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The primary aim of the journal and its mission are to spread information and guidance relevant both for authorities responsible for the effective land administration (local, regional and central), scientists and teachers.

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PLANNING STEPS OF URBAN GREEN INFRASTRUCTURE IN EXISTING CITIES

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ABSTRACT

The negative impacts of climate change have spread widely and calls increased toward finding smarter strategies that can support both climate change adaptation and mitigation. Urban Green Infrastructure (UGI) is considered a certain type of such strategies. The literature review indicates a lack of knowledge regarding the planning steps of UGI in existing cities. In addition, the comparison between the studies that tackle the subject point out that there are differences between the definition and sequence of these steps. The current research aims to find out the optimal planning steps of UGI and the most acceptable sequence of the planning process for climate change smart adaptation in existing cities. By using the methodology of "learning by doing", the research seeks to conclude these steps from the world's real practices. A cross-case analysis was conducted between four main practices to define the relationship between their planning steps and determine their similarities and differences. The cross-analysis revealed that the practices almost followed similar processes but with different definitions and sequences of planning steps. Based on the intersections between practices and by following the planning logic, the optimal definition and sequence of UGI planning were extracted and outlined in "seven planning steps". These steps include: providing the precise identification of the impact, identifying the higher-risk neighborhoods, collecting data about the existing conditions, protecting and enhancing existing green and blue elements, adding new UGI assets, drawing the results, and finally calculating the UGI effectiveness. This set of steps can guide the whole process of UGI planning and ensure the maximum benefits of employing it in existing cities to achieve the climate change smart adaptation.

Keywords: climate change, green infrastructure, smart planning, adaptation, mitigation, existing cities

INTRODUCTION

There is an unprecedented change in the global climate system. Related studies confirmed that human modern activities are the main cause of this change. The atmosphere, ocean, and land warm decade after decade. In the period between (2020–2021), the average temperature of the earth's surface increased by about 0.99°C higher than it has been between 1850–1900, which refers to the pre-industrial period. In general,

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land witnesses a more warming pattern than the other regions (IPCC, 2021). Over time, climate change caused many species' extinction, large people migration, and substantial weather changes. So, it is not a newly appeared phenomenon. The new facet represents in its speed which dramatically increases to surpass the earth's natural ability to absorb or cope (USNAS, 2014). This causes many devastating impacts such as extreme weather (e.g., hurricanes and cyclones, heatwaves, sand and dust storms, wildfire and cold spells, etc.), floods, precipitation change, droughts, temperature rise, and rise in sea level (UNFCCC, 2019). This leads to significant losses representing water scarcity, agricultural land reduction, health degradation, deforestation, etc. (UNFCCC, 2019).

The impacts of global climate change are mainly concentrated in cities where more than 50% of the earth's inhabitants settle and live (Hunt & Watkiss, 2011). There is an interactive relationship between urbanized areas and climate change. From a certain side, cities are the most diagnosed cause of many environmental problems. The impacts of such problems extend beyond the cities' geographical boundaries and directly contribute to the accumulation of global climate change. On the other side, cities are the most vulnerable areas to the negative impacts of this change (Salata & Yiannakou, 2016).

In the first human attempts to counter climate change, the focus was intensively directed toward the concept of "adaptation" which enables societies to deal with climate change's impacts. After a while, great awareness has risen regarding the uselessness of addressing the impacts without addressing the causes. Accordingly, "mitigation" which enables societies to reduce the climate change's causes, acquired the same importance as adaptation in the field of climate change control. Both of them are considered two sides of the same coin of climate change control (Davoudi, 2009; Janetos, 2007). The current research's attention is directed toward finding a win-win approach of climate change mitigation and adaptation. This approach will be named a smart climate change adaptation (CCSA). In the present research. CCSA can be defined as (the process and its results of depending on the appropriate adjustments in the human and natural systems to cope and reduce climate change impacts and causes simultaneously).

For urban planners and designers, achieving synergies between climate change adaptation and mitigation is not an easy mission. That is because of the small number of integrated strategies that can assure this approach (Davoudi, 2009). A review of the related literature revealed that Urban Green Infrastructure (UGI) represents a certain type of CCSA. That is because UGI services support both adaptation and mitigation functions (Samora-Arvela et al., 2017; Abdulateef & Al-Alwan, 2022). In countering the temperature rise, for example, the adaptive role of UGI represents in reducing air and surface temperature via two main processes of evapotranspiration and shading. On the other hand, the mitigative role of UGI represents by reducing greenhouse gases (GHG) emission and their concentrations within the biosphere via the carbon storage and sequestration (Demuzere et al., 2014).

UGI can be defined as "the networks of green and blue spaces in urban areas, designed and managed to deliver a wide range of ecosystem services and other benefits at all spatial scales" (Hansen et al., 2017a). In existing cities, UGI is usually challenged by many barriers such as the built-up layers, the shortage of traditional green spaces, etc. Accordingly, the current research aims to provide knowledge about the planning steps of UGI for CCSA in existing cities. The purpose of this paper is reviewing and analyzing some good practices of UGI planning in existing cities. That is to offer a clear knowledge about the most adopted planning steps in these practices which can be adopted in other cities around the world.

LITERATURE REVIEW

Reviewed studies will be presented concerning the research's basic field which is UGI planning steps in existing cities. In 2013, Firehock conducted a related study that explained six steps of UGI planning (Firehock, 2013). These steps include: setting goals, reviewing data, drawing an assets map, assessing risks,

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determining opportunities, and implementing them. The first step involves a clear definition of what the community values. Reviewing data (step 2) includes the collecting of all available and required data about the identified values. Following this step, all valued assets should be clearly mapped (step 3). Assessing risks (step 4) aims to clearly define the assets which are vulnerable to climatic risk. The fifth step "determining opportunities" involves the identification of the at-risk assets that should be protected and restored. At the final step of Firehock's suggested planning approach, opportunities should be implemented according to daily and long-term maps (step 6).

Landscape Institute (LI) in London city suggested another series of UGI planning steps which are: partnering and vision, contextual review, information audit and resource mapping, needs and opportunities valuing, detailing the planned interventions, implementation, management and maintenance (LI, 2013). Following such steps can ensure the provision of different ecological, social, and economic benefits. Another study conducted by Hansen et al. assured that UGI planning can be conducted according to a different set of steps which represent in: setting goals, identifying the suitable sites, following principles of planning, defining the qualification requirements, making targeted use of instruments, working together for green infrastructure, securing and developing the green infrastructure (Hansen et al., 2017a). This approach sheds the light on the importance of community cooperation in all planning stages.

In 2018, Ruskule et al. revealed that to counter water scarcity and achieve successful management of lowland rivers, UGI should be planned according to three main steps (Ruskule et al., 2018). These steps comprise mapping and assessing current UGI, assessing UGI status and identification of problems, and developing UGI improvement scenarios. The study also includes the testing of the proposed planning methodology at four different planning levels.

The United Kingdom Green Building Council reported that to have an efficient network of UGI, the planning steps should start by having a real corporation with the stakeholders and all collaborative sectors (UKGBC, 2020). Second and third steps should involve the active experts' participation, and the thorough connecting of the landscape policy to the planning framework. The following steps should include assessing the UGI current elements, developing a UGI plan, implementing and managing the UGI plan, and putting the UGI strategy at the organizational scale.

The thorough review of the above-mentioned studies reveals that, although there is a comparative agreement on following some steps of UGI planning, such as drawing a base UGI map and assessing its values, there are also clear differences concerning other steps, such as defining the stakeholders and the use of UGI planning principles. Another difference between the reviewed studies can be noticed as there are cross-studies steps, such as drawing UGI assets map and establishing wide coordination, which appears in a different sequence in each approach.

Previous studies provided knowledge about the steps of general UGI planning as they proposed it for different aims such as conserving natural resources, improving people's health, supporting cultural identity, finding a vibrant community, etc. Adapting UGI for climate change adaptation was also mentioned but without detailing its requirements and challenges.

Therefore, it can be concluded that knowledge concerning the planning steps of UGI as a strategy for climate change smart adaptation is not sufficiently clear. Although there is some agreement concerning some steps of UGI planning such as (drawing a base UGI map and assessing its values), there is also a difference in defining these steps and their sequence. So, there is no agreed-upon theoretical knowledge of planning UGI in existing cities. Accordingly, there is a lack of knowledge concerning the planning aspects of UGI as a strategy for climate change smart adaptation in existing cities. More researches addressing this aspect are required.

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METHODOLOGY

In the Cambridge English dictionary, the word "Step" refers to "one of the things that you do to achieve something" (Cambridge Dictionary, 2020). Hence, following some compatible steps will assist in achieving the pre-defined aims of the planning process. To identify the steps of UGI planning in exiting cities for CCSA, some good cases of UGI planning will be reviewed and analyzed. This method is called "Learning by doing" or "adaptive planning". Learning by doing or learning by practices is a scientific landscape approach that aims to construct the planning process on the available knowledge that is embodied in real practices. This method can provide practical evidence of the usefulness of any landscape intervention (Ahern, 2007). By reviewing some related studies, it was found that the methodology of "learning by doing" was previously used to find some results about UGI (Mell, 2010; Lennon & Scot, 2014; Grădinaru & Hersperger, 2018). So, it is a reliable research method. By using this method, the following stages were proposed to achieve the research aim:

– Stage 1: selecting some practices (case studies) of UGI planning in existing cities for CCSA.
– Stage 2: providing a general overview of each case study with an intentional focus on the city's geographical location, configuration, and climate conditions.
– Stage 3: exploring the impacts of climate change on the city environment and the adopted UGI strategy. This stage presents a clear definition of the steps of the UGI planning process in each case study.
– Stage 4: conducting a cross-analysis between the steps of UGI planning of the case studies.
– Stage 5: extracting the planning steps of UGI for CCSA in existing cities.

The process of selecting the case studies was based on some criteria that were set up to well direct the research towards achieving its aim. These criteria are summarized in the following:

– All selected case studies are existing cities that employ UGI for CCSA such as stormwater management or urban heat island control.
– All selected case studies are existing cities that employ UGI with a clear set of planning steps.

Around the world, there are many cities that employed UGI networks, such as: Malmo; Sweden, Milan; Italy, Edinburgh; Scotland, New York; USA, etc. (Hansen et al., 2017b). Accordingly, four main cities which are fully compatible with the previous criteria are selected namely: Philadelphia; USA, Melbourne; Australia, Tucson; USA, and Singapore; Southeast Asia.

1. Philadelphia, USA

Philadelphia is located at 40°0′N and 75°8′W towards the eastern coast of the country. It is the largest city in Pennsylvania (U.S. Census Bureau, 2016; Focht, 2013). Until 2018, Philadelphia was occupied by about 1,584,138 people with a density of more than 4500 people/ km². The total city area is about 369.62 km², of which 347.52 km² is land and 22.09 km², or 6%, is water. The water ratio includes rivers, lakes, parks, and creeks (United States Census Bureau, 2018). According to Köppen climate classification, the city of Philadelphia has a temperate humid subtropical climate (symbolized as Köppen Cfa). Relatively high temperatures and distributed rainfall throughout the year seasons are the main characteristics of this climatic group (Weatherbase, 2020).

In 2009, Green infrastructure was launched as a basic strategy of the Green city – Clean water program, which was identified by Philadelphia water department (PWD) to control the overflow of the combined sewer system. In Philadelphia, the combined sewer system serves about 48% of the city. In the case of moderate or heavy rainfall, the combined sewer system reaches its peak capacity and directly discharges water into the city water bodies, causing significant water pollution. UGI was employed to control this case of the combined sewer overflow (PWD, 2011). Within Green city – Clean water program, green infrastructure is defined as "a group of soil-water-plants systems that delay and intercept the stormwater flow". They absorb, allow filtration, evaporate, and delay the water release into the combined sewer system (PWD, 2011).

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As a sustainable stormwater strategy, UGI is mainly planned and designed to reduce surface runoff and prevent floods. Other related services of UGI are ranking in second place, enhancing the effectiveness of the strategy. UGI provides a natural ability for onsite rainwater capturing and treating by providing more natural filtration. This leads to reduce the surface runoff and store it as underground water. Simultaneously, it causes a minimization in the volume of the greywater, as well as the pressure on the sanitation system and water treatment plants (Copeland, 2014).

Green city – Clean water program takes place in three parallel paths which combine both private and public sectors (PWD, 2016). The program of public investment or what is named "capital projects" involves the incorporation of UGI assets in the city ownership location (PWD, 2018). The planning phase of UGI capital projects was directed to define and prioritize the opportunities of having green and blue assets in a city-owned and private property where owners have an interest in stormwater management. The planning process had a clear workflow which consists of the following steps (PWD, 2016, 2018):

– Step 1: project initiation: this step included providing a clear definition of the study area. It involved the identification of the project's spatial scope, schedule, and budget. Within this step, hard efforts were conducted to review and understand the available data about the study area such as the GIS maps or any other type of format.
– Step 2: existing conditions evaluation: represented in exploring the physical conditions of the study area and surveying the current planning initiatives. The study area conditions such as land use, vacancy, tree-covered area, major public parcels such as churches, schools, transportation facilities, etc. were identified in a set of separate detail layers. All current and future planning initiatives were also reviewed. That was to define UGI future opportunities and barriers.
– Step 3: drainage area delineation: producing maps of stormwater drainage patterns within the city represented an essential procedure of UGI planning in Philadelphia. The rainwater flow within the city's parcels and streets was thoroughly analyzed and mapped. To have a precise drainage delineation, all influencing factors such as the location topology, site configuration, and inlets positions were considered in this analysis.
– Step 4: feasibility analysis: this step aimed to identify the suitable physical locations of UGI projects within the study area. The potentiality of locations to have UGI projects was divided into three levels of high, medium, and low according to the site exiting constraints. A feasibility analysis was conducted first at the streets level and followed at the parcels level. The analysis showed that some drainage areas can be managed by both streets and parcels UGI projects.
– Step 5: alternative selection: many potential locations for UGI projects were identified from the previous step of feasibility analysis. To select the most suitable alternatives, especially in sites that can be managed by both streets and parcels UGI, PWD plan highlighted some criteria which facilitated the selection process.
– Step 6: Packaging: this stage included the grouping of the proposed UGI locations into packages of about 10-15 assets which were similar and spatially close to each other. This assisted in saving cost, work and time.

2. Melbourne, Australia

Melbourne or Greater Melbourne is located at 37°49'S and 144°58'E, within the state of Victoria and on the southern shore of south-eastern Australia (Australian Bureau of Statistics, 2011). The total city area is about 9992.5 km^2, representing the metropolitan area with 31 municipalities (Australian Bureau of Statistics, 2016). Melbourne is widely known as "Australia's garden city" as it has a unique network of parks and gardens. According to Köppen climate classification, Melbourne has a temperate oceanic climate (symbolized as Köppen Cfb) with moderate winters and warm to hot summers (Tapper & Tapper, 1996). Melbourne is located within the southern

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hemisphere which is recognized for having reverse seasons than those in North America, Europe, and most of Asia. So, changes of seasons in Melbourne are known for starting late. January and February present high summer months, while May, June, July, and August represent the winter months. For rainfall, December has the most amount of about 2.5mm, while February has the least about 1.6" (Melbourne, 2020; Australian Bureau of Meteorology, 2020).

UGI strategy was proposed in Melbourne to control urban heat island (UHI) and cool the microclimate in its different urban spaces (Bosomworth et al., 2013). Melbourne's strategy refers to UGI as a "connected network of natural and human-added vegetation which includes parks, gardens, trees, green walls, and roofs, etc." (Bosomworth et al., 2013). Some basic steps were identified to guide the planning of UGI strategy in Melbourne. These steps were summarized in the following (Norton, et al., 2014):

– Step 1: identify priority areas: these areas represented those of high exposure and vulnerability. Identifying exposure areas depended on a deep analysis of Melbourne UHI. That was to identify the regions of the higher and lower temperature and the thermal variation within the single region. Areas that had intensive pedestrian activities such as the city center were recognized and put first as they had higher exposure to UHI. After that, identifying vulnerability assessment was conducted.
– Step 2: maximize the cooling effect of existing UGI: this aimed to increase the plant's health by, for example, irrigation which would improve the plant's ability to lower temperature and provide shade. To overcome the crisis of water scarcity through the hot seasons, recycled water from sewage systems and the rainwater of the storm infrastructure were used as alternative resources of water. Increasing the built surface permeability was also adopted to allow for more rainwater infiltration. In addition to that, a mix of native and deciduous plants was selected to offer natural adaptive vegetation.
– Step 3: prioritize streets to have UGI: priority points to have UGI are usually represented in car parking, street intersections, and canyons that have intensive exposure to UHI.
– Step 4: analyze and select UGI assets: this step included the process of selecting and designing the most appropriate UGI assets. At the neighborhood level, open green spaces were proposed when there were available open areas. At the canyon scale, trees were adopted where there was enough space in the street. On the other hand, green walls and roofs were proposed for the high built-up areas.

3. Tucson, USA

Tucson is located at 32°13′N 110°55′W in the southwest region of USA. It is one of the biggest cities in the state of Arizona. The city's total area is about 588.65 km². Tucson lies on an alluvial plain in the Sonoran Desert. It is surrounded by five small ranges of mountains (City of Tucson, 2011). According to Köppen climate classification, Tucson has a hot semi-arid climate (symbolized as Köppen BSh) with two main seasons of moderate winter and very hot summer (CLIMATE-DATA.ORG, 2020).

The Southwestern U.S., where Tucson is located, is a broad desert characterized by a hot-dry climate with long months of drought waves. These waves are usually interspersed with heavy rainfall which can cause severe floods. This high-intensive rainfall usually occurs in the form of short-duration thunderstorms which happens in the summer season from July to September and causes severe floods (City of Tucson and Pima county, 2015). Heat stress forms another real climatic issue in the state of Arizona which witnessed the highest national rate of weather-related deaths since 1986 (Ogata, 2014).

Tucson strategy refers to UGI as constructed elements which employ natural systems to provide multiple benefits (WMG, 2015). Tucson's UGI strategy depends on the concept of "stormwater harvesting" at the neighborhood scale. At the same time, UGI can significantly contribute in lowering the city UHI phenomenon (WMG, 2017). Concerning UGI planning in Tucson, some basic steps were identified as a core structure of Tucson UGI strategy. These steps were summarized in the following (WMG, 2017):

– Step 1: identify the watershed: this step was crucial when UGI strategy was adopted for stormwater

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control. The step included determining how water flows and where it collects in the city neighborhood. Areas, where rainwater is usually collected, were carefully mapped and defined.
- Step 2: identify the suitable groundwater recharge areas: these areas represented points where the groundwater level is shallow. Points with lower groundwater levels represented the most ideal points to direct the water flow and have new UGI assets.
- Step 3: identify the vital routes: this step aimed to identify routes that are heavily used by pedestrians and cyclists. The step also included the identification of gathering spaces where people usually meet and recreate.
- Step 4: identify the potential opportunities to have UGI: these opportunities represented the right-of-way, vacant lots, parking, public schools, other infrastructure, etc.
- Step 5: identify the best opportunities: this step included a trade-off comparison between potential opportunities in terms of flood control capacity and cost. That was to define the most appropriate ones.

Accordingly, many maps have resulted. When these maps were overlaid, the priority places where UGI was needed and appropriate became obvious. The most appropriate spots to have UGI appeared where these maps intersected and overlapped (WMG, 2017).

4. Singapore, Southeast Asia

Singapore is an island city-state in Southeast Asia, with an area of about 719 km^2. It has a tropical and coastal climate characterized by high temperature, humidity, and rainfall intensity distributed throughout the year. On average, rain falls about 178 days in the year (Meteorological Service Singapore, 2021). Storms come usually in the form of monsoon surges. Singapore constitutes flat areas with low-lying pockets on the eastern and southern coasts. Having such geography increases the flood risks, particularly when intensive rainfall concurs with high tide movement (PUB, 2013). Despite the land scarcity, the country witnessed a rapid urbanization process over the past few decades and became the third most densely populated country in the world (UN, 2016). Construction of the high-density development leads to an increase in impervious surfaces and a reduction in the green spaces. Accordingly, the site's natural ability to filtrate and absorb the stormwater was reduced significantly. This leads to an increase in the runoff peak and causes terrible floods (PUB, 2013). In addition to causing floods, the resulted runoff forms a major source of water bodies' pollution (Liao, 2019). Unremitting efforts were made in Singapore to find a smart strategy that can prevent the risk and benefit of each drop of rain to ensure water security (Sen, 2014).

In 2016, a program of Active, Beautiful, Clean (ABC) Waters was launched by Singapore's national water agency (Public Utilities Board – PUB) (PUB, 2018). ABC program follows a set of earlier water-vegetated plans which were adopted to enhance Singapore's scene. The outcomes of these plans put the foundations for ABC program (CLC, 2017). Originally, Singapore negated the risk of flooding by the construction of many reservoirs, concretized rivers, canals, and drains. These elements were planned as pathways to convey stormwater and prevent floods. They formed a network of highly used, centralized, controlled, and unattractive places which remained empty and dismal in the dry seasons (Liao, 2019). From this backdrop, ABC instructions regarding stormwater management emerged. The instructions assured the importance of inversing the physical and social image of the existed water elements from drainage channels and tanks to attractive community spaces (PUB, 2018). ABC program also assured that treating stormwater via the original water canals (pathways) is not enough as water should also be treated in spaces where stormwater is generated (sources) and spaces where stormwater may affect other infrastructure and cause risks (receptors) (PUB, 2018). The source-pathway-receptor approach was adopted to mitigate runoff at sources, expand pathways' capacity to convey runoff, and add flood protection at receptors (Lim & Lu, 2016). In a high-density city such as Singapore, planning UGI is significantly challenged by many

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constraints. The most effective constraint is land scarcity. ABC program proved its success to overcome such an issue (Liao, 2019).

ABC program involved many subprograms and applications deeply related to each other. In the current research, an intentional focus will be directed to those parts of the sustainable stormwater management of Singapore that thoroughly discussed UGI planning process. Depending on studies that explored the sustainable stormwater management in Singapore, the planning steps of UGI strategy can be presented as follows:

– Step 1: maximize the benefits of the existing pathways: an essential step of UGI planning in Singapore practice was protecting and enhancing the water pathways. This planning was built upon qualifying what the site had of pathways considering them as the starting point to have a strong and unique UGI network. Dealing with the existing assets is not limited on enhancing the environmental functions of flood reduction only, but also to adding a strong social role to these assets to be a part of everyday life. That is to integrate people with water and the environment (PUB, 2018).
– Step 2: conduct a risk assessment: UGI planning in Singapore practices was based on assessing the flood risk which mainly depends on the site lying and the development type. Singapore strategy referred to the necessity of employing UGI in the eastern and southern coasts of the city as they are low-lying areas and are more vulnerable to flood risk (PUB, 2013). Such areas have the priority to have UGI strategy. The classification of locations into sources, pathways, and receptors also depends on defining the on-site type of risk (PUB, 2018).
– Step 3: add new UGI assets in sources locations: ABC program involved a proactive implementation of UGI assets or what was called (ABC Water design features) (Sen, 2014). To prevent floods sustainably, ABC program sought to employ green elements as a nature-based solution to delay, filtrate and store the runoff (Liao, 2019). The elements store stormwater temporarily and release it slowly to the constructed drainage system. Reducing peak runoff at sources locations depends mainly on injecting different assets of UGI. The injection process implied some certain sub-steps which are:
  - Select the appropriate sites of the new UGI assets: ABC program involved a master plan approach at the country scale. This master plan identified precisely the sites of all UGI projects. The selection process of the appropriate sites was based on five main criteria which are: concerning the sites' potentials that contribute to water quality improvement, incorporation of educational activities benefiting the community, ease of implementation, and the integration with an existing development project or park (Liao, 2019).
  - Define the site's existing and proposed runoff conditions: data was collected about the site area; the potential peak inflow and the expected time to reach this peak. In this sub-step, the allowable peak outflow of the site and the entailed time were also defined. That depended on PUB guidelines of flood reduction (PUB, 2013).
  - Determine and design new UGI assets: to achieve the allowable peak outflow and reduce time to peak, appropriate UGI assets were selected. PUB presented specific guidance for selecting, sizing, implementing, and maintenance of the ABC Water features. Defining the suitable UGI was based on many considerations such as space availability, topography, site obstructions, maintenance, and safety (PUB, 2013).

DISCUSSION

To find out the most adopted definition and sequence of the planning steps of UGI, a cross-analysis between practices will be conducted. To achieve this, the planning step of UGI in each practice will be symbolized (Fig. 1). Each step will have a symbol of a letter and number such as P1 and M2. The letter refers to the city name, for example, P for Philadelphia and M for Melbourne, T for Tucson, and S for Singapore. The number refers to the step sequence, for example, 1 for the first step and 2 for the

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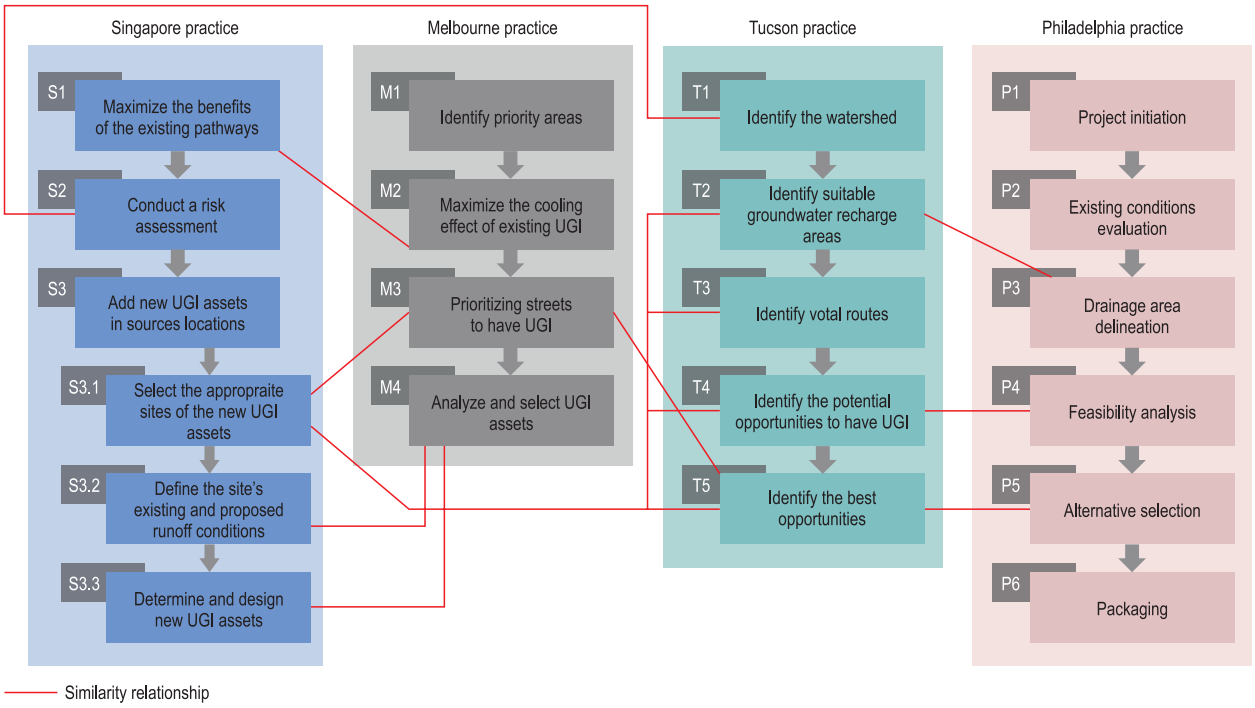

Fig. 1. Cross analysis of the case studies
Source: own preparation.

second step, and so on. The cross-analysis between the planning steps of the four practices represents the following points:

- Step S1 "maximize the benefits of the existing pathways" and M2 "maximize the cooling effect of existing UGI" referred to the same process of protecting and enhancing the existing water and vegetated elements and qualifying them as UGI assets.
- Step S2 "conduct a risk assessment", P3 "drainage area delineation" and T1 "identify the watershed" referred to almost the same process of drawing and understanding the potential risk of climate change impact and its pattern in the study area.
- Step T4 "identify the potential opportunities to have UGI" and P4 "feasibility analysis" aimed to define the available locations for adding the potential UGI in the study area.
- Step S3.1 "selecting the appropriate sites of the new UGI assets", M3 "prioritize streets to have UGI", T5 "identify the best opportunities", and P5 "alternative selection" involved the same process of adopting some priority local criteria to select the most suitable locations for adding new UGI assets.
- Step M4 "analyze and select UGI assets" includes the processes conducted in step S3.2 and S3.3. As they both involved the selection, design, sizing and the definition of other related requirements of the new UGI assets.
- In Tucson practice, many detailed steps (T2 to T5) were followed to define the most suitable locations for adding new UGI assets according to some priority criteria. While, in Singapore practice, the same process was conducted in a single one-step (S3.1) which involved many sub-steps. That means both practices conducted the same process but under different labels.
- Despite not being mentioned as a basic planning step except in P2, (existing conditions evaluation) was an implicit process in all case studies.

Comparing similar steps with each other reveals that there are some detailed differences between them. M2 and S1, for example, refer to the same process of providing more ecosystem services via protecting

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and enhancing the existing UGI assets. In Melbourne, plans were directed to increase the regulation services that relate to the cooling of the environment. While in Singapore, measures were adopted to achieve multifunctionality. Some detailed differences can also be found between M3, T3, and S3.1 which aim basically to define the appropriate location of new UGI assets. These differences relate to the variety of selection criteria. In Melbourne and Tucson practice, the selection process depends on the site's potential exposure to the climate change risk. While in Singapore practice, the selection process was based on the site's potential to contribute in water quality improvement, incorporating educational activities, benefiting the community, etc.

EXTRACTION THE PLANNING STEPS OF URBAN GREEN INFRASTRUCTURE

The cross-analysis between the four case studies shows that although the planning processes of UGI are widely similar in all case studies, they were employed under different steps' definitions and sequences. According to the previous discussion, the optimal definition and sequence of the planning steps of UGI in existing cities for CCSA can be extracted as a set of "Seven basic steps".

These steps can answer some main questions of why, where, and what UGI assets should be used. The extracted seven basic steps of UGI planning are described as follows (Fig. 2):

- Step 1: provide precise identification of the impact: this step involves conducting a detailed identification of the climate change impact for which UGI strategy will be adopted. This identification should include the impact definition, intensity, and causes. If it is possible, projections for the impact of future behavior should also be conducted. This is to consider any potential risks.
- Step 2: identify the higher-risk neighborhoods: this step aims to highlight the higher priority neighborhoods to have UGI. The identifying risk depends on overlapping two factors of impact intensity (the result of step 1) and local vulnerability. Detailing vulnerability depends on the targeted vulnerable sector whether it is people, buildings, or local ecosystems.
- Step 3: collect data about the existing conditions: this step includes collecting data about the physical conditions of the higher priority neighborhoods. This data includes neighborhood location, total area, boundaries, urban geometry analysis, land use analysis, buildings ownership, local related laws and regulations, current and future development projects, local barriers, etc. Many of these parameters should be presented in separate layers and tables.
- Step 4: protect and enhance the existing green and blue elements: this step includes two main processes: mapping the on-site green assets and proposing suitable policies for them. It includes the adoption of a certain policy of protecting, enhancing, and restoring the place's UGI assets. That depends on the full understanding of the previous, current, and potential status of these assets. This step aims to protect and restore what has already functioned well and uplift the poor. Qualifying the existing UGI assets to achieve multifunctionality should be considered the ultimate goal of enhancing and restoring policies. Accordingly, measures should be adopted not just to strengthen the UGI role as a strategy of climate change adaptation but also as a well-being enhancement and economy support strategy.
- Step 5: add new UGI assets: this step involves many sub-steps such as identifying the priority locations (priority streets and parcels), finding available sites for potential UGI in priority locations (availability and feasibility analysis), propose UGI assets for each type of available sites, select the most effective potential UGI assets (alternative selection) and packaging the selected UGI assets in certain similar and closer groups.
- Step 6: draw the result: this step refers to the drawing of on-site and new UGI assets in a single basic map. That is to have a complete image of UGI and its environmental effectiveness. This step is also essential in diagnosing the points of weakness in the network planning and proposing suitable solutions to them.

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– Step 7: calculate UGI effectiveness: calculate the climatic effect of the proposed UGI strategy is an essential step in its planning. That is because it allows measuring the validity of the proposed strategy. This measure can be conducted by using some simulation computer programs such as RayMan and ENVI-met (RayMan, 2022; ENVI-MET, 2022).

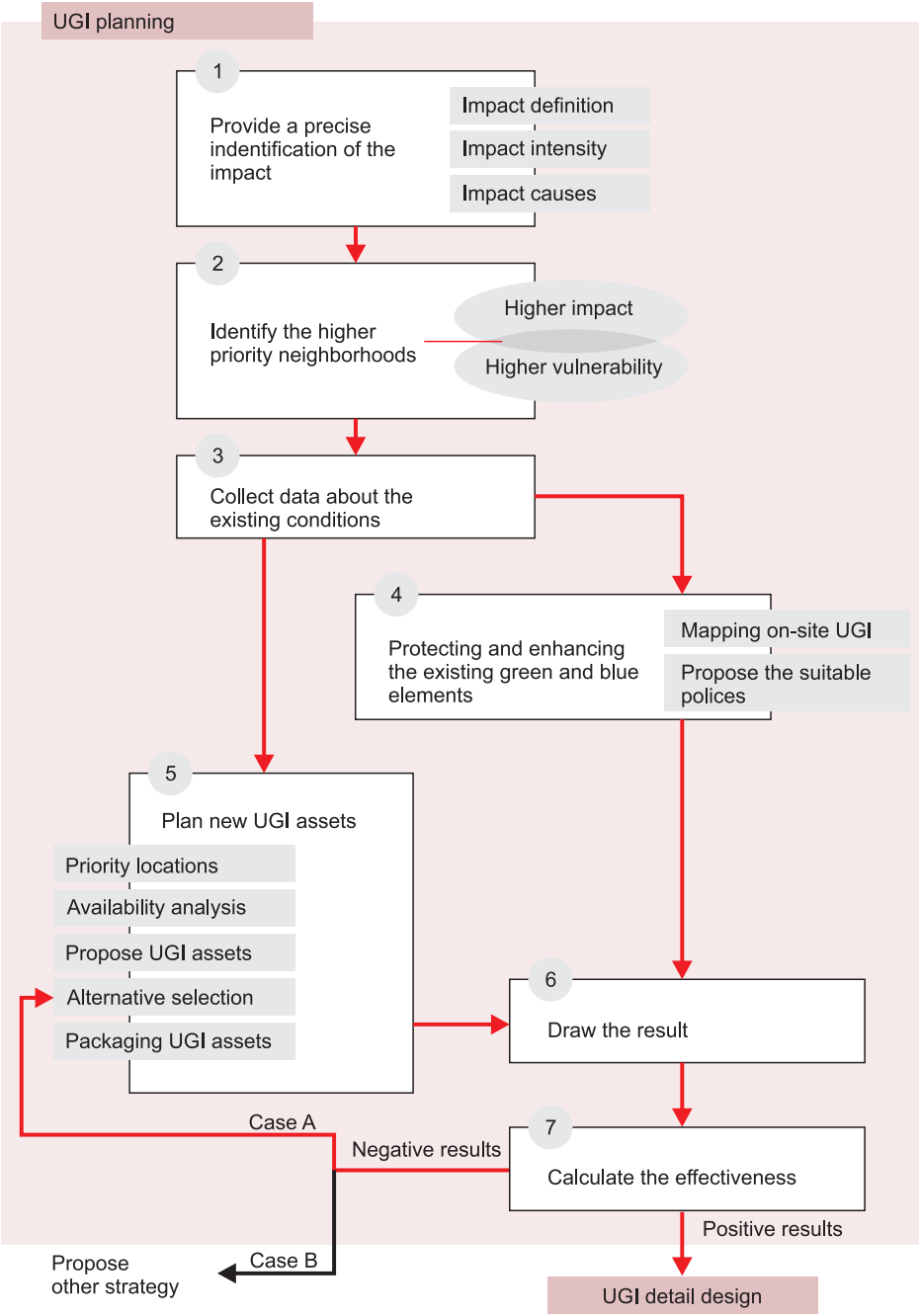

Fig. 2. Planning steps of urban green infrastructure in existing cities
Source: own preparation.

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Depending on the results of the effectiveness calculation, some main paths will be adopted across the planning process. If the results are positive, UGI strategy will be transferred to the next stage of "Detail design". If the results are negative and the effectiveness of UGI in coping with the targeted impact was previously proved (case A), UGI planning should be returned to step 5 as there is something to adjust in the process of adding new UGI assets such as the criteria of the alternative selection. If the results are negative and the effectiveness of UGI was not previously proven (case B), that means that the UGI strategy is not effective in countering this type of climate change impact and another strategy of CCSA should be proposed. This occurs rarely as proposing the strategy of CCSA, from the outset, should be based on its scientific proven success in coping with this type of climate change.

Understanding the extracted steps' definition and following their optimal sequence, can ensure having the best results of employing UGI in the field of CCSA. That can also avoid the risks of following non-reliable methods which can bear both of right and wrong choices. The extracted set of UGI planning steps provides a planning path that will acquire its unique identity from the first step of identifying the climate change local impact. So, these steps reflect a general rule that may vary in its details in different cases.

CONCLUSIONS

Finding a smart way of climate change adaptation gains greater importance, as the impacts of climate change become more severe and the opportunities to cope with them become more limited. Employing Urban Green Infrastructure offers a certain strategy to achieve such type of adaptation. Accordingly, the research imposed the question of what is the most acceptable definition and sequence of UGI planning steps in existing cities for Climate Change Smart Adaptation (CCSA). The research aimed to extract the optimal set of UGI planning steps from some real practices that already proved their efficiency. By exploring and comparing four case studies, it was found that UGI planning usually occurs within similar processes but under different definitions and arrangements. By analyzing these processes and clarifying the intersection between them, the optimal definition and sequence of planning UGI in existing cities were extracted and outlined in a set of "seven steps". Following such steps can ensure success and reduce the possibility of losing spaces or funds. At the same time, commitment with these steps can also offer flexibility to deal with the city's local conditions such as the type of climate change impact or the site opportunities to have UGI. These steps are linked to each other in a continuous chain as the result of each step forms a basic input for the following step. Identifying impact and vulnerability to define risk, for example, are essential steps to define where to begin. So, they form the starting point for UGI strategy at any specific scale. Also, the trade-off between potential UGI assets according to some environmental, social, and economic criteria assists in performing a deep feasibility study for each potential site or UGI assets. Taken together, these steps can form a coherent chain of activities to obtain a vital UGI strategy as they offer a pre-tested framework for UGI successful planning in existing cities. This framework can be applied to any city at it has an adequate amount of flexibility to take the city conditions into its account.

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AN INDUCTIVE PERSPECTIVE OF SINGAPORE HOUSING POLICY: A COMPARATIVE STUDY

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ABSTRACT

The housing market in Singapore has observed extensive development and growth over the past years due to the validation of favourable economic, lawful, social, civilized, and political policies. housing and Development Board is the managerial organization that responsible for the development and improvement of the housing area in Singapore. In Singapore, above 80% of its citizens own homes, apartments, hostels and flats. Singapore has also set up economic facilities such as the Central Provident Fund (CPF) to provide loan to its citizens at a lower interest rate to acquire houses and apartments. Favourable housing policies have also enabled the development and growth of other housing industries in other developed economies such as the UK, USA, Sweden, and Poland.

Keywords: housing policy, housing management, development plan, affordable housing

INTRODUCTION

During the past decades, the housing markets has undergone countless changes to make better it by putting into place several policies. The public homes policy in Singapore is one of the best housing scheme globally. The Housing and Development Board (HDB) has been tasked with providing reasonable, affordable and high-quality houses to Singaporeans to improve their living situations (Khali & Nadeem, 2019). HBD over the last decades they have made a huge success by ensuring that 80% of Singaporeans are enjoying their lifestyles in the HBD flats and 94% of them have their own apartments and flats. Singapore's housing scheme success can be attributed to the strong political dedication to public housing, secondly is an economical commitment through loans and bonus and governmental support, which enables them to provide land economically and fast, and finally is loyal government plans such as the quantization of the Central Provident Fund (CPF). The Singapore housing market is a unique one due to its huge home ownership for the resident households specifically for people from the low earning.

Table 1 shows the part of the population that has owned homes since 1970. It can be deducing the ratio

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Table 1. Population, Land Area, and Density of Singapore, 1970–2015

Year	Land Area (km^2)	Population Density (per km^2)	Total population	Those who are owning homes	Proportion of Foreigners
1970	586	3,540	2,047,507	2,013,563	3
1990	618	3,906	2,413,945	2,282,125	5
2000	633	4,814	3,047,132	2,735,868	10
2010	712	5,897	4,027,887	3,771,721	26
2015	719	7,130	5,535,002	3,902,690	29

Source: Housing and Development Board (2021).

of 2 million members of the Singaporean population owned homes from the year 1970 to 2015, which was a good success.

Singapore's housing area is described by the predominance of HBD housing and the broad inclusion of the public authority in controlling housing market interest openly and private areas. The main goal of Singapore's public housing policies can be interpreted through affordability, quality, community and financial security of individual members for the country's population (Kuah, 2018). To allow the low-income households to afford their own houses, the government of Singapore transformed the pension updated Central Provident Fund into a housing provident fund where member of staff and employers have to make must contributions to the member of staff accounts. The member of staff and employers' savings are then withdrawn for down and loan to purchase homes at a relatively small and affordable price. The loan is designed to mobilize the national savings on a nationwide basis and make house ownership the only choice for households (Sahlin, 2015).

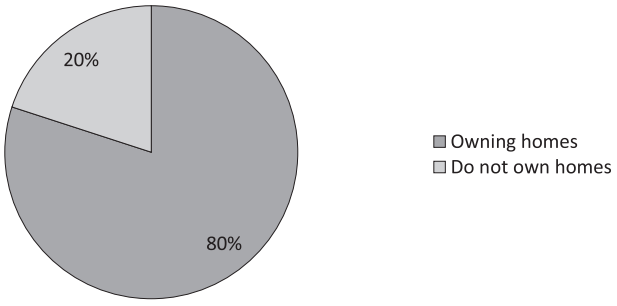

Fig. 1. Distribution of Homeownership among the Singaporeans
Source: Housing and Development Board (2021).

From the pie chart we can easily understand the distribution of number of peoples that lived in Singapore orange colour present the number peoples who do not have their own homes is about 20% on the other hand blue colour present the number of people who have their own homes is about 80% and the huge proportion of homeownership is due to the favourable and aggressive Singapore housing policy, which has ensured homeownership among the different financial groups.

Characteristics of Singapore Housing Policies

The Singapore housing society is characterized by unusually huge homeownership for resident households. The prevalence of HDB housing in Singapore and the wide association of the public authority in adjusting housing organic market in both the general population and private areas. Public homes in Singapore is characterized by the free-market and socialist system where it is observed as right permission, which assist state with giving better houses to its residents or of unrestricted economy frameworks where the market is permitted full control in the housing area (Lee, 2016). Although HDB fully takes support from the public funds, it is essentially a private maker (Ward, 2019). HDB believes that for it to provide enough housing to the Singaporeans, then the economically resources for homes try not to have to contend with the nations monetary interest of different areas of the economy. HDB is the primary controller of housing projects in -++Singapore hence a situation where free-market rule has been wipe

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out to keep away from the provisos related with the market-subordinate frameworks, where costs of housing are regularly past the scope of a high piece of the populace or of the communist frameworks where the shortfall of capital brings to a halt all the housing projects (Marcuse, 2017).

The low cost of creation addresses the Singapore housing program. Singapore's housing policy is categorized by acquiring land reasonably, resulting in a low production price. This is attained by putting a host of measures to increase productivity and keep prices to a smallest level (Yeo et al., 2017). The central housing cost-control features include the scale of the projects, the repetitive nature of the work, tight control over building contracts, and prompt payment. HBD has assumed standardized building plans with a short construction period for large quantities for large housing designs (McFarland, 2021). Designs account for toughness and minimum maintenance prices. The other started that HDB has used designing and overseeing all its projects in its place of outsourcing them and taking private contractors to undertake the construction project. HDB has also been able to keep its production price very low by using technological advancements in its projects, such as the increasing use of the metal form concrete framework system and use of the manufactured system (Wetzstein, 2019). The HDB is also involved in the production and management system of the materials required for the construction processes. Over the last 10 years, HDB has produced more than 1 billion brickworks, tile work, sand, and granite quarries which have massively kept the production in very low cost. This has also made sure that there is acceptable supply to meet the needs of the continually evolving industry at very affordable costs (Zarghamfard et al., 2019). The HDB has also developed plans to help local and foreign constructers (manufacture) develop suitable latest materials for HDB use.

From table 2 above, it can be concluded that the price of owning a home in Singapore is relatively low due to the decreased cost of construction and the availability of grants that can be used to pay for loan to be used to acquire homes. The percentage of the price of houses to individual passing incomes is as low as 2.88 due to Singapore's public housing policy which is a contributing factor.

The target of HDB is to give quality and reasonable public housing to low and big time salary workers. Other than giving rental housing, HDB likewise supports homeownership among Singaporeans (Phang, 2018). The HDB is ordered to continue all parts of the public housing program with the exception of fixing the deal and rental costs of the housing units, which the Ministry of National Development embraces. The HDB has broad abilities concerning land procurement, resettlement, town arranging, structural plan, designing work, and building-material creation. The HDB gives business and modern premises and sporting, strict, and social offices in its housing bequests (Phong, 2020). The HDB additionally leads different tasks like land recovery for the development of reasonable houses. While building the houses, the board considers factors like the accessibility of fast travel, simple admittance to business, modern, institutional, and sporting offices.

From table 3 above, it can be concluded that 32.2% of the population owns a 4-room flat while 24.4% of the country's population owns a 5-room flat and that 18.3% of Singapore's members of the population

Table 2. Price Affordability of HDB Flats in 2019

HDB Flat Type	Average Price [$]	Average Price after Grants [$]	Applicants Annual Household Income [$]	The ratio of Price to Income
2-room	120,000	56,000	19,800	2.88
3-room	189,000	138,000	34,000	4.67
4-room	299,000	269,000	48,000	5.78
5-room	387,000	388,000	76,000	5.79

Source: Housing and Development Board (2021).

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Table 3. Resident Households by Dwelling Type and Household Income in Singapore

Dwelling Type	Residents Households [%]	Average Monthly Income
1 and two-bedroom flats	5.3	2,313
3-room flats	18.3	5,805
4-room flats	32.2	8,293
5-room flats	24.4	11,606

Source: Housing and Development Board (2021).

own a 3-room flat and finally 5.3% of the members of Singapore population re owning 1 and 2 flats despite their low levels of income.

The Singapore Public Housing scheme is upheld by a sound resettlement stratagem. The resettlement strategy is fundamental as a portion of the land obtained for public housing purposes or required advancement projects had been populated by vagrants, limited scope ranchers, and inhabitants of frail structures who must be resettled in adequate convenience. The Singapore public housing strategy furnishes vagrant and ghetto occupants with standard housing and living (Hedin et al., 2016). The resettlement strategy has empowered the public authority of Singapore to procure land for building reasonable houses efficiently and rapidly without going through a ton of cycles thus quicker development of the task (Pow, 2017).

COMPARTIVE METHODOLOGY BETWEEN DEVELOPED ECONOMIES HOUSING POLICIES

United States

The main purpose of Singapore's housing policy is to ensure that all Singaporeans have market standards, quality and affordable housing by adopting various mechanisms such as laws that allow the Singaporean government to buy land at low prices. Is to provide. The United States housing strategy plans to give needs-based, government-financed housing for low-pay families, the old, and those with inabilities (Field, 2017). Furthermore, the Singapore housing strategy occupancy period depends on a rent time of 99 years which is dependent upon restoration after its expiry, while in the United States, the tenure time frame is endless as long as occupants conform to the rent understanding. Their pay stays at as far as possible, empowering the occupant to keep paying for the administrations delivered by the housing supplier (Taruvinga & Mooya, 2018).

In the Singapore housing scheme, there is no standard qualifying income limit that one must contribute to the reasonable housing project. In contrast, in the United States, the citizens have to contribute 50–80% of median income for a specific county or metropolitan area to qualify for the Federal government's housing scheme. Besides, in Singapore's housing policy, there is no basis for calculating rent. In contrast, in the United States housing policy, rent is calculated according to an individual's ability to pay the highest of the following: 30% of adjusted monthly income, 10% of adjusted monthly income, and the individual's current welfare rent (Hoe, 2020).

Singapore housing strategy doesn't give any arrangement to month to month rental instalment since the primary point of the approach is o empower the resident of Singapore, both in the low and medium-class pay levels, to possess homes and not pay lease in such houses. Conversely, the United States housing strategy takes into consideration charging month to month rental instalments, which shift contingent upon the determinants like size, area, and nature of the house that has been involved by the residents of the United States and the time of inheritance (Chew, 2016). The United States housing strategy isn't really that solid of Singapore and has not empowered whatever number residents as could reasonably be expected to possess their own homes and rival different nations, for example, Sweden that additionally give the reasonable housing strategy. The Federal administration of the

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United States ought to change its housing strategy to guarantee the incorporation of all residents, all things considered, regardless of whether from the low-pay bunch or the major league salary bunch, into the program. Other than changing the centre goal of the strategy, it is likewise important to guarantee that it depends on giving homeownership and worse houses.

United Kingdom

The significant reason for the UK housing strategy is to give need-based, government-supported housing for low-pay families, the older, and those experiencing handicaps. Then again, the main role of the Singapore housing plan is to give reasonable housing to all Singaporeans utilizing different official and monetary systems, for example, the commitment of a part of a singular's pay to the housing plan. The commitment is subsequently removed to guarantee that such people have their own home contingent upon the size that their commitments match and different elements that decide the idea of the house to be procured (Powers & Nsonwu, 2020). The United Kingdom housing strategy gives a fixed or endless tenure period relying upon the understanding came to with the public authority or the private designer of such housing units. Interestingly, the Singapore housing strategy accommodates an occupancy period in light of a rent understanding of 99-years which is dependent upon reestablishment after the expiry of the arrangement and regardless of whether the individual has proceeded with interest in remaining in such homes or houses. The reasonable housing strategy has contributed colossally to the singular residents of Singapore who own them since they don't need to contribute a piece of their pay as lease.

The United Kingdom housing strategy arrangement on lease estimation gives that lease is determined on a point framework in view of the nature of housing while at the same time considering key determinants like the size of the house, kitchen apparatuses, private bathroom, and other social.

For example, the offices are consolidating, Singapore's housing strategy is for those who are interested in a housing strategy to donate a portion of their wages to buy a fantastic home for a 99-year lease that relies on restoration. according to the instructions of the national authorities (Sullivan, 2017). Also, the month-to-month housing instalment should not surpass 699.48 pounds as indicated by the UK housing strategy, while as per Singapore housing strategy, there is no month to month pay paid once an individual has gained the house or home.

Sweden

The motivation behind Sweden's housing plan is to give needs-based, government-subsidizing housing advances and endowments for low-economy families, the older, and those with handicaps. Simultaneously, need is given to the destitute, while the Singapore housing strategy's motivation is to furnish the residents of Singapore with homes in spite of their financial level from a commitment made to the housing advancement conspire (Wang et al., 2016). The Sweden housing strategy accommodates a decent occupancy period or cutting-edge that home would presently not 6 be able to be utilized for public housing that is 40 years or less, contingent upon the concurrence with the Swedish district that an individual is residing in. Interestingly, Singapore's housing strategy has a tenure period in view of a rent understanding of 99-years and is dependent upon recharging relying upon the proceeded with interest of the inhabitant to keep residing in such houses or homes. The Sweden housing strategy accommodates the low-financing cost on the housing offices and related items joined by high family investment funds (Teo & Huang, 2016). The Sweden housing strategy has empowered more and more individuals to get homes and lofts at lower costs in spite of their monetary circumstances or levels. The Swedish housing strategy accommodates the structure of new homes, loft squares and rental convenience contrasted with the Singapore housing strategy that primarily centres around the structure of completely possessed homes. The housing strategy pointers in these nations guarantee supportable housing arranging and improvement that is liberated from any monetary segregation.

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Poland

The real estate sector in Poland is one of the mainstays of the national economy, not only inspiring economic growth in a pivotal direction, but also creating an enabling environment for dynamic development. The fundamental nature of this sector consists in its role as a source of fixed assets, as it creates spatial conditions for the development of various other sectors of the economy and presents a very important way to allocate capital (Cellmer et al., 2021). The primary tasks of the government are to promote favourable conditions to meet the housing needs of community. Property needs its efficiency in allocating existing assets and the chance of making new stockpile suitable for worth and amount for notified demand is the result of many groups of economic and non-economic factors. Because the housing market is inconsistently local, local factors are the most important factor. This includes, among other things, factors related to the worker marketplace (unemployment rate, average wages, etc.). Market size due to price fluctuations existing assets and the chance of making new stock etc. (Cellmer et al., 2021). The land charge has been in power in Polish regulation starting around 1991. This is probably the most seasoned regulation among any remaining charges. One of the greatest duty issues in land charge is connected with all exclusions and help, which is Article 7 of the Local Taxes and Fees Act (Journal of Laws 2019 item 1170) K directs nearby duties and expenses. This article will zero in on these guidelines in regards to recompenses and exceptions. General society has a particular arrangement of monetary advantages to a given organization or gathering of organizations, with which the monetary weight is made by open accounts Aid is called (T-55/Court choice in the event that 99) This weight can be through spending public assets on organizations or decreasing the weight of public law on organizations (Jóźwiak, 2020).

Main objectives of the housing policy carried out by majority European countries to create rules and regulations for purchasing or lease for all citizens, making houses for all citizens and ensuring proper standards. According to Article 75, 1 of the Constitution, public establishments are bound to run policy in favour of fulfilling the needs of citizens, especially preventing homeless, supporting social housing industry development, and activities of citizenship The basic aim is to support the people to own their own houses ("Housing Industry Support Policy Housing" – Drafted Version). End of the 1990s, the form of important tools changed in the Polish Housing Policy. In the 1990s, half-new Apartments are used inside the Social Building System, which included a source of housing cooperatives, establishment, Flats and Council flats. Instances of housing Strategy apparatuses in Poland are legislative projects under which the State Reservoir gives monetary help to their needs in the year 2008–2013, with the end goal of the advancement of the structure business in Poland, Rodzina was introduced to the program (a family's place) program so that the situation of youth can be improved and indirectly There is an effect on improvement. The demographic situation in Poland (Cieślak et al., 2020).

RESULT & DISCUSSION

Successful Elements of the Singaporean Housing Model

Today there are about 2m HDB apartments in Singapore due to the successful operation of the Singapore housing model, distributed mainly in two newly developed towns that stretch out in a half circle around the City's waterfront region. Every year the government of Singapore sells a new batch of highly furnished flats to its low and middle-income citizens first-time buyers (Jargowsky & Fletcher, 2019). They all accompany 99-year rents and are sold at lower-than-market costs, albeit the effective candidates of the program should hang tight for three to four years for their condos or pads to be finished. The other option accessible to the Singaporeans decides to purchase existing HDB condos straightforwardly from their proprietors or the public authority, at whatever esteem the buyer and the seller will pick. The first and last Singaporean's purchasers help cash through

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government awards to buy new or old apartments (Lee, 2016). The Singaporean model also ensures that people from different racial backgrounds living in the country are also reflected in each HBD block and able to acquire flats and apartments at relatively medium prices compared to the Singaporean citizens who buy the apartments and flats at low prices depending on their economic status.

The Singapore housing model has brought about the development of new three-room pads proposed to its residents at a somewhat low cost. The expense of the three-room pads is $300,000 all things considered. A method tried government award empowered first-time house purchasers to shave up to $75,000 off the buying value contrasted with different nations in Asia where their residents can't buy houses totally. Purchasing such houses tantamount to the HDB level on the auxiliary market would cost with regards to a fifth to a quarter more while purchasing the indistinguishable lofts worked by private designers can cost multiple occasions the HDB charges for the indistinguishable apartments (Hoffman et al., 2020). This implies that youthful grown-ups will more often than not live home until they resign except if they can stand to lease or purchase their own homes in the open market henceforth needn't bother with government mediation as far as housing arrangement. Gay couples are additionally permitted to add to the CPF conspire on the off chance that they are lawfully hitched in an official courtroom or by an administrative authority perceived by the Singaporean government.

Regulations have likewise been passed to empower single parents to possess houses diminishing the frenzy that has been in presence that moms of little youngsters conceived illegitimately have thought that it is troublesome than different guardians to buy government pads because of how they are seen in the public arena because of social issues.

The Singapore housing model has empowered the Singaporeans to acquire the money they use to purchase HDB's properties given by the Central Provident Fund, an obligatory public investment funds conspire into which the majority of the residents working are needed to contribute 20% of their month to month compensation to the plan. In examination, managers are needed by the arrangement to contribute 17% to add to the plan and empower its residents to gain homes. The strategy empowers the residents to withdrawal their reserve funds to use as a store on the HDB condo they need to buy. HDB has additionally empowered its residents to gain modest home loans and utilize their CPF commitments to meet some or the regularly scheduled instalments in general. The Singapore housing strategy is a triumph by many measures since the nation has essentially no vagrancy. HDB's towers are perfect, safe and spacious enough for the whole family. HDB house is more reasonable then condos and pads in Hong Kong, Stockholm, and other major worldwide prosperous urban communities. The office has guaranteed that whenever purchasers first just give more modest than a fourth of their discretionary cash flow to their home loans; henceforth don't feel the weight of possessing a house. The model is additionally a decent arrangement for the state since they just set to the side $1.8 billion or 2.4% of the public spending plan for housing which is to the point of covering the housing shortage in the country. The public authority of Singapore has paid a little $28 in awards to HDB since its establishing during the 1960s.

The incomes acquired from the housing strategy program have empowered Singapore to figure out how to manage without a convectional charge financed annuity conspire. Every Singaporean will have their own loft upon completion of the work process (Hoe, 2020). The arrangement offers Singaporeans an additional a markdown assuming they decide to purchase a property in similar neighbourhood as their people consequently causing them to secure houses without many difficulties. Additionally, the Singapore government has utilized the control of housing framework to assist with moulding how Singaporeans live and take part in monetary approaches. Rules for a strict housing strategy direct the way that one might purchase and possess pads henceforth assisting with diminishing the expense of creation (Huat, 2017). The Singapore housing strategy has empowered HDB to utilize its Debt Servicing Ratio (DSR) to decide home buying affordability's is the extent of a month-to-month family pay for the housing

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portions. It thinks about interest instalment and is determined on an expected 30-year credit. Moreover, most HDB level purchasers can utilize their CPF investment funds to pay for their month-to-month contract, which is taxed at a specific rate hence acting as a source of Singaporean income, reducing the dependence on external funding from other countries. The Singaporean Monetary Authority has intervened to help the government implement various prudential and regulatory measures such as reducing stamp duties for sellers who sold their properties in the first three years other than an extra purchaser's stamp obligation on the buy. Of the second and subsequent properties has also been reduced to enable as many citizens as possible to own homes (Chew, 2016). The interventions have enabled the reduction and abnormal increase in the country's prices of flats and apartments.

Drawbacks of the Singapore Housing policy

Lack of foresight is one of Singapore's Housing plan downsides. There have been grumblings among Singapore residents about the social-housing program. The connection between HDB proprietorship and agreeable retirement is not so specific because of the lack of foresight of how the commitments ought to be transmitted to the CPF. More seasoned Singaporeans have become surprisingly quick to hold tight to their homes as opposed to delivering capital by moving in with their youngsters in more modest pads (Cao et al., 2019). The strategy has empowered the old populace individuals to sell back the HDB part of their excess rent they expect not to sufficiently live enough to utilize. Notwithstanding, the plan has not wowed, to some extent in light of the fact that HDB-proprietors are as yet dealing with the possibility that their properties could be worthless when their 99-year rent lapses.

The other downside is that it stays indistinct whether a framework focused on homeownership and cavalier of leasing will keep on fitting the Singaporean requirements. A few inquiries remain whether the cash being contributed as far as home loans utilized in building houses addressing the requirements of the singular Singaporeans who contribute such sum. Buying HDB property requires responsibilities that youngsters in different nations would find smothering, above focusing on other business: they should look for power to move or let inside the principal long stretches of proprietorship, despite the fact that they might have effectively trusted that their condos will be constructed.

The other downside is that adjusting reasonableness and growing a substantial financial foundation is a difficult one. In spite of the fact that Singapore's model serves its residents well, adjusting the reasonableness of the sponsored HDB pads with consistent appreciation makes the framework wasteful for everybody residing in the nation and relying upon the strategy to possess homes and condos. Out of Singapore's 5.9 million populace, around one-fifth are not residents (Berry, 2020). These unfamiliar residents or labourers are destined to be remembered for the HDB framework, despite the fact that there are exemptions that have made it conceivable to draw in gifted unfamiliar housing labourers to assist them with advancing the area. Moreover, in excess of 500,000 transient labourers without admittance to HDB pads live in swarmed, messy regions, with up to 100 individuals sharing a solitary latrine. The housing conditions for these low-pay labourers in Singapore are a lot of more terrible than for the typical low-pay expert in the United States and other made economies.

Characteristics of efficient Global Housing Policies

The model is apt in different areas of the planet to tackle their housing issue. Like Singapore's, the social housing program can be copied in other countries globally with similar outcomes of providing government housing at reasonable costs free of politics and bureaucracy (Berner, 2016). Not at all like in the Singapore housing strategy framework, different nations should utilize different government offices are dealing with a cross-reason premise. The worldwide real estate market should be founded on sound a strategy in light of appropriations and

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different motivating forces like that of Singapore's HDB housing strategy which has been more than fruitful. The housing strategies in various created nations like the UK, USA, and Sweden have been in excess of a triumph because of the ideal monetary and legitimate arrangements that help the housing area's development. Developed economies such as UK and Singapore need to make a few adjustments such as flexible housing payment methods and the inclusion of everybody in this housing program despite their race, shading, beginning, political association, or religion to the current housing strategies.

CONCLUSIONS

Reasonable housing policy can result in the growth and development of the housing sector of a country within the shortest time possible, as in the case of Singapore, the USA, the UK, and Sweden. Policies by way of favourable legal, political, and economic policies are the key needles and causes of a booming housing policy. The housing policy has allowed citizens from the low, medium, and high economic levels to acquire homes and apartments without incurring huge budgets. At long last, housing arrangement ought to be made a compulsory job for the states to guarantee that all residents live in a respectable climate through the execution of ideal strategies that help the development and extension of the housing area.

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THE DEGREE OF GREENERY IN LODZ CITY, POLAND – CLEARING UP DISCREPANCIES BETWEEN OFFICIAL STATISTICS AND SATELLITE DATA

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ABSTRACT

Motives: According to public statistics guidelines, areas officially classified in Lodz city as urban greenery include only forests, parks, lawns, squares and cemeteries. Areas of so-called unsealed greenery are omitted, which, however, have a great positive impact on improving the living conditions of the population. By taking information from satellite images and comparing them with official data, we have received a closer to the reality picture of the city, which is much more better than it would appear from official statistical data. Another dimension which the study addresses is the uneven distribution of greenery of a certain quality in individual units of the city.
Aim: Comparing these data with the fact that the distribution of places of residence is also uneven, an attempt was made to assess the accessibility of green areas for the inhabitants of Lodz city.
Results: There are much more green spaces, similar in terms of vegetation abundance to the official green spaces. That means the city is underestimated when talking about the degree of greenery.

Keywords: NDVI; urban greenery; Landsat; urban development

INTRODUCTION

Greenery is an important component of urban space, as it performs a number of very important functions, such as protection against air pollution, maintaining air humidity, mitigating extreme temperatures, reducing noise, while also producing a positive aesthetic impression (Białobok, 1976; Haber & Urbański, 2005; Łukasiewicz A. & Łukasiewicz S., 2016). Green areas also increase the level of satisfaction from living in their vicinity (Wu et al., 2019). Unfortunately, however, there is less and less high-quality greenery in urban areas (DeFries et al., 2010; Konijnendijk, 2003). Nowadays, despite the fact of increasing prices for the space in cities, local governments are more aware of the need for ensuring adequate open space for public use (Sustainable Development Goals). Those areas should be covered by the greenery.

According to currently binding legal acts in Poland, urban green areas are areas within the boundaries of arranged green space performing public functions, such as parks, lawns, promenades, boulevards, botanical gardens, zoos, playgrounds and historic gardens, cemeteries, greenery accompanying roads

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in developed areas, squares, historic fortifications, buildings, landfills, airports, railway stations and industrial facilities (Act, 2004). Such areas are included in official statistics, with the surface area being the main measure of the amount of green resources in a city. In practice, however, it appears that the adopted method of determining the degree of greenery in cities does not fully reflect the actual state of affairs, as there are many green objects in the urban fabric that are not taken into account, and yet perform a number of important functions related to greenery. This is the greenery found in developed plots, industrial and post-industrial areas (Cudny, 2011), along roads and watercourses, and others. What is more – the official data takes different aspect when it came to the classification (e.g function, majority land cover).

The aim of our study is to assess the size of greenery resources (in terms of surface area and quality) in the area of Lodz city (Łódź in Polish, the capital of province and also the 3rd largest city in terms of number of inhabitants in Poland) using publicly available satellite data from the Landsat 8 mission and the NDVI index derived from it, and to compare them with official urban greenery statistics. Based on the NDVI distributions, characteristic boundaries of the range of values for this index were calculated for areas considered as parks, lawns, forests etc. In this way, the different functional areas of the city have been characterised in terms of their greenery and population density. These areas were compared with the whole city, and then the differences between the individual types of areas were presented.

LITERATURE REVIEW

In many scientific works, the NDVI, Normalized Difference Vegetation Index (Deering, 1978; Jackson & Huete, 1991) was used as a measure of the degree of vegetation development in the studied areas. An important feature of the NDVI is its relationship with both the quantity and quality of greenery in a given area (Jarocińska & Zagajewski, 2008; Jarocińska, 2011). If the pixel of an image consists of objects of different reflectance (e.g. buildings, roadway with asphalt or concrete surface, tree crowns, gardens and lawns), then the NDVI is the resultant of the NDVI coefficients of the individual features, weighted by their share in the pixel area (Wirth et al., 1987). To some extent, the NDVI also reacts to the vertical structure of plant complexes – it is higher in areas with extensive, multi-storey vegetation (Krukowski, 2018). The NDVI can be used in analysing both aerial and satellite images, in assessing the amount of plant biomass at different spatial scales, from individual arable fields to global vegetation zones (Tucker, 1979; Wang et al., 2011), recognition of vegetation (Wang et al., 2009) and its condition (Lhermitte et al., 2010; Kopańczyk & Fitrzyk, 2016), crop maturity analysis (Jackson & Huete, 1991; Panda et al., 2010), the LAI – Leaf Area Index (Colombo et al., 2003), the amount of radiation absorbed by plants through photosynthesis (Badgley et al., 2017), biomass, phenological studies (Lüdecke et al., 1996; Zarzecki & Pasierbiński, 2009; Yan et al., 2018), water stress (Niedzielko et al., 2012), and many others. Nouri et al. (2014) used high resolution satellite images from WorldView-2 mission to determine the relationship of the intensity of field evaporation (evapotranspiration) between areas classified as urban green areas and green areas designated on the basis of the NDVI index, consequently determining the level of water stress for classified green areas and those designated on the basis of satellite images. The NDVI allows to differentiate land cover within agglomerations, which could often be considered (in other studies) as homogeneous, such as meadows (Kosiński et al., 2008; 2012; Kosiński & Kozłowska, 2003), which indicates high sensitivity of the index to plant cover diversity. These results are to some extent linked to the observation that the variability of the NDVI in an area covered by natural vegetation shows a greater correlation with climatic conditions than in areas of intensive human use (Musiał, 2009). The above-mentioned features of NDVI mean that it is often used in urban space studies (Gupta et al., 2012).

Different authors define the NDVI limits in different ways in order to distinguish vegetation-covered areas from others located in Poland. Kubalska

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and Preuss (2014) used digital aerial photographs (with 10 cm spatial resolution) and aerial laser scanning data (density 15 points m^{-2}) to take stock of green areas in Wrocław city, Poland. They adopted a minimum value of NDVI≥0.1 calculated from the pixels of an orthophotomap made with the use of an infrared channel (the so-called CIR – Color InfraRed). Krukowski et al. (2016) and Krukowski (2018) used IKONOS 2 images and decided to separate two classes of urban greenery: high and low. The first step was to adopt the NDVI>0.2 threshold to separate the vegetation, then the training fields for the two previously mentioned classes were determined and a supervised classification of green areas was performed. They observed higher values of the index for high vegetation, therefore they corrected the threshold discriminating this vegetation to the value of NDVI=0.35. Będkowski and Bielecki (2017) evaluated the availability of greenery based on the NDVI calculated from the Landsat 8 image. A large part of the city was characterised by index values between 0.2–0.3. It has been found that these are areas of the city where development is accompanied by well-developed greenery. Worm et al. (2019) adopted a low NDVI threshold of 0.1 for the purpose of distinguishing plant cover in the city of Lodz on the basis of a CIR aerial orthophotomap. The same boundaries in the study of urban vegetation in the Ursynów district of Warsaw were adopted by Pyra and Adamczyk (2018). For the purposes of analysing vegetation, understood as an element of the Green and Blue Infrastructure, Pluto-Kossakowska et al. (2018) assumed that the optimum range of NDVI values is <0.2, 1> when using an aerial CIR orthophotomap, and <0.5, 1> for Sentinel-2 images. Michałowska and Hejmanowska (2008), on the other hand, calculated the NDVI differences between 1979 (Landsat MSS) and 2000 (Landsat +ETM) to show changes in plant cover in the area of the Słowiński National Park, and concluded that the value in the range of -0.41 to +0.41 means areas with minor changes. Tomaszewski et al. (2011) assumed that MODIS pixels with an NDVI value lower than 0.3 represent areas without vegetation, while those with a value above 0.7 represent areas with intensive vegetation. Values in the range $0.3 < NDVI \leq 0.7$ are related to partial plant cover.

NDVI values are generally calculated with precision to two decimal places – e.g. Walker et al. (2012) in their study if green cover in North American and Eurasian Arctic transects, Robinson et al. 2017 in their study of the variability of NDVI values over 30 years based on image data from three different Landsat missions (5, 7 and 8).

The experience of many authors shows that it is not possible to indicate unambiguously how to interpret a given NDVI level, or with which forms of land cover it can be associated. It is necessary to check the applicable threshold values experimentally each time, in order to distinguish between plant cover and other forms, and to demonstrate the diversity within the vegetation.

In addition the NDVI indicator can be used as one of the image channels along with selected other images, e.g. for classification purposes (Pyra & Adamczyk, 2018). Supervised and unsupervised classification based on pixels in Pléiades images were tested by Trisakti (2017), who achieved high accuracy using a combination of the NDVI vegetation index and blue channel, while Sulma et al. (2016), based on NDVI spectral indices, NDWI (Normalized Difference Water Index) and MSAVI (Modified Soil Adjusted Vegetation Index), distinguished vegetation covered areas from other urban areas of Jakarta (Indonesia) with an overall accuracy of 86%.

NDVI can be calculated on the basis of image data from many satellite systems. Due to the different spatial, spectral and radiometric resolution of these systems, as well as to the variability of natural conditions between sometimes even close dates of images, variability of the index values determined is inevitable. This is particularly true for comparisons of individual observations, but as shown (Turlej, 2009), the differences between the results averaged over certain time periods are insignificant (approximately 0.1 NDVI). This gives rise to the use, if necessary, of different systems (after appropriate transformation of their resolution parameters).

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The share of green areas can be one of the important indicators (environmental dimensions) used, in addition to social and economic dimensions, in analytical analyses of the sustainable development of a city (Szarek-Iwaniuk, 2021).

MATERIALS

Land use and land cover databases used in Poland

The most important repositories presenting geospatial data in Poland are: Land and Property Register (EGiB), Topographic Object Database (BDOT), General Geographic Object Database (BDOO) and thematic maps created by local geodesy centres, e.g. greenery map according to the Lodz Centre of Geodesy – ŁOG (Table 4). Databases are a public resource, representing the type of land use in terms of functions.

Unfortunately, these databases are not consistent. Data from individual sources use different classification systems and are inconsistent in spatial terms (e.g. recreational areas in the LPR base, forest or bush areas in the TOD base or a park in the LCG urban greenery map that cover the same fragment of terrain but differ in terms of individual boundaries – Fig. 1).

The study used data from the Lodz Centre of Geodesy (LCG), as well as the LPR database, satellite images and demographic data from the voter registry.

Data of the Lodz Centre of Geodesy (LCG)

As part of its tasks, the Lodz Centre of Geodesy creates cartographic studies showing green areas within the administrative boundaries of the city of Lodz.

The geodetic data are the basis for statistics on the size of green areas reported in the state statistics, i.e. in the yearbooks of the Statistics Poland and in the Local Data Base (Fig. 2).

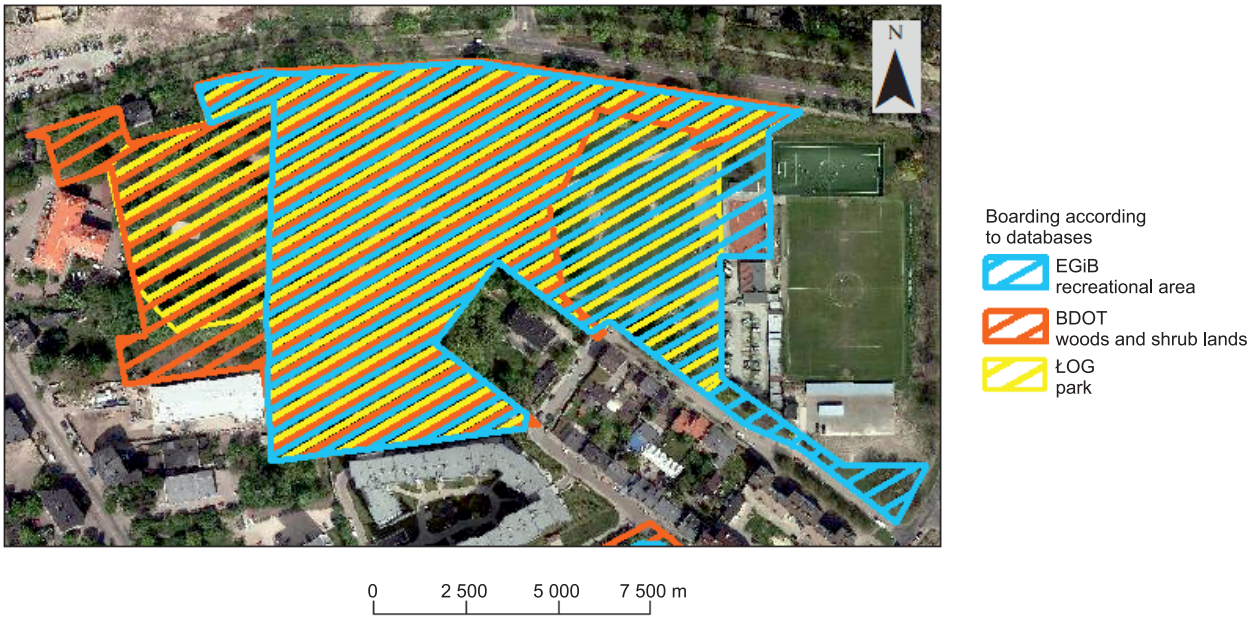

Fig 1. Comparison of boundaries of green areas according to different databases (EGiB = Land and Property Register, BDOT = Topographic Object Database, ŁOG = Lodz Centre of Geodesy)
Source: own preparation based on BDOT.

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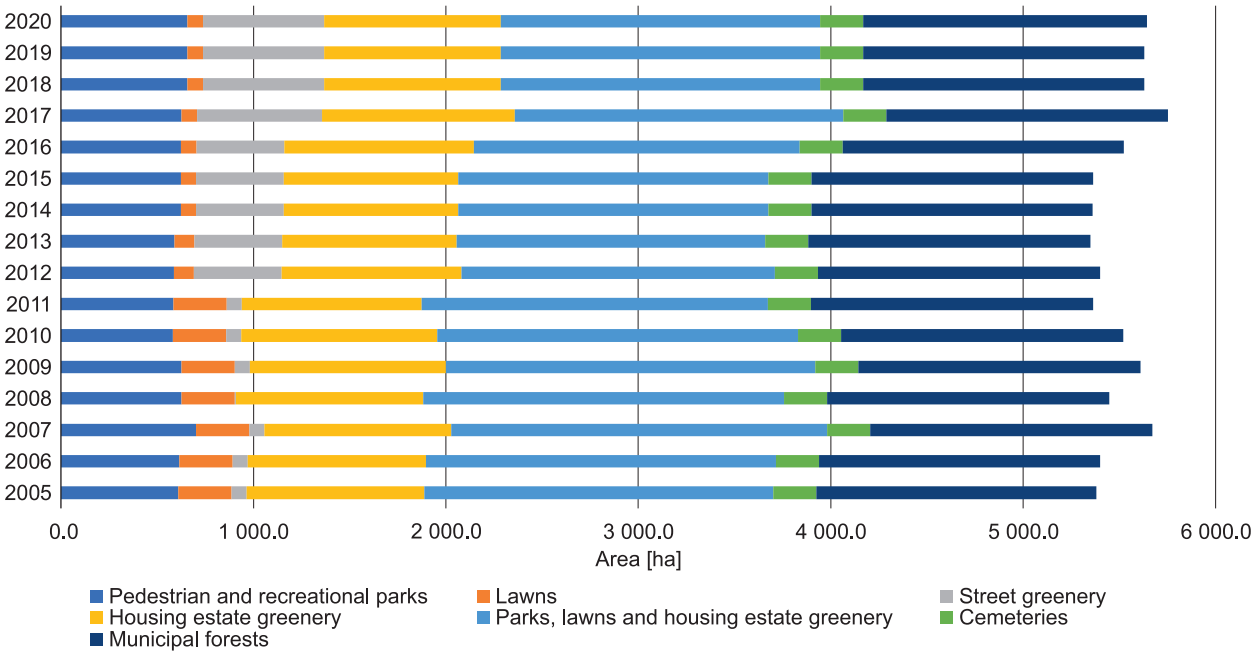

Fig. 2. Greenery in Lodz in 2005–2020 according to the Statistics Poland (Local Data Bank)
Source: own preparation based on CSO data.

Land and Property Register (LPR)

The LPR database primarily contains information on properties collected using terrain or photogrammetric surveying (Borsa et al., 2017). It is used in the performance of tasks in the field of economic planning, spatial planning, tax and benefit assessment, marking properties in land and mortgage registers, public statistics, and property management. The LPR data are used, among others, by tax authorities, as well as local government units (municipalities) for the purpose of spatial inventory of the area they cover (Notice, 2019). The LPR includes information on the location, boundaries, surface area and types of land use (Table 1).

Table 1. Types of land use according to LPR, their area and share in the city of Lodz

Type of use according to LPR	Surface area [km^2]	% of the city
1	2	3
Residential areas	46.17	16.00
Industrial areas	13.02	4.51
Other built-up areas	24.36	8.44
Urbanised undeveloped areas or under development	10.24	3.55
Built-up agricultural land	6.34	2.20
Recreational areas	10.95	3.79
Roads	30.84	10.69
Ecological use	0.91	0.31
Mining land use	1.07	0.37
Forests	24.69	8.55
Wooded and bushed land	3.77	1.31
Wooded and bushed land on agricultural land	0.11	0.04
Wasteland	1.23	0.43

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cont. Table 1

1	2	3
Pastures	6.66	2.31
Arable land	92.60	32.08
Orchards	2.57	0.89
Other communication areas	2.78	0.96
Railway areas	7.11	2.46
Land reserved for the construction of public roads or@railway lines	1.08	0.37
Miscellaneous land	0.34	0.12
Land under ditches	0.27	0.09
Land under surface water flowing	1.21	0.42
Land under surface water still	0.14	0.05
Land under ponds	0.19	0.06

Source: Lodz Centre of Geodesy (2018).

Population data

The population data necessary to carry out this study comes from the electoral register of voters of 30 June 2016 (UMŁ).

The distribution of the population was calculated as follows:

1. On the basis of vector layers of the Land and Property Register and information about the area of building outlines and the number of floors, the total area of all floors of each residential building in the city was determined.
2. The number of inhabitants in each of the 36 administrative auxiliary units of the city of Lodz was determined. Necessary data came from the Lodz Centre of Geodesy (vector data containing the boundaries of auxiliary units) and from the register of voters the Lodz City Hall (number of inhabitants per individual housing estate).
3. The size of the housing space per capita in individual administrative auxiliary units was calculated. The obtained values ranged from 35.06 m^2 to 115.57 m^2 per capita[1].
4. On the basis of the index value set out in point 1 and point 3, the approximate number of inhabitants of each residential building was determined.

The allocation of the number of inhabitants to the primary fields was made taking into account the relevant shares of buildings contained therein. Based on the above calculations, the map shows the distribution of population in Lodz (Fig. 3), and as a consequence, the spatial ratio of population distribution to areas designated as greenery on the basis of satellite images is also presented.

Satellite data

We use the Landsat 8 satellite scene from 3 July 2015 (path 189, row 024), obtained from the US Geological Survey (EarthExplorer). At the time the study was being carried out, it was the latest available image from the full vegetation season, on which the area of Lodz was not covered by a layer of clouds. Spectral bands 4 (Red) and 5 (NIR) were used to calculate the NDVI (Rouse et al., 1973), showing both the quantity and quality of greenery (Forster, 1982) in a given location, according to a classic formula:

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Since the image of the city of Lodz was entirely within the scope of the scene and no comparisons with other cities were planned, no sun and atmospheric correction of the images was made. The data down-

[1] For comparison, in 2002, the average floor area of an apartment in Lodz was 60.7 m^2 (20.5 m^2 floor area per capita). One flat was inhabited by 2.95 people and one chamber by 0.84 people (Parysek, 2004). In the years 2011–2016, according to the Central Statistical Office (Yearbook, 2015), the average floor area of a flat in Lodz was 53–54 m^2, with 27–28 m^2 per person. When comparing the indicators, one should remember about changes in the number of inhabitants of the city (725,055 in 2011 and 696,503 in 2016).

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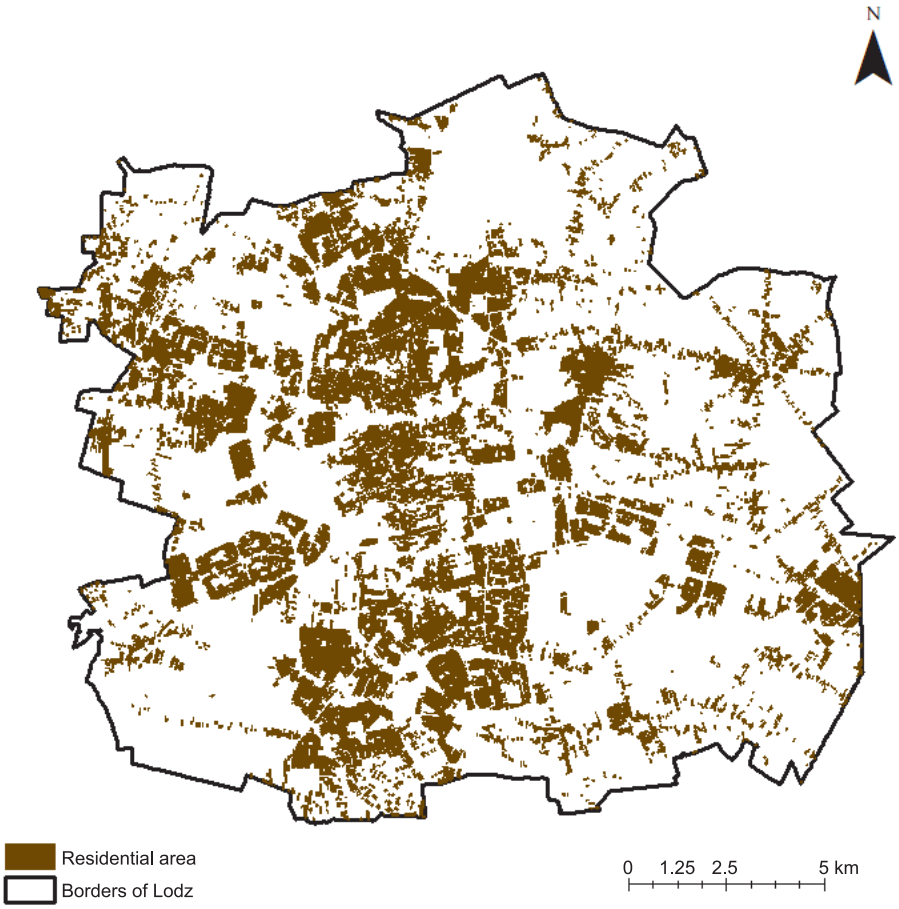

Fig. 3. Population distribution in Lodz
Source: own preparation based on the electoral register of voters (2016).

loaded using the Earth Explorer USGS browser has a topographic correction (USGS, 2020). The calculated NDVI values were between -0.18 and 0.63 (Fig. 4).

In an area covered by a single pixel, there are usually many different forms of land cover/development, not just greenery (Wirth et al., 1982; Kressler et al., 2000). In this case, the recorded NDVI value is the weighted average of the index value of all objects in the pixel area, with the weight being the share of the area of these objects in the pixel area (Figures 5–6):

$$\mathrm{NDVI} = \sum_{i=1}^{n} a_i \mathrm{NDVI_i}$$

$$\sum_{i=1}^{n} a_i = 1$$

where:

a_i – the share of the i-th object in the pixel area,
$NDVI_i$ – NDVI value of the i-th object located in the pixel,
n – number of forms of land cover/use.

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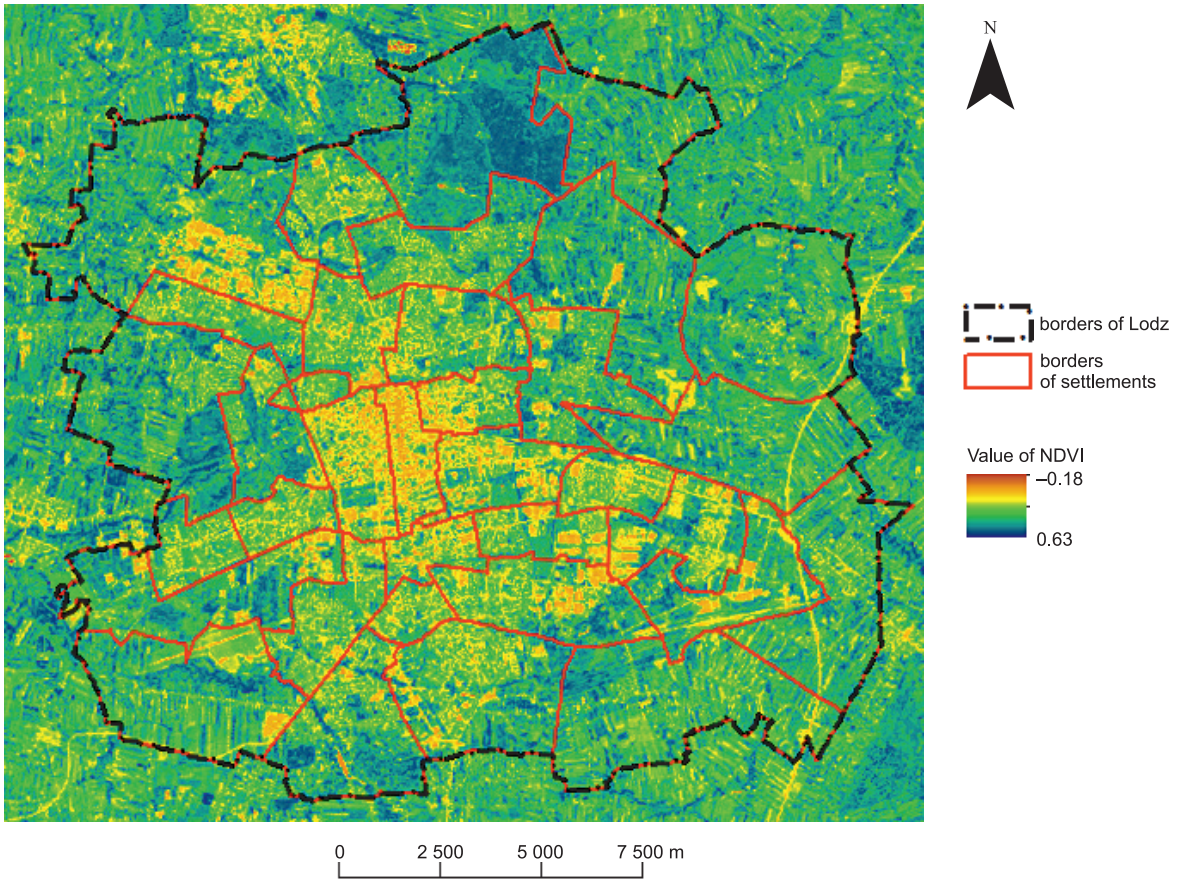

Fig. 4. NDVI for the area of the city of Lodz in the raster 30 × 30 m
Source: own preparation based on Landsat 8 image.

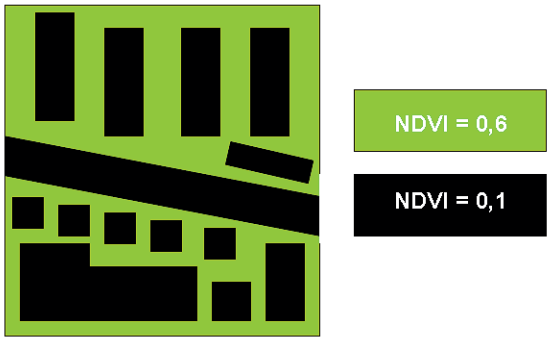

Fig. 5. Method of establishing NDVI values for areas composed of objects with different NDVI values. If the share of built-up areas and green areas are equal (50% each), the NDVI for the whole area is 0.35
Source: own preparation.

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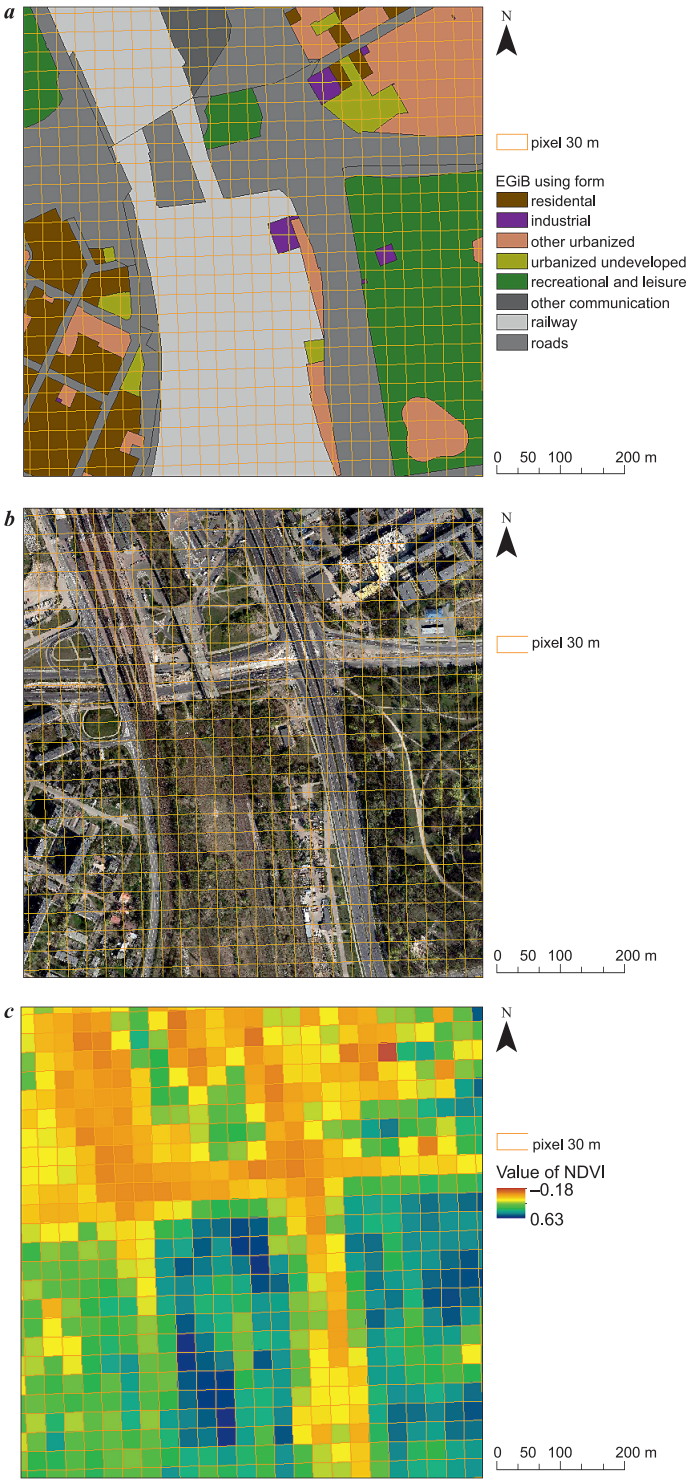

Fig. 6. Forms of land cover and registered NDVI values in pixels 30 × 30 m: a) objects according to LPR database, b) fragment of RGB composition of orthophotomap and grids of Landsat 8 image (30 × 30 m), c) calculated NDVI values
Source: own preparation based on EGiB, orthophotomap and Landsat 8 image.

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METHODS

NDVI of selected functional areas of the city

Areas classified as green areas we focused on, include forests, parks, squares, lawns and cemeteries (Fig. 7, Table 2). The share of these green areas in the total city area is 10.50% (30.77 km^2). They are largely covered with vegetation, but not fully, which is reflected in their average NDVI values (Fig. 8).

Table 2. The green areas in Lodz

Name	Area [km^2]	Share in the city area [%]
Forests	20.19	6.89
Parks	7.41	2.53
Lawns	0.94	0.32
Cemeteries	2.05	0.70
Squares	0.18	0.06
Total greenery	30.77	10.50

Source: own preparation based on LCG data.

Apart from the official greenery, there are many other areas with well-developed vegetation in the city, which successfully perform many important functions. For the precise characterisation of greenery resources, it is therefore necessary to also take into account the vegetation associated with undeveloped areas, i.e. areas called open according to Cieślak (2006) and residential and industrial development, traffic routes, watercourses, post-industrial wastelands, mines, etc. For a full balance, greenery associated with agricultural land (orchards, meadows, arable land) cannot be omitted, as the crops grown also fulfil many positive environmental functions (Lutz & Felici, 2008). According to Trzaskowska (2011) in analyzes of urban greenery, spontaneous, natural and synanthropic vegetation are rarely taken into account. It is most often not accepted by the society due to low aesthetic values and deteriorating sense of security. Nevertheless, it plays an important role, as it complements the spatial continuity of the urban greenery system and for this reason it should be used in the development of urban development strategies

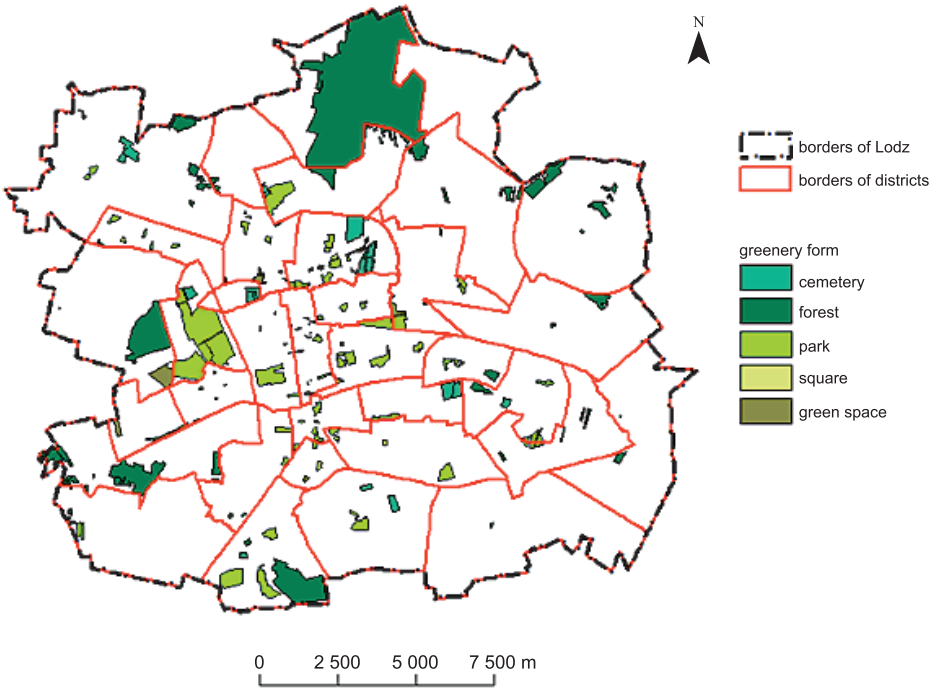

Fig. 7. Green areas in Lodz
Source: own preparation based on LCG data.

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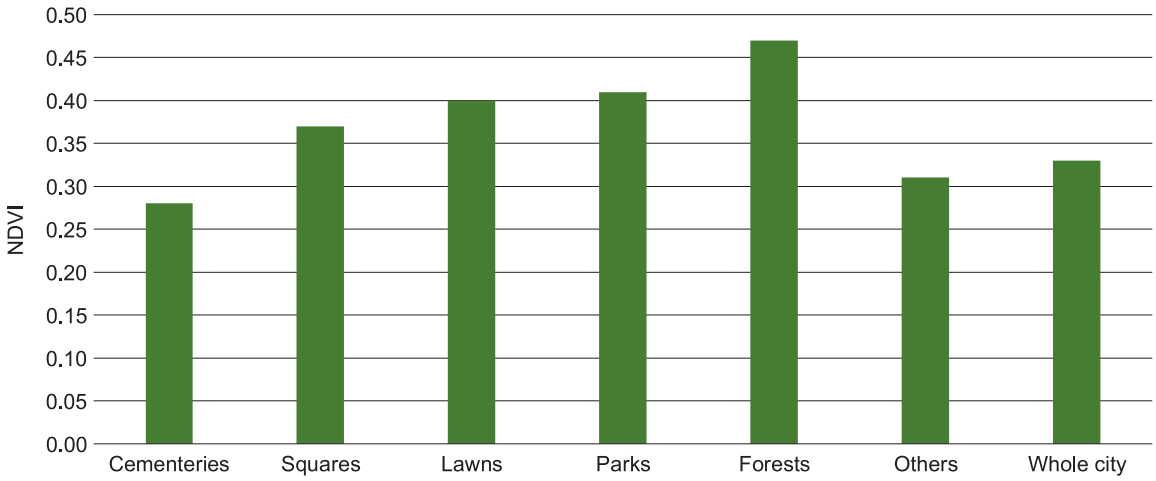

Fig. 8. Average NDVI values of selected functional areas of the city of Lodz
Source: own preparation based on LCG data.

in accordance with the principles of sustainable development.

The presence of greenery is expressed in the NDVI value calculated for each pixel of the satellite image. The distribution of NDVI values (Figures 9–11) is a good characteristic of the variability of vegetation in individual parts of the city. On the basis of NDVI distributions, typical ranges of values for this index were established for areas considered as greenery. These limits have been determined by establishing the modal value for the area under analysis and then including in the range the successive ranges the values adjacent to the modal value until the required percentage of the area is reached. Since such a procedure does not achieve a value exactly equal to the assumed value (68% of pixels in this case), its completion was decided when the next range was included and the number closest to 68% was reached (with the lowest possible undervalue or excess). The adopted method of determining the range for NDVI is similar to that of the mean value and standard deviation, which is, however, more appropriate for variables with distributions close to normal distribution (Wasilewska, 2009).

The established NDVI ranges have been used to designate areas of the city which, although not officially classified as green areas, have the same values of this index. In other words, areas with a level of greenery development similar to known forms: forests, parks, lawns, squares and cemeteries were indicated, so one can expect that in a given location there are similar developed vegetation complexes (Table 3, Figures 12–13).

Green areas and population distribution

In order to assess the living conditions and quality of life of the city's residents, it is important for the city's green spaces to be located in the areas they live in. For the analysis of spatially variable factors of the urban environment, it is recommended to use a network of basic fields, with a hexagonal grid being the best. However, there are no clear guidelines as to their size (Szarek-Iwaniuk, 2020). We have adopted 90 × 90 m grid, corresponding to groups of 9 (3 × 3) pixels of Landsat 8 satellite image as residential areas. The rationale for choosing this size of the primary field was the desire to take into account the condition of vegetation in the place of residence and its immediate surroundings. It was assumed that the immediate surrounding means a space contained within a circle with a 50 m radius, whose area is approximately equivalent to a square of 90 × 90 m. Consequently, the NDVI values determined had to be converted, by averaging, from a grid of pixels to a grid of 90 × 90 m primary units (Fig. 9). This operation

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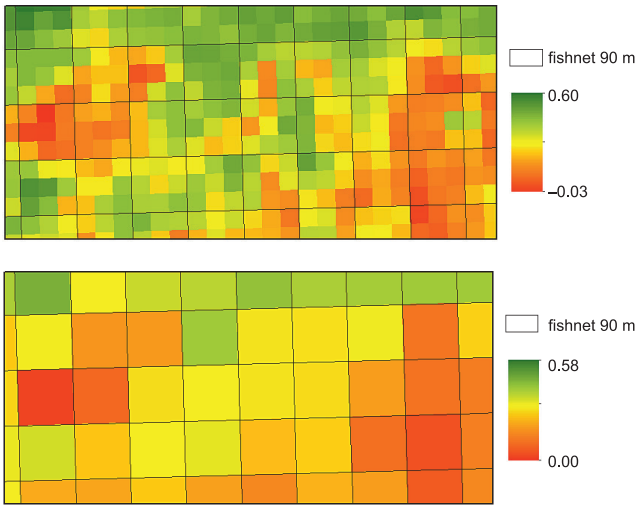

Fig. 9. Conversion of NDVI from a 30 × 30 m pixel grid of the Landsat 8 image into a 90 × 90 m grid of primary fields

Source: own preparation based on Landsat 8 image.

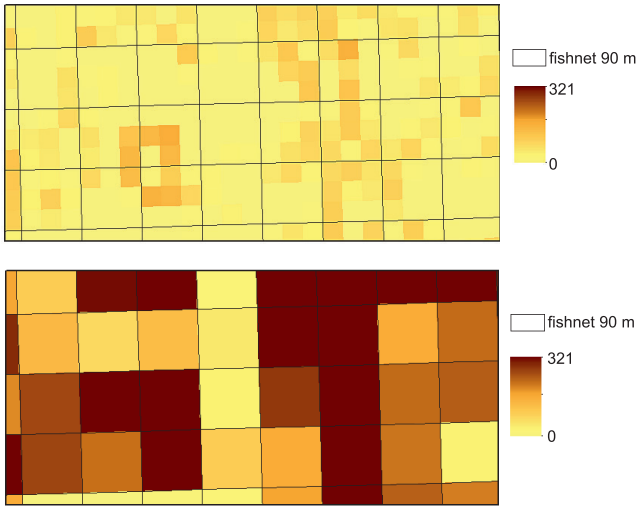

Fig. 10. Population distribution in the grid of 90 m × 90 m primary fields. *Source*: own preparation based on the electoral register of voters (2016)

Source: own preparation.

only slightly changed the range of the index to values from -0.11 to 0.60.

For the purpose of the planned analyses, the number of people living was determined for each of the primary fields of a square grid of 90 × 90 m, corresponding, as was the case with the NDVI value, to the size and range of 9 pixels of the satellite image. The grid schematically divides the city space, including individual housing estates and individual buildings, into smaller sections. The way of calculating the approximate number of inhabitants in the individual primary fields was presented in the chapter Population data.

Tabular lists were prepared (Table 3).

RESULTS

The distribution of NDVI values for many functional areas of the city clearly shows that in some areas the share of greenery in the coverage of these areas is large. The NDVI even reaches values typical of forests and parks in many places (such as wastelands).

The average value of NDVI for the whole Lodz is 0.33 and takes values from -0.18 (surface waters) to 0.63 (forests). The distribution of NDVI values within the city limits is close to the normal distribution with a predominance of areas with a low NDVI (Fig. 11a).

When comparing the NDVI distribution of individual forms of land use, it can be seen that in most cases there is no specific level of greenery for particular areas (Fig. 12).

However, there are land use types that are in practice limited to a narrow spectrum of NDVI values, such as forests. The grid size of 90 × 90 m, as well as the high fragmentation of land use, means that in many cases the NDVI value represents more than one form of land cover (utility function). The analysis shows that as much as 32% of land use in LPR has an area equal to or less than 900 m^2, i.e. less than one image pixel. However, it should not be forgotten that the functions of greenery are not limited to the area it occupies, but also very important for adjacent areas.

An analysis of the distribution of NDVI values for urban-specific land use forms (residential, industrial and wasteland), not associated with greenery, was also carried out. The selected areas vary considerably in terms of the distribution of NDVI values. Residential areas show a distribution close to normal, with the median established for NDVI=0.3 (Fig. 13a). The graph for industrial areas (Fig. 11b) with a high prevalence

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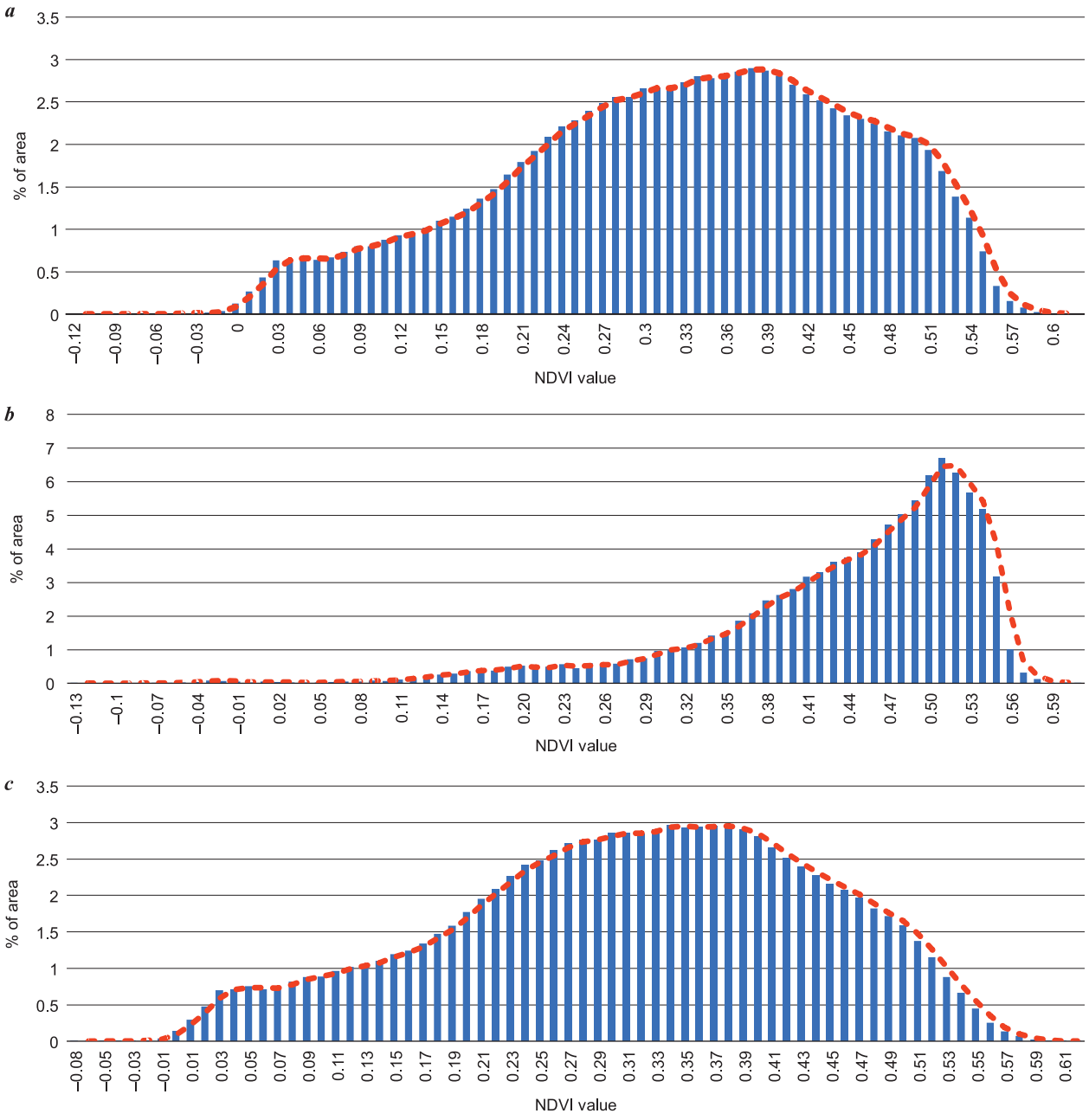

Fig. 11. NDVI distributions in the range ΔNDVI = 0.01 for: a) the whole city, b) areas officially classified as green areas (forests, parks, lawns, squares, cemeteries), c) other areas not including green areas
Source: own preparation based on Landsat data.

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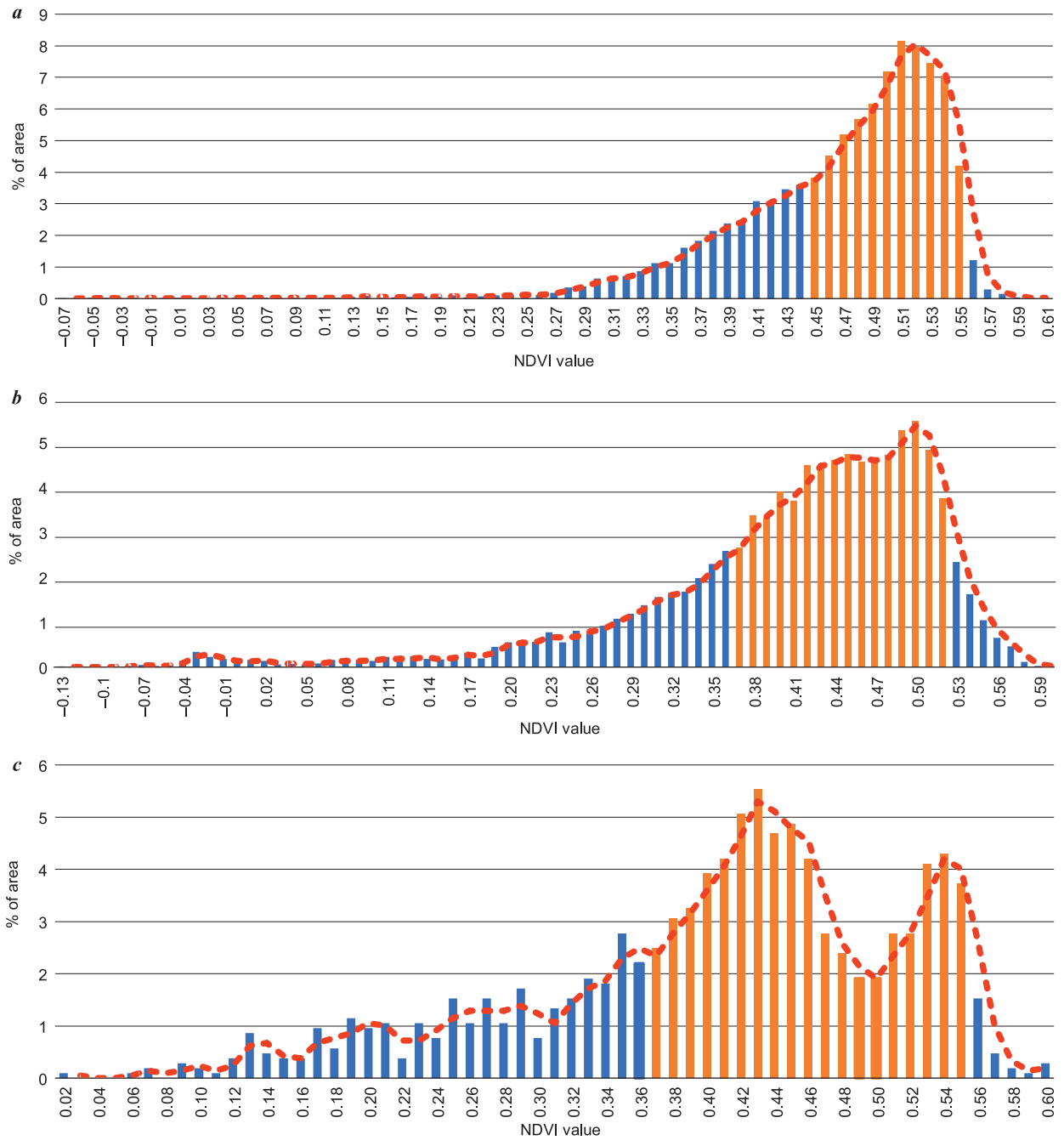

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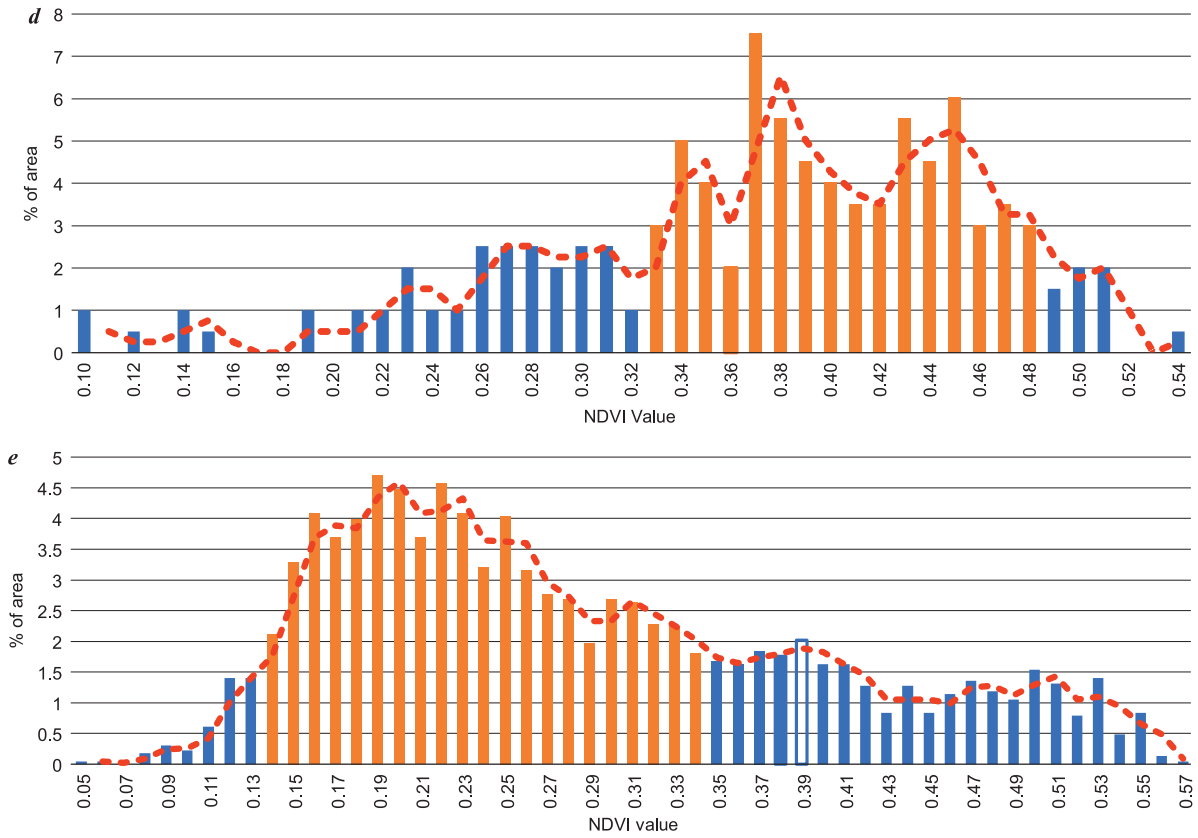

Fig. 12. NDVI distributions in ranges of ΔNDVI = 0.01 for areas officially recognised as green areas in Lodz: a) forests, b) parks, c) lawns, d) squares, e) cemeteries. Red is for the range of typical (68%) NDVI values
Source: own preparation based on Landsat data.

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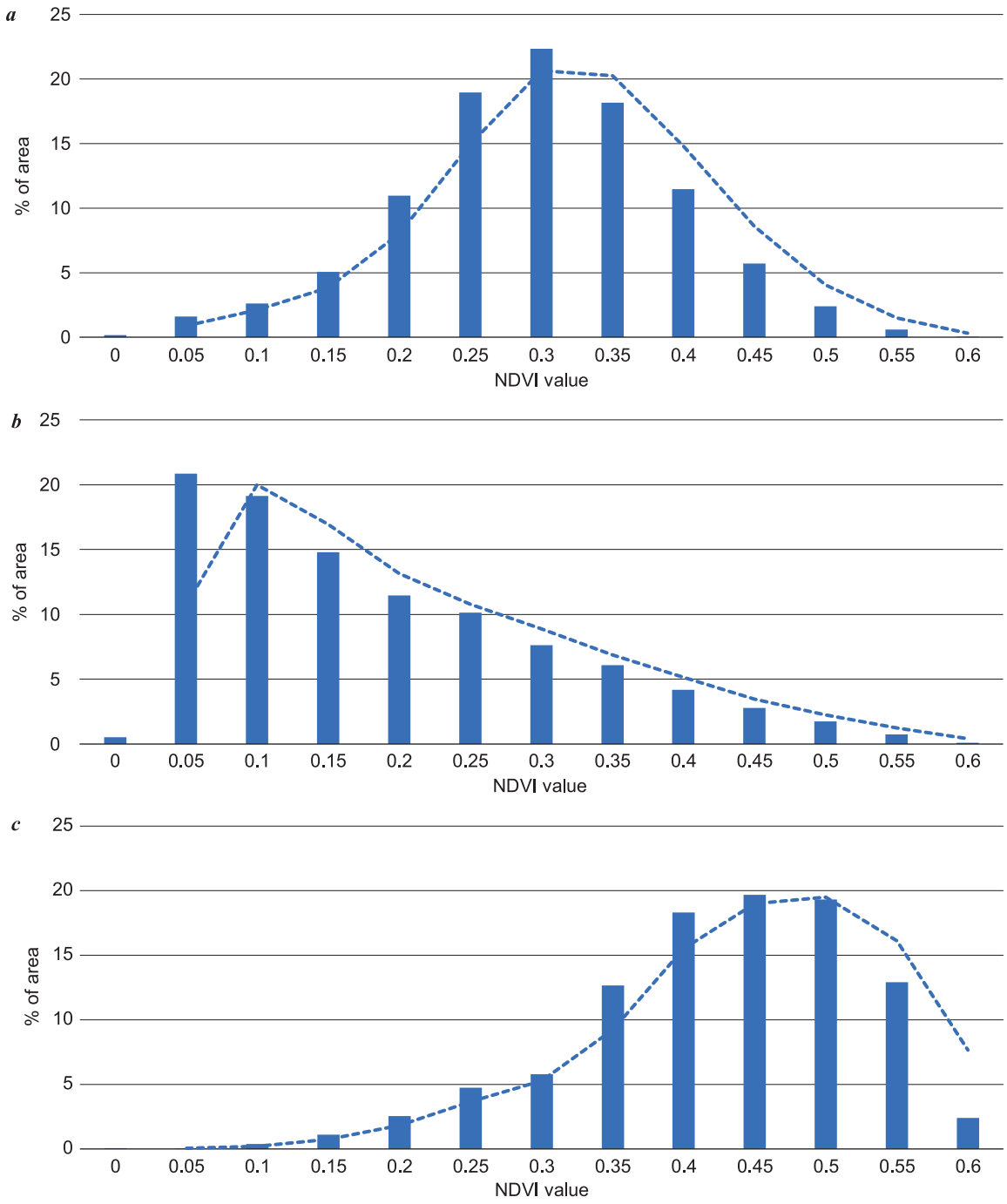

Fig. 13. NDVI distributions within ΔNDVI = 0.05 for areas of Lodz not classified as green areas: a) residential areas, b) industrial areas, c) wastelands

Source: own preparation based on Landsat data.

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of low values and a median = 0.05 clearly shows that greenery is very rare in these areas. The situation in wastelands, where the distribution of NDVI values (Fig. 11c) resembles the distribution for green areas, is the opposite. This is because, after some time, vegetation enters such areas through spontaneous succession (Rostański, 2000).

Based on the determined characteristic NDVI values for individual types of green areas in Lodz, maps were drawn of areas within the borders of Lodz, where the density and quality of vegetation is similar to the specific forms of land use (Figures 14–15), i.e. the NDVI value is within the above mentioned ranges.

The data thus collected were compared with information on the number of inhabitants living in specific characteristic areas (Table 3).

Table 3. Share in the city's area of areas where the NDVI value corresponds to ranges typical for green areas

Typical NDVI range for particular green areas		City area where NDVI is comparable to typical NDVI range		Number of inhabitants	
Object	NDVI range	[km^2]	[%]	[thousands]	[%]
Forests	0.45-0.55	56.11	19.16	3.72	0.57
Parks	0.37-0.52	110.73	37.81	26.99	4.14
Lawns	0.37-0.55	118.78	40.56	27.04	4.14
Cemeteries	0.14-0.39	169.47	57.87	502.85	77.06
Squares	0.33-0.48	137.43	46.93	94.68	14.51
Total greenery	0.42-0.55	77.78	26.56	7.46	1.14

Source: own preparation based on Landsat data.

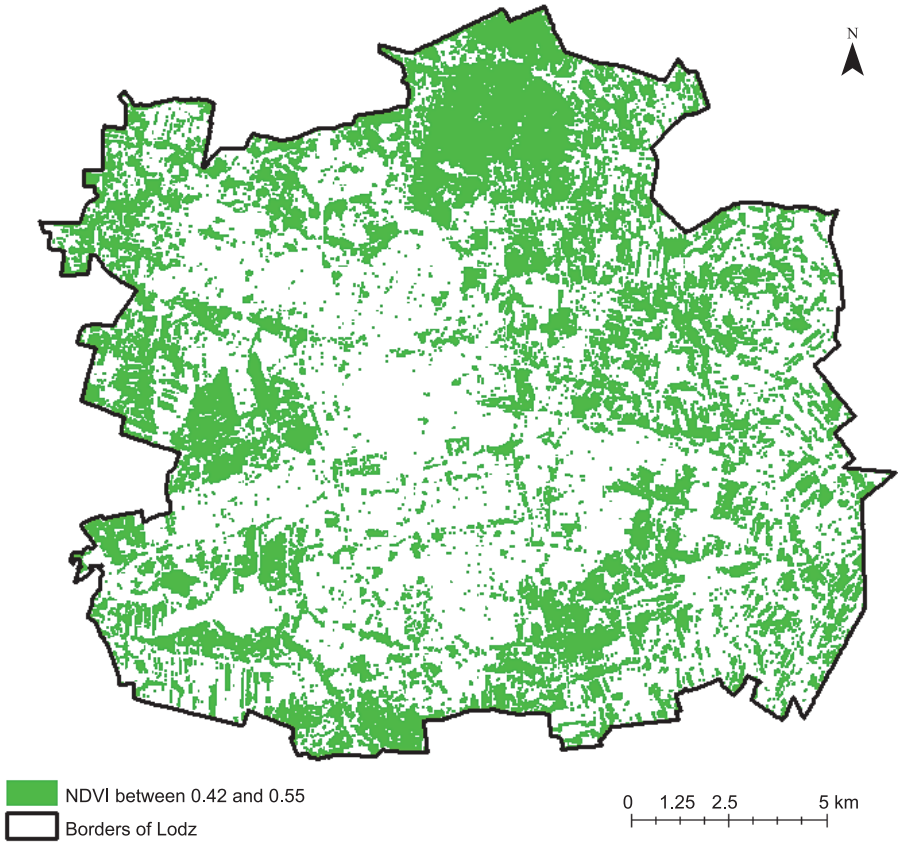

Fig. 14. Areas with an NDVI value within the limits typical for areas officially recognised as greenery in Lodz (0.42<NDVI≤0.55)
Source: own preparation based on own research.

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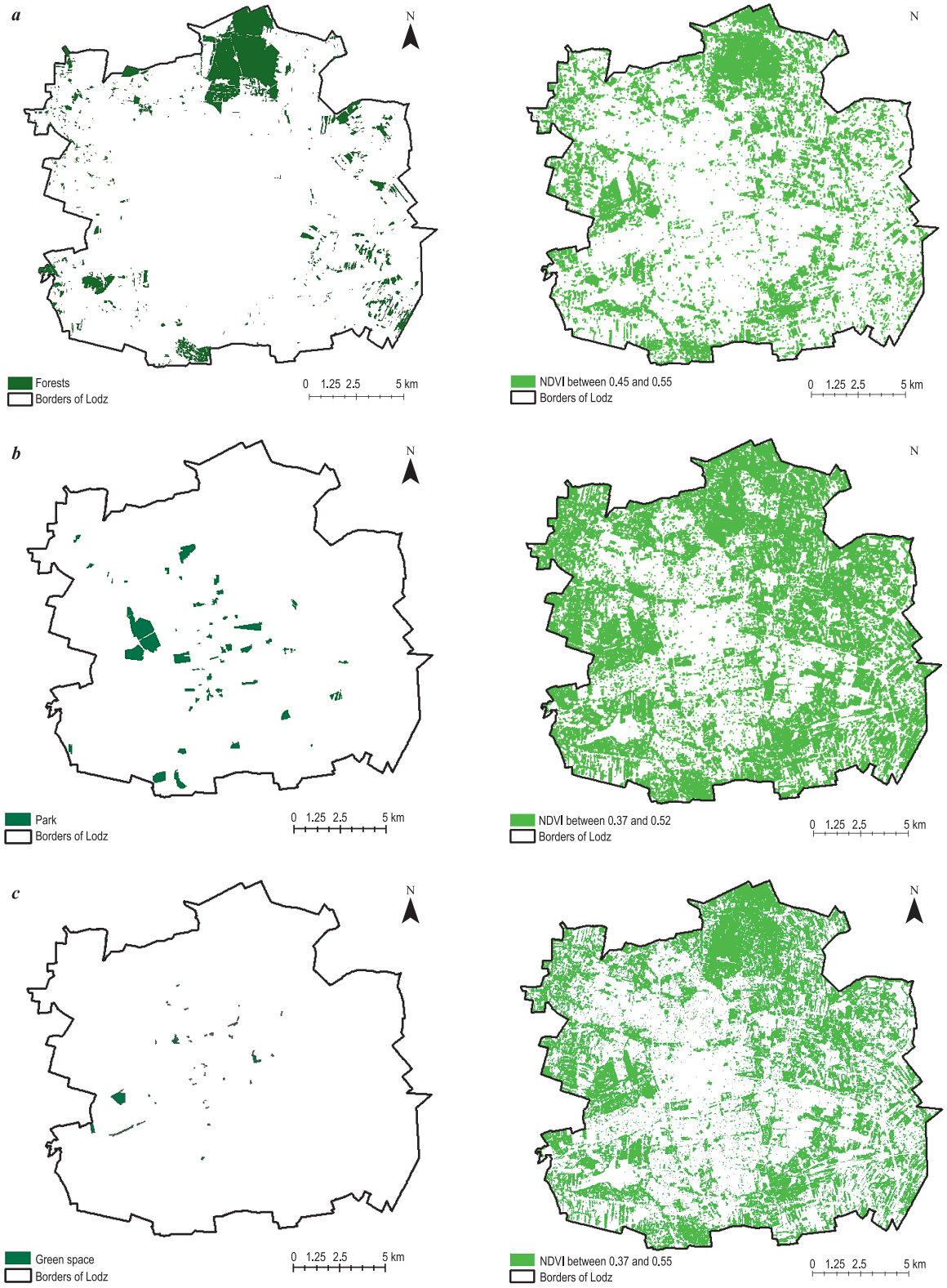

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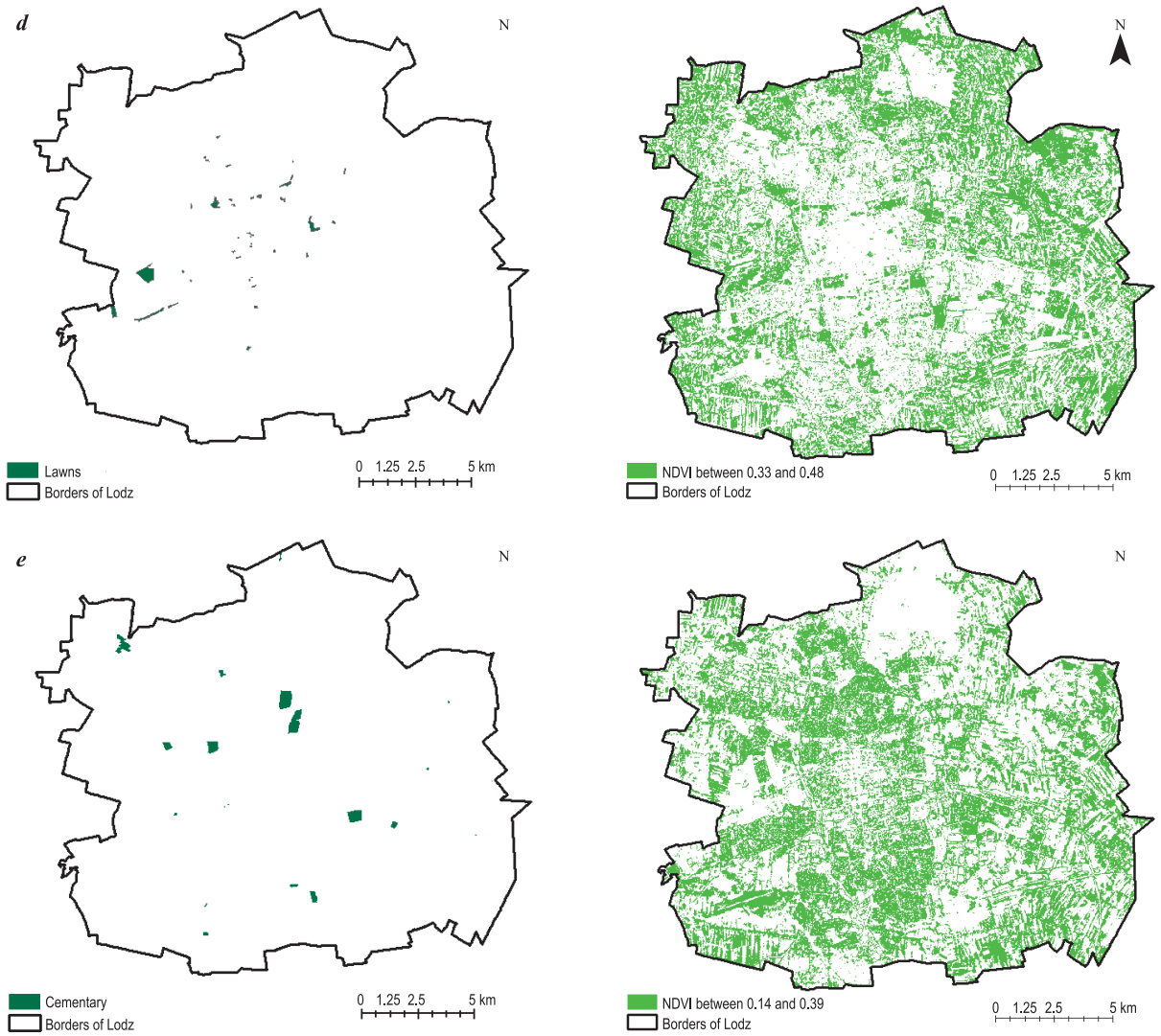

Fig. 15. Location in the Lodz city of (on the left): a) forests, b) parks, c) lawns , d) green squares, e) cemeteries and (on the right) areas where the NDVI value corresponds to their typical ranges (compare with Fig. 10 and Table 3)
Source: own preparation based on Landsat data.

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CONCLUSIONS

The presented overview maps (Figures 14–15) very visibly illustrate the fact that there are many areas in Lodz with vegetation at a level not inferior to that in areas officially classified as green areas. The area within the administrative boundaries of Lodz characterised by a similar level of vegetation development as in the areas included in public reports is over 2.5 times larger (30.77 km^2 to 77.78 km^2). This demonstrates that more than ¼ of the city area (26.56%) does not differ in terms of greenery from the areas officially classified as green. However, it should be noted that the range of NDVI values (0.42–0.55), on the basis of which green areas were determined, was underestimated by the index value for cemeteries (0.14-0.39) and also by squares (0.33-0.48). These areas, due to the fact that they are equipped with various elements of impervious surface, have less greenery, as it mixes with surfaces covered with concrete and asphalt with very low NDVI values (Siciński, 1986). It should be noted that cemetery is defined as a green area in the Act on Nature Conservation, but in the Polish Classification of Buildings it is included in the category of buildings (intended for worship and religious activities), similarly in the Construction Law Act (Długozima, 2020).

On the opposite side, there are urban forests, which are obviously less intensively developed than the other areas of urban greenery (Łonkiewicz, 1997). In the case of Lodz, the limit NDVI values that characterise these areas to the greatest extent, are set at 0.45–0.55. Despite quite characteristic physiognomy, similar NDVI values were detected in an area of over 56 km^2, which is almost three times the area of the forests themselves (Fig. 15a).

In general, the results show that there are much more green spaces, comparable in terms of vegetation abundance with the official green spaces. That means the city is underestimated when talking about the greenery.

Another issue is the presence of these areas in the place where the inhabitants of Lodz live and their immediate surroundings. Despite the fact that almost 1/5 of the area of Lodz has greenery comparable to that of the forest, only one inhabitant in 200 has direct access to it without having to leave their place of residence. In the case of the NDVI zone corresponding to parks and lawns, only 4% of the inhabitants (or 27 thousand in absolute numbers) have similar quality greenery in their place of residence. In the case of cemeteries, the situation is the opposite, as the majority of inhabitants (77%) have similar greenery in their place of residence. This shows that most cemeteries do not have the same environmental functions as forests, parks or lawns (Długozima, 2014).

It is also noteworthy that, despite the often very uneven distribution, the range determined by taking a next value of NDVI in increments of 0.05 starting from the modal values ranged between 67.32% and 68.44% of the analysed areas, while for normal distribution it is 68.3%. The above results therefore indicate that the method used to determine the characteristic values, as regards the NDVI for individual forms of land use, is correct.

It is also worth considering the possibility of linking the NDVI or other vegetation indices with features that describe other qualities of the vegetation, such as its height and volume. Proposals in this area were presented by Worm and others (2019), based on the example of the city of Lodz.

In addition to these research, it might be a good idea to take into consideration an open access spatial datasets, e.g. OpenStreetMap where users who know a specific area classify the space based on its physiognomy.

A similar approach to the assessment of the greenness of the city was adopted by Gupta et al. (2012). They made an attempt to take into account, in addition to vegetation, also the characteristics of buildings (density and height), which were to indirectly indicate the density of the population. The data they used for this purpose came from the interpretation / processing of remote sensing data, while we used information from official databases. Additionally, what distinguishes our approach is the reference of NDVI intervals to easy-to-imagine objects and related forms of covering (and filling) the space

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with greenery (parks, trees, lawns, squares, cemeteries), while the above-mentioned authors adopted the artificial boundaries of the intervals values for NDVI and other products. What is common, however, is the endeavor to identify, finally, areas requiring, as a priority, greater development of green areas.

Table 4. Translated and original names and their abbreviations concerning institutions and databases used in this work

Translated name	Original name in Polish
TOD, Topographic Objects DataBase	BDOT10k, Baza Danych Obiektów Topograficznych
GGOD, General Geographic Objects DataBase	BDOO, Baza Danych Obiektów Ogólnogeograficznych
LPR, Land and Property Register	EGiB, Ewidencja Gruntów i Budynków
LCG, Lodz Centre of Geodesy	ŁOG, Łódzki Ośrodek Geodezji

Source: own preparation.

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TOURISM AND RECREATION IN POLISH NATIONAL PARKS BASED ON SOCIAL MEDIA DATA

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ABSTRACT

Motives: Matters related to monitoring recreational use of national parks and identifying sites with high cultural values of ecosystem services are essential elements for the efficient management of these areas.
Aim: The objectives of this study were to: 1) recognize the spatio-temporal distribution of activities in national parks by users of selected social media platforms; 2) identify the locations with the highest activity among the various groups visiting the national parks; 3) identify the locations (hot spots) with the highest potential for providing cultural ecosystem services (CES).
Results: The spatial and temporal distribution of activities among various user groups in the national park areas was displayed using data from social media platforms and applications. Additionally, CES hotspots for the five most popular national parks were found.

Keywords: recreation, tourism, national park, user-generated geographic information, visitor monitoring

INTRODUCTION

Interest in outdoor leisure and tourism has substantially expanded as a result of changes in recent decades in areas such as: environmental awareness, population mobility, economic conditions, and lifestyle (Ode & Fry, 2002; Kaczmarska, 2014). The beneficial effects of nature on human health and well-being also contribute to this rise (Staats et al., 2013; Furuyashiki et al., 2019). Society's needs for contact with nature and recreation is realized among others, in areas with high natural and cultural values, such as national parks.

The findings show, recreational use of national parks is increasing, which emphasizes their popularity as a travel destination. Due to high demand for recreation in national parks, it is becoming more difficult for management entities to balance the two primary purposes of parks: nature protection and tourism (Ciapała et al., 2010). Excessive recreation and poorly managed tourist traffic may bring threats to national parks, in the form of, among others congestion on tourist routes, fires, damage of vegetation, and ecosystems being used beyond their natural capacity (Hadwen et al., 2007; Lyon et al., 2011). Furthermore, conflicts can also arise

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within the tourism function and affect different user groups (Hunter, 2001). Information on tourist pressure and the needs of different user groups is in interest of national parks management entities in order to provide effective tourism management (such as traffic channelization and zoning) (Matczak, 2002). One of the tools that can support management is the concept of ecosystem services developed in recent years, i.e., the concept of the streams of services that environment provides to humans and that can be identified and valued (Burkhard et.al., 2014; Elmqvist et al., 2015). There are several subdivisions of ecosystem services, and the most popular ones list the following categories: provisioning, regulating, supporting, and cultural (Maes et al., 2016). From the perspective of this paper, the most important category is cultural ecosystem services, which we define as follows: "nonmaterial benefits people obtain from ecosystems", and specifically lists "cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and ecotourism" (MEA, 2003; 2005). According to Kremer et al. (2016), studies aimed at better understanding and evaluating CES have only grown in popularity in recent years, so research in this area is still required.

LITERATURE REVIEW

Costanza (2008) argues that for ecosystem services related to tourism and recreation to take place, users must be present in the ecosystem. The assessment of ecosystem services for tourism requires not only the character and availability of these natural resources, but also the demand for specific services (Kulczyk et al., 2014). As a result, data on tourism is crucial in terms of determining CES. For a long time scientific study has focused on the problem of recreational use of natural areas. A comprehensive analysis of the monitoring was offered by Cesfford & Muhar (2002). The authors distinguished, among others, the following methods: surveying, direct observation, indirect observation, mechanical computing equipment, ticket sales records. There are many ways to conduct surveys, including direct interviewing (Paper and Pencil Interview (PAPI)); direct interviewing with the assistance of computer techniques (Computer Assisted Personal Interview – CAPI); web surveys (Computer Assisted Web Interviewing – CAWI); telephone surveys (Computer Assisted Telephone Interview – CATI). Direct observations, on the other hand, can be conducted stationary or by personnel in the field, usually continuously on scheduled survey days. Aerial photography, pictures from unmanned aerial vehicles, camera traps, and video monitoring are examples of indirect approaches (Arnberger et al., 2005; Arnberger, 2006; Leggett, 2015). Pyroelectric sensors, which use infrared radiation to register movement are a popular monitoring tool in Polish national parks (Spychała & Graja-Zwolińska, 2014). Data from the sensors have enabled the characterization of movement in the following national parks, among others: Stołowe Mountains National Park (Rogowski, 2017; 2020), Tatra National Park (Hibner, 2014) and Bieszczady National Park (Szybki, 2012). However, the approach that counts visitors based on the number of entry tickets sold is the one that is most frequently deployed (Skawiński, 2010).

All these methods have their advantages and disadvantages and, to different extents, allow us to answer the fundamental question related to the recreational use of natural areas. Following questions have been defined by Daniel (2002): "Who is Where and When Doing What?" Willberg (2021) pointed out another important question, namely: "Why does the activity take place?". To find answers to such posed questions, recreational monitoring gathers data on visitor counts, movement patterns, travel routes, spatial distribution, group sizes, demographic characteristics, or behaviour. Currently, there is no single method that allows for the potential of obtaining all pertinent information for natural area management. Indeed, many of them are time-consuming and costly (Heikinheimo et al., 2017), and some of them are conducted in a point-wise manner on small areas. Therefore, it is very common to integrate data from multiple sources when undertaking monitoring

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(Rogowski & Małek, 2016). New methods of data acquisition are also being sought, including data from telecommunication network operators (e.g., data from phones with built-in GPS or data on so-called logs, i.e., places where actions such as text messages are recorded) (Shoval & Isaacson, 2007; Raun et al., 2016), as well as data generated by users of social media and applications (Majewska et al., 2016; Ciesielski & Stereńczak, 2021). Data generated by network users is called user-generated geographic information. In principle, social media data was to share one's experiences and information among a specific community of people. Much of this data also include geo-location information (X, Y coordinates), its creation date, as well as descriptions (hashtags) and images. The characteristics of the data generated by web users, mainly the photos, suggest that it is possible to identify, among other things: locations the authors are attracted to (analysis of coordinates); factors that make a place appealing (title analysis, photo); evaluation of a particular object based on descriptions or tags (Majewska et al., 2016). In the end, the potential of CES can be deduced from the examination of photographs by determining how desirable a location is. This is significant because CES are considered the most subjective and anthropocentric of all ecosystem services (La Rosa et al., 2016). They are therefore challenging to quantify (Keeler et al., 2015). For this reason, in recent years, photographs have become a valuable source of information on public activity in natural areas. Access to data from social media platforms and applications is constrained by their privacy policies and, as a rule, external users have access only to data with public data status (Di Minin et al., 2015). The size of data means that using application programming interfaces to collect and process them typically requires programming knowledge (Antoniou et al., 2016). The data obtained are typically impacted by the overrepresentation of a particular group (portal users) (Li et al., 2013) and the fluctuation in data-recording caused by factors like site availability (Balmford et al., 2015). Despite their limitations, data from Twitter, Flickr, and Instagram have been successfully implemented in studies (Ghermandi & Sinclair, 2019) that identify hot spots of cultural ecosystem services in natural areas at various spatial scales (Willem et al., 2015; Haines-Young & Potschin, 2018); map the distribution of cultural ecosystem services like aesthetic value or recreation (Becken et al., 2017; Figueroa-Alfaro & Tang, 2017) and analyze temporal and spatial distribution of recreational activities (Wood et al., 2013; Ciesielski & Stereńczak, 2020; 2021); differences in spatial use between visitors and locals (Tenerelli et al., 2017); assessing landscape aesthethic appearance and tourist satisfaction (Tenerelli et al., 2016; Tenkanen et al., 2017). According to Majewska et al. (2016), multimedia content published online can be compared to the presentation of particular tourist attractions that have been considered appealing by Internet users, and therefore have high CES potential. It is worth highlighting that the use of social media data, including the studies on the number of tourists in national parks, have confirmed that there is a correlation between the quantity of images taken and the number of admissions sold (Session et al., 2016). This reveals the applicability of these data. The analysis of recreation in forest areas (Ciesielski & Stereńczak, 2021; Grzyb et al., 2021), urban space (Zasina, 2018), the description of the attractiveness of tourist space (Majewska et al., 2016) and urban green infrastructure planning (Guerrero et al., 2016) are just a few of the research that have been done so far in the Polish literature utilizing data from social media.

Considering the significance of issues relating to tourism and recreation in national parks, we defined following objectives for this study:

1. recognize the spatio-temporal distribution of activities in national parks by users of selected social media sites and applications;
2. identify the locations with the greatest activity among the various groups visiting the national parks;
3. identify the locations (hot spots) with the greatest potential for providing CES.

The aforementioned goals were accomplished using information from social media and applications.

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MATERIALS AND METHODS

Study area

The research area included 23 national parks in Poland, created under Article 8(2) of the Act on Nature Conservation (Act on Nature Conservation, 2004) to "preserve biological diversity, resources, formations and components of inanimate nature, and landscape values, to restore proper condition of resources and nature components, and to reconstruct deformed natural habitats, plant habitats, animal habitats, or fungal habitats". Collectively, the national parks in Poland cover an area of about 315,000 hectares. The smallest is Ojców National Park (approximately 21.5 km^2) and the largest is Biebrza National Park (about 592 km^2). The majority of Poland's national parks are forested, with woods covering 70% of their area, waterbodies 10% and other areas 20%. A little over 24% of the national park's areas are under strict protection, while about 66% are partially protected and the remaining area fullfills service functions (privately owned agricultural and forest land, occupied by park infrastructure, etc.).

Because of their natural and landscape values and their role in ecological education, parks are a subject of public interest in terms of tourism and recreation. The areas of national parks are thus accessible to visitors, with the restriction that tourist traffic is limited to specific locations, trails, roads, and paths.

According to the Statistics Poland (Environmental Protection, 2020), the number of visitors to national parks in 2019 ranged from 12.8 thousand in the Narew National Park to 3947.4 thousand in the Tatra National Park (Fig. 1). In addition to Tatra National Park, the top five most visited national parks in Poland are: Karkonosze National Park (with 2160.0 thousand visitors), Wolin National Park (with

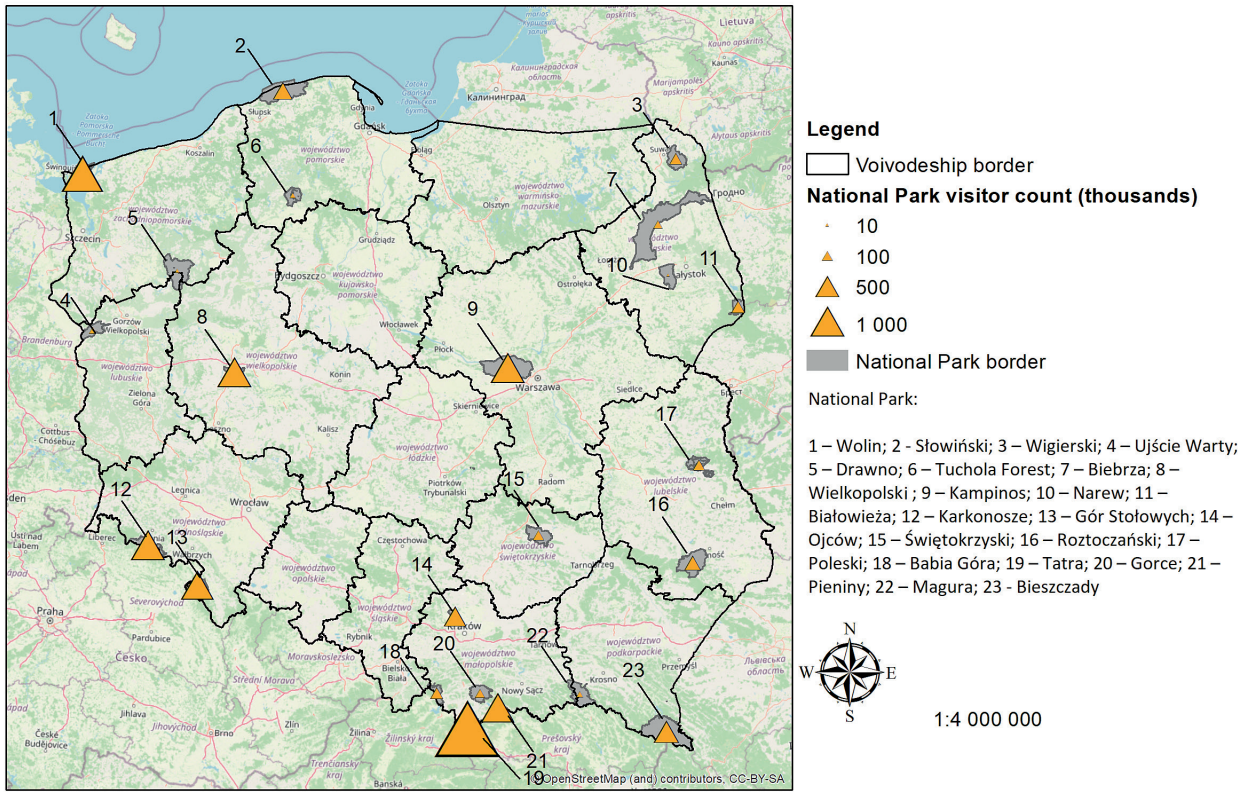

Fig. 1. Number of visitors to national parks in Poland in 2019
Source: own preparation based on data from Statistics of Poland.

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1500.0 thousand visitors), Kampinos National Park (with 1000.0 thousand visitors), and Wielkopolski National Park (with 1000.0 thousand visitors). Nearly 75% of all visits to national parks in Poland are made up of tourists who visit the five most well-known parks. It should be emphasized that some of the data presented are estimates and only few parks monitor their tourist traffic, for example, based on the quantity of tickets sold.

Data description

Photos from the social network Flickr were requested and gathered using the Flickr Application Programming Interfaces and a query built in R software (version 3.6). (Bernetti et al., 2019). Only data with a public status and those with geolocation (X, Y coordinates) were collected in accordace with the platform's privacy policy. The nickname and unique ID of the author of each image, the date and time the image was taken, the image's title and its description were also extracted. For the territory of the entire extent of Poland, 1,035,539 photos were collected, covering the time frame from January 1, 2010, to December 31, 2018. Then from the downloaded dataset, only the photographs that fell within the borders of national parks were selected. Further filtering were done in accordance with the presumptions made in the literature, leaving one image taken by one user on a certain day (photo-user days – PUD) (Tenkanen et al., 2017). In this case, the aim was to eliminate redundant data from a single contributor. Finally, 6787 photos were examined.

GPies.com, Endomondo, and MapMyRide were used to collect data on the activity of users of selected sports apps. The data search was conducted at the applications level. The following criteria were established for the search:

a. the activity or its part took place within the national park area or within 25 km of its boundaries;
b. the activity was recorded using a GPS device;
c. the type of activity included cycling, biking, mountain biking, running and walking;
d. in the Endomondo application, each searched route was linked to the number of recorded activities.

There is a limitation of the GPies.com application as it only allows users to download just the most recent 250 GPS tracks for a particular type of activity. Furthermore, only the GPies.com portal provided details about the date the track was registered and the time it started. In all portals it was possible to search for activities with public status, which means that the user who registered the activity permitted other portal users to view it. Due to the disparity in data types, they had to be converted to shapefile format. This layer was also utilized to determine the locations from which the activities initiated (starting points). The total number of activities included in the analysis was 15,220, with 3,980 falling into the running category, 1,060 under walking and 10,180 under cycling (biking, cycling and mountain biking).

Analysis of spatio-temporal distribution of activities (GRID mesh)

Based on data from GPies.com and Flickr, differentiation of the temporal distribution of activities was performed for all national parks for the aggregated periods (hours, days of the week and months). Data aggregation was designed to allow for a visual comparison of the variation in activity registration between different users. In addition, following the guidelines of Toivonen et al. (2019), the analysis of the temporal distribution of activities was performed for the entire analysis period, without breaking it down by years. Such procedure makes it possible to minimize the impact of gaps in data collection.

For the five national parks with the highest recorded number of activities from social networks (cumulative condition: Flickr data number > 350, Endomondo, GPies.com, and MapMyRide data number > 320), the analysis of spatial distribution of activities was performed using the modified approach described by Nogueira Mendes et al. (2012). The condition defined was met by five national parks: Tatra National Park, Karkonosze National Park, Ojców National Park, Kampinos National Park and Bieszczady National Park. According to the adopted methodology, a grid of 500 × 500 m was created

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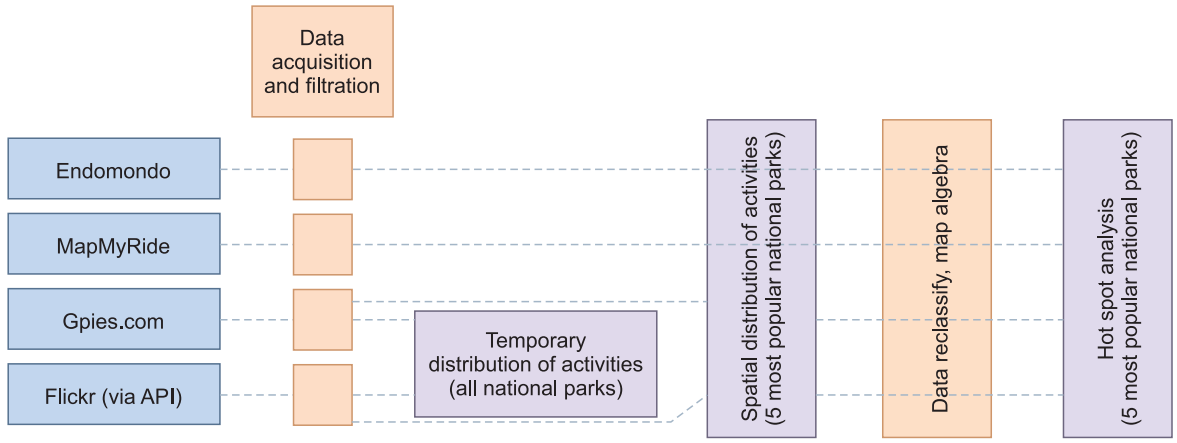

Fig. 2. Workflow
Source: own preparation.

to perform the analysis. The selection of the grid size was conditioned, among others, by the size of the analyzed area. Each grid cell was given information on the number of activities, one for each activity, such as photography (Flickr), running, walking, and cycling. The following phase involved converting vector data to raster data, while taking into account the partition into 10 deciles. The numerical values characterising each decile were reclassified, after creating rasters for all activities (separately for each national park), where:

a. class 1 (deciles 1–3) – low intensity of use;
b. class 2 (deciles 4–7) – moderate intensity of use;
c. class 3 (deciles 8–10) – high intensity of use.

Then, using map algebra, the raster values were aggregated (range 0–12), where the higher the value, the greater the potential to provide cultural ecosystem services (the top quantile – 30% of data) was taken into account. To test the consistency between the number of activities on websites and social network applications and the number of visitors to national parks, the coefficient of determination R^2 was also calculated.

RESULTS

A general overview of recreational activities in the parks

A total of 6787 photos were downloaded from Flickr social network website, with the highest number of images from Tatra National Park (1520), followed by Karkonosze National Park (858) and Ojców National Park (575). The least amount of photographs were taken in Drawno (11), Narew (39) and Magura National Park (48). In the national parks areas: 3,980 jogging, 1,066 walking and 10,058 cycling activities were registered. The parks located within metropolitan areas such as Kampinos National Park (Warsaw agglomeration) and Wielkopolski National Park (Poznań agglomeration), were the most frequently used for running and cycling. Tatra National Park was noted as the one most popular for walking. While data for each national park were recorded on Flickr, there were data gaps on the other portals. The strongest correlation between the number of different activities and the number of walks is found

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Table 1. Registered activities on individual social media data. For Endomondo portal, the number of routes and the number of activities are given (in parentheses)

National Park	Endomondo			GPies.com			MapMyRide			Flickr
	Running	Walking	Cycling	Running	Walking	Cycling	Running	Walking	Cycling	Photo
Babia Góra	6 (6)	3 (15)	3 (46)	6	11	21	7	15	7	217
Białowieża	-	-	3 (4)	-	1	17	-	-	-	126
Biebrza	5 (5)	-	9 (28)	-	1	7	3	1	3	232
Bieszczady	13 (137)	12 (58)	-	3	51	23	15	48	15	421
Tuchola Forest	3 (28)	-	11 (288)	1	5	14	1	5	1	70
Drawno	-	-	4 (17)	-	-	1	1	2	1	11
Gorce	5 (43)	6 (17)	17 (193)	4	25	17	3	19	3	299
Kampinos	65 (745)	10 (15)	68 (5523)	1	6	78	27	25	27	524
Karkonosze	19 (519)	8 (27)	15 (142)	5	37	36	30	69	29	858
Magura	4 (5)	-	7 (23)	1	14	6	-	-	-	48
Narew	2 (171)	1 (2)	3 (10)	-	-	-	-	-	-	39
Ojców	7 (78)	1 (1)	19 (523)	-	6	56	7	8	7	575
Pieniny	10 (58)	3 (3)	1 (6)	-	7	47	5	14	5	196
Polesie	4 (14)	-	4 (23)	-	1	2	5	-	5	98
Roztocze	2 (45)	-	13 (65)	-	-	22	1	-	1	190
Słowiński	3 (208)	-	1 (1)	2	2	15	9	10	9	223
Stołowe Mountains	6 (43)	3 (11)	9 (34)	-	5	15	7	11	7	493
Świętokrzyski	4 (14)	2 (26)	10 (139)	1	1	22	1	6	1	190
Tatra	26 (578)	33 (161)	8 (125)	12	74	50	34	203	35	1520
Ujście Warty	4 (5)	-	2 (4)	-	-	4	-	-	-	98
Wielkopolski	24 (594)	4 (23)	45 (1697)	7	3	6	33	-	33	152
Wigry	11 (276)	-	17 (450)	-	3	22	2	-	2	140
Wolin	13 (154)	3	6 (32)	-	-	-	20	9	13	67
Total	236 (3726)	89 (368)	275 (9373)	43	253	481	211	445	204	6787

Source: own preparation.

in the Flickr data. The coefficient of determination calculated was 0.79.

The number of registered activities from social media websites partially corresponds with the statistical data on the number of visitors to a given park. The coefficient of determination between the Flickr data, walking and running activities, and the number of visitors was 0.66, 0.70, and 0.41, respectively. For the last activity, associated to cycling, it was only 0.03, which is mainly related to the absence of opportunities to practice this sport in difficult-to-reach parts of the national parks (e.g., trails in areas with steep slopes).

Table 2. Comparison of the coefficient of determination between the number of visitors to national parks and data from social media data

	Flickr	Walking	Running	Cycling
Statistic data	0.66	0.70	0.41	0.03

Source: own preparation.

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Temporal distribution of activities national park areas

Daily, about 48% of Flickr photos were taken between 10 a.m. and 2 p.m. In comparison more pictures were shot in the afternoon and evening than in the morning. The temporal distribution of activities recorded on GPies.com indicates that most of them (about 42%) began between 8 a.m. and 1 p.m. The relatively highest percentage of activities was reached at 9 a.m. and accounted for nearly 11% (Chart 1). Grouped by day of the week, data show that about 40% of all activities, regardless of portal, occurred during weekends. On weekdays, the average percentage of registered activities was about 11% (Chart 2). On a monthly basis, we can see intensified activity in the summer months of July and August, with nearly 34% of activity registered on the Flickr portal and 41% on the GPies.com site. Compared to the rest of the year, social network users were much more active from April to September (about 70% Flickr photos and over 77% of GPies.com data) (Chart 3).

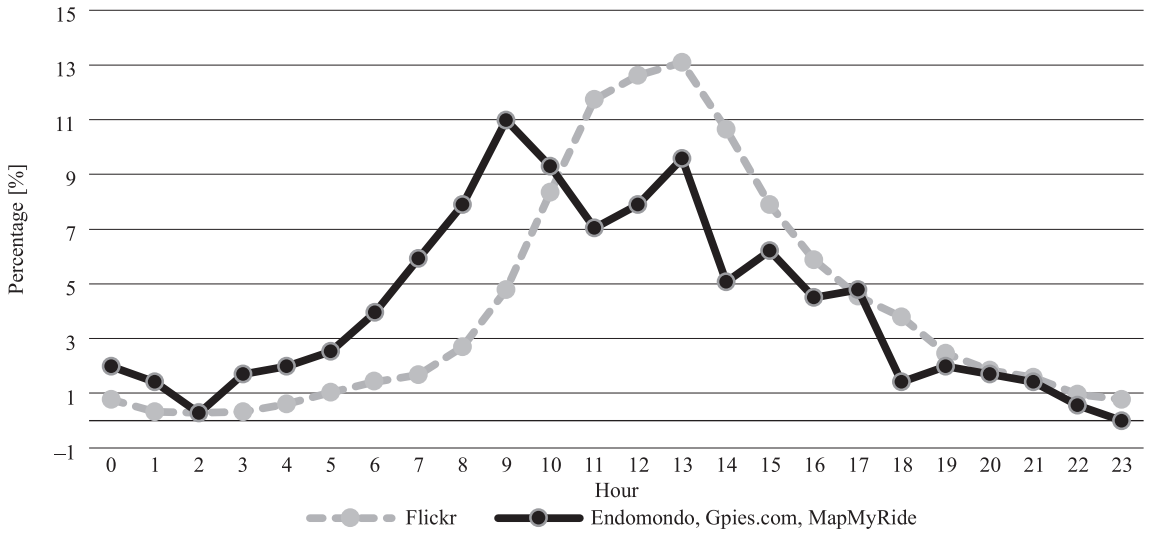

Chart 1. Hourly distribution of photos taken in percentage [%]
Source: own elaboration.

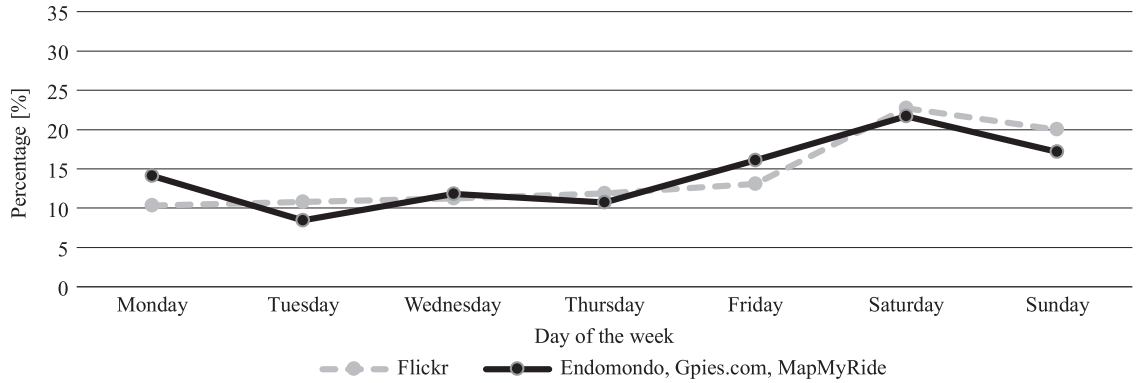

Chart 2. Percentage distribution of photos taken in weekly basis
Source: own elaboration.

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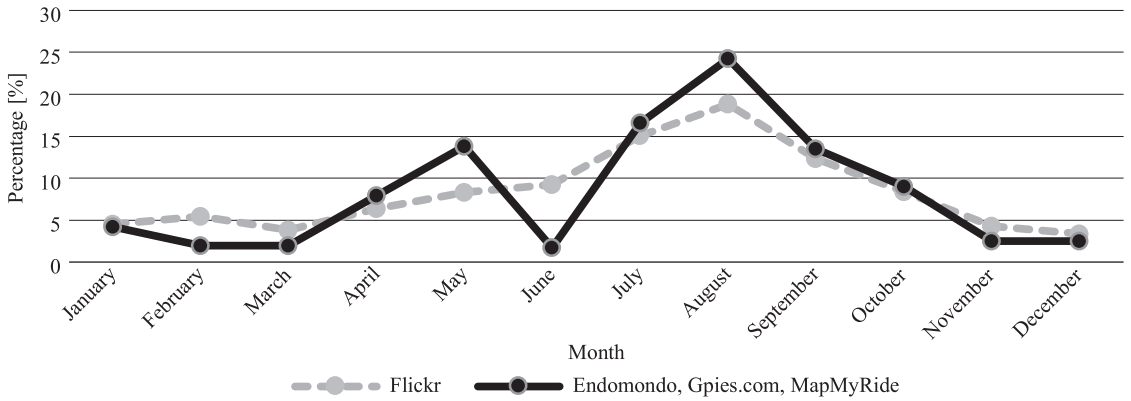

Chart 3. Percentage distribution of photos taken in monthly basis
Source: own elaboration.

Spatial distribution of activities

We were able to show the spatial distribution of activities in selected national parks areas by combining various data sets. The outcomes of two of them, Karkonosze and Kampinos National Park are shown in Fig. 3 and 4. It is evident that various groups of users of the region use and enjoy different locations to different extents. This is linked to the accessibility (adjustment of infrastructure and topography), legal restrictions or tourist attractiveness.

The output of the map algebra facilitated to identify areas with the highest intensity of use by all user groups (hot spots) (Fig. 5). Considering

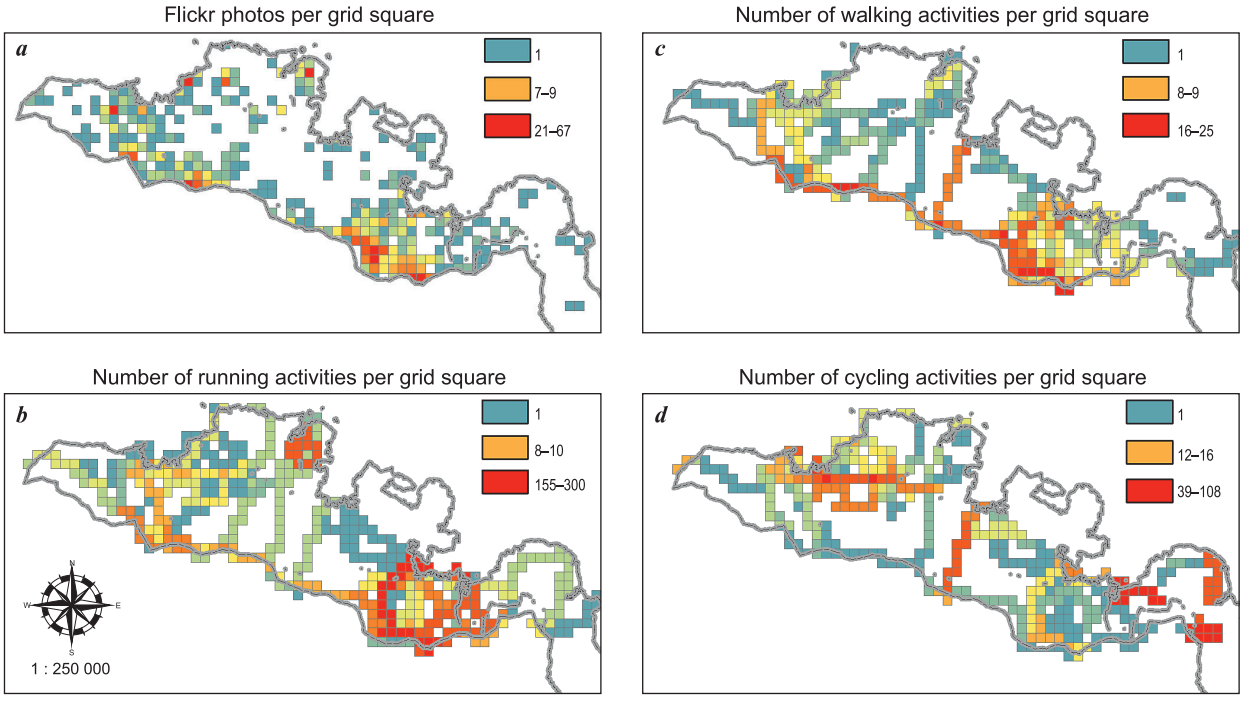

Fig. 3. Spatial distribution of different types of activities in Karkonosze National Park represented as quantiles (blue – quantiles 1–3; orange 4–7; red 8–10) in square grids (500 × 500m): a) Photos (Flickr); b) Running; c) Walking; d) Cycling
Source: own preparation.

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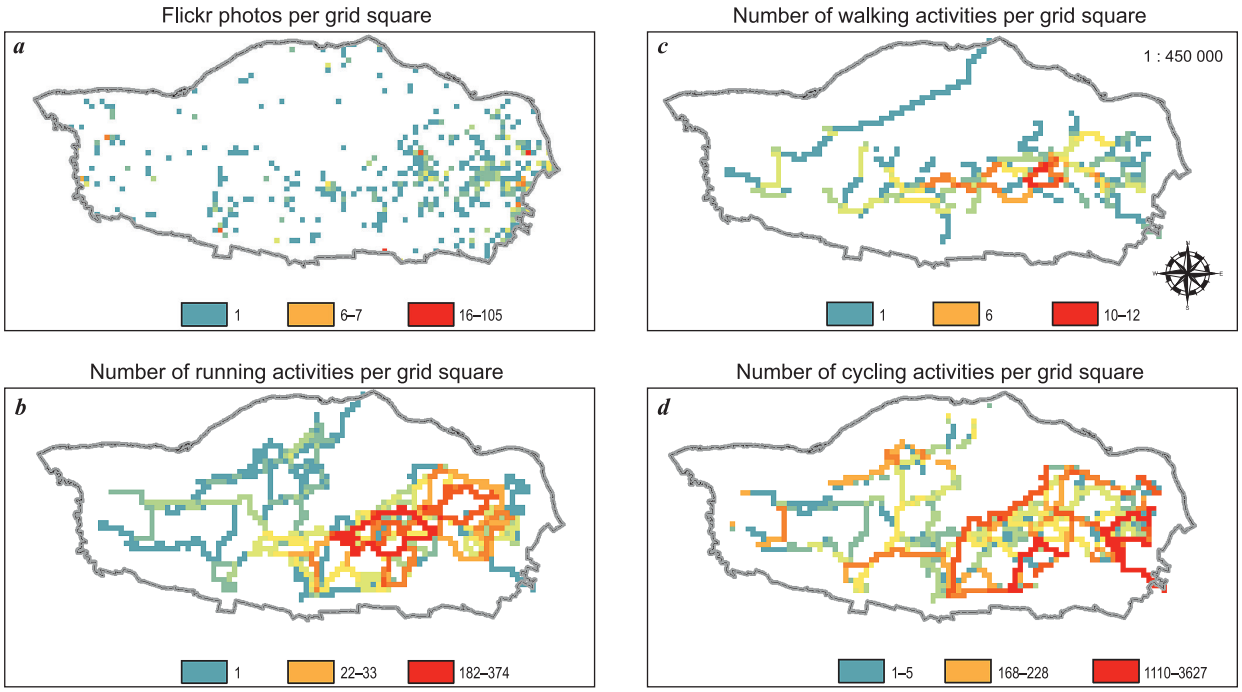

Fig. 4. Spatial distribution of different types of activities in Kampinos National Park represented as quantiles (blue – quantiles 1–3; orange 4–7; red 8–10) in square grids (500 × 500m): a) Photos (Flickr); b) Running; c) Walking; d) Cycling
Source: own preparation.

the size of national park, the proportion of locations with the highest recreational potential (values 10–12) for each park was: 1.70% for Karkonosze, 0.25% for Kampinos, 0.30% for Bieszczady, 3.84% for Tatra and 1.15% for Ojców National Park. In general, the points of the greatest interest are typically clustered around objects with excellent tourist and landscape potential, through which tourist routes pass, with the exception of Kampinos National Park. Only for Kampinos National Park, one can notice a significant impact of the distance from Warsaw. The majority of the park's activities take place in its eastern part, which borders directly with Warsaw, and where access to the park boundaries is also possible thanks to the proximity of a major public transportation hub. Hot spots can either be dispersed, as in Tatra National Park, where the most of them are spread out along the most popular routes or more concentrated, as in Ojców National Park, where the majority of the main attractions are in relative proximity to each other.

DISCUSSION

Our study shows that social media data and applications can be used to determine the spatial and temporal distribution of activities in national parks, as well as identify areas with the greatest potential to provide CES. Prior studies aimed at monitoring recreational traffic in national parks in Poland used traditional methods such as surveys, ticket sales, or pyroelectric sensors (Szybka, 2012; Hibner, 2014; Rogowski, 2017; 2020). Among the authors' knowledge, there has never been a study that used data generated by Internet users within Polish national parks.

According to the finding, the temporal distribution of social activity is similar to that found by, among others, Rogowski (2017; 2018). It is interesting to note that the number of user-generated data (Flickr users and hiker) and the number of national parks tourists match quite well. This shows how useful and credible the data are. Evidently, social media and applications

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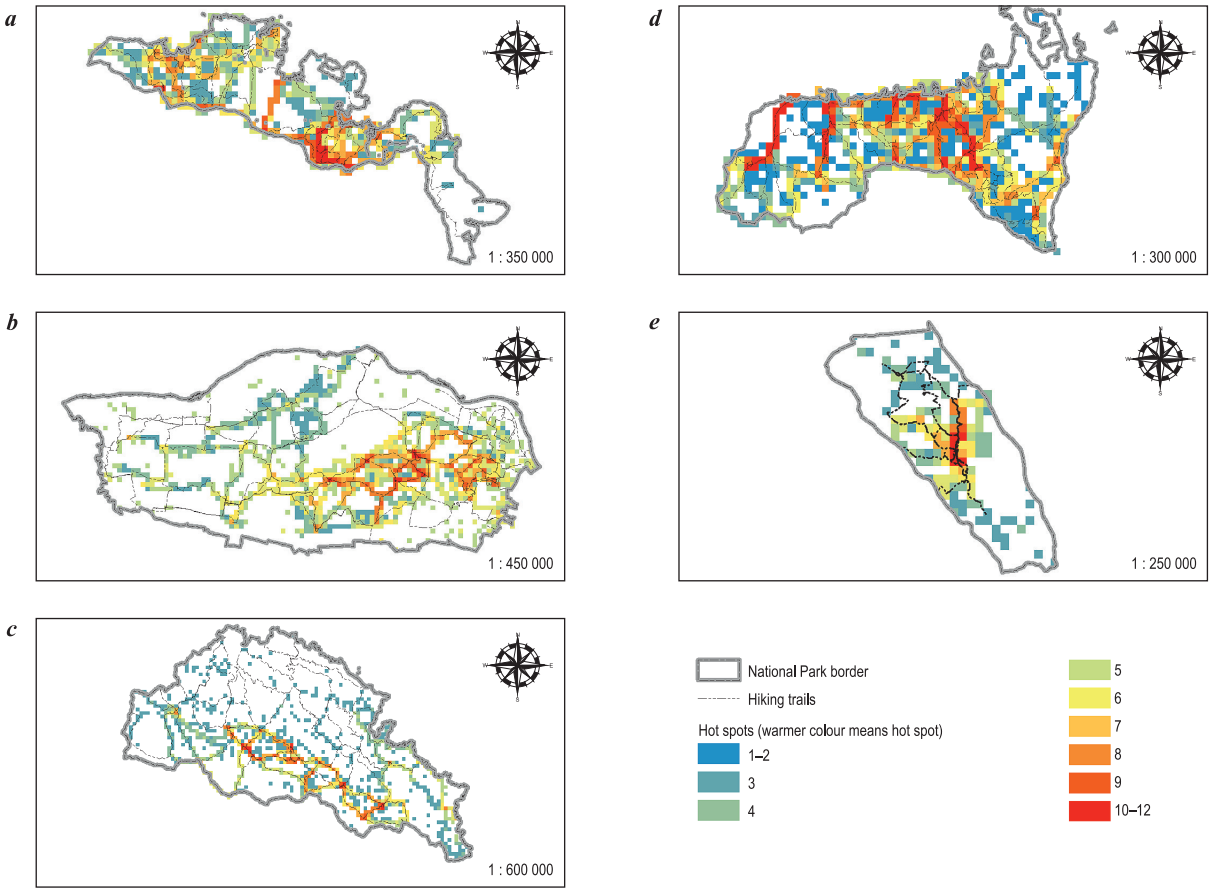

Fig. 5. Spatial distribution of hot spots in national parks: a) Karkonosze; b) Kampinos; c) Bieszczady; d) Tatra; e) Ojców
Source: own preparation.

data do not provide continuous information like pyroelectric sensors and it is avised against using them for one-year analyses, in favor of long-term observations to prevent errors caused, for instance, by missing data or errors in the way events were planned (Toivonen et al., 2019). However, their undeniable advantage, is that the activity occured, because it was recorded by a GPS device and is not a kind of declaration, as in some survey studies (Ciesielski & Stereńczak, 2021). Additionaly, it is possible to obtain spatial information using both point-based (Flickr data) and linear data from many portals (data from sports applications). This enables evaluations of the entire park area, such as the location of public gathering spots outside of designated areas or the disputes arising between various beneficiary groups. Data was acquired for all national parks, including those for which there is no continuous monitoring of the use park exploitation by tourists, which is a substantial advantage. It was possible to identify areas with high potential for CES provision, through the processing of the data i.e. sites that are relevant and valuable from the point of view of particular user groups. Similar studies in the CES field have indicated great potential for applied use of the findings (e.g., Peng & Shen, 2017; Ghermandi et al., 2020).

Undoubtedly, the data from social networks and applications, as well as the results presented, can be used by relevant authorities in the decision-making process of the relevant authorities in terms of channeling tourism, building new infrastructures or protecting areas from overexploitation (Ghermandi

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et al., 2020). These data have their advantages and disadvantages, which are primarily caused by the technological aspects of retrieving them.

Data from applications and social networks both have their limitations. One of them is the sample's lack of representativeness. It must be assumed that the sample population is composed of people who use the chosen portal. Therefore, there is a certain overrepresentation of a particular group, probably younger than the general population or those engaged in the chosen sport. It is quite challenging to construct a user profile because of limitations on access to the users' records, their place of residence and their social status. However, existed advanced data analysis methods can only partially determine such information (Heikinheimo et al., 2017; Lenormand et al., 2018; Sinclair et al., 2020). It is crucial to keep in mind that the privacy regulations of the portals have an impact on the studies when using data from social networks and applications. Only publicly available data (with public status) can be accessed using external queries. Many of the available data can be prohibited since portals policies are subject to change over time (Lomborg & Bechmann, 2014). This creates many problems when multiannual research must be repeated (Heikinheimo et al., 2017). The size of the available data sample is just one of the many benefits of using data coming from portals and social networks, that have been demonstrated by the research provided. It is typically several times bigger than the sample like in survey research. The advantage of this type of data is also its rapid acquisition, which can be facilitated by the use of appropriate tools for automatic data processing (API, scripts, etc.) (Antoniou et al., 2016), making it possible to retrieve the information more quickly and affordably than with traditional research (Ciesielski & Stereńczak, 2021).

CONCLUSIONS

Despite their limitations, information from social media networks and applications enables to map the spatio-temporal distribution of leisure and tourism activities among various user groups in naturally valuable areas. In addition, they provide details on the locations with the greatest potential of offering CES. The information discovered through the analysis of user-generated data can be utilized as supplemental data for tracking recreational use in particular national parks and serve as an important element of the decision-making process in shaping tourism traffic and protection of natural resources. Future research should be steered in two key directions. In order to perform advanced analysis on various aspects of CES it is first necessary to design an automated system for content classification of data descriptions (hashtags, metadata) and photos. Second, the creation of an application for automatic data collection and processing for staff members of national parks to utilize directly.

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URBAN ADAPTATION IMPACT ON OUTDOOR THERMAL COMFORT IN EDUCATIONAL COMPLEXES

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ABSTRACT

Motives: This paper investigates the urban adaptation elements (vegetation cover, water bodies, and different shading patterns) effect on the outdoor thermal comfort for pedestrians in the educational complexes.
Aims: The aim of the research is to determine the impact of urban elements on outdoor thermal comfort in an educational campus with a hot-dry climate, the city of Babylon as an example, The research methodology depends on the ENVI-met program to simulate the case study.
Results: The results showed that urban adaptation elements which are the soft components of the environment include (vegetation cover, water bodies, and different shading patterns) can reduce the temperature by about 3 degrees Celsius in addition to reducing the mean radiant temperature by 8 degrees Celsius and reducing the sky view factor (SVF) by 20%.

Keywords: global warming, outdoor thermal comfort indices, ENVI-met, urban heat island, soft components, thermal adaptation

INTRODUCTION

Urban adaption is one of the strategies that can improve the outdoor environment in cities (Nasir et al., 2018; Archer et al., 2014; Manteghi, 2021). It is the process of dealing with actual and expected climate and climate risks with the aim of reducing negative effects such as reducing greenhouse gas emissions or reducing weather-related deaths (due to heat waves) and economic losses from extreme weather events, that adaptation to climate change include (urban energy transition, urban mobility, and the circular economy of cities, sustainable land use, and nature-based solutions in cities). It is an iterative process, and the adaptation process may be a local process due to the geographical, social, demographic, or economic characteristics of a particular place. Urban adaptation highlights the main issues that must be considered when planning and implementing adaptation. There are five essential steps to applying adaptation, designing an effective adaptation action plan, finding examples of adaptation action plans, mainstreaming, adaptation in urban policies and plans, addressing climate change through adaptation and mitigation, and implementing adaptation: Self-check (European Commission, 2022; Notre Dame Global Adaptation Initiative, 2022).

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These main steps are divided into sub-steps, and for each sub-step, a summary of the specific problem is provided, followed by more detailed instructions. Adaptation includes a variety of methods, including the development of green spaces, climate-resistant infrastructure, and the establishment of vertical gardens, for example (by incorporating trees and plant life in urban architecture, where trees absorb carbon dioxide and convert it into oxygen and cool the environment, thus saving Protection in the hot months of the year.

The most common and environmentally friendly strategies that are used to improve heat sensitivity in hot, dry climates are tree planting and vegetation, which play an important role in the amount of solar radiation absorbed by roofs. Urban trees can modulate air temperature, increase humidity, reduce wind speed, reduce air pollutants, and have effects on the city's bioclimatic conditions, mean radiant temperature, and the human thermal index. Air temperature can also be affected by green coverage and leaf area index (LAI), which are important tree characteristics. Specific features of trees such as structure, tree top density, size, shape, and colour affect the performance of solar radiation, temperature, and air humidity. The amount of shade that trees provide depends on factors including the tree's canopy cover, the types of plants, and the arrangement of plants in the space. Tree shade is a rather adaptation strategy, especially for pedestrians in hot daytime. The use of roofs, arches, and columns (corridors), it is considered one of the elements of protection in a hot and dry climate, which provides shading by reducing solar radiation and thus enhances thermal comfort for humans. Where shade is a prerequisite for cooling outdoor spaces. The importance of shading is:

1. Protection from solar radiation, which has more physiological effects on reducing heat stress than on lowering the air temperature in outdoor spaces.
2. Shading does not include any expenditure of energy or water for irrigation to reduce the air temperature.

The design of the water elements positively affects the local climate by lowering the outside temperature through evaporative cooling, in addition to the fact that the fountains reduce the humidity in the air. And that these systems can reduce resource consumption and reduce long-term operating costs and offset the use of air conditioners.

LITERATURE REVIEW

Ridha et al. (2018) discussed possible mitigation strategies to ensure the improvement of thermal comfort at the pedestrian level in a designed area (high-rise buildings, large distances between buildings, lack of vegetation cover), by using the descriptive analytical approach and presenting four different scenarios to evaluate the role of vegetation elements and different shading patterns using the ENVI-met program. The study concluded that it is possible to reduce the physiological comfort index (PET) and reduce the temperature and the expected comfort coefficient PMV through vegetation cover and shadows (Ridha et al., 2018). The study of Othman et al. (2019) focused on conducting a field study on the campus of UPM University (University Putra Malaysia) by using a descriptive-analytical approach and assessing the thermal comfort of shaded outdoor environments in the hot and humid context of Malaysia and calculating the degree of temperature PET equivalent heat as a thermal indicator for outdoor environments using the Rayman program. The study found that the use of vegetation surfaces and site conditions that provide shades and suitable roofs have a significant impact on outdoor thermal comfort (Othman et al., 2019). While the study of Hwang et al. (2009) dealt with field experiments on the campus of the National University of Formos (NFU) using the method of comparative analysis, by selecting several sites with different levels of shading in different months to clarify changes in thermal conditions in seasons and comparing the measurement results for six selected sites within the university campus with the simulation results using Rayman program. The study concluded that areas with little or excessive shading have short thermal rest periods, and sufficient shading must be provided in trees and buildings to improve thermal comfort in summer (Hwang et al., 2009).

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As for the study of Shashua-Bar et al. (2011) the comparative analytical method was used to show the effects of different landscape formations on heat and stress assessment using the data measured in two semi-enclosed (courtyard) spaces using Computing and virtual energy exchange between the urban environment and pedestrians in space. The study was conducted at the Ben-Gurion University Boker Campus in Negev Heights (30°50'N, 34°40'E) during the month of July to August. The study found that the urban treatment (trees and grass) achieves the highest levels of cooling and efficiency is achieved using the water element. It also showed that the vegetation cover contributes to thermal comfort not only by direct shading of the person, but by reducing long-wave emissions from the surfaces of the yard and by reducing from the amount of solar radiation reflected from them (Shashua-Bar et al., 2011).

MATERIALS AND METHODS

The study area

Babylon governorate is located in the central part of Iraq on the Euphrates River, where it is located at latitude 44° east and longitude 34° north. The city's climate is known to be hot and dry in summer and cold in winter. The maximum temperature recorded was 50°C in the summer. The study area is the University of Babylon, located in the city of Hilla (90 km south of Baghdad), about 14 km from the centre of the city of Hilla. The University of Babylon can be reached from 3 main roads: Baghdad-Babil Road, Babylon-Najaf Road, and Karbala-Babil Road. The main university complex includes 9 colleges with low-rise buildings with relatively close distances between the buildings. The number of employees at the university is about 2,869, while the number of students is 25,462 (University of Babylon, 2022). Figure 1 shows the geographical location of the university in relation to the city and the chosen study area.

ENVI-met program simulation

It is a three-dimensional digital program and model to simulate the interactions between surface, soil, and air in the urban environment. It is used to simulate the effect of urban vegetation cover on the urban microclimate (Zhang et al., 2017), and it also allows analysing the effects of small changes in urban design (trees, greening of internal courtyards, new buildings) on the local climate under medium-sized conditions. Several studies have proven the reliability of using ENVI-met to simulate the thermal performance of outdoor spaces, as these studies indicated that the data measured at local weather stations seem to be consistent with the data shown in the simulation (Sayad et al., 2021; Parapari, 2018; Ayşegül et al., 2020; Chen & Ng, 2013).

Data entry for the model

The weather data used to start the simulation model was provided by the Meteorology and Seismology Authority (World Weather Online, 2022). The characteristics of the local climate represent the air temperature and relative humidity for June 21, 2021, the longest day of the year in terms of daylight hours and the hottest of the regional weather conditions. The basic meteorological settings for the initial conditions of the climate were 5 m/s for wind speed and 315° for wind direction. The simple effect of air temperature and relative humidity was used over a period of one day, where the maximum temperature was 46°C at 12:00, the lowest relative humidity was at 6 pm by 25%, and the maximum relative humidity at 6 am was (35%) (Time and Date, 2022). The total simulation time in the program is (24 hours). The total area specified for the study is (77 m* 86.5 m), the model area was made with the size of the grid (x=50, y=50, z=40), and the size of the grid is represented in the work of the program grid cells, which is: dx=1, dy=1, dz=2, the direction of the site relative to the main north direction is 15°.

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Fig. 1. The geographical location of the university in relation to the city and the chosen study area
Source: own preparation.

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Forming the model

The simulation work within the program focused on analysing the thermal comfort of humans at the pedestrian level in two models (the reality of the situation, the development proposal) and using different strategies for greening such as grass and different types of trees (palms and citruses) because they are local and evergreen trees (Ridha, 2017). A specific pattern of shading was also created and designed by assuming the presence of wooden roofs around the buildings and walkways. The goal of this model is to provide continuous shading for pedestrians by means of a network of canopies on both sides (Aram et al., 2020; Huang et al., 2015). The set of figures shows the simulation model (before and after) about buildings and pedestrian times as shown in Fig. 2–8.

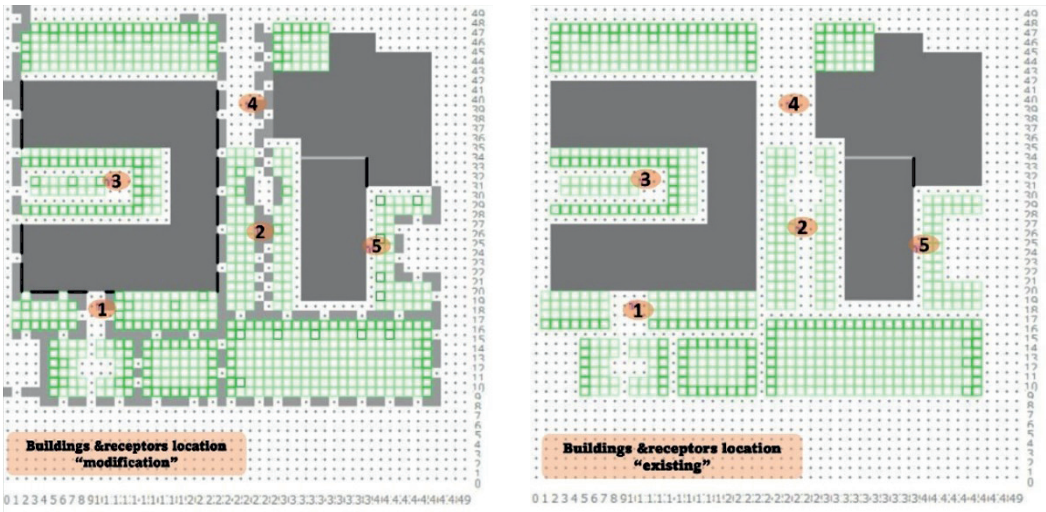

Fig. 2. Simulations plan for study case before and after modification
Source: own preparation.

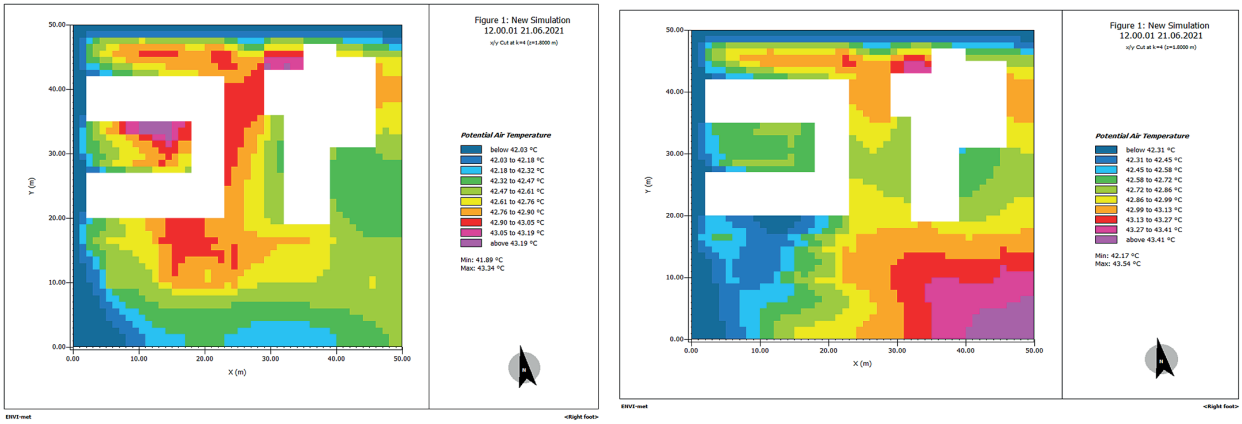

Fig. 3. Air temperature simulation before and after modification
Source: own preparation.

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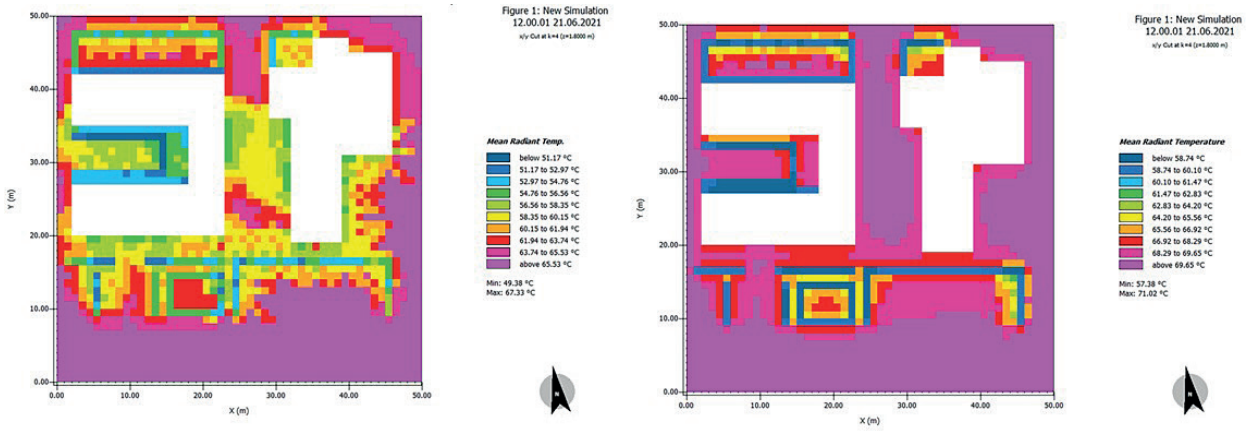

Fig. 4. Mean radiant temperature. Simulation before and after modification
Source: own preparation.

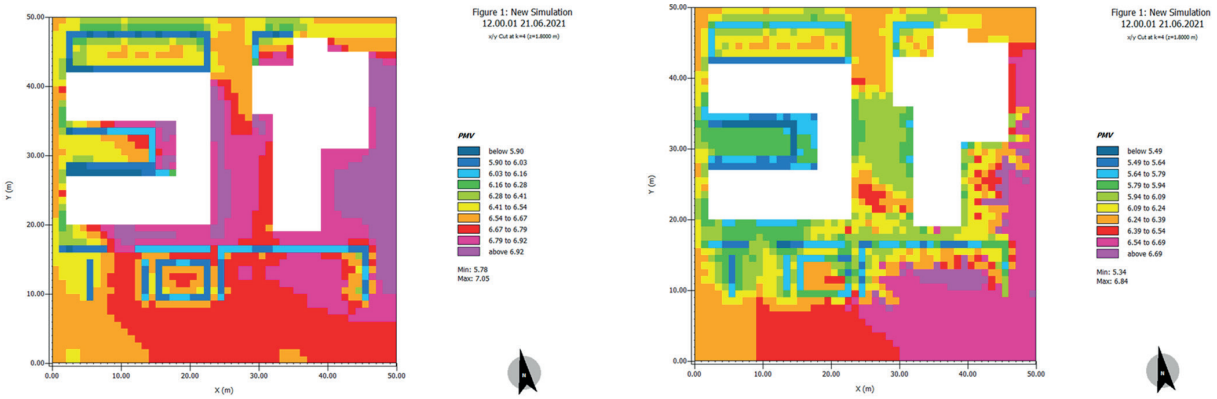

Fig. 5. PMV simulation before and after modification
Source: own preparation.

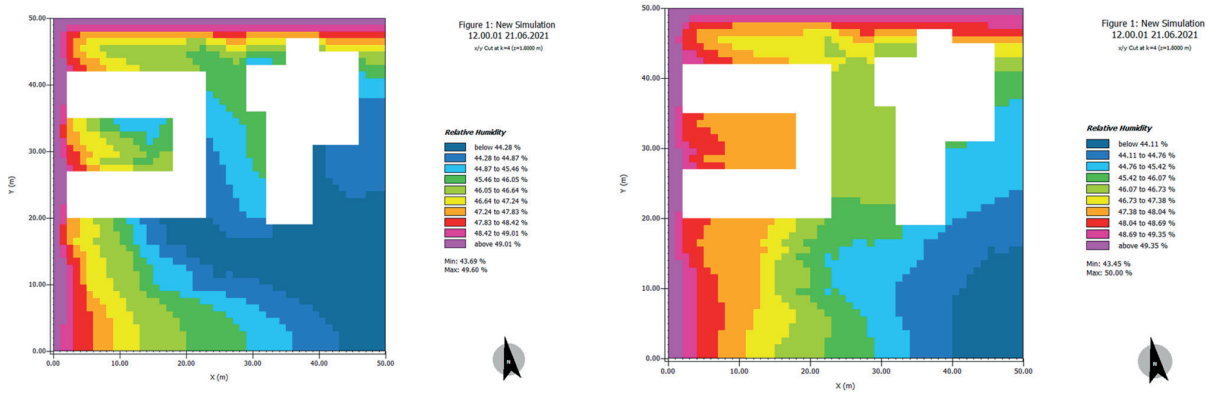

Fig. 6. Relative humidity simulation before and after modification
Source: own preparation.

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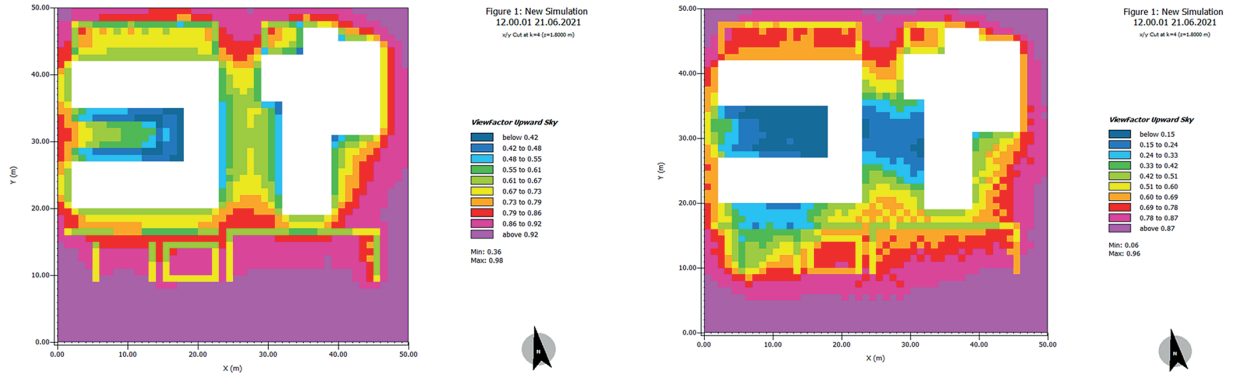

Fig. 7. Sky view factor simulation before and after modification
Source: own preparation.

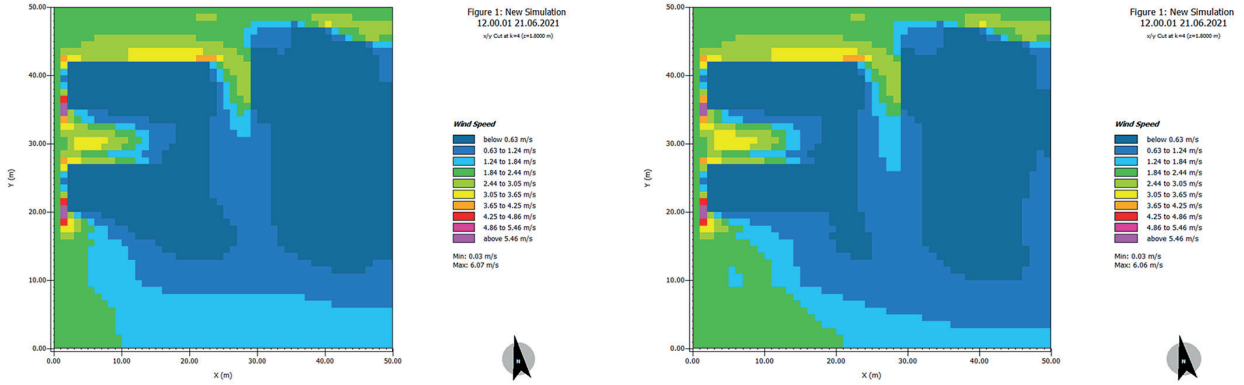

Fig. 8. Wind speed simulation before and after modification
Source: own preparation.

Simulation model of the development proposal

In order to assess the impact of the air conditioning elements on the study area, we have made a development scenario that includes levels of development: at the level of the individual building, and at the urban level. And then we compared the reality of the situation with the development scenario through simulation (noting that the development steps were suggested based on the actions mentioned in the previous studies), where they were reviewed and collected in one scenario. Following are the actions taken in the study area:

At the level of buildings:

1. Changing the materials for finishing the facades of buildings after they were covered with aluminium panels, as it was proposed to remove these panels and finish the facade with a material (stone).
2. A proposal to add green walls to the interior walls of the university presidency building and the Deanship of the Faculty of Engineering, especially in the walls overlooking the open space (the courtyard).

At the level of the site as a whole, and in open public spaces:

1. Adding wooden roofs, so that the site is completely free of them and exposes pedestrians to direct sunlight, to improve green spaces and create a comfortable atmosphere for pedestrians who walk under them.
2. Painting the streets within the study area with light-coloured paint to reduce the amount of heat absorbed and increase the reflectivity.

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3. Adding all kinds of trees (palm trees and citrus fruits) because these types are evergreen, as well as because the study area is free of trees after they were gradually and completely cut down so that the area became free of any vegetable element for shading.
4. Adding water bodies (fountains) to moisten the atmosphere and reduce the temperature on both sides of the corridors leading to the entrance to the University Presidency Building and the Deanship of the College of Engineering.

RESULTS

A set of results was reached regarding the external thermal comfort indicators and how the complementary elements affect them, and the following is a summary of the results as follows:

Air temperature: The temperature decreased on average by 3°C when read by the receptors. It was projected to five different locations and fixed in the graph. This decrease in temperature occurred in the areas where roofs and trees were added in addition to water bodies (especially since the roofs were designed in such a way that they permeate the spaces in which plants were added) and this difference in temperature is explained as in the Table 1.

Table 1. The existing and modified simulation results for air temperature. *Source*: own preparation

Existing simulation results (air temp.)	Modified simulation results (air temp.)
R1 = 42.71°C	R1 = 40.27°C
R2 = 42.69°C	R2 = 40.81°C
R3 = 42.88°C	R3 = 40.63°C
R4 = 42.92°C	R4 = 40.08°C
R5 = 42.45°C	R5 = 40.69°C

Mean radiant temperature: its value decreased by 8°C, the existing: min. 57.38°C, max. 71.02°C, the modified: min. 49.38°C, max. 67.33°C.

Average expected temperature (PMV): The percentage of areas that obtained a value (less than 50%) reached 40% of the site area as a whole. As for the development proposal, the percentage of areas that obtained a value (less than 50%) amounted to 70%, i.e. a change of not less than 30% as a result of the changes that occurred in the study area.

Relative humidity: The relative humidity increased by 2%, as a result of adding plants, green walls and shading areas, the existing: min. 43.69%, max. 49.60%. The modified: min. 43.45%, max. 50.00%.

Sky view factor: the value of this factor decreased as a result of adding trees (palms and citrus trees). The existing: min. 0.36, max. 0.98. The modified: min. 0.06, max. 0.96.

Wind speed: its value decreased by a very small amount. The existing: min. 0.03 m/s, max. 6.07 m/s. The modified: min. 0.03 m/s, max. 6.06 m/s.

CONCLUSIONS

Urban vegetation are considered the most effective element in improving thermal comfort levels, through the effect of shading, which is controlled by the physical properties of trees and their location in space. Trees also help to cool the surrounding environment through evaporation, which depends on the leaves, texture and mass of trees.

The assessment of thermal comfort is subjective and dynamic, dynamic in the sense that adaptation to the surrounding thermal state is naturally progressive, and subjective in view of the fact that thermal sensation is determined primarily through personal experience and subjective evaluation. Therefore, the static and objective aspects of knowledge provision must be measured in terms of the local climate.

The thermal properties of surface materials effectively affect the urban climate, by controlling the amount of solar radiation absorption.

Adaptation provides an opportunity for transformative change in social entities and institutions at the national and local level by encouraging participatory planning or by promoting research into internal planning processes.

The community can provide an insight into the city's development plans and activities that deal with adaptation, and here comes the role of local

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organizations and government bodies to ensure that opinions are converged and taken into account when planning.

The final results of external thermal comfort indicators can lead to recommendations on urban planning for the municipality and city planners, especially since the university is considered a basic nucleus in the city through its active role in providing research on the environment and climate, and involving scientific disciplines in making effective proposals that can be tested on campus of the university.

Author contributions: Authors have given approval to the final version of the article. Authors contributed to this work as follows: Sarah Mohammed Jameel developed the concept and designed the study, collected the data, Susan Abed Hassan analysed and interpreted the data, prepared draft of article, revised the article critically for important intellectual content.

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ADMINISTRATION OF THE LAND CADASTRE SYSTEM UNDER CONDITIONS OF MARTIAL LAW IN UKRAINE

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ABSTRACT

Motives: Since the Russian invasion of Ukraine, the issue of land legal relations has become of particular concern. The urgent task is to introduce the mechanism protecting the information of the State Land Cadastre from unauthorized interference by third parties, to ensure the rights of the state, physical and legal entities to enter data about objects to the cadastral system and to use this information.
Aim: The research aims to identify ways to improve the mechanism of legal regulation of the State Land Cadastre under martial law that will ensure the restructuration and functioning of the agrarian sector of the economy, facilitate recovery of the infrastructure of Ukraine, as well as provide protection of the data from unauthorized interference by third parties, and counteract raider take-over of lands.
Results: In the present research, a particular focus is made on the performance of the system of the State Land Cadastre under martial law in Ukraine which can be used as a reference point and a sample for the administrative decisions in other countries which are vulnerable to threats because of the national security.

Keywords: land cadastre system, land relation, land administration, administrative services, martial law

INTRODUCTION

In our country, land is the greatest value because it is the primary production asset and key to economic development. Ukraine possesses the largest area of agricultural land and the most fertile soils in Europe and the world. The total area of the country is 60 million ha, including 42.7 million ha (70.8%) of agricultural land. Among them, 33 million ha of land is arable, whilst in France the area of arable land is 18 million ha, in Germany – 12 million ha, and in Poland – 11 million ha.

In Ukraine, the land reform has created legal and social fundamentals for further transformation of the system of land relations in the direction of developing different forms of land ownership and running different types of economic activities (Kuryltsiv et al., 2018).

However, the Russian invasion of Ukraine has influenced all spheres of social relations including

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the land ones. The key elements of their functioning include the state information system, particularly the State Register of Property Rights to Immovable Property and State Land Cadastre (SLC). Only their simultaneous work can ensure certification of the contracts of purchase and sale of land plots and thus, registration of property rights.

Thus, to protect the consistency and privacy of information, to prevent unauthorized interference by third parties and distortion of data, and to avoid raiding, the government has suspended the functioning of the state-administered registers and databases.

However, under martial law, land relations continue their functioning. It is often necessary to make some registrations in the land cadastre and get access to its data through administrative services.

A cadastre is a system of major importance for the economy and planning, providing data on these issues, as well as data on land. It is the basis for legal aspects like ownership, and fiscal aspects like taxation of land. The cadastre also provides data for planning assignments (Navratil & Frank, 2004).

Publicity of cadastral data is also needed for land management and land inventory, spatial planning in territorial communities, taking control of the concentration of lands, monitoring of land relations, as well as real estate valuation.

Therefore, under conditions of martial law, it is important to ensure regulation of land relations because it provides security for both land and agrarian spheres, as well as the post-conflict recovery of the country.

The main gist of this paper is to identify the ways to improve the mechanism of legal regulation of the State Land Cadastre under martial law that will ensure the restructuration and functioning of the agrarian sector of the economy, facilitate recovery of the infrastructure of Ukraine, as well as provide protection of the data from unauthorized interference by third parties, and counteract raider take-over of lands.

LITERATURE REVIEW

Land issues are often the root causes of armed conflict, yet often go unaddressed (UN-HABITAT, 2009). Land conflicts commonly become violent when linked to wider processes of political exclusion, social discrimination, economic marginalization, and a perception that peaceful action is no longer a viable strategy for change (Grzybowski, 2012).

During a conflict people are killed, buildings and physical infrastructure are destroyed, legal frameworks are set aside, public registers are destroyed, markets do not function anymore, properties are taken, and lands are occupied (van der Molen & Lemmen, 2004).

Cadastral systems have a dynamic nature. Initially designed to assist in land taxation and real estate conveyancing, cadastres have been extended to land administration systems. This situation forces cadastral systems to be re-engineered over time to meet the change (Yomralioglu & McLaughlin, 2017).

The relation between land cadastre and land administration was recognised in earlier research in conflict and post-conflict contexts. These publications address the issue of conflict and post-conflict land administration (Todorovski et al., 2016a), land records in support of land administration (Manirakiza, 2014), and land administration in post-conflict state building (Todorovski et al., 2016b).

Land and its administration are always negatively affected by armed conflict, and if they are not addressed properly in the post-conflict period they can be a reason for new disputes or a cause for renewed armed conflict (Dimo et al., 2016).

Land plays a specific role in the conflict. Therefore, it is important to acknowledge how it is administered in these circumstances. Addressing land and land administration in such a context should therefore be coherent with the state's efforts to support the legitimacy of the land cadastre system and strengthen the capability to fulfil its core functions.

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MATERIALS AND METHODS

In military and political terms, the crisis in the current security system requires great concern and has forced the leading countries to make a strategic choice about planning their political processes in the long term for the following political and administrative decision-making.

In the present research, a particular focus is made on the performance of the system of the SLC under martial law in Ukraine which can be used as a reference point and a sample for the administrative decisions in other countries which are vulnerable to innovative challenges and threats because the national security of these countries and their social and economic prosperity depends on the timely implementation of such decisions.

The theoretical and methodological basis of the research is made by a complex of methods, namely the dialectic method used to identify conditions of the SLC functioning, its focus, efficiency, and effectiveness; system analysis necessary to assess the importance and position of the SLC in the system of land relations; a synthesis applied to combine different doctrines concerning the functioning and exercising the regulatory framework under martial law; structural and functional analysis made to determine the main stages of the SLC administration and its constituents; a cartographic method used for visualization of the proposals on the functioning of the system of land cadastre based on the approved decisions.

The information basis of the research is provided by the current legislative and regulatory documents, statistical and analytical materials of the State Service of Ukraine for Geodesy, Cartography and Cadastre (State Geo Cadastre), State Statistics Service of Ukraine, and works of domestic and foreign scientists, which disclose the negative impact of military conflict on the system of land management.

RESULTS

The SLC is a unified state geo-information system of data about lands within the state borders of Ukraine, along with their purpose and restrictions in exploitation. It supplies data on the quantitative and qualitative characteristics of lands, their evaluation, and distribution between owners and users (Law of Ukraine, 2011).

The system of the SLC provides the opportunity to quickly obtain needed information on land plots in the whole territory of Ukraine. The information is entered into the databases, checked, systemized and arranged following the unified and prescribed rules. Due to the applied modern information technologies in administrating the SLC, the information about land plots is available both for specialists engaged in the field of land relations and for external users.

According to part 3 of Article 6 of the Law of Ukraine "On State Land Cadastre" (Law of Ukraine, 2011), paragraph 3 of p. 4 of the Procedure of administrating the SLC, and referring to the order of the State Service of Ukraine for Geodesy, Cartography and Cadastre No. 36 of 28 January 2016 "On appointing the administrator of the State Land Cadastre", the State company "Centre of the State Land Cadastre" is the appointed Administrator of the SLC.

The Administrator of the SLC ensures:

1. Permanent functioning of the engineering and technical infrastructure of the SLC;
2. Improvement of the hardware-software complex of the National Cadastral System;
3. Supplying e-services by updating the Public Cadastral Map.

By using e-services, people can order administrative services on getting information from the SLC, an extract from the technical documentation on the normative monetary valuation of land, information about property rights to a land plot, information about people who have looked through the information about the property right to the land plot, information from the state statistical reporting on the availability of lands and their distribution, and submit requests

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to obtain documents on the land organization from the State Fund of Land Management Documentation.

Without authorization, one can submit a request on obtaining a qualification certificate and a duplicate of the qualification certificate of a land surveying engineer, as well as get extracts from the State Register of certified geodesy engineers, State Register of certified land surveying engineers, and State Register of evaluators of the expert monetary estimates of land plots.

By using the web-service e.land.gov.ua, the certified land surveying engineers can request the state registration of a land plot for entering improved information to the SLC and submit a land organization project for approval.

Since the adoption of martial law, the functioning of all information systems has been suspended for security reasons. However, nowadays their performance is being gradually restored. Today, the Resolution of the Cabinet of Ministers of Ukraine No. 480 of 19 April 2022 has recovered the functioning of the State Register of Property Rights to Immovable Property, but with some restrictions. In particular, only the notaries who are on the list of notaries approved by the Ministry of Justice of Ukraine authorized to conduct notarial acts on valuable property under martial law can certify contracts, including agreements of purchase and sale of land plots.

The situation with the SLC has long stayed unchanged and only in late April, its functioning was recovered after approval of the Law of Ukraine No. 2211-IX "On amendments to certain legislative acts of Ukraine concerning peculiarities of land relations regulation under martial law". The Law aimed to ensure the operative placement of production capacities of the enterprises displaced (evacuated) from the combat zone, to simplify the procedure of changing the purpose of lands, to improve some other rules partially approved by the Law of Ukraine No. 2145-IX of 24 March 2022 "On amendments to certain legislative acts of Ukraine on providing conditions to ensure food security under martial law". The Law also enshrines the right of the Ministry of Agrarian Policy and Food of Ukraine to make decisions on recovery or the further suspension of the SLC functioning on agreement with the State Service of Ukraine for Geodesy, Cartography and Cadastre. The powers of the state cadastral registrars are also restricted.

The next step was to approve the Resolution of the Cabinet of Ministers of Ukraine No. 564 of 7 May 2022 "Some issues of conducting and functioning of the State Land Cadastre under martial law". The Resolution also declares that under conditions of martial law in Ukraine and a month after its cancellation, the actions of entering the information (changes to information) about objects of land cadastre, using these data, particularly by getting access to the cadastral system, publication of the cadastral information through the Public Cadastral Map, should be done in compliance with the following rules:

1. The information (and changes to information) and the data about objects of the SLC can be introduced into the SLC exclusively by the state cadastral registrars, included in the list of those who are authorized by the State Service for Geodesy, Cartography and Cadastre and the Ministry of Agrarian Policy and Food under martial law (Fig. 1).

That list may have some restrictions (conditions) on making decisions by the state cadastral registrars concerning entering information (changes to information) to the SLC, supplying such information, as well as refusing to enter or provide such data.

There are, however, no legislative demands to the publication of the cartographic basis, index cadastral maps (plans), basic analytical and cadastral information layers and all data of the SLC, particularly in vector form, on the official website of the State Service for Geodesy, Cartography and Cadastre, i.e. through the Public Cadastral Map.

2. Information from the SLC can be provided by administrators of the centres of administrative services in compliance with the procedure adopted by the Law of Ukraine "On Administrative Services" or authorized officials of local executive bodies who have successfully passed advanced training in the field

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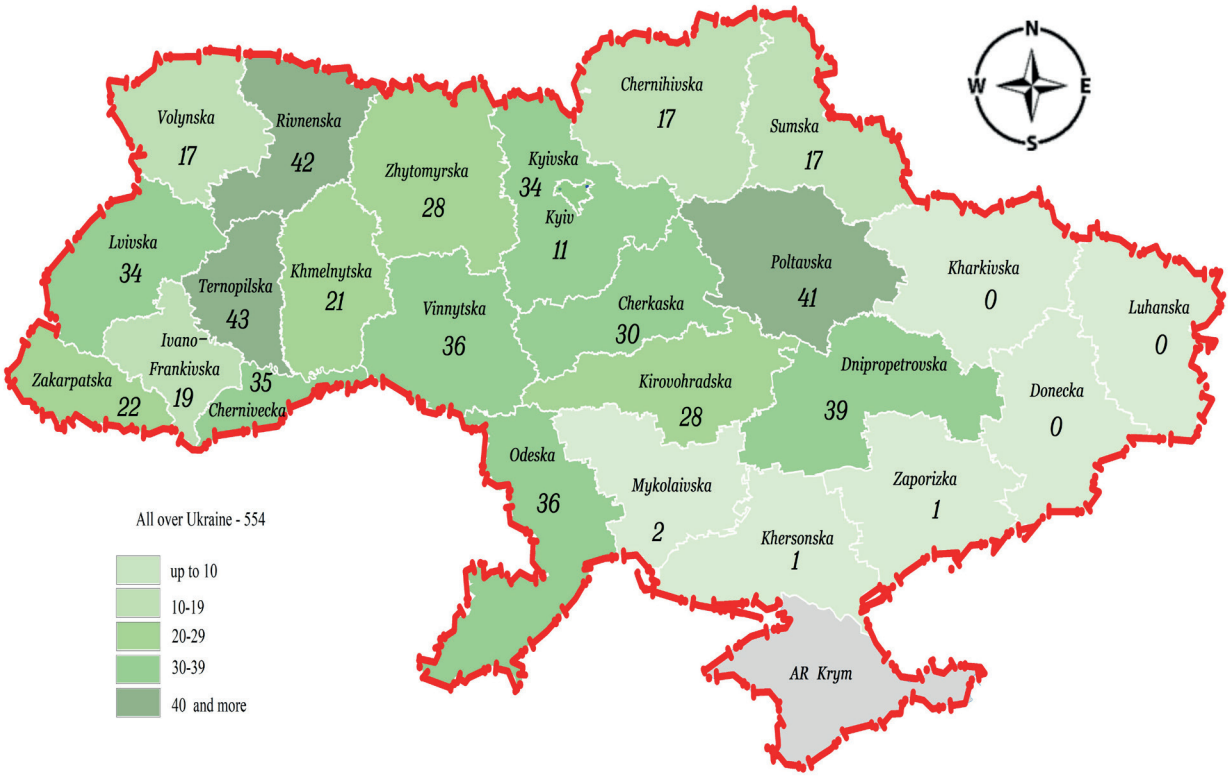

Fig. 1. Restoring the access to the SLC for the state cadastral registrars (in terms of regions and persons)
Source: own preparation based on the State Service of Ukraine for geodesy, cartography and cadastre (2022).

of land relations in the cases identified by the Law of Ukraine "On State Land Cadastre" within the area of the corresponding administrative-territorial unit in case it is not included in the list of the administrative-territorial units in which the access to the SLC is suspended for users (Fig. 2).

Thus, the access to SLC for users is suspended in the Autonomous Republic of Crimea, Kharkiv, Luhansk, Donetsk, and Kherson regions, as well as on the territory of Kryvyi Rih, Synelnykove districts of Dnipropetrovsk region, Berdiansk, Vasylivka, Zaporizhzhia districts of Zaporizhzhia region, Bashtanka, Voznesensk, Mykolaiv districts of Mykolaiv region, Konotop, Okhtyrka, Sumy, Shostka districts of Sumy region.

3. For physical and legal entities, the information from the SLC in the form of extracts from the SLC, official copies of the cartographic basis (plan), copies of documents which have been made during the functioning of the SLC, namely cadastral plans of land plots, are provided without the data about coordinates of the turning points of boundaries of the SLC objects.

4. Payment of the administrative fee for providing information from the SLC can be certified by e-copy (including screen-copy) of the corresponding payment document.

At the end of 2021, the government initiated a pilot project on entering information about land plots to the SLC by certified land surveying engineers. The project was expected to run until 31 December 2022. However, it is terminated under conditions of martial law and a month after its cancellation.

Thus, for the period of the pilot project implementation, the responsibilities of the state cadastral registrars, i.e. certified land surveying engineers, included:

a. entering information (changes to information) to the SLC or refusal to enter information (changes

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Fig. 2. List of the administrative territorial units in which the access to the SLC is suspended for users
Source: own preparation based on Order of the State Service (2022).

to information) on land plots (shares of them) located within a district or a city of a republic (the Autonomous Republic of Crimea) of regional significance, a district in Kyiv and Sevastopol, as well as towns, villages, and settlements within their boundaries;

b. making registration: requests on entering information (changes to information) to the SLC; claims on withdrawal of the requests on entering information (changes to information) to the SLC; requests on the state registration of a land plot; requests on entering information (changes to information) to the SLC concerning boundaries of a share of the land plot that is a subject to the rights of the sublease, easement;
c. making state registration of land plots, restrictions in their use, cancellation of such registration;
d. running land records of land plots, making records about them, and maintaining them;
e. assignment of cadastral numbers to land plots;
f. inspection of compliance of the submitted document with the legislative requirements;
g. providing extracts from the SLC about land plots to confirm entering the corresponding data to the SLC;
h. publication of the information on the official website of the State Geo Cadastre.

The approved powers were exercised by certified land surveying engineers exclusively in reference to land plots (their shares) and by developers of documentation on land organization under the supervision of the corresponding land surveying engineers who were responsible for the work quality.

The main differences in conducting and functioning of the SLC in peacetime and under martial law are presented in Table 1.

In the period when the SLC functions with certain restrictions, the information about a change of the purpose of a land plot is not entered into the SLC, and the state registration of a change of the land plot

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Table 1. Peculiarities of conducting and functioning of the SLC in peacetime and under martial law

Peacetime	Martial law
Exercising powers by the state cadastral registrars	
powers are exercised by all state cadastral registrars on the whole territory of Ukraine	powers are exercised only by the approved list of state cadastral registrars and only on the territory of specified administrative-territorial units
Exercising powers on providing information from the SLC by administrators of the Centres of Administrative Services or authorized officials	
powers are exercised on the whole territory of Ukraine, and access to the information of the SLC is provided for all users in compliance with the legislative requirements	powers are exercised only on the territory of specified administrative-territorial units, the access for users is restored on a special request, the access for new users is provided according to the legislative requirements
Publication of information of the SLC on the official website of the Public Cadastral Map	
all information from the SLC is made public from the moment of its entering the system; the Public Cadastral Map is active, and all layers and data obtained during interaction with other cadastres and information systems are made public	information of the SLC is not made public, the Public Cadastral Map is not active
Access to the information about coordinates of the turning points of boundaries of the SLC objects	
no restrictions on providing such information from the SLC, information can be found in all forms of documents, provided in the form of administrative services	information can be used only by specified cadastral registrars, certified land surveying engineers and geodesists, information is not provided in extracts, official copies, or copies of documents of the SLC
The procedure of suspension (termination) of access to the SLC for cadastral registrars and other users	
access to the SLC is suspended for cadastral registrars in case of appealing against their decisions, actions, inaction, or because of violation of the legislative requirements, access for other users is deprived with the opportunity to be restored in case of violation of the legislative requirements	access to the SLC for cadastral registrars is suspended in case of violation of the approved restrictions (conditions) of decision-making, and legislative requirements. Access is deprived for other users in case of violation of the legislative requirements without the opportunity of restoration. On the territory of temporary occupied administrative-territorial units, access to the SLC is suspended for all users
Confirmation of payment for the services of providing information from the SLC	
mechanism of the payment confirmation by e-copy (screen-copy) of the payment document is not provided	payment can be confirmed by the e-copy (screen-copy) of the payment document

Source: own preparation.

purpose is done by district military administrations in the Book of land ownership and land use registration under martial law.

The Book of land ownership and land use registration under martial law is kept both in paper and electronic variants. The electronic Books of land ownership and land use registration under martial law are conducted in MS Excel (Order of the Ministry, 2022).

State registration of a change of the purpose of a land plot with no entering of the corresponding data in the SLC is done at the request of a body of executive power or a local authority which has decided to change the land plot purpose. The request is made in electronic form and sent by e-mail to the district military administration with the attached documents certifying the decision about the change of the land plot purpose. State registration of the change of the land plot purpose or motivated refusal to make the state registration should be done within five working days from the day of the request submission (Law of Ukraine, 2022).

The purpose of a land plot can be changed in no compliance with the rules of correlation with the form

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of the functional purpose of the territory, approved by the corresponding city-planning documentation, in case of:

a. displacement of production capacity of the enterprises evacuated from the combat zone;
b. placement of river ports (terminals) along the Danube River;
c. placement of seaports;
d. placement of multi-modal terminals and production transhipment complexes;
e. placement of the objects of temporary stay of the internally displaced people;
f. construction of power supply networks, gas distribution, water distribution, heat-conducting, and sewage networks.

Such changes cannot be done in relation to the lands of the nature reserve fund and other environmental-protection purposes, lands of historic and cultural purposes, as well as in the cases when according to the city-planning documentation the territory of the corresponding land plot is expected for placement of the objects of education, healthcare, culture, social support, housing and communal services, civil defence, military and other defence facilities, line objects of engineering transport and energy infrastructure.

A change of the purpose of particularly valuable lands (apart from the lands of a nature reserve and other environmental-protection purposes, lands of historic and cultural purposes) is also possible for the above-mentioned cases, apart from the p. 2 "placement of river ports (terminals) along the Danube River". By changing the purpose of land plots in the mentioned cases, losses of agricultural and forestry production are not reimbursed. They are also not paid when changing the purpose of land plots for placement of temporary storage of trash from destructions caused by combat actions, acts of terrorism, diversions, or by works on elimination of their consequences.

Within 30 days from the date of restoration of the SLC functioning, the owner or user of a land plot that has changed its purpose and the corresponding information was introduced into the Book of land property and land use registration, should submit a request on entering such data to the SLC according to the procedure approved by the Law of Ukraine "On Land State Cadastre".

On 25 July 2022, the government initiated an automatic formation of the extract from technical documentation of the SLC on the normative monetary valuation of agricultural land plots (outside populated areas) in electronic form (Resolution of the Cabinet, 2022).

According to the Resolution, the form of such extracts from technical documentation on the normative monetary valuation of a land plot has been changed and is today certified by applying the corresponding QR code.

The introduction of such functionality enables getting an extract of the normative monetary valuation of an agricultural land plot in a digital form immediately after the corresponding request is made without the participation of the staff of the territorial bodies of the State Geo Cadastre.

The service, however, is restricted by a list of administrative-territorial units in which the access to the SLC is suspended for users and thus, they cannot get an extract from technical documentation on the normative monetary valuation of a land plot in those districts.

CONCLUSIONS

Since martial law has been adopted, the functioning of all information systems has been suspended for security reasons. However, nowadays their performance is being gradually restored and requires the appropriate conditions to recover the work of the SLC under martial law in Ukraine. Among them, the most important tasks are to introduce the mechanism to protect the information of the SLC from unauthorized interference by third parties, to ensure the rights of the state, physical and legal entities to enter data about objects of the SLC and use this information through the access to the National Cadastral System.

In the conditions of the armed aggression against Ukraine, it is extremely important to protect and ensure the right to property and use of land

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plots, to counteract raider take-over of land plots. The issue is currently of crucial importance because unscrupulous actions of state cadastral registrars can cause harm to land owners and land users. In peacetime, access to the state cadastral registrars was suspended in case of appealing their decisions and actions, as well as in case of violation of the requirements of land legislation by other users. Today, above these requirements, access to the SLC is also suspended on the temporarily occupied territories.

To sum up, the regulation of land relations under martial law should have a system character because it expects both a lot of simplifications to provide functioning of the agrarian sector of the economy and fast recovery of the infrastructure of Ukraine, and significant restrictions concerning the access to the SLC data and other information systems. Moreover, such restrictions are introduced to minimize the misuses the number of which can significantly increase under martial law and lack of appropriate state control.

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MANAGEMENT OF PUBLIC-PRIVATE HOUSING CONDOMINIUMS: THE CASE OF MUNICIPALITIES IN THE WARMIA AND MAZURY PROVINCE IN POLAND

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ABSTRACT

Privatization of municipal housing in Poland has led to the emergence of public-private housing condominiums. The aim of the study was to investigate the ownership structures of common property management entities in such condominiums in Poland. The intended investigation was conducted on the sample of the 30 largest urban municipalities located in the Warmia and Mazury province. The empirical data was collected by questionnaire interviews using the public information access technique. The aim of the study was achieved through hierarchical cluster analysis using the agglomerative method.

The results showed that the structures of common property management entities in studied housing condominiums varied in nature. In most municipalities surveyed, these structures were dominated by municipal entities. However, there is a growing group of municipalities where the surveyed structures have been dominated by private property managers. The in-house management model proved to be not very popular in the surveyed sample of municipalities.

Keywords: common property management, public-private condominiums, municipal housing, cities

INTRODUCTION

Condominium ownership is the prevalent form of multi-owned housing (MOH) in the world (Blandy et al., 2010; Lehavi, 2015). This housing ownership model consists of three components: (1) individual ownership of housing units (dwellings), (2) co-ownership (joint ownership) of the land and the common parts of the building, and (3) membership of an incorporated or unincorporated owners' organization (van der Merwe, 2015). In this system, owners own their dwellings, or more precisely, they own the space that is defined by the inner walls of the dwelling, which may not be connected to the land on which the building stands. The ownership of individual dwellings is connected to the relevant co-ownership shares in the land and common parts of the building (common property), which are jointly owned by all unit owners (Lujanen, 2010). The third element of the condominium model is membership in an owners' organization (called homeowners association, owners corporation or body corporate, etc.), which is in principle inseparable from unit ownership and is compulsory for all unit owners,

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as it is statutorily required in this form of MOH developments (Johnston & Too, 2015; Easthope et al., 2020). This non-profit organization is responsible for the management of the common property. Housing condominiums are now increasingly proliferating in many parts of the world, particularly in post-socialist European countries (e.g. Mandič, 2010; Lux & Sunega, 2014; Pojani & Baar, 2016; Muczyński, 2022). Accordingly, the management problems of such a form of housing cannot be overlooked, as it has a huge impact on the configuration of the urban environment, people's quality of life, and the sustainable use of housing resources (Johnston & Reid, 2013).

This paper focuses on the structural problem of common property management in the system of statutory housing condominiums in Poland. Like in many other countries, Poland has a special law called the Ownership of Units Act (OUA, 1994), which sets out the legal framework for the management of housing condominiums, including responsible bodies, decision-making rules, and organizational models for common property management. The relevant decision-making body in Polish condominiums is an organization formed by all the unit owners, with the membership of each in this organization being mandatory. This organization – called the Homeowners Association (HOA) – is automatically formed when separate ownership of the first unit in the condominium scheme is established. The Act defines „common property" as the land and those parts of the building that do not serve the exclusive needs of individual owners. In turn, common property management is understood as all tasks and duties related to the administration, operation, and maintenance of the common property (UNECE, 2019). Among the possible organizational models of common property management in housing condominiums in Poland, there are three basic models in which the listed management activities are carried out by (Szczepańska, 2015): (1) a professional property management entity that simultaneously serves as the HOA's board (notary entrusted model), (2) directly by the HOA's board (in-house model), or (3) by the HOA's board and a professional entity that manages (administers) the common property (mixed model).

The main aim of the study was to investigate the actual ownership structures of common property management entities (administrators) in public-private housing condominiums in Poland. Public-private housing condominiums (PPHCs) are marked by a hybrid structure of unit owners, meaning that they consist of dwellings owned by both public and private owners, who are also co-owners of the common property. The subject of research in this study was PPHCs in which the functions of public owners of dwellings are performed by municipalities. This means that they were housing condominiums with the participation of municipal ownership. These PPHCs have been created as a result of the ongoing privatization (sale) of social rented municipal dwellings to their occupiers (Muczyński, 2011). Municipalities, while owning a portion of the housing units in such PPHCs, act as public co-owners, i.e. members of HOAs with certain rights and obligations over the common property. This means that they decide collectively with private unit owners on the adoption of a specific common property management model and can influence the choice of a particular property management entity to perform certain activities in this model. Such decisions and choices determine the effectiveness and efficiency of the common property management under consideration. They are presented in the paper on the example of municipalities located in the Warmia and Mazury province.

Following the Introduction, this paper contains fourth sections. The first section outlines the literature review on the rationale and motives (drivers) for the development of housing condominiums in many parts of the world; the second section induces material and methods used for achieving the aim of the study; the third section presents and discusses obtained results of the empirical research; the fourth section concluded the results and formulates recommendations for future research.

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LITERATURE REVIEW

The growing popularity of housing condominiums in recent decades was due both to more general trends in housing policy and real estate markets, as well as to many specific national and local factors. As Gruis et al. (2009) pointed out, the later part of the 20th century marked a turning point in both Eastern and Western European housing policies as well as in other continents. Europe, Australasia, and the USA were characterized by a receding involvement in public housing and general instability within different housing systems in the 1980s and this trend has continued through the 1990s and into the new century (Forrest & Lee, 2003). As part of these changing policies, a significant portion of public housing stock has been sold to tenants (Jones & Murie, 2006). This was particularly evident in post-socialist countries in Europe, where, after the transition to a market economy, new housing systems were introduced, which were distinguished by a significant reduction of the role of central governments, decentralization of housing services, and mass privatization of public housing (e.g. Mandič, 2010; Lux & Sunega, 2014; Dawidowicz et al., 2019; Muczyński & Goraj, 2021). These changes were associated with the shift from the model of an omnipotent state to a minimal state, placing decision-making closest to those affected (Glasze, 2005). In support of condominiums in transition countries, the United Nations has developed a set of guidelines (UNECE, 2003) that paved the way for the spread of this type of multi-owned housing as a standard form of housing ownership (Pojani & Baar, 2016). The new version of these guidelines (UNECE, 2019) expands their scope to include contemporary challenges (e.g. new technologies, changing global weather conditions, increasingly rapid rates of urbanization that require the protection of vulnerable groups, etc.) across the entire UNECE region. In general, regardless of the manner and pace of the privatization of public housing in different parts of the world, it has always been one of the key drivers of housing condominiums.

Other drives of this phenomenon are related to market forces, which result from the motivation of both developers and local governments on the supply side as well as consumers on the demand side (McKenzie, 2003). This type of MOH allows developers to build higher-density developments to maintain profits and keep unit prices at an affordable level despite rising land prices and enables local governments to increase tax revenues with minimal public spending. In addition, enabling the condominium model in residential buildings by dividing them into smaller units reinvigorates local property markets by making the apartments more tradable, consumable, and accessible to a larger market (Dredge & Coiacetto, 2011). In turn, the consumer's motivation to join the condominium results from searching for a privatized utopia with many dwelling buyers, offering a sense of neighborhood control, enhanced security, a homogenous population, and small-scale managerial private government that enforces high standards of property maintenance (McKenzie, 2003). Moreover, the introduction of this housing model was driven by the desire to offer a form of ownership 'equivalent' to that of detached houses and so enable mortgage lending under the same conditions (Lasner, 2012). The lower purchase prices and maintenance costs of condominium dwellings compared to detached houses make this model particularly popular among low-income households, including the young, elderly, and immigrant families (Levin & Arthurson, 2020). However, due to the close proximity of residents in a condominium scheme and the risk of conflicts with neighbors (owners or tenants) who may change regardless of the will of the original unit owners, in some countries (e.g. Australia) this model has traditionally been considered a temporary housing option, more attractive to investors than owner-residents (Yates, 2001). The academic debate also often emphasizes that rapid population growth in cities, mass urbanization combined with limited land availability and affordability, cause increasing political pressure to promote more intensive and sustainable forms of urban development, leading to a higher

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density housing and a greater proportion of residential development in the form of condominiums. Housing condominiums are attractive to the government at national and local levels because they are seen as a means to reduce urban sprawl and to enable inner-city regeneration (Blandy et al., 2010) and urban land consolidation (Easthope & Randolph, 2009; McCrea & Walters, 2012; Easthope et al., 2014) using sometimes different infill development scenarios (Puustinen & Viitanen, 2015; Puustinen et al., 2017). The use of the condominium model in medium-density and high-density housing development has also been driven largely by an embedded cultural drive for home ownership (Dredge & Coiacetto, 2011). Ultimately, housing condominiums are an instrument to promote general objectives such as economic growth and political stability (van der Merwe, 2015).

The housing condominium is also understood as a common property resource, collectively managed by co-owners to maintain the quality of the built environment (Vergara et al., 2019). In general, it is widely recognized that the management of this form of MOH development is much more complicated compared to single-owner developments because it consists of both private and public spheres (Yau, 2018). In the private sphere, unit owners have the exclusive right to own and use their dwellings, but in the public sphere, they are co-owners of the common property and jointly share the management rights and responsibilities associated with them. In other words, co-owners making voluntary decisions concerning common property management are legally, economically, and socially interdependent, and these decisions become collective rather than individual decisions.

MATERIALS AND METHODS

The intended investigation of actual ownership structures in public-private housing condominiums (PPHCs) with the participation of municipal ownership was conducted on the sample of the 30 largest urban municipalities located in the Warmia and Mazury province in Poland (Fig. 1). Empirical data describing the structures of common property management entities in the collections of these condominiums in the sampled municipalities were collected as of the end of 2021 by questionnaire interview method using the public information access technique. In larger municipalities, the standardized questionnaire was addressed to separate organizational units of municipalities responsible for managing the municipal housing stock, while in smaller municipalities the questionnaire was addressed directly to the relevant municipal executive bodies. The questionnaire research combined with direct follow-up interviews was conducted between March and September 2022. Proper identification and analysis of the structures of common property management entities in the PPHCs in question were carried out by grouping the structures found in the surveyed municipalities using hierarchical cluster analysis. The studied municipalities were grouped from the point of view of the adopted clustering criterion related to the percentage of each type of common property management entity in the analyzed structures. The process of grouping municipalities according to the types of common property management structures in PPHCs was conducted with the agglomeration method. A distance function based on the Euclidean distance metric was used as a measure of the similarity of the grouped structures. Due to the variation in cluster sizes, binding rules based on the weighted pair-group method using the centroid average were applied.

The methodology used enabled to separate in the research sample groups (clusters) of municipalities, which are characterized by relatively homogeneous structures of common property management entities in PPHCs with the participation of municipal ownership. This means that the surveyed management structures in municipalities included in one group are as similar as possible to each other, while these structures in municipalities belonging to different groups these structures differ maximally from each other according to the adopted similarity measure. The number of clusters (groups) was determined by analyzing the agglomeration graph. The intersection

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Fig 1. Location of the Warmia and Mazury province in Poland and Europe
Source: own preparation.

point of the graph was chosen at the point of its pronounced flattening, where the distance between successive clusters (nodes) increases. Deeper cluster analysis leads to better recognition of the population under study (Grabiński et al., 1989; Muczyński, 2009), including the discovery of hidden dimensions or data structures, as well as finding regularities in data sets and formulating generalizing conclusions.

RESULTS AND DISCUSSION

The investigated ownership structures of common property management entities in public-private housing condominiums (PPHCs) were primary influenced by ownership changes in the urban housing stock caused by the long-term privatization of municipal dwellings, which was carried out by the dispersed method (Muczyński & Goraj, 2021). As a result of such privatization, the municipal housing stock (MHS) has been significantly reduced and furthermore fragmented to the point that the majority of municipal dwellings in the surveyed municipalities are now in numerous PPHCs, which raises various ownership and management problems. This phenomenon is reflected in the quantitative characteristics of the housing stock formed as a result of the above privatization (with a shortage of municipal housing investments) in the 5 largest municipalities of the Warmia and Mazury province (Table 1).

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Table 1. Quantitative characteristics of housing stock in the largest municipalities of Warmia and Mazury at the end of 2020

Total Housing stock		Municipal Housing Stock		Public-Private Housing Condominiums	
Municipality	Number of all dwellings	Number of all municipal dwellings	Percentage in all dwellings [%]	Number of municipal dwellings	Percentage in all municipal dwellings [%]
Olsztyn	80 967	4 017	5.0	2 608	64.9
Elbląg	47 934	5 097	10.6	3 327	65.3
Ełk	24 380	1 321	5.4	869	65.8
Iława	13 565	868	6.4	592	68.2
Ostróda	13 457	797	5.9	488	61.2
in total:	180 303	12 100	6.7	7 884	65.2

Source: own preparation based on data obtained from Central Statistical Office in Poland, Local Data Bank (GUS, 2022).

This table shows that the percentage of municipal dwellings in the total housing stock has fallen in the selected municipalities at the end of 2020 to between 5.0% and 6.4% (with the country average at 5.4%). Only in Elbląg was the percentage of municipal housing almost twice as high (10.6%). This table also reveals that almost two out of three municipal dwellings in these municipalities were located in PPHCs.

The research sample, consisting of the 30 largest urban municipalities in the Warmia and Mazury province, represented 60% of the number of all urban municipalities in the province under study. The surveyed municipalities varied widely both in terms of the total number of residents (from over 170,000 in Olsztyn to less than 5,500 in Orzysz) and the number of public-private housing condominiums with the participation of municipal ownership (from 735 such facilities in Elbląg to just 16 in Lubawa). Quantitative data describing these PPHCs in the surveyed municipalities as of the end of 2021, including the numbers of different types of common property management entities in such condominiums, are summarized in Table 2. This table distinguishes three main structural types of common property management entities in studied PPHCs, such as municipal property management companies (MPMCs), private property management firms (PPMFs), and other entities (in-house management). It should be emphasized that the data presented in Table 2 are raw data obtained directly as a result of the applied data collection procedure by the questionnaire interview method using the public information access technique. These data, after being checked and verified through direct follow-up interviews, became the basis for cluster analysis.

The detailed results of grouping the surveyed municipalities according to the types (characteristics) of the common property management structures in PPHCs are presented in the tree diagram (Fig. 2), and also visualized on the map (Fig. 3). The conducted cluster analysis identified three major groups of municipalities with relatively homogeneous structures of common property management entities in public-private housing condominiums and two municipalities atypical in this regard. The first group includes 8 municipalities (26.7%), where the common properties in the surveyed PPHCs were managed exclusively (as in Pisz, Lidzbark Warmiński, Orneta, Lidzbark, and Susz) or almost exclusively (as in Ełk, Bartoszyce, and Olsztynek) by municipal property management companies (MPMCs) operating mostly in the form of limited liability companies, which in smaller municipalities often performed multi-branch activities. In other words, they combine the common property management services in PPHCs with the operations of heat supply, water supply, sewage disposal, etc. (as in Lidzbark and Susz).

The second group (cluster) covers 11 municipalities (36.7%) with the dominant share of MPMCs in the structure of common property management entities in PPHCs. It combines the subgroup 2A (containing such municipalities as Ostróda, Biskupiec, Kętrzyn,

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Table 2. Quantitative characteristics of public-private housing condominiums in the surveyed municipalities at the end of 2021

Municipality	Number of residents	Number of public-private housing condominiums (PPHCs)			
		in total:	including with common property managed by:		
			MPMCs	PPMFs	other entities
Olsztyn	170 622	634	444	188	2
Elbląg	117 952	735	0	734	1
Ełk	61 782	180	170	8	2
Iława	33 111	91	65	21	5
Ostróda	32 547	172	135	32	5
Giżycko	28 803	114	0	113	1
Kętrzyn	26 609	181	155	19	7
Bartoszyce	22 785	92	86	6	0
Szczytno	22 671	123	106	13	4
Mrągowo	21 179	39	26	9	4
Działdowo	21 014	55	48	7	0
Pisz	18 890	87	87	0	0
Braniewo	16 907	137	0	137	0
Olecko	16 241	114	50	57	7
Lidzbark Warmiński	15 420	137	137	0	0
Gołdap	13 571	73	51	16	6
Nidzica	13 439	38	0	38	0
Morąg	13 325	70	51	7	12
Pasłęk	12 085	97	0	83	14
Węgorzewo	11 155	51	0	46	5
Nowe Miasto Lubawskie	10 657	25	22	3	0
Biskupiec	10 576	84	66	15	3
Lubawa	10 369	16	0	16	0
Dobre Miasto	9 943	53	3	50	0
Orneta	8 598	112	112	0	0
Lidzbark	7 596	18	18	0	0
Barczewo	7 478	69	0	52	17
Olsztynek	7 474	44	41	3	0
Susz	5 490	57	57	0	0
Orzysz	5 473	62	0	62	0
intotal:	773 762	3 760	1 930	1 735	95

Source: own preparation.

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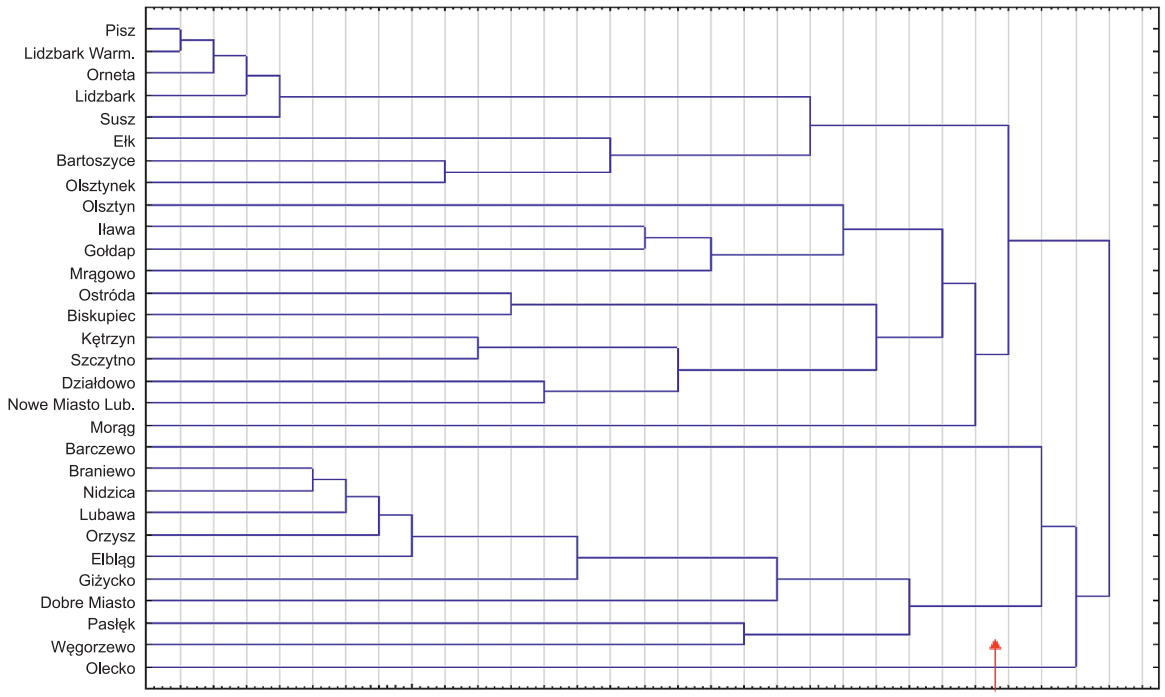

Fig. 2. Tree diagram of grouping the sampled municipalities in the Warmia and Mazury province in Poland
Source: own preparation.

Szczytno, Działdowo, and Nowe Miasto Lubawskie), in which the share of MPMCs ranged from 78.6% to 88.0% with the subgroup 2B (containing such municipalities as Olsztyn, Iława, Gołdap, and Mrągowo), in which the MPMCs' share dropped to about 70%. The share of private property management firms (PPMFs) in the surveyed structure varied in this group from 10.0% to 18.6% (subgroup 2A) and from 21.9% to 29.7% (subgroup 2B). The third group includes 9 municipalities (30.0%) in which the PPMFs were either exclusive (as in Braniewo, Nidzica, Lubawa, Orzysz, Elbląg and Giżycko) or dominant (as in Dobre Miasto, Pasłęk, and Węgorzewo) entities in the considered structure of common property managers. In this group, it was also observed that the dominant private entity (PPMF) combined the discussed property management services in PPHCs with other services, such as road maintenance of public roads, garbage collection, heat supply, or cemetery management (such as in Dobre Miasto). Atypical municipalities were Barczewo and Olecko. The former was marked by a lack of MPMCs and a high share of in-house management in the surveyed structure and the latter by a balanced proportion of private and other management entities in that structure.

The conducted research showed that the studied ownership structures of common property management entities in PPHCs differed significantly in the separated groups of municipalities, especially between the first two groups and the third group. Indeed, the first two homogeneous groups were dominated by municipal property management companies (MPMCs), while the third group was dominated by private property management firms (PPMFs). Overall, MPMCs prevailed in the management structure of the surveyed condominiums in 19 municipalities, accounting for 63.3% of the number of all surveyed territorial units. In 6 municipalities around Olsztyn (such as Iława, Kętrzyn, Szczytno Mrągowo, Orneta, and Olsztynek) and atypical Olecko, the entities responsible for the common property management in PPHCs were special municipal companies (called TBS), which were primarily responsible for providing social housing with moderate rents. Full privatization

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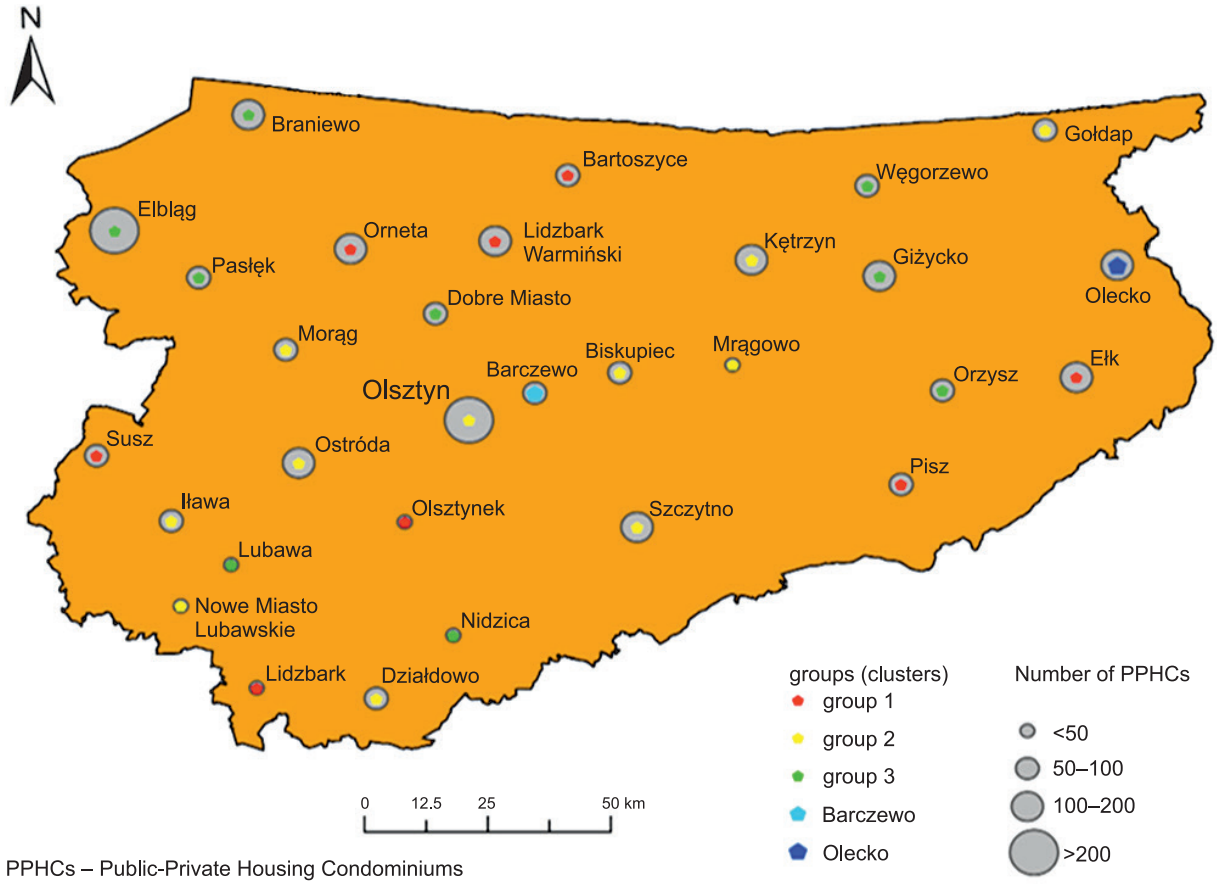

Fig. 3. Visualization of grouping the sampled municipalities in the Warmia and Mazury province in Poland
Source: own preparation.

of the common property management in PPHCs was introduced in only 6 municipalities, accounting for 20.0% of the total number of sampled municipalities. In addition, a relatively low popularity of in-house management in the surveyed housing condominiums was found, as its share in the structure of common property management entities exceeded 10% in only 4 municipalities (such as Mrągowo, Morąg, Pasłęk, and Barczewo).

CONCLUSIONS

The progressive privatization of municipal housing stock, as part of the overall transformation of Poland's housing system, has led to the creation of public-private housing condominiums. One of the significant problems associated with this form of housing ownership is the selection of an appropriate entity to manage the common property. The main aim of the study was to investigate the ownership structures of common property management entities in PPHCs located in municipalities of the Warmia and Mazury province in Poland. The results showed that in the studied municipalities, these structures in PPHCs with the participation of municipal ownership varied in nature. Most of them were marked by the exclusive or dominant share of municipal entities (MPMCs) operating as limited liability companies. This means, on the one hand, that in most municipalities, local governments continued to retain (prefer) their own entities to manage common property in PPHCs under study. This situation persisted despite the existing

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controversy over the legality (Bończak-Kucharczyk, 2003; Tertelis, 2009) of common property management in this type of housing condominiums by MPMCs and the widely acknowledged lower efficiency and effectiveness of municipal (public) property managers compared to private (PPMFs) ones (Majchrzak, 2005; Nalepka, 2005; Muczyński, 2022). On the other hand, this situation showed that there is still a relatively high level of interest among private unit owners in PPHCs to outsource common property management activities in such housing condominiums to MPMCs.

The study found that the ownership structures of common property management entities in PPHCs were determined by the autonomous policy of municipal authorities regarding the creation and upkeep of municipal companies to perform tasks arising from this management, even though these tasks are not part of municipalities' own responsibilities. The formation of such structures was also influenced by the situation in local housing markets, including the availability, credibility, and efficiency of PPMFs. The PPHCs have been in a long-term transitional phase, in which ownership of individual dwellings is gradually being transferred from the municipality as the original owner to their tenants. Accordingly, the common property management structures are far from being stable, as they are undergoing gradual evolution triggered by changes in the local market conditions of this management, including changes in the number and characteristics of PPHCs resulting from the privatization of MHS. Therefore, based on the results obtained, it is difficult to unambiguously indicate in many municipalities the future direction and ultimate effect of the evolution of the studied common property management structures.

Finally, it should be concluded that the research at this stage has not revealed clear dependencies between the identified types of common property management structures and the number of residents or PPHCs in the analyzed municipalities, as well as the geographic location of these municipalities in the province. Therefore, a more in-depth recognition of internal and external factors influencing the considered common property management structures is recommended as a direction for further research.

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WORK DURING THE COVID-19 PANDEMIC – FEELINGS OF THE INVESTMENT AND CONSTRUCTION SECTOR EMPLOYEES IN POLAND

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ABSTRACT

Motives: The COVID-19 pandemic directly affected the lives of Polish workers. The literature on the subject focuses its attention on the medical sector, security services, education, and commerce.
Aim: In order to broaden the analysis, the impact of the pandemic on the investment and construction sector, closely related to spatial management, was assessed by conducting a questionnaire survey among its workers. The survey was anonymous and conducted remotely via the Microsoft Forms platform. The study sample comprised 109 workers.
Results: The study results show clearly that the pandemic had a significant impact on working life. The negative effects include a deteriorated mental state and a feeling of increased anxiety, problems with the timely completion of investment projects, prolonged working hours, and numerous absences from work. As regards the positive phenomena, the respondents indicated the flexible working hours (remote and hybrid work), the advantages resulting from the accelerated digitisation of the administration (faster acquisition of data), and a change for the better in terms of the forms of communication with superiors and co-workers.

Keywords: employees, investment and construction sector, working conditions, work organisation, COVID-19

INTRODUCTION

More than two years have passed since the outbreak of the COVID-19 pandemic, during which the entire world reorganised its functioning. The limitations resulting from the introduced restrictions affected both the private and professional spheres. They left their mark on all spheres of life and, in particular, on mental health, which the WHO defines as "a state of well-being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community" (WHO, 2001). People's mental health worsened, resulting in a wide range of psychological symptoms and problems throughout the world (Javed et al., 2020; Richter et al., 2021; Szcześniak et al., 2021; Hisham et al., 2021; Usher et al., 2020; Cullen et al., 2020; Xiong et al., 2020). Similar observations apply to the Polish population (Księska-Koszałka, 2021; Heitzman, 2020; Babicki

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& Mastalerz-Migas, 2020; Rybarczyk & Koweszko, 2021; Talarowska et al., 2020).

A similar deterioration in mental condition was also noted for the well-being of workers (in particular health care workers), as the pandemic had a significant impact on different spheres of work (including work organisation) and various branches of the economy (construction industry – Iqbal et al., 2021; Alsharef et al., 2021; Bsisu, 2020; Pamidimukkala & Kermanshachi, 2021; Ogunnusi et al., 2020; infrastructure sector – Jallow et al., 2020; the other – Meyer et al., 2021; Yu et al., 2021; Lancet, 2020; Buselli et al., 2020; Spoorthy et al., 2020; Saragih et al., 2021; Muller et al., 2020; Niebuhr et al., 2022; Parent-Lamarche, 2022). Thus, the research carried out in different countries confirms the contribution of the pandemic to the deterioration in workers' mental health, which is particularly important for the proper performance of occupational duties (Tlatlik, 2020) and significant changes in work organisation. On the other hand, the results of the questionnaire survey conducted among Polish workers by Olearczyk and Walewska-Zielecka (2021) indicate that the areas most affected by the epidemic in a negative way include the level of perceived stress, access to medical care, and relationships with co-workers, while a positive impact was noted only for the adherence to hygiene recommendations.

Besides health and safety, the new reality of the working world also concerns e.g. work-family issues, telecommuting, virtual teamwork, jobs in security, precarious work, leadership, human resources policy, the aging workforce and careers (Rudolph et al., 2021). Transparent internal communication played a significant role in the changes introduced to work organisation (Jo-Yun et al., 2021). Therefore, the COVID-19 pandemic had a significant effect on work organisation. Numerous organisational changes were introduced, and, in many cases, there was a shift in the working mode to a remote or hybrid mode. The working world is currently going through the fourth industrial revolution driven by digital information, with the digitisation and information and communication technologies (ITC) contributing to both a decrease and an increase in psychosocial risks (Safety and health…, 2019). This has already resulted in a worldwide increase in work performed via the Internet, i.e. Working From Home (WFH) (Bloom et al., 2015; Allen et al., 2015). Undoubtedly, however, the pandemic imposed and accelerated changes in the organisation of work (Alam, 2020; Prochazka et al., 2020), in particular the shift to the remote working mode, to a greater extent and in an abrupt manner (Kaushik & Guleria, 2020; Da et al., 2022; Kramer & Kramer, 2020). This was a result of the restrictions introduced to minimise interpersonal contact, which forced employers to introduce new principles of work organisation.

In Poland, many employees were also required to shift to remote working, which increased the possibility of performing work remotely in selected sectors of the economy (Dolot, 2020; Chomicki & Mierzejewska, 2020; Kolasińska, 2021). The possibility of remote working and the principles of performing it were set out in 2020 in the Anti-Crisis Shield 4.0, in which remote working was defined as performing work away from the place of its regular performance at the employer's instruction, in order to prevent the spread of COVID-19. Statistics Poland is conducting a survey "Demand for Work" among the national economy entities, with one of the questions concerning the number of employees who worked remotely due to the epidemic situation (as of the last day of the reporting quarter of the year). Table 1 below shows the percentage of employees who worked remotely due to the epidemic situation, broken down by the public and private sectors.

Another aspect worth noting in the context of the pandemic is the digitisation process. The process of administration digitisation in the European Union was progressing steadily (Pérez-Morote et al., 2020), but the COVID-19 pandemic contributed to a significant acceleration of activities (Grinin et al., 2022; Burlacu et al., 2021; Rozhkova et al., 2021; Hodzic et al., 2021). In Poland, the pandemic accelerated, in an unprecedented way, the operations aimed at developing a digital administration model, implementing public e-services, and developing remote communication

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Table 1. Percentage of employees who worked remotely due to the epidemic situation, broken down by ownership sector

Sector	2020				2021			
	1st quarter of 2020	2nd quarter of 2020	3rd quarter of 2020	4th quarter of 2020	1st quarter of 2021	2nd quarter of 2021	3rd quarter of 2021	4th quarter of 2021
total	11.0	10.2	5.8	10.8	14.2	6.8	5.0	6.9
public	17.9	11.4	3.3	15.4	24.8	5.0	2.1	8.0
private	8.6	9.8	6.6	9.2	10.5	7.2	6.0	6.6

Source: The effect of the COVID-19 epidemic on selected components of the labour market in Poland in the first, second, third, and fourth quarters of 2020 and 2021. Statistics Poland.

systems (Kwaśny, 2022; Uścińska, 2021). This is all the more important because the digitisation of public services translates into considerable improvement. Effective e-administration can provide a wide range of benefits, including greater efficiency, transparency, openness, and savings, e.g. for entrepreneurs (Chądrzyński et al., 2021; Miłek & Nowak, 2021) and simplified office procedures for customers (Ganczar, 2010). In addition, due to the change in the work organisation model, offices became subject to the technological development of organisations, which resulted in increased data flow and easier access to information (Goździewska-Nowicka et al., 2020). The development of e-administration was a response to the new reality. As part of its efforts, the public sector has been introducing an ever-growing catalogue of online services, which enables an increasingly better remote contact between entrepreneurs and the public administration (Włodyka, 2021).

LITERATURE REVIEW

Most publications on changes in working conditions due to the COVID-19 pandemic and its effects on workers' well-being address, for natural reasons, issues related to health care workers. Few studies have analysed this issue in relation to other professions, including in Poland. As indicated above, papers have emerged worldwide on the impact of the pandemic on the construction industry and infrastructure sector, closely related to spatial management. This study is aimed at determining the impact of the new reality on employees of the investment and construction sector in Poland, particularly how the introduced restrictions affected their mood and mental condition, and how strong the impact of the pandemic on their professional life has been – the impact on investment projects, administrative support of investments and changes in professional relations and communication methods. To this end, a questionnaire survey was conducted among employees of companies in the business/construction and investment sectors, which concerned the impact of the two-year COVID-19 epidemic period announced for the territory of Poland on mental health and working conditions.

MATERIALS AND METHODS

The research method applied in the study was a diagnostic survey using a questionnaire. This method enables the collection of quantitative and qualitative data. The questionnaire comprised the general characteristics of the respondents and three thematic sections. The questionnaire form included closed questions: alternative (yes/no), disjunctive (responses are to be chosen from the list), and conjunctive (more than one response can be chosen from the list).

The survey questionnaire comprised 21 survey questions and five questions concerning the respondents' characteristics (gender, age, education level, professional experienceand the form of employment). The survey questions were grouped into three thematic sections: the working mode, mental health and realisation of investments. Each section asked the respondents to express their opinion on the issues concerned. The first section included questions concerning the effect of the pandemic on the respondents' work, a change in the working mode that emerged due to the pandemic, the number of hours spent working

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during the pandemic, and the respondents' and co-workers' absences from work. The second section included detailed questions on the respondents' mental health. The following were verified: the varying mental condition and stress levels at work before and during the pandemic, the anxiety levels experienced at work, and the respondents' use of support from mental health specialists. The issues of changes in interpersonal relationships and communication methods during this particular period were also addressed. The final section included supplementary questions concerning the effect of the pandemic on the realisation of investments and its strategic components, e.g. the duration of investment implementation, additional impediments, administrative processes and the acquisition of data.

The random selection procedure was applied. However, due to the specificity of the analysed economy sector, young people were dominant among the respondents. This sector is distinguished by a large number of lower-rank employees and a small management staff. The study involved 109 people working in the investment and construction sector in the positions of project manager, designer, analyst and advisor (legal, spatial, and economic aspects of investments). These people have daily contact with implementing infrastructural investments of strategic importance for the country, including the design and construction of fibre optic networks, power lines, gas pipelines, oil pipelines and road networks. This remote study was conducted online via the Microsoft Forms platform from January to March 2022.

RESULTS

The study sample comprised 109 people, including 54% women and 46% men. The predominant age group were people under 30 years of age (50% of respondents), in which women were predominant, as in the entire sample. The smallest group (9%) comprised people over 50 years of age. Since higher education is the basic requirement for a worker to be employed in the investment and construction sector, 92% of the respondents completed this level of education. There were single people with secondary education, but all of them were in the process of completing an extramural course of relevant study. Professional experience is strongly correlated to the respondents' age and education, although not related to gender. Young people usually have experience of up to 5 years (42%), while 32% of the respondents have experience of 5–15 years. The final question from the part characterising the participants addressed the form of employment. The respondents indicated that they had an employment contract (62%), a contractual agreement (18%) or were self-employed (8%). The remaining group (12% in total) comprised people working on a contract of mandate basis, with this form of employment offering no professional stability.

The issues addressed in the survey concerning the global COVID-19 pandemic and its impact on work in the investment and construction sector began with questions concerning the general determination as to whether the pandemic has strongly affected the respondents' work. The employees' feelings were very similar, with up to three-quarters indicating that the pandemic had strongly impacted their working lives. On the other hand, the impact was not noted by 25% of the respondents, among which the dominant group were people with limited professional experience.

The first thematic panel of the survey questionnaire included issues related to the changes that occurred in working modes during the COVID-19 pandemic and the absences from work resulting from mass infections. The pandemic brought many changes and restrictions, including moving around and travelling limitations. The school and kindergarten facilities were temporarily closed, which affected employees with children. The limits on the number of people allowed per square metre of floor space in public spaces such as offices and shops were changed. Many companies decided to introduce either a remote or hybrid work mode given the above-mentioned determinants.

The mode of work in the investment and construction sector changed during the pandemic, as confirmed by as many as 80% of the respondents. However, depending on the decisions of company

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Table 2. Working mode in the investment and construction sector during the COVID-19 pandemic

Change in the working mode – COVID-19 pandemic [%]		Preferred working mode – COVID-19 pandemic [%]		Was the change in line with the respondent's preference
changed into the remote mode	26	remote mode	15	yes
		hybrid mode	5	no
		on-site mode	6	no
changed into the hybrid mode	54	hybrid mode	37	yes
		remote mode	12	no
		on-site mode	5	no
did not change	20	on-site mode	12	yes
		hybrid mode	5	no
		remote mode	3	no

Source: own study.

management boards, it was a shift to either a remote or hybrid working mode (Table 2). However, this change was not always in line with the employees' preferences, as they had divergent views on the form of work performance. The respondents showed the greatest satisfaction with hybrid work, which they prefer (47%), while the on-site work mode is the least popular (23%) as it requires the employee to be constantly present in the office. The supplementary question was intended to verify whether the hybrid/remote mode of work resulted in the respondents working more hours than the on-site mode. Overall, they indicate that "yes", 70% of people work more – however, the responses are not related to seniority, the respondents' age, or other parameters.

The pandemic, however, brought about another change that no one had encountered on this scale before. It was also noted in the investment and construction sector and concerned mass absences from work, which was not avoided by the employees and subcontractors of the sector concerned either, as noted by 84% of the respondents. Mass infections resulted in mass absences from work (Fig. 1). Only a few people managed to avoid infection, while the others in the study sample acquired one or more infections.

The second section of the questionnaire directly addressed the feelings of employees of the investment and construction sector as well as their well-being

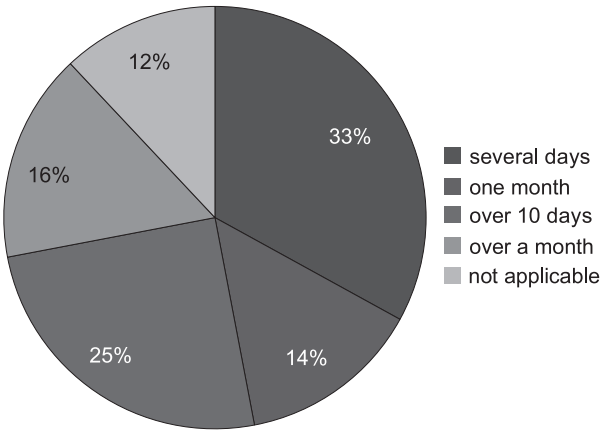

Chart 1. Absences from work in the investment and construction sector during the pandemic
Source: own study.

and mental health. Their subjective feelings about their mental well-being were subjected to verification. Attention was focused on stress, anxiety at work and its potential exacerbation in the face of sudden changes during the pandemic and the effect of those changes on investment processes (Table 3).

Evidently, the mental state of a significant proportion of the respondents deteriorated. Only 30 respondents felt their mental condition had not changed. Further, 46 people felt deterioration on the indicated scale by one level, 21 respondents felt deterioration by two levels of the scale, and four people felt deterioration by three levels. It should not

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Table 3. Mental condition of investment and construction sector employees during the pandemic

Mental condition before the pandemic [%]		Mental condition at present [%]		Change [percentage points]
very poor	2	very poor	16	+14
poor	5	poor	20	+15
average	29	average	29	0
good	42	good	22	-20
very good	22	very good	13	-9

Source: own study.

Table 4. The level of stress at work of investment and construction sector employees during the pandemic

The level of stress at work before the pandemic [%]		The level of stress at work at present [%]		Change [percentage points]
very high	5	very high	19	+14
high	23	high	23	0
average	38	average	32	-6
low	27	low	16	-11
very low	7	very low	10	+3

Source: own study.

Table 5. Interpersonal relationships at work among investment and construction sector employees during the pandemic

	Work – interpersonal relationships		Change in the communication method			Assessment of the change in the communication method	
	improvement	deterioration	yes	no	I do not know	positive	negative
superiors	83	17	61	33	6	83	17
co-workers	80	20	63	30	7	76	24
investors	61	39	35	52	13	73	27
subcontractors	62	38	38	48	14	78	22

Source: own study.

be ignored that eight people felt improvement: five people by one level, and three people by two levels, respectively. The issues of the link between work and the respondents' mental condition and the changes in stress levels at work during the pandemic were also analysed. The study results in this regard are provided in Table 4.

Several new positive and negative emotions accompanied the changing reality and relationships at work. The respondents indicated that it had directly affected their daily well-being (Table 5).

In general, the interpersonal relationships at work improved, with the respondents indicating mutual support under the new circumstances. There was a significant improvement (by 80%) in relationships with the superiors and co-workers and a smaller improvement (by 60%) in relationships with investors and subcontractors. The communication method at the place of employment changed as well (online meetings, teleconferences, dedicated software to coordinate the company's work online). Such a change was not noted regarding the external actors (investors, subcontractors). In general, the occurring changes were assessed positively.

Mental health specialists supported the decreased mental condition among the investment and construction sector employees. Forty-one respondents received this form of support during the pandemic (Table 6).

Table 6. Psychological support for investment and construction sector employees during the pandemic

Percentage of respondents receiving support from a psychologist / psychiatrist during the COVID-19 pandemic		Percentage of respondents requiring support from the employer in dealing with stress	
yes	38	yes	62
no	62	no	38

Source: own study.

It is worth noting that despite the significant deterioration in mental health, 41 out of 71 people experiencing such deterioration went to see a specialist. The responses provided to another question, where the

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Table 7. The effect of the pandemic on individual aspects of investments in the investment and construction sector

	The effect of the pandemic on:				
	investment realisation	an extension of the investment realisation time	the occurrence of additional difficulties	an extension of administrative processes	the occurrence of difficulties in acquiring data
yes	78	72	73	72	14
no	12	13	14	13	65
I am unable to assess	10	15	13	15	21

Source: own study.

respondents (62%) claimed that the employer should offer such support in different forms, shows that professional help is important and that the employees are aware of that.

The specific nature of infrastructural investments, manifested in the rather inflexible pace of work (resulting from the predetermined deadline imposed by investors) in the pandemic era, resulted in the introduction of numerous changes in the daily lives of employees in this sector. The survey questionnaire included questions concerning the investments they were making. The panel of questions about the investment was included in the third (final) section of the questionnaire concerning investments (Table 7).

The pandemic had a clear, adverse effect on the realised investments, including their duration, and this fact was confirmed by the overwhelming majority of the respondents (over 70%). Despite additional difficulties and the extension of administrative processes, there was a simultaneous minimisation of difficulties in acquiring data due to the significant acceleration of the digitisation of offices, and the possibility of a greater impact on the course of administrative processes using remote means of communication.

DISCUSSION

In the study concerned, people under 30 years of age were predominant. This is related to the fact that the questionnaire survey was conducted in large companies where teams consist of more than one director, several project managers, and several hundred lower-ranking employees who are just starting their professional careers. The level of stress at work increased significantly but not as greatly as the respondents' mental well-being level decreased. This proves that stress at work is among the factors of impaired well-being. However, this does not change the fact that as many as 75% of the respondents felt a significant impact of the pandemic on their working lives. A strong feeling of anxiety associated with the investment under realisation was experienced by almost 70% of the respondents. The pandemic also created a need for psychological support – almost 40% of the respondents benefitted from specialist help. Unfortunately, even in large companies, there is still a lack of psychological support in different forms, which was indicated by more than 60% of the respondents.

The greatest support from boss given to remote working, in which an employee could choose on which days to appear at the workplace, which offered a greater freedom of choice. The remote mode of working is not without significance for the functioning of individuals and their mental well-being, as indicated by the respondents. Lubrańska (2021) points out that in relation to the effect of the pandemic on employees' mental well-being, the factors of uncertainty, a sense of threat, and social isolation significantly determine the individual's health and quality of life are mentioned. On the other hand, a study by Wontorczyk & Rożnowski (2022) demonstrated no differences in the commitment to work depending on three different working forms (remote, hybrid, and on-site work).

Remote working is possible under the conditions of increasing digitisation. As regards the employees from

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the sectors under analysis, not only does it refer to the way work is performed (using IT technologies) but also to acquiring the necessary documents and making arrangements in digital form (e-administration). The respondents' responses in this regard indicated reduced difficulties in acquiring data and a saving of time. As indicated by the respondents, this was a result of the accelerated digitisation and the lack of need to visit offices.

CONCLUSIONS

Work is an essential part of human life. Professional activity is such an important aspect for humans that it is necessary and desirable to create a healthy work environment (Rogowska, 2020; Borkowska & Rutkowska, 2013; Pyżalski et al., 2008). During the pre-pandemic period, the percentage of Poles experiencing stress in the workplace increased, which had a destructive effect on the intellectual, moral, and psychological levels (Młokosiewicz, 2018). As a result of the pandemic, these adverse phenomena were exacerbated, which is confirmed by various studies. What is worrying is that it also affects, to a large extent, young people, which may have significant consequences in the future.

The study results show that the new forms of work (remote or hybrid) were widely used in the investment and construction sector. Flexible working hours are accepted by the majority of respondents, which is consistent with the results of studies conducted in other countries (Diab-Bahman & Al-Enzi, 2020; Bolisani et al., 2020). Another study conducted among Polish employees by Mierzejewska & Chomicki (2020) indicates that when performing work on-site, employees exhibit higher levels of vigour, dedication, and preoccupation than when they work in the remote mode. The lack of social contacts was identified as the most significant disadvantage associated with remote working, and long-term remote working may adversely affect the individuals' commitment to these three dimensions. Therefore, the presented study results confirm all the above-mentioned observations – depending on the human preferences and the workplace and environment, the respondents prefer remote (30%), hybrid (47%) or on-site working (23%). At the same time, the respondents indicated that the change in the work form contributed to a significant extension of working hours, which is also confirmed by other studies (Mierzwińska et al., 2021).

The lockdown associated with the COVID-19 pandemic generates difficulties in investment management, thus leading to delays in operations (Jallow et al., 2020). These conclusions are also confirmed by the results of conducted studies. While no delays were noted at the design stage, the administrative processes were prolonged, and the actual implementation of the investment itself became problematic. This resulted from, e.g. staff shortages, absences from work, material shortages, price increases, and outage periods in factories manufacturing semi-finished products for investment realisation, etc. Many people working in the sector indicated that for the first time in recent decades, it was possible to directly apply contract provisions concerning the occurrence of force majeure/sudden and unexpected events. Consequently, it extended the time for investment completion and helped avoid many penalties for the occurring delays.

In general, the pandemic aroused many negative feelings among investment and construction sector employees, yet there are several reliable changes for the better. It should be stressed that the forms of communication with the superiors and co-workers changed for the better. The improvement occurred at a level of over 80%. Improvement was also noted in relations with investors and subcontractors. Face-to-face meetings that required business trips and took up many hours of the respondents' both professional and private lives were brought to a minimum. All the noted changes were assessed positively by the respondents. However, they are only appreciated in retrospect.

In conclusion, while the adverse impact of the pandemic on work organisation and the employees' well-being is mostly noted, there are also areas in which positive effects can be identified.

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contributed to this work as follows: K.P. and A.S. developed the concept and designed the study, K.P. collected the data, A.S. analysed and interpreted the data, K.P. prepared draft of article, A.S. revised the article critically for important intellectual content.

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THE DYNAMICS OF THE AIR TRANSPORT DEVELOPMENT IN THE WARMIA AND MAZURY REGION

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ABSTRACT

Motives: Regional passenger airports are an important component of a developed transportation system that reflects the broader development of the region and the country. Due to the small number of studies examining air transport at the regional micro-scale, it is important to carry out a diagnostic of this mode of transport to determine the possibility of regional development. The article presents the reasons for the creation, stages of construction and transformation of selected airports of northeastern Poland.
Aim: The main aim of the study was to determine the impact of the COVID-19 pandemic on the dynamics of air transport development in the area of northeastern Poland. The entire air transport system in the region was analyzed with a detailed inventory of the largest airport Olsztyn-Mazury.
Results: As a result of the study, data on the number of passengers and directions of travel for the past six years were compared. It was determined that Olsztyn-Mazury Airport has a significant development potential, providing an opportunity to rebuild passenger air traffic in Warmia and Mazury hampered by the effects of the COVID-19 virus pandemic.

Keywords: airports in north-eastern Poland, sustainable regional development, COVID-19

INTRODUCTION

The air transport system is the main factor stimulating the proper functioning of continents, countries or regions (Schäfer & Waitz, 2014; Golbe, 1986), and that a well-organized air transport system has a positive influence on the economic, social, and political effect of the connected countries (La Porte, 2019; Path, 1968). In the past, the problem was viewed mainly from the perspective of the flow of material resources, such as raw materials and products (Hesse & Rodrigue, 2004). Nowadays, to a large extent, we also consider transporting people who participate in economic and production processes, as well as passengers who travel for tourism, health, and research purposes (Duval, 2013; Spasojevic et al., 2018; Hakuć-Błażowska & Kupren, 2022).

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Despite the fact that air transport is the most expensive type of transport (Brons et al., 2002; Onghena et al., 2014), its development rate is the fastest. It performs a significant role in the economy of every country (Barnhart et al., 2003), strengthening international relations in the fields of culture, tourism, trade, and science. It has the largest range, is the fastest and it is hard to imagine further intensive development of interpersonal relations or coexistence of nations in the 21st century (Young, 2020; Prussi & Lonza, 2018).

There is a lot of research in the literature on the subject of air transport and its essence in terms of economics, energy or environment, and pandemic COVID-19, on global development (Magniszewski, 2022; Zawojska, & Siudek, 2021; Nižetić, 2020; Arena & Aprea, 2021). Also, many authors undertake an evaluation of air transport in international-transregional terms, e.g. the Baltic Sea region (Lindholm & Behrends, 2012), in Europe (Van de Vijver et al., 2016). However, there is a lack of approaches geared towards analyzing this transportation system on a micro scale to determine its importance in a country's region. To such a narrow extent, the topic is described in the branch magazines and popular periodicals (Lasociński, 2022; Tłoczyński et al., 2021).

Therefore, we undertook to study the level of development of air transport by answering the following research question: To what extent did the COVID-19 pandemic affect the directions of passenger traffic and the dynamics of air transport development carried out using the technical infrastructure of Olsztyn-Mazury Airport? For this purpose, quantitative (number of passengers in relation to maximum service capacity) and qualitative (directions of preferred flights, the state of the port infrastructure and the type of additional use) data were analyzed. The methodological approach adopted in the study stems from earlier research by Bieger & Wittmer (2006) that the determinant of the development of the port and the entire region is the number of passengers (users of transport services) and was supplemented by primary data obtained in the field.

MATERIALS AND METHODS

The problem addressed in this study, due to its niche, local nature and difficulties in accessing open data on regional air passenger traffic, required the selection of specific research methods and techniques. In order to carry out the research in the planned methodological approach, information was sifted from various sources, such as locally obtained annual reports of the port and collection of data from industry national statistics on flight directions and number of passengers by period from before and during the pandemic. Some of the data was obtained from censuses and industry records provided by the Civil Aviation Office in Warsaw as well as the Olsztyn-Mazury Airport website. The rest of the qualitative data needed for the planned approach, as primary information, was collected in the field through a face-to-face interview (interview conducted with facility managers) and a field visit (taking photographic material documenting the technical condition of the facilities, and taking an inventory of the way they are developed and currently used). The subject of analysis was passenger airports in the region of Warmia and Mazury (Fig. 1), with a detailed focus on Olsztyn-Mazury Airport.

Therefore the study of the dynamics of passenger air traffic in the area of northeastern Poland included a comparison and interpretation of the data obtained from 2016–2021.

RESULTS

Chronology of the location of chosen airports in the region of Warmia and Mazury

In 1926, it was decided to build an airport 5 km from Olsztyn, which was originally a civil facility and later also a military one. In order to launch the investment, the largest possible flat area was chosen (3.75 km^2). Soon after finishing construction works, on 1st June 1926, the first regular passenger flights to Gdansk started. During the war, the airport

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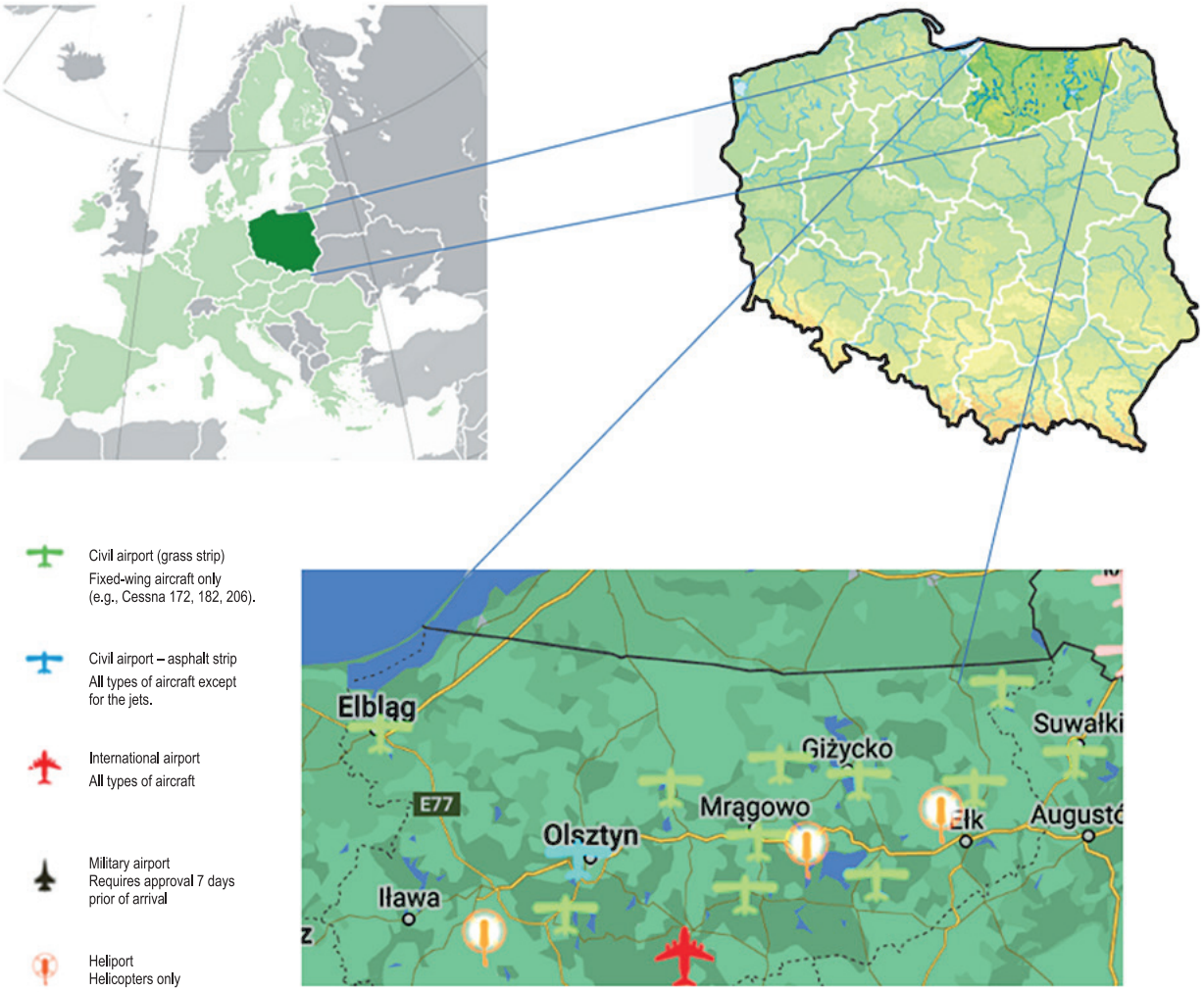

Fig. 1. Location of Warmia and Mazury region in Poland
Source: own elaboration.

infrastructure was used by the German army (mostly for gliders' training). It was taken over by the Red Army on 22nd January 1945. Before the end of the war, on 18th April 1945, Polish Airlines LOT launched regular Warsaw–Olsztyn–Gdansk–Bydgoszcz–Warsaw flights (Łukaszewicz, 2006). In the post-war period, the airport continued to be a gliding training center. From 1955 to 1956, Regional Aeroclub councils were established, which in 1957 led to the founding of an independent Polish People's Republic Aeroclub, dealing with training and air sport. During that period, the aeroclub changed its name from the League of Soldier's Friends Aeroclub to the Warmia-Masurian Aeroclub, used to this day (Areoklub Olsztyn, 2022). In 1966, the poor technical state of the airfield and the inability to organize passenger flights were used as an excuse to create Aviation Economic Services, providing services for agriculture and forestry. In 1990, after the political-economic transformation in Poland, the aeroclub found itself in a very difficult situation. Due to the lack of income and the need to maintain the infrastructure, equipment and staff, some steps had to be taken, which ended in obtaining a concession and certification for aviation services. The aeroclub started earning money on tourist flights; contacts were developed with pilots from

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Germany, for whom flights were organized, using the Dajtki airport infrastructure (Fig. 2). Currently, the employees and members of the Aeroclub are still organizing recreational, as well as training flights for young parachutists and motor gliders. Despite some organizational changes, the airport does not operate commercial passenger flights.

Fig. 2. Part of the area of Dajtki Airport
Source: own resources (26.06.2022).

The first reports on aviation activity in Masuria come from 1910. They reveal the fact of manufacturing a plane designed by engineer Bloess from Kętrzyn at the factory owned by Friedrich Fest from Rachel. 18 years later, as part of the rapid development of air transport, flights between the Reich and Eastern Prussia started (Great Masurian Lakes District), using a then-modern water plane, landing on Niegocin Lake (by the city of Giżycko), (Kętrzyn Airport, 2022). In 1929, it was one of the largest passenger aircraft in the world, which could board up to 100 people. Unfortunately, after six years of flying, in 1935, due to a number of safety problems, it was withdrawn from use. In the same year (1935), the first airport providing service for the region in question (Masuria) was open. Initially, the facility functioned as a sports airport, bearing the name of the destination where it was situated – Weischnuren (presently Wajsznory). The location of the investment was largely determined by the area physiography: the runway was built on an elevation that formed a kind of plateau, which made take-offs considerably easier. As a result of military operations at the outbreak of World War II, the airport changed its character to military. This change was a consequence of the decision taken in July 1940, to build Hitler's secret quarters, called "Wolf's Lair" (German: *Wolfsschanze*), 8 km away from the airport (presently Gierłoż). From that moment, the Weischnuren airport served as a transport base for the "Wolf's Lair" and the "Anna" quarters in Mamerki, as well as operated the military passenger flights. Being a military facility, the airport became a part of the protection system for the main and the other quarters. The runways which handled the passenger and cargo traffic were situated in the southern section of the airport. They were two intersecting concrete belts, which made it possible to adjust take-offs to the wind directions. Changing the airport from sports to a military facility required reconstruction. After finishing modernization works in December 1941, the airport was capable of receiving passenger planes (Ju-52) and four-engine ones (Focke-Wulf 200 FwCondor).

In 1945, the Weischnuren airport (currently Kętrzyn-Wilamowo) was taken over by the Polish Army, the Institute of Aviation, and Polskie Zakłady Lotnicze (Polish Aviation Works), Warszawa-Okęcie. From 11th June 1973 to 1983, the facility was administered by the Kętrzyn Aeroclub (Fig. 3). Unfortunately, after it was dissolved, the airport underwent gradual degradation, until 18th September

Fig. 3. Part of the area of Kętrzyn-Wilamowo Airport
Source: own resources (25.06.2022).

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1998, when the application for reactivating the Kętrzyn Aeroclub was approved by the Aeroclub of Poland. It started to function as the Lake District Aeroclub, the present owner of the facility. As of today, the airport is used mostly by tourists who arrive in their private planes for recreational purposes, as well as, once a year, pilots who take part in an annual event, Mazury AirShow.

The decision to build another airport in the Masuria region was not taken until the 1930s. The location included the area of Szymany – a large village, which in the early 20th century was inhabited by 1100 people (Orłowicz, 1991) was chosen for its sustainable distance to selected cities in the region and to the Polish capital (Table 1).

Table 1. Distance by road and the predicted time of travelling from the village of Szymany to selected towns in the region and to the capital of Poland

Destination	Distance by road/road marking	Predicted time of travel
Bezledy	107 km/DK57	1h 52m
Białystok	188 km/DW645	2h 48m
Łomża	101 km/DW645	1h 41m
Olsztyn	57 km/DK53	1h 2m
Ostrołęka	72 km/DK57	1h 17m
Suwałki	186 km/DK58	2h 46m
Szczytno	9.7 km/DK57	11m
Warsaw	162 km/DK57	2h 58m

Source: authors' elaboration based on (Targeo Map, 2022).

The main assumptions of investment pointed to the need to build a temporary airport of military type, prospectively handling aircraft used in a blitzkrieg. The original idea to build a temporary facility is noticeable in the type of the material used for constructing buildings that were permanently connected with the ground (the buildings near the landing site consisted mainly of wooden sheds). The role of the airport was performed by a station installed on a lorry, STAR 66 (Fig. 4).

During intensive training, there were additional radiolocation stations at the airport, also fitted on lorries. Due to the lack of an on-site meteorological station, weather reports were received by phone, from Olsztyn or Warsaw.

Fig. 4. Star 66
Source: own resources (25.06.2022).

Identification of the current state of airports in the Warmia and Mazury region

After a detailed analysis of the history of the location and use of airports in the Warmia and Mazury region, the following airports were identified (Table 2).

There are 19 airports of varying development and character in the region. Most of them are active airports used regularly for various purposes, but only one Port Olsztyn-Mazury offers permanent passenger flights within the country and abroad.

Airport Olsztyn – Mazury

The end of the 1980s brought huge changes in Poland. On 4th June 1989, the talks of the Round Table began, which led to the first, partly free elections. Soon after coming to power, the Prime Minister together with the Minister of Finance announced a program of reviving the Polish economy, which started to be implemented from 1st January 1990.

As a result of profound political-economic transformations, the airport in Szymany, performing the military function from the start, was not needed anymore. On 16th January 1996, it was decided that the facility would be used for civil purposes, and on the strength of the decision of the district court

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Table 2. Airports in the Warmia-Masuria Province

Facility	Location	Airport profile	Airport type	Runway	Runway length	Runway width	Airport status (working)
Olsztyn – Mazury Airport	Szczytno (Warmia-Masuria Province)	irregular air traffic airport	civil	concrete	1988	60	yes
Elbląg Airport	Elbląg (Warmia-Masuria Province)	sports	civil	grass	600	100	yes
Giżycko – Mazury Residence Airport	Giżycko (Warmia-Masuria Province)	sports	civil	grass	700	50	yes
Grunwald Airport	Grunwald (Warmia-Masuria Province)	undefined	undefined	grass	300	undefined	no
Gryźliny Airport	Łańsk (Warmia-Masuria Province)	multifunctional, formerly military, governmental	civil	grass	800	60	no
Kętrzyn – Wilamowo Airport	Kętrzyn (Warmia-Masuria Province)	sports	civil	grass	1105	80	yes
Kikity Airport	Kikity (Warmia-Masuria Province)	multifunctional	civil	grass	800	35	yes
Muszaki Airport	Muszaki (Warmia-Masuria Province)	military	military	asphalt-concrete	500	30	no
Mrągowo Airport	Mrągowo (Warmia-Masuria Province)	multifunctional	civil	grass	600	50	yes
Olsztyn – Dajtki Airport	Olsztyn (Warmia-Masuria Province)	sports	civil	concrete	850	23	yes
Orneta Airport	Orneta (Warmia-Masuria Province)	undefined	civil	asphalt-concrete	2000	30	no
Prejłowo Airport	Muszaki (Warmia-Masuria Province)	sports	civil	grass	330	23	yes
Rostki Airport	Rostki (Warmia-Masuria Province)	air force base	military disbanded	grass	870	20	no
Stare Juchy Airport	Stare Juchy (Warmia-Masuria Province)	multifunctional	civil	grass	560	undefined	yes
Giże airstrip	Giże (Warmia-Masuria Province)	multifunctional	civil	grass	700	50	yes
Babięta airstrip	Babięta (Warmia-Masuria Province)	undefined	undefined	grass	600	50	yes
Mikołajki airstrip	Mikołajki (Warmia-Masuria Province)	multifunctional	civil – for helicopters	damaged concrete/ grass	undefined	undefined	yes
Niewodnik - Święta Lipka airstrip	Niewodnik (Warmia-Masuria Province)	multifunctional	civil	grass	420	undefined	yes
Wielbark airport road sector	Wielbark (Warmia-Masuria Province)	airport road sector	airport road sector	asphalt-concrete	200	undefined	no

Source: authors' elaboration based on (Planes, 2022).

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in Olsztyn, the Mazury-Szczytno Airports Company was established. It functioned until 2003, being the only airport in Warmia-Masuria Province.

The first plane of Polish Airlines LOT (PLL LOT), taking a civil flight with passengers on board, landed at the airport in Szymany on 2nd June 1996. From that moment to 10th October 2001, the airport handled only domestic passenger traffic in the summer season, offering a flight once a week, mainly between Warsaw and Szymany. At the beginning of the fourth quarter of 2001, the facility was put on the list of airports operating international passenger flights. In accordance with the Ministers' Council' resolution of 10th October 2001 on the determination of airports where takeoffs and landings of aircraft in international traffic may be carried out (Resolution, 2001), Szymany Airport and 17 other airports, were put on the list of airports that handled departures and arrivals in international air traffic. In 2002, after creating the customs zone, PLL LOT started to organize flights to some cities in Germany (Olsztyn-Mazury Airport, 2022).

Despite the fact that on 14th May 2003, the Mazury-Szczytno Airports company obtained the Airport Handling Agent Certificate (No PL-15H/03) regarding passenger and luggage service, ground handling of airships, providing aircraft with fuel, as well as handling the ground transport between planes and the airport. In the same year (2003), PLL LOT suspended its flights. On 30th November 2003, the military left the airport, which made it possible to include the facility in the Civil Airports Register as a public utility civil airport, reference code 3C (an airport equipped with a radio navigation system that allows landing in limited visibility conditions) (ILS, 2022; Navigation Systems – Level 3., 2022), known as the ILS System, which allows automatic landing (Sky brary, 2022).

It should be said that despite suspending flights, the facility, equipped with a 2000 m long concrete runway and the ILS System, was capable of handling medium-sized planes.

Closed on 30th November 2003, after 7 years (2010), the airport was taken over by the Warmia-Masuria Province Self-government and just one year later (2011), a new company was founded, named "Warmia and Masuria". Modernization works started in 2014 and lasted until 2015. As a result, the airport changed its class from 3C to 3D, and became a facility equipped with landing devices: ILS category II and VOR/DME.

The success of the investment shows in the fact that on 18th January 2016, the airport received the Civil Aviation Authority certificate, which confirmed meeting all the requirements for public utility airports, subject to certification (the airport joined the group of 15 largest airports in Poland):

1. Chopin Airport in Warsaw;
2. Kraków – Balice;
3. Katowice – Pyrzowice;
4. Wrocław – Strachowice;
5. Poznań – Ławica;
6. Łódź;
7. Gdańsk – Lech Wałęsa Airport;
8. Szczecin – Goleniów;
9. Bydgoszcz;
10. Rzeszów – Jasionka;
11. Zielona Góra – Babimost;
12. Warszawa/Modlin;
13. Lublin;
14. Radom – Sadków;
15. Olsztyn-Mazury.

Two days later, Warmia-Masuria Province Marshall, Gustaw Marek Brzezin officially opened the Olsztyn-Mazury Airport for passenger flights, and on 20th January 2016, the first charter flight to Berlin took place (ILS, 2022). The inaugural flight from Krakow to Berlin was made one day later (21st January 2016) – it lasted only 105 minutes, which was much shorter than a journey by car, coach or train (The Olsztyn Newspaper, 2022).

Subsequent air connections were initiated in 2016–2017:

1. 21 January 2016 – Berlin-Tegel [6];
2. 22 January 2016 – Kraków-Balice [3];
3. 6 June 2016 – Wrocław [18];
4. 17 June 2016 – Munich [4];
5. 2 July 2016 – Warsaw-Okęcie [5];
6. 20 May 2017 – Oslo-Torp [8];
7. 5 July 2017 – Rodos [7].

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From that moment, interest in flights offered by the Olsztyn-Mazury Airport started to grow considerably.

On 7th July 2017, the airport welcomed its 100,000th passenger, travelling from Oslo. In the same year, also the amount of general aviation (small planes) grew significantly – the airport in Szymany became the leader on the Polish market as regards operating this type of flights. The Masurian airport developed, as a result of which the company was able to launch new flights:

1. 27th October 2019 – the first flight to Bremen (Ostróda NEWS, 2022);
2. 7th November 2019 –launching the Szymany – Cologne connection (Passenger, 2022).

The "Warmia and Masuria" Company, which was the airport operator, continued to care for the passengers' comfort by opening an additional Gate 3 on the first floor of the terminal, on 28th October 2019 (Passenger, 2022).

At that time, it was possible to fly from Olsztyn to six destinations in Poland and Europe.

1. Cologne/Bonn (Ryanair, twice a week – on Thursdays and Sundays);
2. Bremen (Wizz Air, twice a week – on Wednesdays and Sundays);
3. London-Luton (Wizz Air, twice a week – on Mondays and Fridays);
4. Dortmund (three times a week – on Mondays, Wednesdays and Fridays);
5. Stansted (Low-Cost, twice a week – on Mondays and Fridays).

The development of Olsztyn-Mazury Airport in the aspect of the findings of the Airport Master Plan for 2019–2039 and the facility's affiliation to the TEN-T NETWORK

Implementation of the Airport Master Plan (AMP), is an obligation imposed on the operator of a public-use airport by the Act of July 3, 2002 Aviation Law (Journal of Laws of 2020, item 1970). It is a document that defines the facility's development plans for the next 20 years. This document should take into account operational and technical assumptions related to the operation of the facility (airport) and the compatibility of these activities with regional development goals and the principle of sustainable development of transport infrastructure.

In the case of Olsztyn-Mazury Airport, the need to update the PGL resulted directly from Article 55, paragraph 10 of the Aviation Law (Journal of Laws of 2020, item 1970), which stipulates that – The AMP shall be updated in five-year periods or more frequently if the existing or projected technical and operational features of the airport or economic, operational, environmental and financial conditions require significant changes to this plan. Due to the occurrence of the premises necessitating the update (COVID-19) PGL on December 2, 2021. The Minister of Infrastructure approved a new AMP Olsztyn-Mazury for 2019-2039, which is important, including in terms of its compliance with the country's transportation policy.

The approval of the new AMP in the 2019-2039 outlook confirmed that:

1. The concept of development of Olsztyn-Mazury Airport is in line with the Strategy for Responsible Development by 2020 (with an outlook to 2030) (Resolution, [2017] No. 8 of the Council of Ministers of February 14, 2017 on the adoption of the Strategy for Responsible Development until 2020 [with a perspective until 2030]), especially in the area of "transport", which is one of the key areas affecting the achievement of the objectives of the Strategy;
2. The operation of Olsztyn-Mazury Airport is in line with the Strategy for Sustainable Transport Development until 2030, the main goal of which is to increase transport accessibility while improving the safety of traffic participants and the efficiency of the transport sector, through the creation of a coherent, sustainable, innovative and user-friendly transport system in the national, European and global dimensions;
3. The concept of development of Olsztyn-Mazury Airport is in accordance with the Program for the Development of the Network of Airports and Aeronautical Ground Equipment adopted by

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Resolution No. 86/2007 of the Council of Ministers on May 8, 2007, in particular with the objective: 4.3 Ensure the competitive position of Polish airports in relation to the infrastructure of neighboring countries, taking into account economic and demographic potential, and Objective 4.5 Include Polish airports in the national and EU intermodal transport network. Improve regional and local accessibility of airports (roads, railroads, public transport).

In 2021 year, the regional authorities could boast of yet another major success, related to the development of air traffic in Warmia and Masuria: on 14th December 2021, the Olsztyn-Mazury Airport was incorporated into the trans-European network, TEN-T. It was possible due to the approved application submitted by the Marshal of the Warmia-Masuria Province to the European Commission. The Trans-European Transport Network membership opened new opportunities to receive EU funds, which became an important impulse for the development of the airport. Currently, the airport functions on the strength of the certificate complying with the Commission's resolution No 139/2014 of February 12, 2014 laying down requirements and administrative procedures for airports in accordance with Regulation (Resolution, 2014). On 3rd January 2018, the certificate was handed in by the Civil Aviation Authority Chairman to the Warmia and Masuria Company Chairman.

Table 3. The number of passengers and operations performed in domestic traffic – regular and charter-based, in 2016–2020

The number of served passengers and performed operations	2016	2017	2018	2019	2020	2021
Number of passengers	6 947	4	0	6 630	5 692	No data
Number of pax operations	364	0	0	138	186	No data

The data regards the number of passengers served in Polish airports. NOTE! Every passenger recorded in the statistics is served twice (at the port of departure and arrival).
Source: authors' elaboration based on: ULC, 2022 *(25.04.2022).*

Table 3 below contains data regarding the number of passengers and operations performed in domestic traffic – regular and charter-based, in 2016–2020.

At present, the Olsztyn-Mazury Airport has the airport code 4C, which means that it is adjusted to handle planes with the wingspread of up to 36 m, such as Boeing 737-800 or Airbus A321 (Fig. 5).

Fig. 5. Olsztyn-Mazury Airport
Source: own resources (25.06.2022).

The airport infrastructure and certificate also make it possible to receive larger aircraft, which in such cases is connected with the necessity to use special means.

The main element of infrastructure is the asphalt-concrete runway, 2500 m in length and 45 m wide. Direction 01 runway is fully equipped, which allows operations in limited visibility conditions, i.e. operations category I (CAT I). This makes it possible to approach and land according to the indications at the decision altitude, not lower than 800 m, or within the visibility range on the runway (RVR), not smaller than 550 m. Moreover, the runway is equipped with a number of sensors and devices supplying meteorological and technical information for the airport staff.

The Olsztyn-Mazury Airport offers aprons covering the total area of 27,000 m^2, aviation fuel AVGAS 100LL and JET A-1, as well as a full range of airliner ground handling. One of the airport services is Fire and Rescue Service, which provides fire protection for airports category 5 (ICAO). It can be raised to category 7 on request. Other services operating at the

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airport include air traffic, meteorological services, the customs and Border guard (Olsztyn – Mazury Airport, 2022).

The airport can be reached by bus. Transport is provided by two regular bus lines from Olsztyn and Grajewo, and during the summer season – there is a bus connection with Mikołajki (Table 4).

Table 4. Regular and seasonal bus lines serving the Olsztyn-Mazury Airport

Olsztyn-Mazury Airport	Destination	Transit destinations
Szymany Airport	Olsztyn	Pasym, Szczytno
Szymany Airport	Grajewo	Ełk, Orzysz, Pisz, Ruciane-Nida
Seasonal connection – holiday season		
Szymany Airport	Mikołajki	Mrągowo, Szczytno

Source: authors' elaboration.

The high standard of the airport was also noticed by foreign carriers. Currently, flights from the runway are made by Ryanair, Wizzair and LOT planes.

Tables 5 and 6 present flight times, distances and the times of journeys by car, with the possibility to choose a fast or short route.

Considering the above and analysing the data presented in Table 7, we can see that the number of served passengers and performed operations in domestic and international traffic – regular and charter in 2019, was 147,446; compared to the year 2016, it increased by 106,156 served passengers.

The increase was substantial until 2020, when, due to the occurrence of the first case of COVID-19 in Poland on 4th March 2020, it was decided to introduce the sanitary cordon along the borders of Poland (15th March 2020), which significantly limited border traffic (Resolution, 2020 a. Resolution of the Minister of Internal Affairs and Administration of March 13, 2020 on the reintroduction of temporary border control of persons crossing the state border constituting an internal border; Resolution, 2020 c. Resolution of the Minister of Internal Affairs and Administration of March 13, 2020 on the temporary reintroduction of border control of persons crossing the state border constituting an internal).

In the later period, i.e. from 20th March 2020, following the Minister of Health's resolution, the state of the epidemic was officially announced (Resolution, 2020 b. Resolution of the Minister of Internal Affairs and Administration of March 13, 2020 on temporary suspension or restriction of border traffic at certain border crossings). The situation caused by the COVID-19 virus resulted in a complete, temporary suspension of domestic and international flights, which directly affected the number of served passengers and performed operations in domestic and international traffic – regular and charter (Table 7, 2020 – 56,120 passengers).

A similar situation took place at other airports in Poland. Due to the COVID-19 pandemic, the number of passengers served at Polish airports decreased by 70.3%, compared to the year 2019 (Civil Aviation Authority, 2022).

CONCLUSIONS

Using a descriptive method, the authors of the article presented selected airports in north-eastern Poland, with particular consideration of the historical aspect of building these facilities, as well as their current influence on the transport system of Warmia and Mazury region. The studies and analyses regarded mainly the Olsztyn-Mazury Airport, as an airport handling passenger traffic on the largest scale in the region.

The study indicates that the facilities situated in Warmia and Mazury have performed or may perform the function of both, a civil and a military airport because the decisions to build them have often been strictly connected with prospective or current military operations. It should be noted that the decisions to change the character of these facilities were usually related to the economic situation of the country, which was a consequence of political and social transformations, particularly intense in the 1990s.

Despite the difficult economic situation in the 1990s, the pace of the development of today's Olsztyn-Mazury Airport has always been admired by the tourists visiting the region. It can be seen

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Table 5. Time of flight, distance by road and time of journey by car, with a possibility to choose a fast or short route

Departure	Arrival	Carrier	Time of flight	Fast route		Short route	
				Distance by road [km]	Time of journey by car	Distance by road [km]	Time of journey by car
Olsztyn-Mazury [Poland]	Kraków [Poland]	LOT	1h 10m	510	5h 54m	490	7h 58m
Olsztyn-Mazury [Poland]	Kraków [Poland]	Ryanair	1h 10m	510	5h 54m	490	7h 58m
Olsztyn-Mazury [Poland]	Wrocław [Poland]	Ryanair	1h 5m	516	5h 20m	437	8h 33m
Olsztyn-Mazury [Poland]	Rzeszów [Poland]	LOT	1h 10m	549	5h 42m	504	7h 58m

Source: authors' elaboration based on Olsztyn – Mazury Airport (2022).

Table 6. Time of flight, the distance by road, and time of journey by car, with a possibility to choose a fast or short route

Departure	Arrival	Carrier	Time of flight	Optimal route	
				Distance by road [km]	Time of journey by car
Olsztyn-Mazury [Poland]	Dortmund [Germany]	Wizzair	1h 45m	1084	10h 51m
Dortmund [Germany]	Olsztyn-Mazury [Poland]	Wizzair	1h 40m	1084	10h 51m
Olsztyn-Mazury [Poland]	London – Stansted [Great Britain]	Ryanair	2h 25m	-	-
London – Stansted [Great Britain]	Olsztyn-Mazury [Poland]	Ryanair	2h 10m	-	-
Olsztyn-Mazury [Poland]	London – Luton [Great Britain]	Wizzair	2h 30m	-	-
London – Luton [Great Britain]	Olsztyn-Mazury [Poland]	Wizzair	2h 20m	-	-

Source: authors' elaboration based on Olsztyn – Mazury Airport (2022).

Table 7. The number of served passengers and performed operations in domestic and international traffic – regular and charter (Olsztyn-Mazury Airport) in 2016–2021

The number of served passengers and performed operations	2016	2017	2018	2019	2020	2021
No of passengers	41 290	101 306	117 102	147 446	56 120	30 466
No of pax operations	882	680	862	1110	532	430

Source: authors' elaboration based on ULC (2022).

in the increased number of served passengers, traveling on both, domestic and international routes. The close distance to the capital of the region, Olsztyn, as well as the easy and fast access to the city centre, using suburban transport, make the airport in Szymany an even more attractive place for tourists visiting Warmia and Mazury. Using air transport, passengers also save valuable time, significantly lowering the cost of travel.

Based on the analyses of the number of served passengers and the range of the air flights operated

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by the Olsztyn-Mazury Airport, the authors are inclined to claim that the rapid decrease in the passenger-tourist traffic caused by the COVID-19 pandemic, which started on 4th March 2020, will not stop further development of the Olsztyn-Mazury airport.

Although passenger flights were temporarily suspended, Olsztyn-Mazury Airport maintained operational continuity, providing service to training, medical, business, military and transport flights, among others. Despite the difficult situation caused by the COVID-19 pandemic faced by the domestic and global aviation industry, the authorities of Olsztyn-Mazury Airport took measures aimed at further development of the port. Construction work has begun on adapting the airport's infrastructure to the second category of the ILS precision approach system, which in the future will increase the port's traffic accessibility, especially in difficult weather conditions. Recently, the airport's authorities have also established cooperation with PLL LOT S.A. in terms of servicing the carrier's CARGO flights, resulting in the addition of Olsztyn-Mazury Airport to LOT's RFS transport network, thus enabling the Szymany airport to be selected as the so-called "exit port" in the secure supply chain for air shipments. As a result, local entrepreneurs interested in shipping their products by air will be able to send them to Mazury, and the products will continue their journey to the destination airport aboard LOT aircraft.

The effective development of the airport as a tool for the economic and tourist development of the Warmia and Mazury region is also guaranteed by the recently adopted Airport Master Plan for the inclusion of the facility in the TEN-T NETWORK. At the same time, the airport authorities are focusing on the development of services for users of the General Aviation sector, which can largely contribute to the creation of optimal conditions for business development in the investment zone around the airport.

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