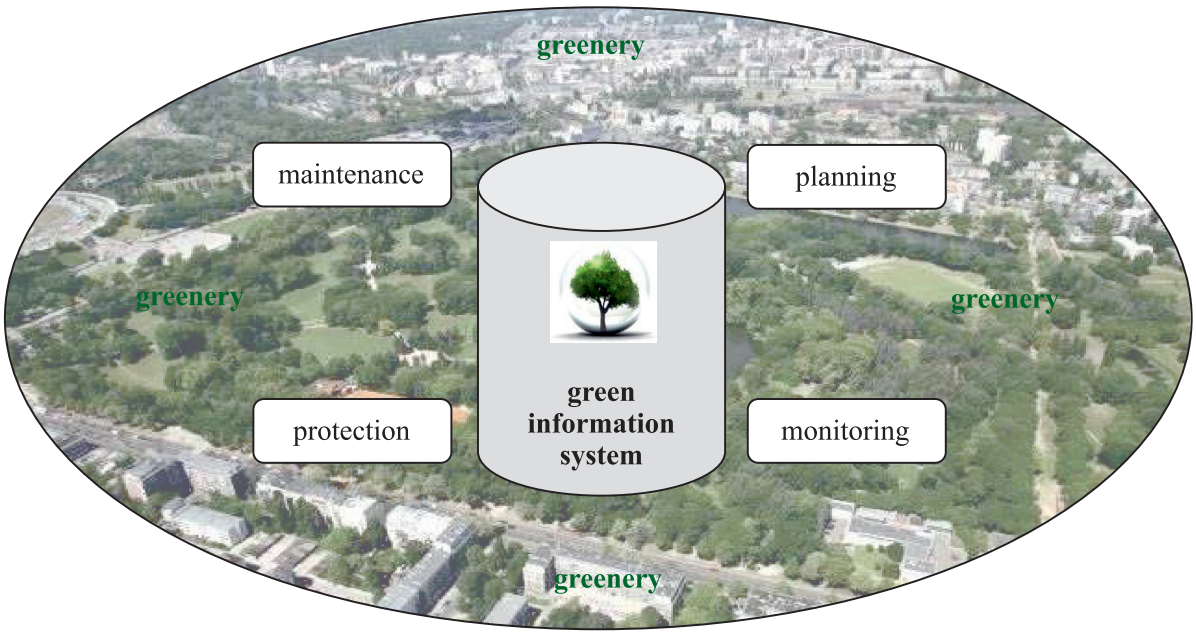

Fig. 1. The role of a green information system for urban areas
Source: own elaboration

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Table 1. Significance of urban green spaces

Social dimension	Economic dimension	Environmental dimension
Greater aesthetic appeal	increase in property value	greater biological diversity
Stronger social bonds	stimulation of local business	improved air quality, pollutant absorption, oxygen production
Improved well-being	reduction in heating and air-conditioning costs	reduction in the quantity of rainwater evacuated by sewers
Slower traffic	effective wastewater management and reduction in watering costs	reduction in noise levels
Stress reduction	business development in green districts	lower temperature in the shade
Improved concentration in children	trees have a high return on investment for pollution reduction	bird and insect habitats

Source: own elaboration based on Kosmala and Okołowicz (2014)

of advanced technology, but they should also be adapted to social needs (Enemark et al. 2014) and should promote the achievement of sustainable development goals (UN 2015, Dawidowicz and Źróbek 2017, 2018) to improve living conditions and social relations. The green IS should be an effective system which is integrated with the Land Administration System (LAS) (Williamson et al. 2010) and fit-for-purpose (Enemark et al. 2014).

Despite successively published scientific research on green IS (Dedrick 2010 Jenkin et al. 2011) and guidelines for the implementation of green IS (Brocke et al. 2012, Mishra et al. 2014), difficulties in implementing information systems for urban greenery in EU countries are still being recorded (Naumann et al. 2011). They result from various reasons, eg. inadequate funding, lack of experience in the implementation of individual project phases; lack of economic motivation, because the benefits of using green infrastructure are difficult to measure in financial terms. Hence, there are significant discrepancies in the creation of GI, not only in EU countries, but also at the level of individual cities in different countries. It is difficult to compare the scope of GI implementations, as in most cases there is no full data on this subject (Baycan et al. 2002).

In Poland, few cities have so far taken the effort to create a green IS due to the costs of starting and maintaining the system. Municipalities give up the creation of this system because it is not a good first necessity. However, green infrastructure is developing in Poland and there is a strong demand for green IS for easier GI management. Therefore, the aim of the research was to identify various determinants (factors) that may affect the development of green IS in Poland. Analysis of determinants is necessary and important from the point of view of knowledge of mechanisms affecting the development of green IS and may be useful to develop a strategy for further activities promoting the creation of green IS in all cities in Poland. The research results provided the basis for distinguishing groups of impact factors due to their specificity and showed which instruments are applied to them taking into account global and local initiatives.

MATERIALS AND METHODS

The subject of the research were determinants influencing the development of green IS. Empirical and qualitative research was carried out. Determinants were selected after analyzing the literature and reports and legal acts. The study involved an analysis of national and EU laws, local regulations, selected projects and procedures relating to the management of urban green spaces. The authors also relied on the results of a survey carried out in selected departments and institutions which keep databases on urban green spaces. Determinants were grouped due to their properties:
– key legal framework (national and EU laws),
– Key technology (systems reviews),

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– Key trends (global development paradigms, research directions),
– Key initiatives (local and international activities promoting green infrastructure).

The scope of the research process is presented in Figure 2.

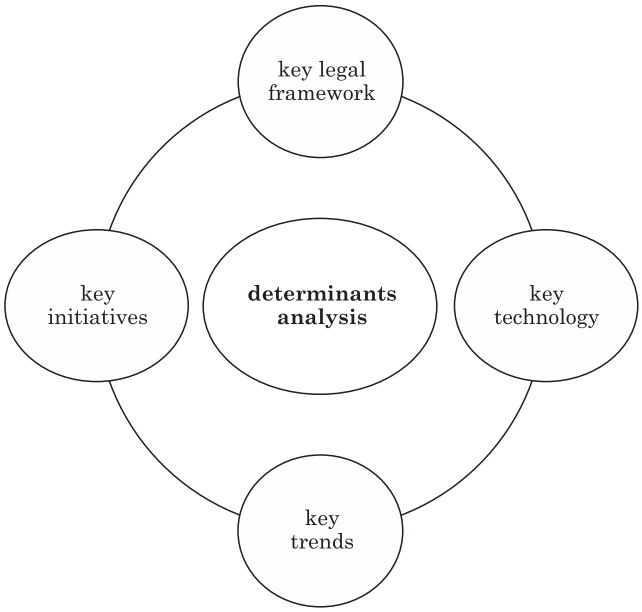

Fig. 2. The scope of the research
Source: own elaboration

RESULTS AND DISCUSSION

Key legal framework

EU Programs and Directives. Sustainable management of nature resources is an important and constructive element of international politics. In the General Union Environment Action Program adopted by the European Commission in 2013 'Living well, within the limits of our planet' (Decision EP 2013) the following strategic objectives are mentioned, taking into account the development of urban greenery in an interdisciplinary approach:
– to protect, conserve and enhance the Union's natural capital,
– to turn the Union into a resource-efficient, green, and competitive low-carbon economy,
– to safeguard the Union's citizens from environment-related pressures and risks to health and wellbeing,
– to maximise the benefits of the Union's environment legislation by improving implementation,
– to increase knowledge about the environment and widen the evidence base for policy,
– to secure investment for environment and climate policy and account for the environmental costs of any societal activities,
– to better integrate environmental concerns into other policy areas and ensure coherence when creating new policy,
– to make the Union's cities more sustainable,
– to help the Union address international environmental and climate challenges more effectively.

The Strategy "Europe 2020" (Europe 2020) supporting programs in the field of environment and climate change, energy, transport, industry, agriculture, fisheries and regional development, for sustainable management and management of natural resources is also important for EU member states. According to Europe 2020, resource management should be: intelligent, sustainable (taking into account the long-term effects of resource management) and pro-social. The goal of the flagship initiative for a resource-efficient Europe is to invest and innovate through policies related to climate change, energy, transport, industry, raw materials, agriculture, fisheries, biodiversity and regional development.

The European Commission (EC 2013) promotes the Green Infrastructure Strategy, for which it received a mandate from the European Council and the European Parliament "as a contribution to further integration of biodiversity issues with other EU policies" (Biodiversity strategy 2011). The strategy refers to the GI, which is a successfully tested tool that provides ecological, economic and social benefits through natural solutions. It helps us understand the value of benefits that nature provides to society and mobilizes investments to sustain and improve them. As a new policy concept, GI sets ambitious goals to bridge the gap between the different sectors and to integrate benefits for biodiversity with those

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for socio-economic interests, to improve delivery of ecosystem services, climate change mitigation and, more than that, it aims to promote innovative solutions and the use of same land for multiple purposes (Čivić and Jones-Walters 2014). The report (EC 2012) identified groups of functions performed by green infrastructure, ecosystems as the protection of ecosystems and biodiversity, providing services and improving their functioning, shaping living conditions and improving health, supporting the development of green economy and sustainable water and space management. Whereas in the report (EC 2016) attention was drawn to the interdisciplinary nature of entities responsible for implementation to implement the GI concept, where the most important economic sectors are: finance, construction (in the scope of green roofs, green walls), health (in the scope of availability of elements of green infrastructure for residents), environmental protection (prevention and adaptation to climate change), industry (cost-benefit analysis in the field of green infrastructure development). Green infrastructure can make a significant contribution to many of the EU's main policy objectives, in particular regarding regional and rural development, climate change, disaster risk management, agriculture and forestry (Neumann et al. 2011).

Analysis of legal regulations concerning urban green spaces in Poland. Environmental protection and management are regulated by numerous legal acts. The Environmental Protection Law (2004) defines green spaces as developed land which is occupied by technical infrastructure and buildings, is covered by vegetation and is open to the public, in particular parks, pocket parks, promenades, boulevards, botanical gardens, zoos, playgrounds, historical parks, cemeteries, roadside trees, squares, historical fortifications, buildings, storage yards, airports, railway stations and industrial sites. The most important legal acts relating to environmental protection and their provisions are presented in Table 2.

Highly generalized laws which create interpretation problems (such as tree replacement requirements) and frequent changes in legislation pose the greatest obstacles to the protection of urban green spaces

Table 2. Environmental protection in selected legal acts

Legal act	Provisions relating to environmental protection
Environmental Protection Law of 16 April 2004	Permission is not required for the removal of: a shrub or a cluster of shrubs occupying an area of up to 25 m^2; trees whose circumference at the height of 5 cm above ground does not exceed the value specified for the given tree species; trees and shrubs growing on private property which are not felled for business purposes. The property owner will pay a license fee for removing a tree or a shrub. The fee is stated in the felling license and is collected by the competent authority (municipal governor or city mayor). Under the felling license, the property owner may be required to transplant trees or plant at least one new tree for every removed tree.
Act on the Protection and Maintenance of Historical Monuments of 23 July 2003	The removal of a tree or a shrub growing on property entered into the register of monuments has to be approved by the regional monument conservation officer.
Public Roads Act of 21 March 1985	The road administrator is responsible for maintaining, planting and removing roadside trees and shrubs.

Source: own elaboration based on legal acts

(Masłowska-Gądek 2017). Local zoning plans should contain clear provisions regarding the protection of urban greenery, but Polish authorities do not make full use of their law-making powers. The existing solutions should be promoted and new options should be made available in urban planning documents to improve the quality of life in cities (Burlińska 2013). Some Polish cities, such as: Jaworzno, Kraków, Łódź, Warsaw, Olsztyn and Wrocław, implement internal procedures both at the urban level (resolutions adopted by city mayors) and at the level of the competent departments or institutions (internal standards that do not have to be approved by city mayors) to improve the quality of urban green spaces (Biejat 2017). Many Polish cities have developed or are currently developing urban greenery plans based on geographic information systems (GIS). In Olsztyn, replacement tree planting is an important

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element of the city's sustainable tree management policy. The local authorities work closely with local community members to identify areas that are in greatest need of trees (Łukaszkiewicz 2013). A comprehensive green cadastre will support the development of uniform standards for urban green spaces and will contribute to the sustainable management of urban greenery on the national scale.

Key technology

Fit-For-Purpose Land Administration System. Local governments use the most extensive and stable technology to conduct land administration.

The term "Land Administration System" (LAS) was first used in the literature in 2005 (Williamson et al. 2010). The Land Administration System is the infrastructure for implementing land policies and land management strategies that are consistent with sustainable development principles. The system incorporates a platform for the exchange of data between various institutions, a legal framework, processes, standards, land information, management and dissemination systems, as well as technologies that support allocation, the real estate market, property valuation, monitoring of land use and demand on the real estate market. Numerous countries are currently in the process of developing their Land Administration System. Databases from many public registers, including cadastres, land registries, tax registries and land-use plans, are being integrated to improve the registers' functionality and provide effective support for other systems and economic processes. The Land Administration System should be designed to meet public information needs, secure property ownership rights and effectively support sustainable management of property and natural resources, including green spaces.

The term "fit-for-purpose" is not new, but what is new is that it has been recently used in the context of building sustainable land management systems. Fit-for-purpose Land Administration System should adapt flexibly to the needs and problems of regions and local communities rather than blindly follow advanced techniques and standards. The discussed approach is participatory and inclusive, and it is fundamentally based on the concept of human rights. It delivers numerous benefits, including opportunities for building Land Administration System within a relatively short time and at relatively low cost. The fit-for-purpose approach enables governments and land professional to resolve global land issues. The discussed approach is realistic and scalable, and it could deliver numerous benefits in the intermediate timeframe.

A fit-for-purpose approach (Enemark et al. 2014) includes the following elements:
- flexible in the spatial data capture approaches to provide for varying use and occupation,
- inclusive in scope to cover all tenure and all land,
- participatory in approach to data capture and use to ensure community support,
- affordable for the government to establish and operate, and for society to use,
- reliable in terms of information that is authoritative and up-to-date,
- attainable in relation to establishing the system within a short timeframe and within available resources,
- upgradeable with regard to incremental upgrading and improvement over time in response to social and legal needs and emerging economic opportunities.

Every country needs to adapt its legal and institutional framework to implement the above elements of the fit-for-purpose approach. The above implies that the fit-for-purpose approach should have a sound legal basis, should be gradually implemented within a sound land administration framework, and the information should be made available to all users.

Geographic information systems for urban greenery management on the example of selected Polish cities. Polish cities differ in their ability to manage urban green spaces effectively and rationally. Some cities subscribe to the smart city concept and rely on modern technology and the creative potential of the local residents to popularize social initiatives and raise funds for the development of urban green spaces.

Participatory environmental management is a recent approach to the effective management

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of public greenery. One of the most noteworthy programs is the "Count on green" project which relies on softGIS tools (Putkowska et al. 2017). The participants fill out an interactive questionnaire, and the collected data are used to formulate conclusions about the quality of green urban spaces. The project was a success, and it revealed that the softGIS platform is a highly promising tool for encouraging community participation in the management of urban greenery in the digital era. The project generates information relating to the participants' preferred recreational sites and routes in natural surroundings, urban green spaces which are badly designed and not adequately maintained, urban open spaces that lack vegetation, and the participants' opinions regarding residential greenery. The project was promoted by a series of articles on the website of the Sendzimir Foundation, a competition for school students who designed the ideal playground, city games, information in the local media and promotional meetings. The campaign encouraged local residents to fill out an interactive questionnaire. According to the local authorities, the project has made an invaluable contribution to long-term urban renewal planning. The project will be continued with the involvement of local community members. The institutions and organizations responsible for the management of urban green spaces in Kraków, Łódź and Poznań participated in three workshops as part of the project (Putkowska et al. 2017).

The **www.naprawmyTo.pl** website, where local residents can report problems and contribute ideas, has been launched in 17 Polish cities (Laboratorium EE 2012). The **"Million Trees**" mobile application is yet another example of community participation in urban greenery management. Warsaw residents can use the application to indicate areas where trees are scarce. If trees cannot be planted in the suggested location, the application provides the user with the reasons for the above (Google Play 2018).

In Kraków, local residents can communicate with the Urban Greenery Board, report problems and suggest ideas for managing urban green spaces via the Collectively platform. The advertising slogan promoting the mobile application is "**My city – my concern**". The application has been launched to demonstrate that local residents can solve problems in collective effort. Through the platform, Kraków's residents can find out about the local planning process and can report problems to the Urban Greenery Board. The users can suggest community campaigns and monitor other users' activity online. In the future, the application will be expanded to include new functionalities, including online communication with other public institutions and automatic classification of user reports (Magiczny Kraków 2018). Kraków's cohesive and long-term policy of urban greens development is presented in the official document entitled "Directions for the development and management of urban green spaces for 2017–2030" (Kraków 2017). As part of this plan, dispersed urban green areas will be combined into a cohesive system, greenery maintenance standards will be improved and perfected, and urban green spaces will be managed with the involvement of modern GIS tools. Kraków has launched the Green Spaces Register, an online platform which supports management operations. The Urban Greenery Board relied on the register to develop R3Trees, a mobile application for managing urban green spaces. R3Trees can store vast amounts of information relating to urban greenery, including historical data, and it supports greenery management. The application can be used to communicate with service providers, commission services, report on the performed services, effect payments and impose fines on defaulting service providers. The system can be installed on personal computers as well as tablets and smartphones (R3Trees Mobile). System users have different access levels, and access can also be restricted locally, for example to a district or a park. Local residents can also report problems by submitting the GPS coordinates of the problem area via the platform (Atlas pokrycia terenu… 2016). Kraków is the first Polish city to have implemented a modern tool for managing urban green spaces.

The "naprawmyTo" service had been tested in Olsztyn in 2012. The local authorities rely on traditional paper document workflow, and mobile applications and geosurveys are not used. Social

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consultations take place during meetings, and the relevant information is available on the city's website. The tested service contained useful information about the location of urban vegetation as well as green areas that are neglected, inadequately planned or deficient in vegetation. The application contained scalable maps, and the results could be visualized on different scales in space and time. The maps were easy to update to monitor the latest trends. The resulting data could be highly useful for municipal GIS systems (Putkowska et al. 2017). If a tree cannot be planted in a suggested location, the application provides the user with the reasons for the above. Not all locations are suitable for planting trees and numerous factors have to be taken into account, including protective zones around railway tracks and flood embankments, property ownership, presence of underground infrastructure, street lamps, posts, other trees and buildings, as well as local zoning plans. The application can suggest alternative locations for planting trees (Google Play 2017).

Urban green spaces can be inventoried with the use of the Monit-Air application as part of the Integrated Spatial Data Monitoring System for Improving Air Quality in Kraków (Kraków 2017). Trees can be accurately mapped by laser scanning. Information about tree health is available to greenery inspectors who can monitor changes in the condition of urban greenery (Więcławska 2016). In some cities, trees are inventoried during local surveys which are conducted at the beginning of a construction project or when felling licenses are issued. Inventories are often conducted with the use of paper documents, and they cover small areas, such as private property. Numerous requests concerning the removal of tall trees are submitted by residents of housing estates, but the results of these inventories are not available to the public (Biejat 2017).

Trend analysis

Sustainable Development Goals (SDG). All Land Administration Systems (LAS) as well as green information systems (green IS) should support the sustainable land management and policy moving towards achieving Sustainable Development Goals – SDG (UN 2015). SDG alongside continuing development priorities, such as the eradication of poverty, health, education and food security, and nutrition, it sets out a wide range.

Deep interconnections and many cross-cutting elements ahead the new Sustainable Development Goals (17) and targets (169) are reflecting the integrated approach (UN 2015).

The particular importance of green IS is to achieve Goal 11: Sustainable Cities and Communities (Make cities inclusive, safe, resilient and sustainable). There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more. The relevant targets will be related to the launch of green IS:

- **11.3.** By 2030, enhance inclusive and **sustainable urbanization** and capacity for participatory, integrated and **sustainable human settlement planning and management in all countries**;
- **11.4.** Strengthen efforts to protect and safeguard the world's cultural and **natural heritage**;
- **11.6.** By 2030, reduce the adverse per capita **environmental impact of cities**, including by paying special attention to air quality and municipal and other waste management;
- **11.7.** By 2030, provide universal access to safe, inclusive and accessible, **green and public spaces**, in particular for women and children, older persons and persons with disabilities;
- **11.A.** Support positive economic, social and **environmental links between urban, peri-urban and rural areas** by strengthening national and regional development planning.

Smart Cities. The smart city concept integrates advanced information and communication technology (ICT) solutions in the process of managing urban areas. This multifunctional concept advocates an intelligent approach to problem solving (Stawasz and Sikora-Fernandez 2015). Rapid technological progress in the past 30 years has encouraged national and local authorities in various regions of the world to define a set of guidelines for deploying ICT tools to stimulate

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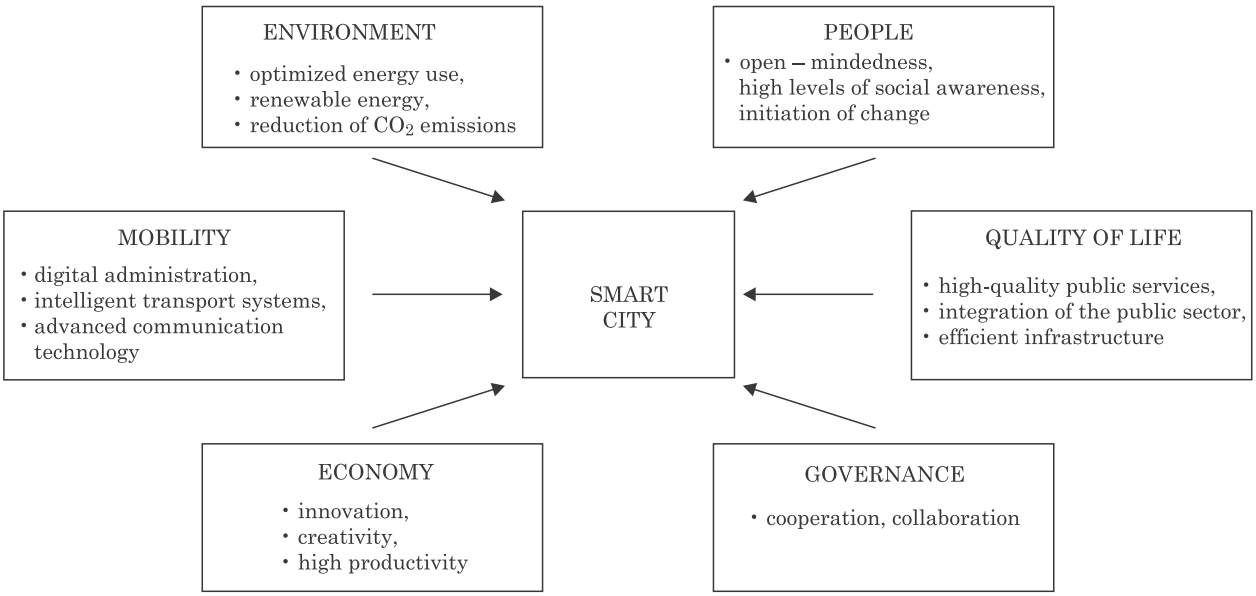

Fig. 3. Characteristic factors of smart cities
Source: own elaboration based on the TUWIEN Team (2018)

urban development. However, consistent criteria for describing a city's "smart" status have not been laid down to date (Tranos and Gertner 2012). The availability and quality of ICT solutions is not the only criterion defining a smart city, and the relationship between ICT infrastructure and economic performance is equally important (Roller and Waverman 2001). There is no single definition of a smart city because the characteristic elements of an intelligent city are difficult to describe. Various definitions have been proposed in the literature. According to Komninos (2002), smart cities are territories with high capacity for learning and innovation, which are built on the creative potential of their population, research and development institutions, higher education institutions, and digital infrastructure for communication and knowledge management. In addition to their technological advancement, intelligent cities are also characterised by suspensivity, creation and distribution of wealth, investment in infrastructure, reduction of poverty and social exclusion (Marceau 2008) and unique urban management strategies (Van der Meer and Van Winden 2003). The above definition accounts for the multidimensional character of smart cities and their ability to transform the urban environment.

Despite their inability to propose a cohesive definition of a smart city, researchers are in agreement on the number of factors that make up the concept. The characteristic factors of a smart city are presented in Figure 3.

Spatially Enabled Society. The concept of a Spatially Enabled Society (SES) marks the growing demand for timely and accurate spatial information. It is derived from the concept of an Information Society (IS) which is defined as a society where advanced digital information and communication technologies are the main drivers of economic growth and the main sources of income for most citizens (Goban-Klas and Sienkiewicz 1999). Steudler and Rajabifard have elaborated on the above concept and argued that an information society should also be spatially enabled (FIG 2012). Spatial enablement denotes the ability to add location to the existing information (localization of knowledge about objects in space), which enables societies to harness

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the existing knowledge about land and water, its legal and economic status, resources, potential uses and hazards. A spatially enabled society relies on the concept of location to organise information and processes. This is one of the strategic goals of many development programs initiated by governments.

Spatial enablement enhances innovation, transparency and democracy. This concept marks the beginning of a revolution in the realm of spatial information. Societies and governments have to be spatially enabled and provided with the right tools and information to make appropriate decisions.

The SES concept creates new opportunities for nations and societies. Its main goal is to promote the effective use and supply of spatial information and services. For this goal to be met, the extent to which spatial data is made available, the quality of spatial information and the relevant responsibilities have to be regulated by law (Onsrud 2010). Flexible legislation could significantly expand the role of SDI in promoting good governance. In a paper analysing the role of SDI in governance, Box and Rajabifard (2009) emphasised the role of governance and defined the most effective governance concepts. They observed that governance is traditionally regarded as a "steering" function which provides leadership and creates a framework for collective decision making. However, in the context of SDI, governance becomes the basic tool for institutional arrangements, and it encompasses functions such as coordination and management. These functions expand the scope of governance to include the implementation of decisions.

Governance plays a key role in SDI; therefore, social participation and spatial enablement foster agreements that bind people with spatial resources (data and technology). However, other functions are also needed to effectively channel collective efforts towards the achievement of common goals.

A socially enabled society derives numerous benefits from access to spatial information and services and relies on these resources to manage land and water. The SES concept has been incorporated into government programs in many countries. The importance of spatial information for strategic policy development decision-making has also been recognised at the local, regional and national level. A socially enabled society operates largely in a virtual world, but these initiatives have to be accompanied by institutional and structural reforms regarding the use of spatial information and SDI as access platforms.

Key activities

Spatial Data Infrastructure (SDI). The past decade has witnessed the development of Spatial Data Infrastructures (SDI), which encompass basic network infrastructures as well as platforms promoting the vision of a spatially enabled society (SES). The aim of the SDI is to provide societies and governments with access to spatial data and to assist them in making the right decisions, in particular decisions relating to spatial management. In this context, the SDI and Land Administration Systems, which contain information about the legal status of property, can be used to generate valuable data for various sectors of the economy. These data are generated and used by different entities. Therefore, the SDI contributes to social awareness and community participation in public life.

The SDI concept was developed on the assumption that the development of products and services based on data gathered at all levels of public administration and society, from government agencies to the private sector and individuals, can promote economic growth, social stability and environmental protection. Spatial data integrated on a single platform play a key role in this context. The first efforts to develop a national SDI were made in the United States in 1990. In successive years, networks for sharing spatial data were launched in other countries. The concept of a pan-European infrastructure for spatial information emerged in 2001. The legal framework for creating SDI in Europe was provided by the INSPIRE Directive (Directive for establishing an Infrastructure for Spatial Information in the European Community) which was adopted by the European Parliament and the Council in 2007 (INSPIRE Directive 2007).

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Table 3. Spatial data themes proposed by the INSPIRE Directive with an indication of the themes that relate to urban green spaces

Annex to INSPIRE Directive	No	Theme
Annex I	1	coordinate reference systems
	2	geographical grid systems
	3	geographical names
	4	administrative units
	5	addresses
	6	cadastral parcels
	7	transport networks
	8	hydrography (complex)
	9	**protected sites (complex)**
Annex II	1	elevation
	2	**land cover**
	3	orthoimagery
	4	geology
Annex III	1	statistical units
	2	buildings
	3	**soil**
	4	**land use**
	5	human health and safety
	6	utility and governmental services
	7	**environmental monitoring facilities**
	8	production and industrial facilities
	9	**agricultural and aquaculture facilities**
	10	population distribution — demography
	11	area management/restriction/regulation zones and reporting units
	12	natural risk zones
	13	atmospheric conditions
	14	meteorological geographical features
	15	oceanographic geographical features
	16	sea regions
	17	**bio-geographical regions**
	18	**habitats and biotopes**
	19	**species distribution**
	20	energy resources
	21	mineral resources

Source: own elaboration based on the INSPIRE Directive (2007)

The SDI concept has various definitions. According to one of them, SDI consists of legal, organizational, economic and technical measures which create public access to spatial data relating to the national territory and geographic information services, make effective use of geographic information to increase the competitive advantage of the national economy in accordance with the principles of sustainable development, promote rational management of geographic data at the national and local level, and contribute to the development of an information society (GISPLAY 2014). The INSPIRE Directive (2007) defines the infrastructure for spatial information as metadata, spatial data sets, spatial data services, technologies, processes and procedures which are applied and shared by public authorities and third parties who co-create the infrastructure.

The above definitions indicate that the SDI concept has emerged to enable various communities to access, use and share spatial data in the process of pursuing different goals. The key function of SDI is to provide a mechanism for integrating spatial data, including cadastral and topographic data, for the needs of the decision-making process. The SDI concept has been implemented in many countries. Modern SDI are platforms that integrate multilevel and hierarchical systems of GIS data and property data based on partnership agreements concluded at the local, regional, national, international and global level. This approach supports effective network management, and it provides institutions and private users with access to spatial information across national borders. The described concept contributes to the development of a spatially enabled society whose members can use information effectively to save money, time and effort. Data can be acquired from many sources without the need for costly copies and maps, and datasets can be integrated (Table 3) to give rise to new services.

The INSPIRE Directive (2007) has laid down five main principles for developing a unified spatial information infrastructure in Europe:

– data should be collected only once and properly stored and maintained by the relevant institutions and services,

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– the continuity of spatial data should be ensured with the aim of acquiring information from various sources and sharing data with multiple users and applications,
– spatial data should be stored at an appropriate (one) level of public administration and made available to operators at other levels,
– spatial data necessary for the proper management of space at all levels of government should be publicly available (without conditions that limit and/or hamper free data use),
– potential data users should be provided with information about the types of available spatial data, the requirements for accessing spatial data as well as information that enables them to determine whether these data meet their individual needs.

Various spatial data themes have been proposed by the INSPIRE Directive (2007), but despite the above, the SDI can be flexibly expanded in the future. The proposed spatial themes are presented in Table 3, and the themes that are directly or indirectly related to the collection and sharing of information on urban green spaces are marked in bold font.

National SDI are used for a variety of purposes, in particular for coordination of space, analyses, property management and land administration. The significance of the SDI in the context of cadastral reform was emphasized in the Bogor Declaration in 1996. The signatories concluded that the spatial cadastral framework, usually a cadastral map, should be the fundamental reference layer within a nation's spatial data infrastructure (UN/FIG 1996). Every system should have specific functionality: the cadastre generates information about property, whereas SDI organises spatial information.

The Land Administration System concept emphasises the need for data integration and proposes changes to the principles of cooperation between the main stakeholders. Above all, it recognises that SDI is a vital tool for collaboration and sharing spatial data. The combined resources of the cadastre and SDI will provide the authorities and the public with unprecedented access to information about land use. The SDI is a major milestone on the way to a spatially enabled society.

Green city competitions. The European Green Capital Award (EGCA 2019) is the result of an initiative taken by 15 European cities (Tallinn, Helsinki, Riga, Vilnius, Berlin, Warsaw, Madrid, Ljubljana, Prague, Vienna, Kiel, Kotka, Dartford, Tartu & Glasgow) and the Association of Estonian cities on 15 May 2006 in Tallinn, Estonia. This award has been granted since 2010 by the European Commission. It is important to reward cities which are making efforts to improve the urban environment and move towards healthier and sustainable living areas. The satisfaction involved in winning a prestigious European award spurs cities to invest in further efforts and boosts awareness within

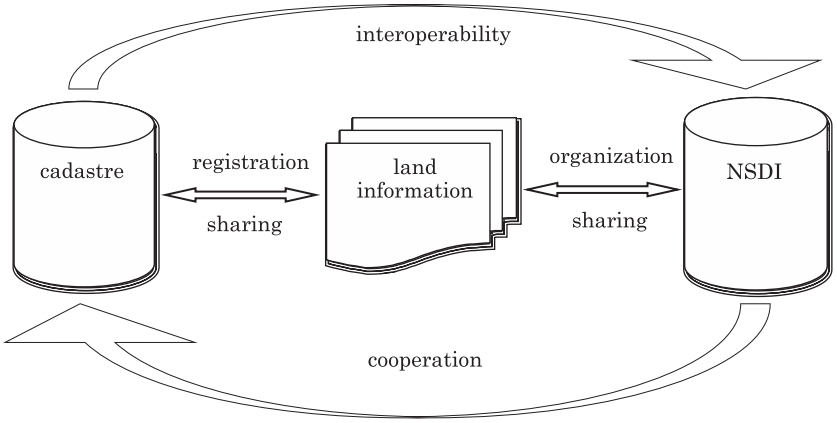

Fig. 4. The relationship between the cadastre and the national SDI
Source: own elaboration

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the city as well as in other cities. The award enables cities to inspire each other and share examples of good practices in situ.

Starting in 2010, one European city is selected each year as the European Green Capital of the year. The award is given to a city that:
- has a consistent record of achieving high environmental standards.
- is committed to ongoing and ambitious goals for further environmental improvement and sustainable development,
- can act as a role model to inspire other cities and promote best practices to all other European cities.

The award aims to provide an incentive for cities to inspire each other and share best practices, while at the same time engaging in friendly competition. In other words, the cities become role models for each other.

Two competitions promoting green city have been launched in Poland, i.e. '**Green cities**' and '**Eco City**'. The Green Cities competition – Towards the Future (GDOS 2019), organized by the Ministry of the Environment, is addressed to cities that carry out environmental protection activities. The competition promotes modern, ecological investments in various areas of urban life and activities aimed at sustainable urban development. The competition is open to cities with poviat rights and municipalities whose projects or investments started not earlier than in 2006 and ended at least 1 month before submitting the competition application.

The competition is conducted in three categories:
- environment and health: projects or investments that directly affect the health of residents, in particular in the field of sustainable transport, greenery in the city and air protection;
- resource saving: projects or investments that affect the saving of natural resources, in particular in the field of water and sewage management and water protection, waste management, energy efficiency;
- environmental education: educational projects or projects implemented by cities that promote environmental behavior among residents.

The inspiration for the Green Cities competition – towards the future is the concept of the European Green Capital.

The ECO-CITY Competition (GRIDW 2019) aims at promoting environmental sustainability by awarding those among large and small-sized municipalities in Poland which are leaders in environmentally responsible sustainable development. **ECO-CITY** project is being organized for the fifth time this year. The project involves a range of events including the Poland-wide contest for municipalities, a conference on environmental sustainability, and a number of associated activities such as seminars and meetings for sharing best practices. Complex greenery design is a long-term process which effects (e.g. in the case of tree plantings) can be felt only after many years, so it is very important to include future challenges and problems in it. **ECO-CITY** is a space for exchange of experiences between city authorities, which helps to imitate good practices.

SUMMARY AND CONCLUSIONS

Despite the fact that urban greenery is not often considered as a good of first necessity, especially in the last decade many factors have appeared that promote greenery in cities and its optimal management using modern information technology. It has been noticed that green information systems are becoming more and more popular and needed.

The green IS is a cohesive information system which can offer considerable support for managers of urban green spaces. Many of green IS contributes to the development of smart cities, fit-for-purpose land administration systems and spatially enabled societies. Cities need reliable information systems to manage urban green spaces in line with the principles of sustainable development. A cohesive green IS can raise the standards for maintaining green areas and can contribute to the implementation of transparent management policies.

Research results have shown a multitude of determinants that influence and guide the development

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of green information systems. They were grouped due to their properties on: key legal framework (national and EU laws), key technology (systems reviews), key trends (global development paradigms, research directions), key initiatives (local and international activities promoting green cities). All conditioning factors are related to and result from each other. Designing new systems will be conditioned and closely related to the identified determinants. The study showed that there is a growing trend of pursuing green cities and developing systems supporting urban greenery management. More impressive results in running green IS could be obtained by implementing Sustainable Development Goals (SDG) solutions in EU or national law. Then one would expect that the development of green IS would be uniform and standardized in different countries.

Cohesive management standards can facilitate the development of urban green spaces and can support the identification of areas where maintenance and remedy measures are most needed. The green IS will provide tools for proposing alternative development scenarios, evaluating and comparing those solutions based on preliminary assumptions and indicators. This is a highly useful feature in complex systems where various management scenarios have to account for the needs of diverse stakeholder groups.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Act on the Protection and Maintenance of Historical Monuments of 23 July 2003. Journal of Laws, 2017, item 2187, as amended.

Atlas pokrycia terenu i przetwarzania Krakowa (Atlas of land cover and processing in Krakow). (2016). Eds. K., Bajorek-Zydroń, P., Wężyk, http://docplayer.pl/51868315-Atlas-pokrycia-terenu-i-przewietrzania-krakowa.html, access: 4.03.2018.

Baycan, T., van Leeuwen, E., Rodenburg, C. (2002). Development and management of green spaces in European cities. A comparative analysis paper presentad at the 38'" International Planning Congress on 'The Pulsar Effect" Planning with Peaks, Glifadafithens, Greece, September 21–26, 2002.

Biejat, K. (2017). Zarządzanie oraz ochrona zieleni w polskich miastach. Raport (Management and protection of green areas in Polish cities), https://uslugiekosystemow.pl/wp-content/uploads/2017/09/Raport_Zarzadzenie_Zielenia.pdf, access: 20.02.2018.

Biodiversity strategy 2011. Council of the European Union, EU Biodiversity Strategy to 2020 – Council conclusions (2011), http://ec.europa.eu/environment/nature/biodiversity/strategy/index_en.htm#stra, access: 21.03.2019.

Box, P., Rajabifard, A. (2009). SDI governance. To steer or row. GIM International 23(2). Retrieved on 20 February 2018, http://www.gim-international.com/issues/articles/id1276-SDI_Governance_to_Steer_or_Row.html.

Brocke, J.V., Watson, R.T., Dwyer, C., Elliot, S., Melville, N. (2012). Green information systems. Directives for the IS discipline. Communications of the Association for Information Systems (CAIS) 33(30), pp. 509–520

Burlińska, A. (2013). Miejscowy plan zagospodarowania przestrzennego jako narzędzie zarządzania przyrodą w mieście (Local zoning plan as a tool for managing nature in the city. Zrównoważony rozwój. Zastosowania 4, 133–143, http://ww.sendzimir.org.pl/sites/default/files/wzr4/wzr4-10.pdf, access: 5.03.2018.

Čivić, K. Jones-Walters, L.M. (2014). Implementing green infrastructure and ecological networks in Europe. Lessons learned and future perspectives. Journal of Green Engineering 4, 307–324, doi: 10.13052/jge1904-4720.444.

Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' of the Polish cadastral system based on the global cadastral model. Land Use Policy 73, 59–72, https://doi.org/10.1016/j.landusepol.2018.01.037.

✉magda.nowak@uwm.edu.pl

Dedrick, J.L. (2010). Green IS. Concepts and issues for information systems research. CAIS 27(1), p. 11.

EC. (2012). The Multifunctionality of Green Infrastructure, In-Depth Report, DG Environment News Alert Service, http://ec.europa.eu/environment/nature/ecosystems/docs/Green_Infrastructure.pdf, access: 21.03.2019.

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, http://ec.europa.eu/environment/nature/ecosystems/docs/green_infrastructures/1_EN_autre_document_travail_service_part1_v2.pdf, access: 20.04.2019.

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.

EGCA. (2019), http://ec.europa.eu/environment/europeangreencapital/about-the-award/#Background%20to%20the%20European%20Green%20Capital%20Award, access: 21.08.2019.

Enemark, S., Bell, K.C., Lemmen, Ch., McLaren, R. (2014). Fit-For-Purpose Land Administration. International Federation of Surveyors (FIG). Jensen Print, Frederiksberg, Denmark, p. 44.

Environmental Protection Law of 16 April 2004. Journal of Laws, 2016, item 142.

Europe 2020. Integrated guidelines for the economic and employment Policie of the Member States, part I i II, Brussels, 27.4.2010 SEC(2010) 488 final {COM (2010) 193 final}, http://ec.europa.eu/europe2020/pdf/brochure_integrated_guidelines.pdf, access: 10.03.2018.

FIG. (2012). FIG 'Spatially Enabled Society'. Eds. D., Steudler, A., Rajabifard. FIG Publication no. 58, Copenhagen, FIG Press, Denmark.

GDOS (2019), https://www.gdos.gov.pl/zielone-miasta-w-strone-przyszlosci, access: 21.08.2019.

GEO INFO Strategies. (2018). Cadastre of green areas. Retrieved on 23 February 2018, http://geoinfo.mycpanel.rs/wp/en/cadastre-of-green-areas/.

GISPLAY. (2014), http://gisplay.pl/gis/krajowy-system-informacji-przestrzennej.html, access: 21.02.2018.

Goban-Klas, T., Sienkiewicz, P. (1999). Społeczeństwo informacyjne. Szanse, zagrożenia, wyzwania (Information society. Chances, threats, challenges). Wyd. Fundacji Postępu Telekomunikacji, Kraków.

Google Play. (2018), https://play.google.com/store/apps/details?id=umw.architects.pl.treelionHYPERLINK "https://play.google.com/store/apps/details?id=umw.architects.pl.treelion&hl=pl"&, access: 5.03.2018.

Google Play. (2017), https://play.google.com/store/apps/detailsid=umw.architects.pl.treelion&hl=pl"HYPERLINK, access: 20.02.2018.

GRIDW. (2019), https://gridw.pl/innowacyjneecomiasto/eko-miasto?lang=en, access: 21.08.2019.

INSPIRE Directive. (2007). INSPIRE 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).

Jenkin, T.A., Webster, J., McShane, L. (2011). An agenda for 'Green'information technology and systems research. Information and Organization 21(1), 17–40.

Komninos, N. (2002). Intelligent cities. innovation, knowledge systems and digital spaces. Taylor & Francis, London. p 301.

Kosmala, M., Okołowicz, M. (2014). Jak uzdrowić miasto (How to heal the city?) Przegląd Komunalny 8, 36–38.

Kierunki rozwoju i zarządzania terenami zieleni w Krakowie na lata 2017–2030 (Directions of development and management of green areas in Krakow for 2017–2030). (2017). Wydział Kształtowania Środowiska Urzędu Miasta Krakowa, https://dialogspoleczny.krakow.pl/wp-content/uploads/2017/04/1_OPIS-05_04_17.pdf, access: 20.01.2018.

Laboratorium EE. (2012), http://naprawmyto.pl/p/czym_jest_naprawmyto.pl%3F, access: 9.03.2018.

Lelova, R., Blikov, I. (2012). Digital cadastre of urban greenery – case study municipality of kavadarci (an extract from BSc diploma thesis). First Serbian Congress 'Future with forest'. University of Belgrade, Faculty of Forest, p. 946.

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, 27–37, http://sendzimir.org.pl/sites/default/files/wzr4/wzr4-2.pdf, access: 25.01.2018.

✉magda.nowak@uwm.edu.pl

Magiczny Kraków. (2018). Wypróbuj nową aplikację Zarządu Zieleni Miejskiej, http://krakow.pl/aktualnosci/213700,29,komunikat,wyprobuj_nowa_aplikacje_zarzadu_zieleni_miejskiej_.html, access: 7.03.2018.

Marceau, J. (2008). Innovation in the city and innovative cities, Innovation. Management, Policy and Practice, 10(2), 136–145.

Marian, M.C. (2014). Green cadastre and its importance in long-lasting development. Baltic surveying. Proceedings of Scientific Methodical Conference, Jelgava, Latvia, 7–9 May 2014, pp.10–15, http://www.vbf.llu.lv/sites/vbf/files/2017-03/Proceedings%20Baltic%20Surveying.pdf#page=11, access: 19.03.2018.

Masłowska-Gądek, A. (2017). Analiza prawna przepisów i ustaw w kontekście ochrony przyrody w mieście. Raport (Legal analysis of laws and regulations for the protection of nature in the city), https://uslugiekosystemow.pl/wp-content/uploads/2017/09/Analiza_prawna.pdf, access: 3.03.2018.

Mishra, D., Akman, I., Mishra, A. (2014). Theory of reasoned action application for green information technology acceptance. Computers in Human Behavior 36, 29–40.

Molla, M.B. (2015). The value of urban green infrastructure and its environmental response in urban ecosystem. A literature review. International Journal of Environmental Sciences, 4(2), 89–101.

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.

Onsrud, H. (2010). Legal interoperability in support of spatially enabling society, in: Spatially enabling society. Research, emerging trends and critical assessment, Belgium: Leuven University Press, pp. 163–172.

Public Roads Act of 21 March 1985. Journal of Laws, 2017, item 2222, as amended.

Putkowska, R., Czepkiewicz, M., Pietrzyk-Kaszyńska, A., Konenberg, J. (2018). Raport. Świeże spojrzenie na zieleń. Geoankiety – nowe źródło informacji o mieście (A fresh look at greenery. Geo surveys – a new source of information about the city), https://uslugiekosystemow.pl/wp-content/uploads/2017/08/raport_final_press-1.pdf, access: 20.01.20018.

Roller, L.H., Waverman, L., (2001). Telecomunication infrastructure and economic development. A simultaneous approach. American Economic Review 91(4), 909–923.

Stawasz, D., Sikora-Fernandez, D. (2015). Dobre praktyki inteligentnego zarządzania w polskich miastach (The best practices of smart management in Polish cities). Studia Miejskie 19, 35–46.

Tranos, E., Gertner, D. (2012). Smart networked cities? Innovation. The European Journal of Social Science Research 25(2), 175–190.

TUWIEN team Works. (2018). Vienna University of Technology, http://www.smart-cities.eu/?cid=--1HYPERLINK "http://www.smart-cities.eu/?cid=--1&ver= 3"&HYPERLINK "http://www.smart-cities.eu/?cid=-1&ver=3"ver=3, access: 14.03.2018.

UN. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. UE Sustainable Development Agenda, Resolution A/RES/70/1, pp. 35,

UNDP. (2016). The former Yugoslav Republic of Macedonia. Creating a green cadastre to help make Skopje a greener city, http://www.mk.undp.org/content/the_former_yugoslav_republic_of_macedonia/en/home/presscenter/articles/2016/02/15/creating-a--green-cadastre-to-help-make-skopje-a-greener-city-.html, access: 21.02.2018.

UN/FIG. (1996). The Bogor Declaration. United Nations Interregional Meeting of Experts on the Cadastre, Bogor Indonesia, http://www.fig.net/commission7/reports/bogor/BogorDeclaration.html, access: 15.02.2015.

Więcławska J. (2016). Wydobyć potencjał (Bring out the potential). Zieleń Miejska 12, 11–13.

Williamson, I.P., Enemark, S., Wallace, J., Rajabifard, A. (2010). Land administration for sustainable development, ESRI Press, p. 487.

Van der Meer, A., Van Winden, W. (2003). E-governance in cities. A comparision of Urban Information and communication technology policies. Regional Studies 37(4), 407–419.

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