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APPLICATION OF ROBUST ESTIMATION METHODS IN REAL ESTATE VALUATION

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ABSTRACT

Motives: Conducting real estate appraisals in well-developed markets presents a multitude of data analysis challenges. Some property price data may contain outliers that can significantly affect the valuation process and, as a result, the estimated value. In the case of real estate valuation regression models, estimation is most often based on the least squares method, where outliers are taken into account just like the rest of the data. Eliminating or minimizing the influence of outliers can lead to more reliable estimation results. Such problems can be solved by implementing robust regression methods.
Aim: The main goal is to determine whether robust estimation methods using M-estimators with multiple regression models can provide more accurate estimates of property values.
Results: Research has shown that multiple regression models using robust regression methods can be applied to estimate property values. The use of different types of M-estimators allows for the objective elimination of outliers through algorithms that operate on the entire data set. The calculations are carried out iteratively, and at each iteration step the residuals are verified and the observations are re-weighted. The following M-estimators were considered: Huber, Hampel, Tukey, Faire, Cauchy and Welsch. The reference point was the estimation results from the ordinary least squares method (OLS). All analysed M-estimators led to an increase in the coefficient of determination value and a decrease in standard estimation errors. Each algorithm detected the outliers. The valuation results for the selected properties were also more reliable. The results obtained depend on the characteristics of the data, and the choice of the best estimator may vary across different property markets. The selection of the best estimator may even vary within the same local property market, where the valuer makes subjective assessments of the location or other attributes.

Keywords: robust regression, M-estimator, property valuation, multiple regression, robust estimators

INTRODUCTION

Many current engineering problems can be formulated as multiple linear regression (MLR) problems for data forecasting. Mathematical models based on multiple linear regression are also used to enhance the reliability of price forecasting and analysis in property markets. Price forecasting is defined as the process of using past and present data, along with statistical methods and other analytical

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techniques, to predict future prices. Multiple linear regression is a well-established statistical technique, and MLR models are relatively simple, providing easily interpretable mathematical formulas.

If a data set is characterized by the presence of extreme values, known as outliers, classical estimators may fail to perform efficiently in practical scenarios. An outlier is a data point that differs significantly from other observations. In several cases, such as those involving short-term statistics, the impact of outliers can be considerable and significantly affect the assessed value of a property.

In practical applications of statistical methods, it is not uncommon to encounter situations where the requisite assumptions are not fully satisfied. For instance, an assumption may be made that errors follow a normal distribution, but in practice, this may not hold true. In such circumstances, the efficacy of classical methods can be limited (Ruckstuhl, 2016). Robust estimation strategies, which are not sensitive to outliers, can be employed in these cases.

Several alternative estimation techniques that are less sensitive to outliers have been proposed in the literature. The purpose of this paper is to examine one of the most commonly used robust regression techniques, namely M-estimation, and to conduct an empirical comparison of several well-known M-estimators in the context of property value estimation.

LITERATURE REVIEW

Regression analysis is a significant statistical tool employed across numerous scientific disciplines, and the application of robust M-estimators has been successfully implemented in a wide range of fields, including electrical, electronic, and telecommunications engineering; image processing; econometrics and finance; civil engineering; meteorology and geodesy; chemical engineering; astronomy; mechanical engineering; petrochemical engineering; nuclear engineering; industrial pharmaceutics; and various medical, biomedical, and biotechnological applications (de Menezes et al., 2021).

In electrical engineering, regression analysis is used for power system state estimation (PSSE). One of the earliest estimation methods employed to "clean up" potentially contaminated raw data was Weighted Least Squares (WLS). The non-quadratic estimation criteria for PSSE were first proposed by Merrill H.M and Schweppe F.C in 1971 (Pires et al., 1999).

For image processing, a mask coefficient based on the M-estimator reduces the influence of noisy pixels and pixels in occluded regions. For this purpose, Huber's and Tukey's M-estimators are used (Arya et al., 2007).

In economic surveys, the flexibility of weighted M-estimation makes it useful for a wide variety of data models (Mulry et al., 2018). M-estimation-based models are also utilized for evaluating economic performance, using data from surveys of small and medium-sized businesses. Functions such as the following can be used for this purpose: Andrews', Tukey's (bisquare), Cauchy's, Fair's, Hampel's, Huber's, logistic, Talworth's, and Welsch's weighting functions (Dehnel & Gołata, 2016).

M-estimation has been continuously evolving in civil engineering, metrology, and geodesy. Wiśniewski proposed some generalizations of M-estimation, known as Msplit estimation (Wiśniewski, 2009) and Msplit(q) estimation (Wiśniewski, 2010). A new approach, inspired by the theory of squared Msplit(q) estimation, was proposed by Nowel in 2019 for the identification of stable potential reference points (Nowel, 2019).

For chemical processes, data reconciliation is an important step in the real-time online optimization of a plant. In addition to Weighted Least Squares (WLS), several other objective functions can be used for data reconciliation. These functions, along with different weighting functions (e.g., for Hampel's redescending M-estimator), are implemented to adapt data for the process's distributed control systems (DCS) (Özyurt & Pike, 2004).

M-estimation methods are useful for a variety of common epidemiological analyses (e.g., estimating the marginal risk difference of anemia on preterm birth), including cases when data are not independently

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and identically distributed (i.e., IID) in data fusion analyses (Ross et al., 2024).

Outliers in property datasets can be identified using surveying methods. Baarda's method and residual analysis can be used to eliminate outliers and improve the accuracy of functional model parameters. A comparative analysis of the two methods based on sample data leads to the conclusion that they are equally effective for property market data (Śpiewak & Barańska, 2020). The elimination of outliers (outlying transactions) in the property market can be achieved using passive robust estimation methods. It provides a consistent dataset free from observations that could be affected by significant human error (Śpiewak, 2018). Active methods of robust estimation have also been applied to real estate market data. In particular, Huber and Hampel functions were considered for real estate market data. Robust estimation methods were analysed in regression models of property price changes over time and in property valuation models (Adamczyk, 2017).

Due to the significant impact of outliers on least squares estimates, the use of robust regression methods is recommended in such cases. The studies highlight the importance of applying robust methods for this purpose and suggest that such approaches may be broadly beneficial for property datasets (Janssen et al., 2001).

The examples presented demonstrate that robust estimation methods based on M-estimators and other statistical methods are applicable for analyzing various types of data.

Multiple regression models are a commonly used analytical method in many practical cases. When modeling the regression, it is first necessary to understand the characteristics of the data to be used. Understanding these characteristics makes it easier to determine the most appropriate method. For data with outliers, a robust regression model is required, for example M-estimation, MM-estimation, or S-estimation.

In the paper "A Robust Method for Multiple Linear Regression" Andrews introduced the theory of robust estimation in multiple linear regression models. The method, based on M-estimators, requires a reliable initial fit, which is then refined to yield a procedure that is relatively efficient for nearly Gaussian data (Andrews, 1974).

A comprehensive view of robust estimation in multiple regression models was presented by Padrul Jana, Dedi Rosadi, and Epha Diana Supandi. The authors compared and presented results using two data sets: one with outliers and one without, applying both the OLS (Ordinary Least Squares) method and robust regression models with M-estimation, MM-estimation, and S-estimation. Their research indicates that understanding the characteristics of the data is crucial for effective analysis, as described in the conclusions (Jana et al., 2023).

Multiple linear regression is an effective method for accurately predicting house prices from a large dataset with a significant number of both categorical and numerical predictors (Abdulhafedh, 2022). The use of multiple regression models for estimating the market value of commercial real estate has been presented in other publications by Banaś, Czaja, and Dąbrowski (Banaś et al., 2022).

Statistical tools are also used in mass appraisal. Valuation models often rely on multiple regression analysis, but literature also includes models using spatial relationship. Property value estimation methods based on geographically weighted regression, spatial autoregressive models, and regression-kriging have also been verified as useful for mass valuation (Walacik et al., 2013). However, beyond the potential application of mathematical models, it is also essential to consider the quality of property data, as well as the legal, economic, and social aspects of conducting mass valuation for property value taxation (Grover & Walacik, 2019).

The promising results of studies predicting property sale prices based on MLS (Multiple Listing Service) data for Ottawa, Canada, in comparison with machine learning methods, have led to the conclusion that multiple regression methods warrant further development and researching on other data sets. The MLS is one of several databases created by collaborating real estate brokers to share information

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on properties available for sale. The results achieved with Random Forest regression were as favorable as those obtained with multiple regression models (Lemeš & Akagic, 2022).

MATERIALS AND METHODS

In statistics, linear regression is used to model the relationship between a scalar response (or dependent variable) and one or more explanatory (or independent) variables (Susanti et al., 2014). Multiple linear regression is a statistical technique used to investigate the relationship between two or more variables: the dependent variable (also known as the response variable, outcome, or target) and the independent variables (the predictors). Multiple linear regression is also referred to as multiple regression. The multiple regression model is widely used in real estate market analysis and property value modeling.

In 1964, Huber proposed a new type of robust estimator as a generalization of maximum likelihood estimation (MLE), termed M-estimators. From a practical standpoint, an M-estimator can be analysed as a weighted mean, where the weights are designed to minimize the influence of outliers on the estimator. The fundamental concept of M-estimation is based on minimizing a model deviation function (Huber, 1964).

M-estimation is not sufficiently robust with respect to leverage points. Not all leverage points are influential unless they have large residuals. Even though it lacks robustness against leverage points, it is still widely used for analysing data where it is assumed that contamination primarily occurs in the response direction (Chen, 2002). A leverage point is defined as an observation that exhibits an anomalous predictor value, significantly diverging from the bulk of observations. Therefore, it is recommended to employ this approach only in situations where leverage points are absent. This limitation has implications for the range of potential applications. Robust regression methods can have a significant impact on the accuracy of estimates, but they should not automatically be used instead of classical methods (Dehnel, 2016).

The characterization of M-estimators is based on three fundamental functions: the objective (loss) function, the influence function, and the weighting function (Banaś & Ligas, 2014). Compared to the least squares method, the loss function is less sensitive to extreme residual values and increases more slowly than a square (Banaś & Ligas, 2014; Dehnel, 2016).

In its general form, the loss function $\rho(v)$ may be represented by the following equation:

$$\rho(v) = w(v)v^2 \tag{1}$$

where:

$w(v)$– weighting function.

The influence function is defined as the first derivative of the objective function:

$$\psi(v) = \frac{\partial \rho(v)}{\partial v} \tag{2}$$

Influence functions are a valuable analytical tool for assessing the impact of each variable on an estimator's value.

Weighting function is represented by $w(v)$:

$$w(v) = \frac{\psi(v)}{v} = \frac{\partial \rho(v)}{\partial (v^2)} \tag{3}$$

The shapes of the weighting functions are markedly different. The choice of function is contingent upon the desired weighting of outliers, among other factors. The weighting functions [$w(v)$] are controlled by parameters that regulate the effect of outliers on the estimation of results.

Table 1 shows the influence function and weighting function for selected M-estimators used in this work.

M-estimators can be divided into three categories: monotone (e.g., Huber, Fair), soft-redescending (e.g., Cauchy), and hard-redescending (e.g., Andrews, Hampel, Smith).

Using M-estimators in data regression problems is often associated with the trade-off between efficiency and robustness. Efficiency refers to the quality of the estimator's fit, while robustness refers to the estimator's performance (Albuquerque & Biegler, 1996). An additional measure of robustness is provided by the concept of Breakdown Points (BP). The Breakdown Point is the proportion of incorrect

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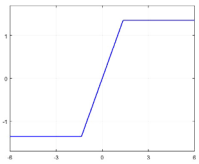
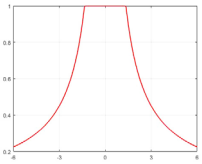
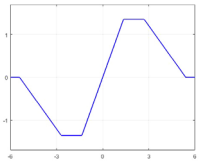
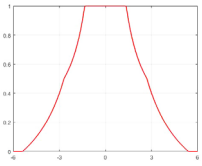
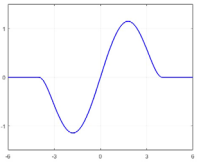
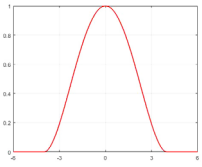
observations in a dataset that a robust regression technique can tolerate. The value of BP cannot exceed 0.5 (50%) (Hampel, 1968; de Menezes, 2021).

Huber devised the M-estimation method, which has become the most prevalent general robust regression approach (Huber, 1964). This work was further developed by other researchers who introduced various types of estimators, such as Yohai (MM-estimators), Rousseeuw (S-estimators, GM-estimators), Siegel's Repeated Median Estimators, Least Trimmed Squares (LTS) estimators, Minimum Volume Ellipsoid (MVE estimators), Baraud & Chen

Table 1. Characteristic functions of selected M-estimators

Huber M-estimator	
Influence function	Weighting function
1	2
$\Psi(v) = \begin{cases} v & if \quad \lvert v\rvert \le k \\ k \cdot \frac{v}{\lvert v\rvert} & if \quad \lvert v\rvert > k \end{cases}$	$w(v) = \begin{cases} 1 & if \quad \lvert v\rvert \le k \\ \frac{k}{\lvert v\rvert} & if \quad \lvert v\rvert > k \end{cases}$
	
Hampel M-estimator	
Influence function	Weighting function
$\Psi(v) = \begin{cases} v & if \quad \lvert v\rvert \le a \\ a \cdot sign(v) & if \quad a < \lvert v\rvert \le b \\ \frac{a \cdot (c \cdot sign(v) - v)}{c - b} & if \quad b < \lvert v\rvert \le c \\ 0 & if \quad \lvert v\rvert > c \end{cases}$	$w(v) = \begin{cases} 1 & if \quad \lvert v\rvert \le a \\ \frac{a}{\lvert v\rvert} & if \quad a < \lvert v\rvert \le b \\ \frac{a(c - \lvert v\rvert)}{(c - b)\lvert v\rvert} & if \quad b < \lvert v\rvert \le c \\ 0 & if \quad \lvert v\rvert > c \end{cases}$
	
Tukey M-estimator	
Influence function	Weighting function
$\Psi(v) = \begin{cases} v \cdot \left(1 - \left(\frac{v}{c}\right)^2\right)^2 & if \quad \lvert v\rvert \le c \\ 0 & if \quad \lvert v\rvert > c \end{cases}$	$w(v) = \begin{cases} \left(1 - \left(\frac{v}{c}\right)^2\right)^2 & if \quad \lvert v\rvert \le c \\ 0 & if \quad \lvert v\rvert > c \end{cases}$
	

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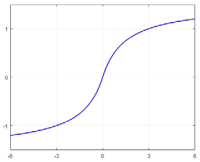
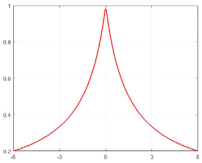
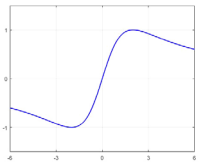
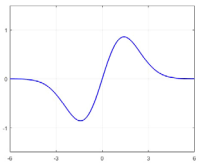
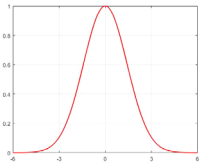
cont. **Table 1**

Fair M-estimator	
Influence function	Weighting function
$\Psi(v) = \frac{v}{1 + \frac{\lvert v \rvert}{c}}$	$w(v) = \frac{1}{1 + \frac{\lvert v \rvert}{c}}$
	
Cauchy M-estimator	
Influence function	Weighting function
$\Psi(v) = \frac{v}{1 + (\frac{v}{c})^2}$	$w(v) = \frac{1}{1 + (\frac{v}{c})^2}$
	
Welsh M-estimator	
Influence function	Weighting function
$\Psi(v) = \frac{v}{1 + (\frac{v}{c})^2}$	$w(v) = \frac{1}{1 + (\frac{v}{c})^2}$
	

Source: own elaboration based on de Menezes et al. (2021).

(robust estimators for exponential families of distributions), Hampel (three-part M-estimators), and Tukey (biweight or bisquare M-estimators), as well as Andrews, Cauchy, and Fair (Raza et al., 2024).

RESULTS AND DISCUSSION

Verification of the selected M-estimation methods was carried out on the basis of properties from Tarnów. The database included 103 properties, which were selected from the central part of the city. The properties were sold over a 12-month period. The properties were described by typical characteristics: location (3-degree scale), surroundings (3-degree scale), transport accessibility (3-degree scale), standard (3-degree scale), floor location (3-degree scale), belonging premises (3-degree scale). The location of the sold properties is shown on the signature map (Fig. 1). The unit price level of the properties is shown in terms of colour intensity.

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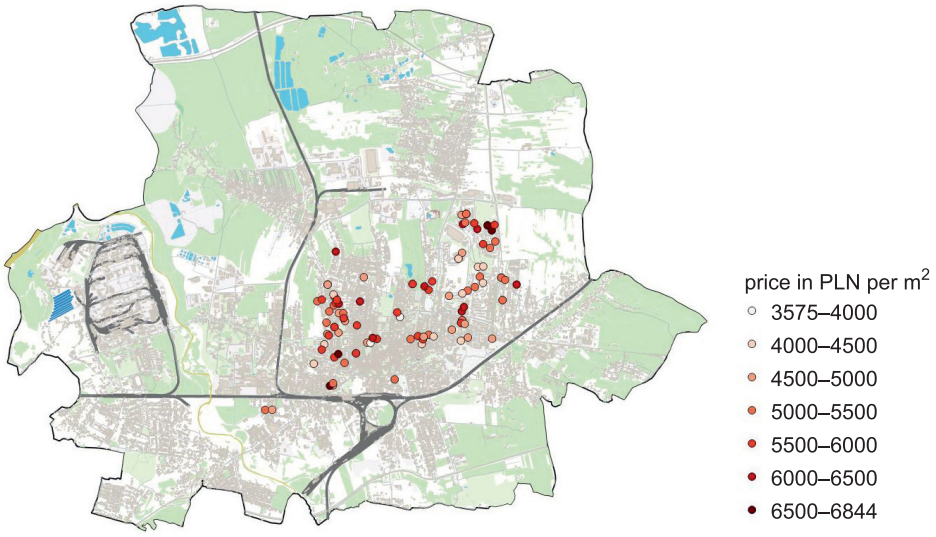

Fig. 1. Transactions in the form of signatures on the map of Tarnów
Source: own elaboration.

The calculations were made taking into account the following models and functions:
– ordinary least squares (OLS) method,
– iteratively reweighted least squares (IRLS) method with Huber weighting function,
– IRLS method with Hampel weighting function,
– IRLS method with Tukey weighting function,
– IRLS method with Fair weighting function,
– IRLS method with Cauchy weighting function,
– IRLS with Welsch weighting function.

Parameters of weighting function are usually tuned to 95% efficiency in respect to the normal distribution. In this work, the parameters were assumed according to (de Menezes, 2021).

The MAD (absolute median deviation), which is commonly used as a robust scale estimator, was used to scale the residuals. MAD uses the median twice, the first time to obtain the median value in a set of observations, and then to determine the median of a set composed of the absolute differences between the median value and the individual observation values.

The model tested is based on a linear relationship between the variables, the estimated parameters for the different estimation variants are shown in Table 2:

When M-estimation was applied, more reliable model parameter values were obtained in each case compared to the ordinary least squares estimation method. Additionally, one of the model's parameters was found to be insignificant when using the least squares method. In contrast, with M-estimation, each model parameter was statistically significant. This was due to the suppression of the influence of outliers. It is worth noting that no observations were excluded during the M-estimation process. Even methods that assign a weight of zero to large residuals, did not result in such changes. This outcome was attributed to the relatively good selection of variables for the model and the consistency of the data.

Based on statistical tests for the coefficient of determination, it can be concluded that the variance of the part of the dependent variable explained by the model is significantly greater than the unexplained part (Tab. 4). The coefficient of determination for models estimated using M-estimation increased by 0.03 to 0.07, depending on the applied estimation method.

The property values presented in Table 5 indicate an increase in reliability for the results obtained from models estimated using M-estimation compared to the model based on the least squares method.

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Table 2. Estimated model parameters and their standard deviations

	Model parameter							
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7
	Standard deviation							
	σa_0	σa_1	σa_2	σa_3	σa_4	σa_5	σa_6	σa_7
Ordinary Least Square	3,091.71	593.69	332.20	245.00	169.28	359.78	95.01	166.08
	164.88	75.84	81.47	80.22	61.91	54.78	55.96	53.72
Huber M-estimator	2,998.64	622.07	340.02	291.55	161.97	351.10	116.17	172.46
	140.76	66.81	69.77	69.73	53.28	46.81	48.24	46.26
Hampel M-estimator	2,987.33	629.16	343.73	293.01	160.27	349.11	119.59	171.78
	139.98	66.56	69.36	69.37	52.92	46.59	48.00	45.97
Tukey M-estimator	2,981.69	631.75	345.90	295.65	159.86	353.36	112.22	168.32
	139.67	66.28	69.31	68.91	52.65	46.48	47.70	46.00
Fair M-estimator	3,029.89	614.73	336.04	283.76	163.57	355.68	100.24	169.43
	132.61	64.17	66.31	64.59	50.47	44.34	45.74	44.69
Cauchy M-estimator	3,005.51	621.91	340.39	289.18	162.86	353.93	107.76	170.56
	137.77	65.68	68.42	67.68	52.14	45.73	47.18	45.65
Welsch M-estimator	3,041.67	609.15	337.58	267.52	166.31	355.93	104.93	168.17
	151.53	70.89	75.02	74.26	57.04	50.36	51.63	49.67

Source: own elaboration.

Table 3. Verification of statistical hypotheses on the significance of model parameters

	Model parameter							
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7
Test function OLS	18.75	7.83	4.08	3.05	2.73	6.57	**1.70**	3.09
Test function Huber	21.30	9.31	4.87	4.18	3.04	7.50	2.41	3.73
Test function Hampel	21.34	9.45	4.96	4.22	3.03	7.49	2.49	3.74
Test function Tukey	21.35	9.53	4.99	4.29	3.04	7.60	2.35	3.66
Test function Fair	22.85	9.58	5.07	4.39	3.24	8.02	2.19	3.79
Test function Cauchy	21.82	9.47	4.98	4.27	3.12	7.74	2.28	3.74
Test function Welsch	20.07	8.59	4.50	3.60	2.92	7.07	2.03	3.39
Critical area $\alpha = 0.05$	$(-\infty ; -1.96) \cup (1.96 ; \infty)$							

Source: own elaboration.

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Table 4. Determination coefficients of models with statistical tests

	R^2	R^2-R_0^2	Test function F	Critical area $\alpha = 0.05$
Ordinary Least Square	0.75	–	40.71	(3.27; ∞)
Huber M-estimator	0.81	0.06	57.86	
Hampel M-estimator	0.81	0.06	57.86	
Tukey M-estimator	0.81	0.06	57.86	
Fair M-estimator	0.82	0.07	61.83	
Cauchy M-estimator	0.81	0.06	57.86	
Welsch M-estimator	0.78	0.03	48.12	

Source: own elaboration.

The property values derived from the various models are similar to each other. For the standard deviations of the estimated values, an improvement of several to several dozen percent was achieved compared to the standard deviation values obtained from the least squares method.

A dataset containing information on properties sold in the local market of Tarnów was used for the calculations. The market value was estimated using various M-estimators from the group of monotone estimators (Huber estimator and Fair estimator), soft-redescending estimators (Cauchy estimator and Welsch estimator), and hard-redescending estimators (Hampel estimator and Tukey estimator). All analysed M-estimators led to an increase in the coefficient of determination value and a decrease in standard estimation errors. Each algorithm detected the outliers. The highest value of the coefficient of determination was observed for the monotonic estimation using Fair's estimator. For Fair estimator, the standard errors were the smallest. Results for most estimators are comparable and clear. The smallest changes in results compared to the least squares method were observed for the Welsch estimator.

The results obtained depend on the characteristics of the data, and the choice of the best estimator may

Table 5. Determined value for several properties with analysis of accuracy

	Value [PLN/m^2]					
	W_1	W_2	W_3	W_4	W_5	W_6
	Standard deviation [PLN/m^2]					
	σW_1	σW_2	σW_3	σW_4	σW_5	σW_6
Ordinary Least Square	5,052.73	6,408.98	3,791.49	5,001.03	5,455.93	4,510.75
	61.63	145.70	151.00	157.65	135.54	182.76
Huber M-estimator	5,053.98	6,466.66	3,757.47	4,947.65	5,486.90	4,538.24
	53.46	124.45	128.38	137.15	115.74	156.84
Hampel M-estimator	5,053.97	6,478.49	3,749.03	4,944.22	5,494.29	4,534.56
	53.15	124.02	127.75	136.64	115.30	155.97
Tukey M-estimator	5,048.73	6,466.76	3,742.91	4,932.80	5,486.98	4,532.90
	53.08	123.75	126.90	135.16	114.66	155.04
Fair M-estimator	5,053.34	6,437.35	3,769.57	4,946.81	5,475.97	4,545.14
	51.01	119.38	119.26	125.91	108.12	146.70
Cauchy M-estimator	5,052.09	6,455.58	3,756.37	4,943.08	5,482.94	4,539.20
	52.54	122.15	124.74	132.54	112.70	152.73
Welsch M-estimator	5,051.25	6,437.39	3,770.05	4,973.02	5,470.78	4,520.34
	57.19	133.95	138.07	145.81	124.27	168.09

Source: own elaboration.

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vary across different property markets. The absence of universal methods for fitting estimators is demonstrated by the continually growing number of available estimators, with more than 50 currently known. The selection of the best estimator may even vary within the same local property market, where the valuer makes subjective assessments of the location or other attributes. These estimators also influence the characteristics of the data analysed. The use of M-estimators makes it possible to objectively reduce the impact of data that may be related to abnormal behavior in the property market, which could otherwise affect the valuation.

CONCLUSIONS

The use of robust estimates enables the objective filtering of data through algorithms, reducing the risk of discretion and error in analysis or the failure to detect anomalies. It is important to understand the characteristics of the data being used, as this understanding facilitates the selection of the most appropriate robust estimation method, including the choice and fitting of the best weighting function or estimation technique. The choice largely depends on the nature of the outliers. It is important to note that robust analysis with M-estimation is not resistant to leverage points, and robust regression should not be automatically used as a replacement for classical methods. The higher the Breakdown Point (BP) of an estimator, the more robust it is. However, as stated by Albuquerque and Biegler (1996), "The more robust an estimator is, the less efficient it is".

Developed to study the large-sample properties of robust statistics, M-estimation is a general statistical approach that simplifies and unifies estimation. However, it may not be appropriate for small samples. M-estimation can be easily implemented in statistical analysis software, with examples of solutions available in applications such as Matlab, R, SAS, or Python.

M-estimation is a useful tool when data are not independent and identically distributed, a common occurrence in data fusion analyses. Consequently, data from the real estate market can be subjected to this type of analysis. This assumption may also be relevant for property data, which may contain certain imperfections.

Robust estimation models can be successfully applied to the analysis of real estate markets. Using robust estimation for data "clean-up" allows for the removal of transactions exhibiting price discrepancies from the data set, treating them as outliers. This is a complex process that requires the selection of appropriate estimators, which can vary depending on the specific property market.

Many M-estimators have been proposed in the robust statistics literature, and some of these have been used extensively for regression analysis.

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THE ECONOMIC ROLE OF BALTIC SEA REGION SEAPORTS IN CHANGING GEOPOLITICAL CONDITIONS

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ABSTRACT

Motives: Seaports are key nodes in the Trans-European Transport Network (TEN-T), handling a significant part of the European Union's trade and freight transport. Baltic Sea ports, including those in Poland, have gained strategic importance due to their high growth rates and intense maritime traffic.
Aim: This article examines the economic role of Baltic Sea ports under changing geopolitical conditions. It proposes two hypotheses: one on the relationship between economic growth and port cargo turnover, and the other on the strengthening positions of Baltic ports as key logistics hubs. The study analyzes statistical data on port cargo turnover, functional models, and classifications using Pearson's correlation and structural analysis.
Results: The main conclusions highlight the strengthening positions of Baltic Sea ports despite current challenges, emphasizing the need for further infrastructure development and service quality improvement. This article contributes to the field by providing a comprehensive analysis of the role of Baltic Sea ports, taking into account current geopolitical and economic factors, and by proposing an approach for assessing their current status and development prospects. The results are potentially useful for strategic planning in maritime transport.

Keywords: Baltic Sea Region, seaports, ports model, ports classification, hinterlands

INTRODUCTION

Seaports in the Baltic Sea Region (BSR) occupy a central role in the global logistics system, performing functions such as delivery, processing, and storage of various types of cargo. They serve as key nodes in the distribution network for goods and services, meeting the region's needs for essential resources like food, raw materials, equipment, hydrocarbons, etc. According to recent data, 87 ports in the BSR are part of the Trans-European Transport Network (TEN-T), specifically comprised of 22 core ports with the remaining 65 being comprehensive ports (Baltic Ports Organization, 2022).

The article proposes a comprehensive assessment of the current economic and strategic role of Baltic Sea ports amidst changing geopolitical and macroeconomic conditions. In particular, an analysis of the dynamics of Baltic Sea port's key performance indicators is conducted in order to identify leading trends and patterns. In addition, the role of Baltic Sea ports in ensuring regional countries' transport and logistics needs is considered.

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Two research hypotheses are presented:

H1: There is a statistically significant positive correlation between the Gross Domestic Product (GDP) and cargo turnover of Baltic Sea ports. This hypothesis posits that during the analyzed period, there was a positive relationship between economic growth, as measured by GDP, and port cargo turnover in the region. It suggests that along with GDP growth, there was an increase in the port cargo turnover. This hypothesis was tested using Pearson's correlation method.

H2: Despite problems associated with the pandemic and geopolitical changes, Baltic Sea ports, including Polish ports, are confidently strengthening their position as key logistics hubs in Europe. To test the hypothesis, this article analyzes key performance indicators of ports, their functioning models and classifications. This will assess the current situation in the Baltic ports and determine the direction for their further development.

The development and operation of seaports require a thorough methodological approach due to their complex structure and multifaceted role in the economy. A port is not just an infrastructure complex; it is also an important transport hub that facilitates effective interaction between maritime and land transport.

The importance of BSR seaports is enhanced by their strategic location, which provides a link between Western and Eastern Europe. This strategic location makes them an integral part of the European economy, promoting trade and investment growth. In addition, BSR ports are actively integrating with other modes of transport, such as rail and road, to create multimodal logistics chains. This integration enhances their efficiency and resilience to external challenges. In light of global environmental trends and the pursuit of sustainable development, ports are also actively introducing "green" technologies aimed at reducing emissions and minimizing their negative impact on the environment. For example, some ports are developing and implementing applications to improve coordination mechanisms and information exchange between ports and vessels. The ports of Rauma in Finland and Gavle in Sweden have been selected as pilot ports (De A. Gonzalez et al., 2021).

With globalization and the accelerated development of international trade, the seaports of the BSR have evolved into not just logistics hubs but also significant economic centers. These centers contribute to the growth of local economies. Their role in regional development is amplified by job creation, investment attraction, and the stimulation of scientific and technological progress.

In addition, BSR ports actively cooperate at the international level, participating in various projects and initiatives aimed at improving infrastructure, safety, and environmental sustainability. This cooperation, in turn, facilitates the exchange of experience and the best practices between ports from different countries. In a constantly changing world and faced with new global challenges such as climate change and digital transformation, BSR ports are actively adapting by introducing new technologies and methods. This adaptability allows them to remain competitive in the global market as well as meet modern requirements and standards. The seaports of the BSR not only ensure the efficient movement of cargo and passengers but also play a key role in the socio-economic development of the region, serving as a bridge between different cultures, economies, and technologies.

LITERATURE REVIEW

As cities grew in size and port capacities expanded, an initial spatial and functional segregation emerged between ports and cities. The development of "outports" in Northwestern Europe (Pounds, 1947) and the growth of ports in the UK illustrates the trend of ports moving away from central urban areas. The "Anyport" port development model, proposed by Bird (1963), examines the emergence of a port, its expansion, the specialization of berths and docking lines, handling equipment, as well as spatial development characterized by deep-water, multipurpose berths in the city's open spaces.

Hayuth (1982), who presented the concept of port-city interaction, noted that with the advent of con-

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tainerization and new cargo handling technologies, port land use has changed dramatically, and many previously profitable port sites have ceased to be seen as competitive. Moreover, such an expansion was seen as a movement in port development and hinterland strengthening[1].

The hinterland is defined as an inland area where a transport terminal, such as a port, offers its services and interacts with its customers. The hinterland constitutes the terminal's regional market share in comparison to other terminals serving the same region. Each transport terminal has its hinterland, which represents the complete set of consumers involved in production and trade activities with which the terminal interacts. As a result of these transactions, cargo is moved, and in some terminals, this cargo is transshipped. This movement is associated with areas known as the primary hinterland and the competitive range. The primary hinterland is the area where the terminal holds a dominant share of cargo flows and serves as the terminal's traditional core market area, being the most territorially accessible (Rodrigue & Notteboom, 2006).

Thus, the hinterland refers to the inland catchment area of a seaport, transport hubs and networks that are focused on and specialized in serving a port's cargo.

Morgan (1958) proposed a hierarchy of hinterlands that includes primitive, commodity, and trunk line port hinterlands. Primitive hinterlands lack alternative maritime "outlets" (e.g., islands), and transportation to other coastal ports is underdeveloped. Commodity hinterlands are associated with bulk cargo and utilize specialized ship types such as tankers. The ports in these hinterlands are strategically located to minimize the inland transportation of bulk cargo over the shortest possible distance. Trunk line port hinterlands, which are the most complex in structure and largest in size, are multifaceted; they handle a variety of cargo types (both bulk and general) and require the provision of diverse services.

In the early 1990s, a model was endorsed at the United Nations Conference on Trade and Development (UNCTAD) to evaluate changes in types of cargo flow as well as long-term port development strategies. Additionally, the model provides for the expansion of port territory as a "service center" (Beresford et al., 2004). Subsequent research has shown that the existing model has exhausted its potential, leading UNCTAD to propose new approaches for port development in 2014. Greater attention is now being paid to the port management system. To this end, a program has been created to support port administrations in ensuring efficient and competitive port management, which in turn strengthens trade support and economic development. Within the framework of this program, port networks are established that bring together state, private, and international organizations. In these networks, port operators from both public and private organizations share information, knowledge, and experience.

New trends in port development have been identified, which envision the creation and development of special port economic zones and free customs zones. Additionally, there are plans to increase port throughput capacity via enhanced logistics and upgraded port equipment, especially for serving container ships. Significant attention is being paid to the automation of management processes and the active use of information systems, with plans for their subsequent integration into global supply chain management systems.

The port regionalization model by Notteboom and Rodrigue (2005) has gained significance in scientific research on port development. This model examines port development in the context of increasing urbanization, which helps explain the emergence of various logistics centers and the challenges of integrating ports into their hinterlands. The port regionalization model considers "offshore ports", which operate on islands, and continental ports with limited hinterlands as the foundation for a single container freight consolidation system through the creation of hubs and back-office logistics platforms.

[1] Every seaport has a strong attraction to the surrounding territories, known as hinterlands. However, the term "hinterland" can be applied not only to the area beyond a seaport but also to areas beyond other natural or technical objects. Hinterlands are most commonly associated with ports.

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Additionally, the model highlights the active role of inland freight terminals in shaping the regional freight turnover network and expanding the port hinterland.

It should be noted that the seaports of the Baltic Sea Region occupy a central place in global transport infrastructure, performing the function of critical transport hubs that contribute to the economic and sociocultural development of the region. In particular, the ports of Poland, as well as the port of Klaipeda (Lithuania), located on the Baltic Sea coast, act as important transport hubs of the West-East corridor, integrating land and maritime communication routes (Gaidelys & Benetyte, 2021). Their strategic importance as an intersection between East and West has increased since the Baltic Sea became an internal sea of the European Union (2004) (Serry, 2022).

Nevertheless, a number of small- and medium-sized Baltic ports face limited financial support from European funding programs due to their remote locations from the core TEN-T network (Meyer et al., 2021). Despite these challenges, they continue to play a key role in the regional economy by providing access to individual regions and stimulating both socio-economic and environmental development. This role is becoming increasingly relevant in light of the EU Commission's policies on food security and Smart Specialization, which are aimed at supporting regional economic growth and innovation (Meyer, 2021).

In addition, the creative industries are one of the most dynamic sectors in the Baltic Sea Region's economy, accounting for 3% of global GDP and providing 29.5 million jobs. These industries play a crucial role in improving the quality of life by promoting social integration and cultural exchange (Klein et al., 2021).

The seaports of the Baltic Sea Region are entering a new era of digital transformation and sustainable development. Digital innovations can become a catalyst for sustainable economic growth in the Baltic Sea coastal areas. This highlights the commercialization of territorial resources and the effective use of the unique opportunities of coastal zones. Despite facing numerous challenges related to financing and environmental issues, ports are discovering new pathways toward sustainable development through research and innovative approaches, such as Blue Growth (Rijkure, 2017). Port benchmarking demonstrates how ports can optimize their infrastructure and cargo flows to achieve maximum efficiency (Liebuvienė & Čižiūnienė, 2022).

A thorough analysis of legal acts and strategic documents, both at the European Union and Polish levels, indicates the growing importance of seaports in the Baltic Sea Region. This importance manifests itself not only in the strictly economic dimension, as a driving force for economic development, but also in the context of complex challenges related to sustainable development and environmental protection. The "Transport Development Strategy until 2020 (with a perspective until 2030)" unequivocally identifies seaports as key nodes in the transport network, emphasizing the urgent need for their modernization and increased competitiveness (Ministerstwo Transportu, Budownictwa i Gospodarki Morskiej [Ministry of Transport, Construction and Maritime Economy], 2013). In turn, the "Development Program for Polish Seaports until 2030" presents a holistic and far-reaching approach to strengthening the position of Polish ports among Baltic ports and increasing their role as strategic links in global logistics chains (Ministerstwo Gospodarki Morskiej i Żeglugi Śródlądowej [Ministry of Maritime Economy and Inland Navigation], 2019).

At the level of national legislation, the Act on Seaports and Harbors creates a solid legal framework for the functioning and management of ports in Poland, regulating in detail issues such as ownership structure and financing principles (Ustawa z dnia 20 grudnia 1996 r. o portach i przystaniach morskich [Act of 20 December 1996 on Maritime Ports and Harbors], 1997). These regulations are of fundamental importance for ensuring a stable and predictable legal environment, necessary for long-term investments and sustainable port development.

In the international dimension, the Baltic Sea Action Plan adopted by the Helsinki Commission gives priority to the role of ports in reducing negative

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impacts on sensitive marine ecosystems, including through the development of advanced infrastructure for receiving waste from ships (HELCOM Baltic Marine Environment Protection Commission, 2021). This strategic document fits into the broader trend of sustainable development and emphasizes the need for a holistic approach to the maritime economy, in which ports play a key role in reconciling the imperatives of economic growth with environmental protection. The updated action plan sets ambitious goals and defines concrete actions to achieve good ecological status of the Baltic Sea, which has significant implications for the functioning and development of ports in the region.

The Baltic Sea Action Plan strengthens and updates the premises regarding the growing role of seaports in the Baltic Sea Region, with particular emphasis on environmental aspects and sustainable development. This strategic document highlights the need for ports to adapt to changing conditions and challenges, such as climate change, biodiversity loss, and marine pollution. At the same time, it points to the potential of ports as key players in the transition towards a green and sustainable maritime economy.

The EU Strategy for the Baltic Sea Region, a key instrument of cohesion policy, lists among its priorities the improvement of transport connections and the elimination of infrastructure bottlenecks. The implementation of these postulates is necessary for the efficient functioning of ports and the full utilization of their potential as catalysts for economic development (European Commission, 2012). In a complementary manner, the "Sustainable Blue Growth Agenda for the Baltic Sea Region" recognizes the enormous potential for sustainable development of the maritime economy, including ports. This agenda emphasizes the need to find a delicate balance between the imperative of economic growth and the urgent need to protect unique marine ecosystems (European Commission, 2014).

At the EU legislative level, the directive establishing a framework for maritime spatial planning plays a fundamental role in harmonizing port development planning with competing forms of maritime space use, such as wind energy, fisheries, and nature protection (Directive 2014/89/EU). On the other hand, the regulation on Union guidelines for the development of the trans-European transport network (TEN-T) sets high standards for port infrastructure and highlights the strategic importance of ports as multimodal transport hubs, integrating various modes of transport (Regulation (EU) No 1315/2013).

The discussed documents unequivocally point to the urgent need for strategic investments in modern port infrastructure, increasing the competitiveness of ports in the international arena, and strengthening multifaceted cooperation in the Baltic Sea Region. At the same time, they strongly emphasize the necessity of fully integrating environmental aspects into port development and harmonizing maritime spatial planning. The analysis shows a high correlation and consistency between these documents and the issues presented in the article, providing a solid theoretical foundation for the thesis of the growing role of seaports in the Baltic Sea Region in dynamically changing geopolitical and economic conditions.

DETERMINANTS OF THE FUNCTIONING AND CLASSIFICATION OF BALTIC SEA PORTS

The Baltic Sea connects the territories of nine countries: Germany, Poland, Sweden, Russia, Estonia, Latvia, Lithuania, Denmark, and Finland. These countries, diverse in both development potential and culture, are united in terms of integration by their seaports. Moreover, seaports serve as nodal centers on the Baltic Sea, performing a variety of complex functions, ranging from serving as capital cities to acting as the world's largest transport centers. Sweden and Finland have the longest coastlines along the Baltic Sea. The seaports of the Eastern and Western Baltic Sea differ significantly from each other. For instance, the ports of Germany, Denmark, Southern Sweden, Poland, and the Kaliningrad region are closely linked to the handling and processing of cargo in Western and Central Europe. Meanwhile, the Eastern ports

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are more focused on managing cargo flows within the Baltics, Russia, and Scandinavia (Bilczak et al., 2020).

The structure of ports typically consists of specialized terminals for specific types of cargo, strategically distributed at berths. These ports also feature sites for cargo storage, warehouses, and cold storage facilities. Additionally, they house port administration and control services, as well as freight forwarding, insurance, and logistics companies that engage in complex cargo handling and transportation.

Each seaport serves its primary functions. Beyond handling, transport, and distribution, individual ports also fulfill spatial and transport-technological functions. These are often associated with port and industrial complexes. Industrial enterprises located near terminals benefit significantly from this proximity, as it reduces the transportation costs of finished products to other countries and eliminates the time and financial expenses associated with delivering finished products to the port.

Another feature of a Baltic Sea port is their ice regime, port basin depths, and the length of the approach channels. These conditions are especially important for the transportation of oil and petroleum products, as ice conditions play a crucial role. This is because, the Gulfs of Finland and Bothnia, as well as many other coastal areas of the Baltic Sea, are covered with ice throughout the winter period. This significantly hampers navigation and necessitates additional financial expenditures for the use of an icebreaker fleet. Therefore, from a safety perspective, many countries are compelled to increase and apply differentiated port tariffs for tankers with double hulls and other double-hulled vessels. The depth of the port basin is also a critical factor for port development, as it determines the size and draft of ships that can enter the port. In many Baltic ports, channel depths must be continually deepened, which is a costly endeavor (Bilczak et al., 2020).

Currently, the seaports of the Baltic Sea Region are evolving into centers of innovation and technological development. Many ports are actively introducing digital solutions to optimize operations and manage cargo flows (de la Peña Zarzuelo et al., 2020). Environmental considerations are also a focus in port upgrades. Due to growing attention to environmental safety, ports are adopting "green" technologies, such as the use of alternative energy and transitioning to more environmentally friendly fuels for vessels (Stankevičienė et al., 2020). Additionally, ports are active participants in international cooperation, implementing joint programs to develop infrastructure, improve maritime safety, and protect the marine environment (Gänzle, 2018; Grönholm & Jetoo, 2019). Owing to the growth in tourism, many ports have become significant tourist centers. The annual arrival of cruise liners contributes to an influx of tourists and the development of the local economy (Djakona & Kikste, 2023). Thus, Baltic ports continue to play a key role in the region's development, spanning the areas of logistics, innovation, ecology, and tourism (Gänzle, 2018; Gløersen et al., 2019; Raszkowski & Sobczak, 2019).

The determinants of the Baltic Sea ports model may be presented as follows (Fig. 1):

- External markets – sources and destinations for goods passing through Baltic Sea ports. These markets may include other countries or continents that engage with the Baltic Sea Region through seaborne trade.
- Baltic Sea ports – major hubs through which goods enter or exit the region. These ports facilitate the transshipment, storage, and onward distribution of goods.
- Inland transport – after goods pass through the ports, they are transported to their final destinations within the region by various means of inland transport, such as roads, railways, or inland waterways.
- Regional markets – final destinations for goods passing through the ports. These can include cities, industrial zones, or other key markets within the Baltic Sea Region.
- Digital infrastructure – modern ports are increasingly integrating digital technologies for process automation, efficiency improvements, and ensuring seamless interaction between various supply chain stakeholders.

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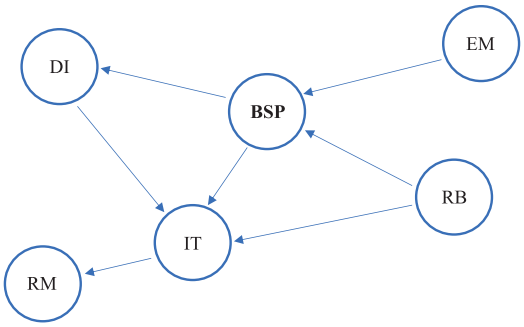
– Regulating Bodies – Authorities that establish rules and standards for port operations, ensuring safety, resilience, and compliance with international standards in light of changing geopolitical conditions.



Where: EM – External markets, BSP – Baltic Sea ports, IT – Inland transport, RM – Regional markets, DI – Digital infrastructure, RB – Regulating bodies.
Fig. 1. Baltic Sea ports model
Source: compiled by the author.

The model is based on various classifications, including population, development of marine-sector industries, employment in marine-sector industries, output in marine-sector industries, and the role of coastal regions in global GDP production. Each of these classifications is applied in specific studies focused on the activities, potential, and throughput of seaports. Table 1 presents a universal classification of EU Baltic Sea ports.

The Baltic ports, especially the large and medium-sized ones, have a universal cargo turnover structure. When evaluating the operations of ports in general – such as cargo turnover, passenger turnover, and container turnover – a very interesting specificity emerges: while the ports of the eastern Baltic specialize in handling bulk cargo (both liquid and dry), the ports of the western Baltic focus on general cargo, which accounts for the majority of cargo turnover in Baltic Sea ports.

Table 1. Universal classification of Baltic Sea ports

Classification	Port type	Examples of ports (EU)
1	2	3
Cargo turnover	Large (> 50 million tons)	Gdansk (Poland)
	Medium (10–50 million tons)	Riga (Latvia)
	Small (< 10 million tons)	Haapsalu (Estonia)
Strategic significance	International hub ports	Gdansk (Poland)
	National hub ports	Klaipeda (Lithuania)
	Regional ports	Liepaja (Latvia)
Interaction with other transport modes	Multimodal ports	Port of Gdansk (Poland) – connection with rail and road transport
	Ports with limited interaction	Port of Paldiski (Estonia) – predominantly maritime transport
Technological classification	Ports with digital infrastructure	Ports of Rauma (Finland) and Gavle (Sweden)
	Ports with sustainable practices	Helsinki (Finland)
Geographical location	Seaports	Gdansk (Poland)
	Riverine ports	Riga (Latvia) on the Daugava River
	Lacustrine ports	Vuosaari (Finland) on Lake Saimaa
	Canal ports	Ports on Göta Canal (Sweden)
	Ports of inland water bodies	Narva (Estonia) on Narva River

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cont. **Table 1**

1	2	3
Functional purpose	Commercial ports	Klaipeda (Lithuania)
	Bulk ports	Riga (Latvia)
	Container ports	Gothenburg (Sweden)
	Fishing ports	Liepaja (Latvia)
	Passenger ports	Tallinn (Estonia)
	Military ports	Military Port of Klaipeda (Lithuania)
	Specialized ports	Ventspils (Latvia) – oil port
Degree of accessibility	Perennial operation	Helsinki (Finland)
	Seasonal	Paldiski (Estonia)
Degree of automation	Automated	Gdansk (Poland)
	Non-automated	Kunda (Estonia)

Source: compiled by the author.

RESULTS AND DISCUSSION

The study conducted two separate Pearson correlation analyses to examine the relationship between GDP and cargo turnover of European Union seaports in the Baltic Sea Region.

The first analysis focused on the correlation between GDP and port cargo turnover for individual countries in the region from 2018 to 2022. This approach enabled the assessment of whether a relationship exists between these variables and how they evolved within individual economies during the analyzed period.

The second analysis concentrated on examining the correlation between GDP and port cargo turnover (Tables 2 and 4) in spatial terms, encompassing all countries collectively over specific years. This provided insights into the variation in the strength and direction of the relationship between these variables on a regional scale in the Baltic Sea.

Conducting both analyses was aimed at a more comprehensive study of the interdependence between economic environment and port cargo turnover at both national and regional levels in the Baltic Sea Region's EU countries.

The statistical analysis using the Pearson correlation coefficient showed a differentiation in the strength and direction of the relationship between GDP and seaport cargo turnover in the 8 Baltic Sea countries studied in 2018–2022. In Germany, Denmark and Poland, positive correlations were identified with coefficients of 0.35, 0.57 and 0.94, respectively. This indicates the presence of a positive relationship from weak to strong. Thus, GDP growth contributed

Table 2. GDP of EU Baltic Sea Region countries in 2018–2022 (current price, EUR million)

Countries	2018	2019	2020	2021	2022
Poland	499,004.1	532,504.7	526,147.2	576,382.6	654,594.4
Sweden	470,673.1	476,869.5	480,556.4	540,734.0	562,526.3
Germany	364,584.0	372,150.0	371,790.0	395,580.0	434,374.0
Denmark	302,328.7	309,526.4	311,356.3	342,961.7	380,617.8
Finland	233,462.0	239,858.0	238,038.0	250,923.0	268,645.0
Lithuania	45,515.2	48,959.2	49,873.2	56,478.1	67,399.1
Latvia	29,153.6	30,572.9	30,109.5	33,348.9	38,870.0
Estonia	25,932.2	27,951.0	27,430.0	31,169.0	36,011.1

Source: compiled by the author based on Eurostat data.

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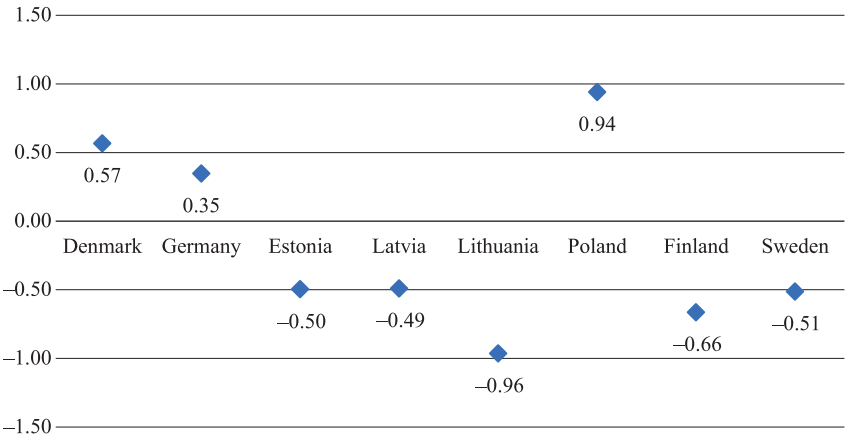

Fig. 2. Pearson correlation coefficients between GDP and seaport cargo turnover in selected Baltic Sea Region countries in 2018–2022

Source: compiled by the author.

to an increase in port turnover. Consequently, it can be assumed that in these countries, economic development during the analyzed period stimulated the activities of seaports (Fig. 2).

However, in some countries of the Baltic Sea Region, notably Estonia, Latvia, Lithuania, Finland, and Sweden, the correlation coefficients ranged from –0.49 to –0.96. These values indicate moderate to strong negative correlations. In these countries, GDP growth was associated with a decrease in port turnover, suggesting that economic development either did not positively influence the port sector or may have had a negative impact on it.

The study thus revealed a distinct divergence in the relationship between the economic environment and port turnover across the Baltic Sea Region. Positive correlations were observed in only three out of the eight countries studied. In the remaining countries, the relationship was inverted, with Lithuania exhibiting the strongest negative correlation. These results indicate that economic growth in the region did not uniformly translate into positive effects on the port sector.

The study aimed to verify the hypothesis of a statistically significant relationship between the GDP of selected Baltic Sea countries and the cargo turnover in their seaports from 2018 to 2022. The Pearson correlation coefficient was employed to measure the strength of the correlation, and the value of the t-test statistic was compared with the critical region for an assumed significance level of $\alpha = 0.05$ with 8 degrees of freedom to verify statistical significance.

The Pearson correlation coefficients obtained suggest the presence of a positive relationship between the examined variables throughout all the analyzed years. The strength of this relationship intensifies from moderate (0.65) in 2018 and 2019, to quite strong in 2020 (0.69), and to strong in the years 2021–2022 (0.77 and 0.80, respectively).

Table 3. Statistical analysis of the correlation between GDP of selected Baltic Sea Region countries and seaport cargo turnover in 2018–2022

	n	α	P_{xy}	t	T	R^2
2018	8	0.5	0.65	2.12	2.454	42.80%
2019	8	0.5	0.65	2.12	2.454	42.90%
2020	8	0.5	0.69	2.34	2.454	47.70%
2021	8	0.5	0.77	2.98	2.454	59.60%
2022	8	0.5	0.80	3.30	2.454	64.50%

Source: compiled by the author.

Nevertheless, only in the last two years did the t-test statistic values surpass the critical threshold (with $\alpha = 0.05$ defining the critical region as (–2.454, 2.454), which substantiates the rejection of the null hypothesis and confirms the statistical significance

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of the relationship at the 0.05 level. In the years 2018–2020, despite increasing Pearson coefficient values, the t-test statistics did not support a definitive conclusion regarding the existence of a statistically significant correlation.

Considering these outcomes, it can be concluded that in the last two years, the variables under study exhibit a statistically significant, positive, and strong correlational relationship.

The total cargo turnover of ports in the Baltic Sea Region for 2022 amounted to 670.019 thousand tons, representing a 2.39% increase over 2021 (654.355 thousand tons). However, compared to 2018 (696.182 thousand tons), cargo turnover decreased by 3.76%. Among the Baltic Sea Region countries, Sweden had the highest cargo turnover in 2022, with 168.181 thousand tons, or 25.11% of the total turnover. This was followed by Poland, with 118.972 thousand tons or 17.76%, and Finland, with 106.566 thousand tons or 15.90%. The most significant growth in cargo turnover in 2022, compared to 2021, was observed in Poland (23.06%) and Latvia (15.21%). At the same time, Poland showed positive dynamics compared to 2018, with a growth rate of 29.60%. Cargo turnover data for the EU Baltic Sea ports are presented in Table 4.

On the other hand, the largest declines in cargo turnover in 2022, compared to 2021, were recorded in Lithuania (18.52%) and Estonia (15.39%). Latvia experienced a significant decrease in turnover, by 27.35% compared to 2018, making it the least stable among the countries considered. It should also be noted that the impact of the COVID-19 pandemic in 2021 was less burdensome than in 2020.

As can be seen from the data (Table 5), Sweden is the key player among the countries considered, with the largest share in 2022 (83.604 thousand tons, or 28.88% of the total general cargo turnover). This country's performance has remained stable over all the years considered, experiencing a slight decrease in 2020 and a minimal change of –0.06% between 2022 and 2021.

Finland and Denmark also demonstrate relative stability, each showing a slight decrease in 2020. Their shares in 2022 amount to 15.43% (44,666 thousand tons) and 14.12% (40,882 thousand tons), respectively. At the same time, Finland shows a positive trend, with an increase in indicators of 1.04% between 2022 and 2021, while Denmark shows an increase of 0.89%.

The situations in Germany and Poland differ. Germany's figures decreased in 2020 but recovered in 2021; however, they decreased again in 2022 by 6.10%. Poland maintains relative stability, with a minimal decrease of 0.17% between 2022 and 2021. Lithuania stands out among the other countries, showing the highest growth in indicators of 12.22% between 2022 and 2021. In Estonia, there is a strong decline in indicators, amounting to 24.61% over the same period. Latvia shows moderate growth, at 3.29%.

Of particular interest is the volume of cargo transshipment in the five largest EU ports in the Baltic Sea Region (Fig. 3). The Port of Gdansk shows the most pronounced positive dynamics, with a growth rate

Table 4. Cargo turnover of EU Baltic Sea ports in 2018–2022 (thousand tons)

Countries	2018	2019	2020	2021	2022	Average	2022/2021	2022/2018	Share 2022
Sweden	179,042	169,792	167,594	168,181	168,251	170,572	0.04%	-6.03%	25.11%
Poland	91,798	93,864	88,520	96,680	118,972	97,967	23.06%	29.60%	17.76%
Finland	118,311	121,567	109,948	103,727	106,566	112,024	2.74%	-9.93%	15.90%
Denmark	95,989	93,727	91,271	94,255	97,196	94,488	3.12%	1.26%	14.51%
Germany	56,480	56,844	54,052	60,626	57,080	57,016	-5.85%	1.06%	8.52%
Latvia	66,175	62,380	44,928	41,731	48,078	52,658	15.21%	-27.35%	7.18%
Lithuania	52,463	52,244	51,529	49,751	40,537	49,305	-18.52%	-22.73%	6.05%
Estonia	35,924	37,690	37,688	39,404	33,339	36,809	-15.39%	-7.20%	4.98%
Total	696,182	688,108	645,530	654,355	**670,019**	**670,839**	**2.39%**	**-3.76%**	-

Source: compiled by the author based on Baltic Transport Journal (2020, 2021, 2022, 2023).

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Table 5. General cargo turnover of EU Baltic Sea ports in 2018–2022 (thousand tons)

Countries	2018	2019	2020	2021	2022	Average	2022/2021	2022/2018	Share 2022
Sweden	84,923	83,419	78,979	83,652	83,604	82,915	-0.06%	-1.55%	28.88%
Finland	49,212	49,207	43,713	44,207	44,666	46,201	1.04%	-9.24%	15.43%
Denmark	38,551	37,903	37,850	40,520	40,882	39,141	0.89%	6.05%	14.12%
Germany	40,229	39,474	37,446	43,297	40,656	40,220	-6.10%	1.06%	14.04%
Poland	37,841	37,312	35,640	38,520	38,453	37,553	-0.17%	1.62%	13.28%
Lithuania	12,640	11,636	10,949	12,410	13,926	12,312	12.22%	10.17%	4.81%
Latvia	15,517	12,406	12,362	13,352	13,791	13,486	3.29%	-11.12%	4.76%
Estonia	14,274	13,440	12,015	17,984	13,559	14,254	-24.61%	-5.01%	4.68%
Total	**293,187**	**284,797**	**268,954**	**293,942**	**289,537**	**286,083**	**-1.50%**	**-1.24%**	–

Source: compiled by the author based on Baltic Transport Journal (2020, 2021, 2022, 2023).

of 30.8%, especially given the significant increase in 2022 to 68,220 thousand tons. This growth was associated with the import of energy raw materials from abroad, due to the imposition of sanctions against Russia. Additionally, over the entire analyzed period, the ports of Szczecin – Świnoujście exhibited moderate growth of 20.6%, which may indicate a gradual development of port operations. It should also be noted that the transshipment volume in all Polish ports in 2022 was influenced by the handling of Ukrainian exports; ore and grain from Ukraine were transshipped at the Ports of Gdansk, Gdynia, and Szczecin – Świnoujście.

The opportunities for container terminal handling play a significant role in both the development and competitiveness of ports, as illustrated in Figure 4. Between 2019 and 2022, the five largest container ports in the EU's Baltic Sea Region exhibited divergent trends in container handling volumes. The average handling volume increased from 1,006,930 TEU in 2019 to 1,135,680 TEU in 2022, representing an increase of 18.87%. The Port of Klaipeda stands out in particular, showing a growth rate of 57.17% in 2022 compared to 2021, and 49.07% compared to 2019. These high container-handling figures are attributable

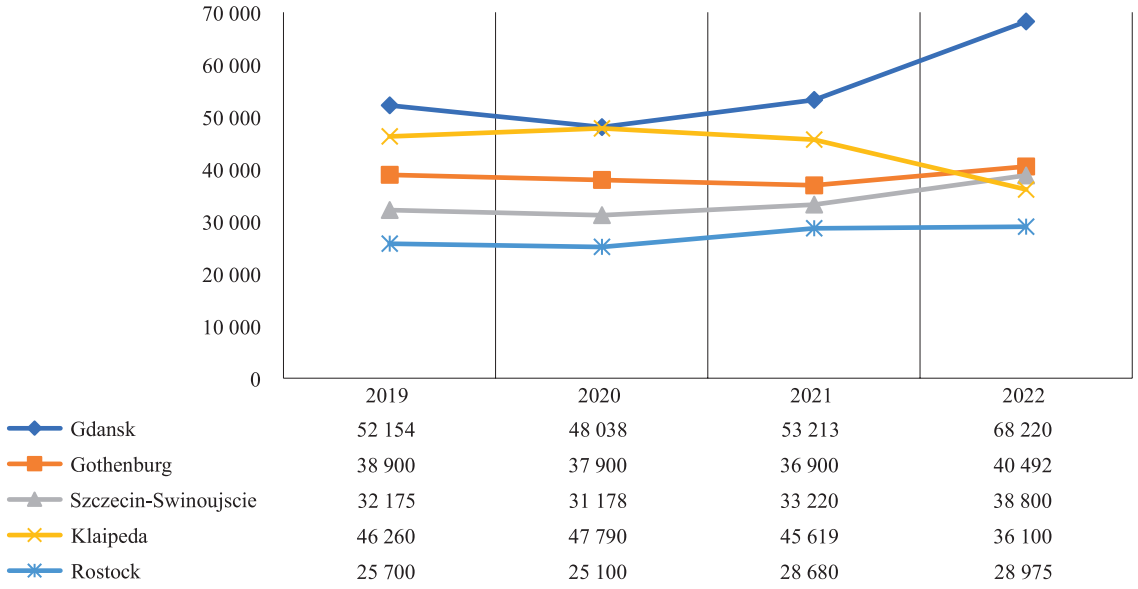

Fig. 3. Transshipment volumes in the five largest EU ports in the Baltic Sea in 2019–2022 (thousand tons)
Source: compiled by the authors based on Port Monitor (2022, 2023); Główny Urząd Statystyczny (2022).

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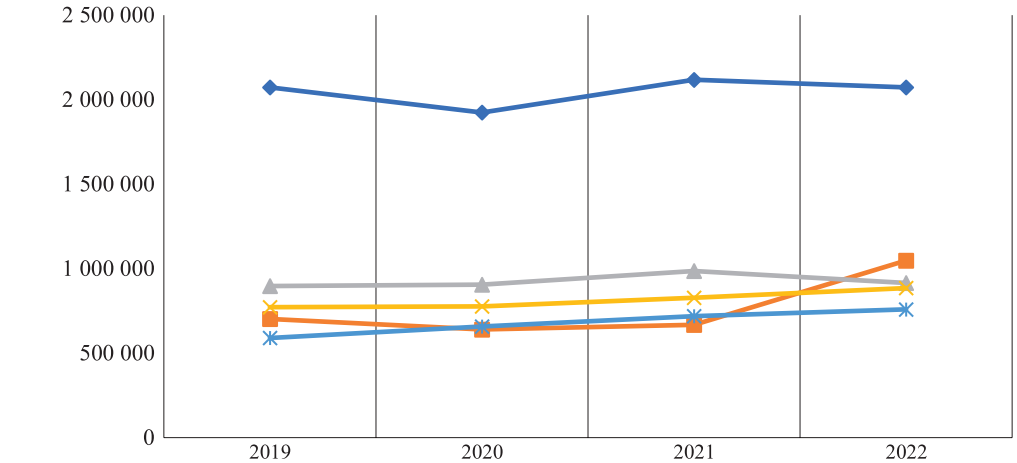

	2019	2020	2021	2022
Gdansk	2 073 215	1 923 785	2 117 829	2 072 122
Klaipeda	703 000	640 148	666 775	1 047 941
Gdynia	896 968	905 121	985 919	914 448
Gothenburg	772 000	776 000	828 000	884 900
Aarhus	589 486	657 786	718 000	759 000

Fig. 4. Handling volumes at the five largest container ports in the EU Baltic Sea in 2019–2022 (TEU)
Source: compiled by the authors based on Port Monitor (2022, 2023); Główny Urząd Statystyczny (2022).

to the launch of new routes, including the MSC service (ScanBaltic – US East Coast) that operates between Klaipeda, Gdynia, Gothenburg, and New York. While the ports of Gdansk and Gdynia experienced slight decreases and increases, respectively, the ports of Gothenburg and Aarhus demonstrated moderate growth.

Currently, there is a need to facilitate increased business activity for the innovative and investment-driven development of coastal regions, as well as the expansion of their hinterlands. Even now, most large and major ports are becoming advanced development territories due to the successful operation of industrial and manufacturing enterprises within the ports and the expansion of stevedoring and logistics capabilities. The prerequisites for establishing industrial zones in these areas include modern trends and specific developments in the global economy, as well as the presence of a highly efficient logistics infrastructure built on the latest innovative developments and ongoing research.

CONCLUSIONS

The new challenges and shifts in economic activity under crisis conditions compel us to reevaluate the environment in which BSR seaports operate. One of the most pressing issues today is whether the functional system – comprising the transport infrastructure in general and seaports in particular – will be able to handle increasing cargo traffic volumes. The primary conclusion is that it is essential to plan the future development of seaports based on strategic scenarios and the identification of shared development priorities.

The research conducted revealed a statistically significant positive correlation between GDP and port cargo turnover in the Baltic Sea Region. This empirical evidence supports the hypothesized positive relationship between economic growth and the cargo turnover of EU Baltic Sea ports (H1).

Despite the challenges posed by the COVID-19 pandemic and the evolving geopolitical landscape,

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Baltic Sea ports, including those in Poland, have significantly strengthened their roles as key logistics hubs in the region (H2). This assertion is supported by the analyzed indicators, such as increased cargo turnover and enhanced container handling capacities. Notably, Polish ports, particularly the Port of Gdansk, have exhibited dynamic growth. They serve as hubs connecting maritime routes with land transport.

At the same time, Baltic ports demonstrate high activity in implementing innovations to meet future challenges. They have implemented digital solutions, such as process automation, as well as environmental measures like the use of alternative fuels. They also actively participate in international cooperation aimed at exchanging experience and knowledge.

The analysis has also revealed the need for further sustainable development of Baltic ports. Particularly important are: improving the quality of services provided, developing transport infrastructure, integration with infrastructure, and increasing resilience to crises. Strategic planning and investments in new technologies and infrastructure are of key importance.

There are challenges in ensuring the balanced development of port functions, which are integral to the development of the maritime zone. Primarily, this involves the transport and technological function, closely linked to port and industrial complexes. Recently, the location of many industrial enterprises in the port hinterlands (the territory adjacent to the port) has led to issues concerning the availability of modern utility fleets, approach roads, railways, and coordinated tariff policies. To address these challenges, a high degree of coordination is required among organizations and institutions involved in the balanced development of seaports. These include organizations like ESPO (The European Sea Ports Organisation), local governments, business representatives, and other economic agents.

Despite facing serious crises, the ambitious goals, objectives, and implementation mechanisms of the EU's Blue Policy in the field of maritime transport and seaport development still need to be addressed. In-depth, comprehensive research is needed, along with the creation of a new maritime policy and Poland's "Program for the Development of Polish Seaports until 2030"[2]. This program aims to establish Poland as a major player in transportation turnover in the North-South and West-East directions and to redirect cargo from the Black Sea to the Baltic-Atlantic direction.

A significant qualitative improvement in the functioning of BSR seaports, as well as the resolution of existing problems in their development, creates conditions for balanced and sustainable growth in the EU's Blue Policy overall. The establishment of the main priorities and mechanisms for achieving set goals through research will elevate the quality of services provided by the Baltic Sea port sector. This will elevate it in terms of ensuring European foreign trade flows and enhancing the competitiveness of BSR ports on the international stage. The methods and analytical tools proposed in this article can be used for further comprehensive research and strategic planning regarding Polish seaports. An in-depth analysis of the activities of Polish ports using the proposed tools will enable strategic planning for their sustainable development, considering new political and economic realities.

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[2] The need to adopt a program arises from the absence of a comprehensive government document addressing port development for several years. The most recent document of this kind was the 'Strategy for the Development of Seaports until 2015'. The primary aim of the program is to continually strengthen Polish seaports as leaders among Baltic Sea ports. These ports should function as key nodes in global supply chains for Central and Eastern Europe and contribute to the country's more active socio-economic development.

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SOCIAL RESILIENCE OF YOUNG PEOPLE DURING THE COVID-19 PANDEMIC. THE CASE OF THE GDANSK – GDYNIA – SOPOT METROPOLITAN AREA IN POLAND

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ABSTRACT

Motives: Social resilience is increasingly attracting the interest of researchers and practitioners due to the need to stabilize and adapt societies to new challenges. These challenges result from successive crises, including pandemics. The answer lies in understanding, exploring, and building social resilience.
Aim: The theoretical aim of the article is to identify the components of social resilience based on a review of international literature. The empirical aim is to present a methodology and to examine social resilience based on a survey.
Results: The results show that social resilience is determined by the resources and capital of individuals or households. Among them, social, human, financial and material capital should be distinguished. The surveyed respondents were characterized by high social resilience to the crisis caused by the pandemic due to their predominantly young age, good education, and extensive social contacts despite limited financial and material resources.

Keywords: social resilience, adaptability, Gdańsk, resources, capitals, survey

INTRODUCTION

The concept of resilience refers to various dimensions and components, and their interrelationships that allow us to understand and interpret this concept. The basic dimensions of resilience include environmental, economic, institutional, and social dimensions, while its components include spatial, infrastructural, environmental (i.e. adaptation to climate change; Kalbarczyk & Piegat, 2021), social, and cultural components (Irani & Rahnamayiezekavat, 2021; Masik, 2022).

Initially, the concept of resilience originated in the natural sciences, whereas now it encompasses not only natural or ecological aspects, but is also rooted in the social sciences and, as mentioned above, refers to the social dimension. In social resilience, as well as in social vulnerability, a research pattern has been adopted in line with the constructivist tradition, where the subjective factor of human perception and value is an important consideration (Miller et al., 2010). The social dimension of resilience (social resilience and community resilience) has become an increasingly important area of interest for researchers due to the

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consequences for societies resulting from various types of threats (Adger, 2000; Norris et al., 2008; Obrist et al., 2010; Quinlan et al., 2016).

At the beginning of this century, Adger (2000, p. 347) referred to social resilience. According to the cited author, social resilience is "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change." These stresses can be various types of continuous or sudden threats, known as shocks or crises. These include financial, economic, geopolitical and public health crises, such as the COVID-19 pandemic. Social resilience is also understood as the ability of various actors to access capital in order not only to overcome or adapt to unfavorable conditions (reactive capacity), but also as the ability to seek and create new opportunities (proactive capacity) (Obrist et al., 2010). Research on social resilience emphasizes the importance of livelihood, which includes financial resources, but also other resources and capitals (Speranza et al., 2014).

Although the livelihoods approach is derived from the concept of sustainable development (Sustainable Livelihoods Approach; Chambers & Conway, 1992; Weichselgartner & Kelman, 2015), it is a key perspective in social resilience research. Livelihoods, broadly defined, are the fundamental determinants that result from the possessed human capital, participation, i.e. influence on political and social processes, and social capital, including social networks (Adger et al., 2002). Therefore, in a new study in the context of the COVID-19 pandemic, the following types of capital related to social resilience can be distinguished: human capital, community capital, social and cultural capital, as well as social cohesion, social networks, social trust, risk knowledge, and the demographic characteristics of societies (Alizadeh & Sharifi, 2021). As part of the social capital, Aldrich (2012) points to the importance of linking social capital. It is defined as the relationship between individuals and local governments, administrations or leaders. It is therefore a capital that allows for the empowerment of individuals and social groups and an appropriate response of both parties to possible future threats.

The aim of this article was to examine social resilience, taking into account the resources and capitals possessed by individuals or households. The survey assessed the respondents' financial and material resources as well as human and social capital. The respondents' self-assessment provided an original insight into individual social resilience in the face of the challenge of the public health crisis. This type of research provides a new perspective on social issues in the context of future crises and allows the identification of those characteristics of society that may constitute potential resilience to threats of both natural and non-natural origin.

LITERATURE REVIEW

As noted in the Introduction section, social resilience refers to the adaptive capacity of people during a crisis (Copeland et al., 2020). The study of social resilience during a pandemic is particularly relevant. Many recent studies suggest extending the concepts of social capital and resilience to a pandemic case (Alizadeh & Sharifi, 2021; Champlin et al., 2023; Fraser & Aldrich, 2021; e.g. Kimhi et al., 2020; Schubert et al., 2024). Research on social resilience has identified the resources and capitals possessed by individuals, households or societies that can become useful when adverse events occur. The size of these capitals, their number, diversity and balance in their possession positively affect the resilience of societies. Moreover, it should be noted that the more capital individuals or households have at their disposal, the more opportunities they have to protect their livelihoods, and therefore the more resilient they are (Speranza et al., 2014).

Despite the increasing number of studies on resilience, many analyses underestimate the role of social capital in the process of adaptation to adverse events, which has been particularly highlighted by Gong and Hassink (2017). Although resilience related to human and social capital has been studied in the regional perspective (Sagan & Masik, 2014), these issues have been ignored in many studies.

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The importance of social capital was emphasized by Walker et al. (2004) who noted that the adaptive capacity of social groups with higher levels of social capital implies a higher degree of resilience in the process of adapting to adverse events. Research conducted by Kaya and Eraydin (2012), and Kakderi and Tasopoulou (2017) suggests that social groups with networks of connections are less sensitive to crises, and thus have a greater adaptability to changing circumstances. Strong social ties allow for better information exchange, joint activities and better support in the event of threats, creating the so-called "informal insurance".

Recent studies on social resilience have considered the role of bridging and bonding social capital in the response of regions to crises in the context of economic diversification. Their findings indicate that economic diversification (as well as personal skills and qualifications) allows for the building of bridging capital in society. However, bridging social capital is not crucial in the first phase of the crisis. Then, it is the bonding capital that makes societies more resilient to shocks (Antonietti & Boschma, 2021). This is due to the fact that close non-work ties allow people to keep their jobs, even temporarily, or to get a new job quickly.

Other studies highlighting the importance of social capital (Bristow & Healy, 2014) point to the importance of positive relationships between employers and employees as key to mitigating the negative effects of the crisis. The issues concerning employers and enterprises in general have been highlighted by Graddy-Reed and Feldman (2015) who noted that enterprises engaged in social innovation are more active in periods of recession and tend to address environmental issues and support local communities. Therefore, it should be emphasized that social innovations are conducive to building adaptability over a longer period of time. In turn, Huggins and Thompson (2015) demonstrated that local culture and its openness as well as population activity may be more important for building resilience by strengthening entrepreneurship than the classic focus on economic growth. For example, residents and entrepreneurs of metropolitan and suburban areas, who are more active and entrepreneurial, have higher levels of human and social capital, and are better prepared for economic shocks (Di Caro, 2015).

Community resilience is a similar but slightly different category. According to Norris et al. (2008), community resilience is a process that combines adaptive capacity with a positive trajectory of functioning and adaptation following disruptions. Community resilience refers to a small group of people living in a city or neighborhood, while social resilience is a more general category in many studies. However, researchers often use these terms interchangeably, which is not correct. In this context, the behavioral change perspective within social resilience research should be mentioned (Champlin et al., 2023). Such studies conducted in cities actually refer to community resilience.

Research on social resilience also highlights the importance of physical (material) resources that can become capital if used to minimize losses caused by the crisis. Pelling (2003) draws particular attention to the importance of tangible capital through the example of property ownership, which is one of the most important forms of capital, especially for the poor. For example, by owning an apartment, they do not have to rent it on the market or from the city, and thus have more resources at their disposal.

Having a job is also important in determining the level of resilience to threats. Meekes and Hassink (2019) studied the resilience of working people in the context of the housing market. This type of research focuses on the characteristics of the people participating in it and their position on the labor market. In general, it should be noted that skilled workers with high incomes have a relatively strong position on the labor market, while younger people at the beginning of their careers are in a weaker position. For this reason, the latter are characterized by lower social resilience.

Summarizing the issues of social resilience, it should be noted that there are more and more studies related to this dimension of resilience, but in most of them social resilience is not indicated as a key.

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Social resilience, if one indicates not only the importance of capitals, but also the causal role of social, economic or local and regional government actors connected with a network of contacts, finds common issues with the institutional resilience / agency perspective (Masik, 2018, 2021). For this reason, in some studies, the agency perspective is associated with social or local resilience, where it is indicated that the resilience of local communities lies in the mobilization of residents, while the resilience of local authorities concerns the readiness to take anticipatory actions and appropriate measures (Chmutina et al., 2016). The above issues are also taken into account in social resilience research.

MATERIALS AND METHODS

The literature review has shown that the available resources and capital have a positive effect on social resilience. In order to measure the social resilience of individuals during external threats (in this case the health crisis caused by the pandemic), a survey was conducted using the Goole Forms internet tool among geography and spatial planning students at the University of Gdańsk. The research was carried out between November 2020 and January 2021, i.e. during the second wave of the COVID-19 pandemic in Poland, and between November 2021 and February 2022, i.e. during the fourth and fifth waves of the pandemic. The students were asked to send the form to ten people in their family or circle of friends for completion and to have them send the form to two more people. This created a relatively large research sample. In the first and the second stage of the study, 735 and 368 completed questionnaires were returned, respectively, giving a total of 1,103 completed forms. Due to the slight differences in the responses obtained for the two research periods, the results of the survey were combined and discussed together.

With the simplified assumption that each of the 87 students involved has a total of one hundred contacts (the average number declared by the students) to whom they could send the questionnaire, i.e. friends and close and extended family members, the population in the study amounted to 8,700 people. Relating the number of received questionnaires to the population of the "students' family and friends" and assuming a random selection of the sample, i.e. random sending of a link with the questionnaire by the students to their family and friends, the result of the survey as a whole can be considered as representative at the level of plus/minus 3%. The survey is not representative of other populations. The presented results should be treated as a kind of research proposal presenting the method of assessing individual social resilience.

The present study considered measures of social resilience (e.g. Masik, 2020), including questions and surveys recommended by the OECD (Figueiredo et al., 2018). This implies, among other things, the use of dichotomous and Likert scales in survey research and, as well as questions related to possible support from different institutions. The questions related to crisis resilience concerned the level of social capital, expressed through the network of social contacts, including, in particular, the possibility of obtaining financial support, the possibility of finding a job with the help of family or friends, possible help from neighbors and involvement in local affairs, as well as raising qualifications. The research took into account the basic demographic and social characteristics of the respondents, such as gender, age and education, as well as additional characteristics that also indicate greater or lesser social resilience, i.e. the number of children, paid work, assessment of own income, material resources such as real estate and a declaration of financial resources. The analysis was performed using the SPSS program and the results were presented using structural graphs and cross tables, taking into account the number of responses in individual categories and statistical significance at a level lower than 0.05.

RESULTS

Approximately 64% of women and 36% of men participated in the study. 59% of the respondents were 18–24 years old, 27% were 25–44 years old,

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11% were 45–64 years old, and 3% were 65 years old or older. Thus, the vast majority of respondents were of the mobile working age (86%), i.e. people who could probably adapt most easily to unfavorable crisis phenomena, e.g. by changing their job or place of residence. Among the respondents, 37% were people with higher education, 53% with secondary education, only 6% with vocational secondary education, and 4% with primary education. The results of the study should therefore be applied to better educated people, including those who are studying and have noy yet received a diploma.

Additional questions were included in the survey to define the characteristics of the respondents in terms of work performed, financial and material resources, and having children (which indicates their potential adaptability). Among the respondents, 37% worked without pay, studied or did not work, while 63% worked for pay. The characteristics of the employment status and income suggest that most of the respondents had an income and were employed, which favors greater resilience. This implies potentially high social resilience.

When assessing financial resources, the respondents were asked to report their income and savings. As many as 79% of the respondents considered their own or their household's income to be sufficient, and only 21% of them considered it to be insufficient. 25% of the respondents admitted that they had significant savings, and 75% of them declared that they had little or no savings. The respondents' assessment of their financial capital was inconclusive. On the one hand, the vast majority of the respondents felt that their income was sufficient, and on the other hand, most of them had little or no savings. These characteristics suggest that the respondents were potentially vulnerable to crises in terms of financial resources.

Similarly, the lack of material (physical) resources implies greater sensitivity, therefore the respondents were asked about property ownership (or family ownership). The survey revealed that 68% of the respondents owned some property (e.g. an apartment) or the family owned such a property, while the remaining 32% of the respondents, gave a negative answer. A relatively large group of respondents without real estate results from the sample selection. The sample was largely composed of students who rented an apartment on the market. The same applies to the number of children. Namely, as many as 77% of the respondents had no children, 10% had one child, 11% had two children, and 2% had three or more children. A large group of respondents were residents of the Tri-City (Gdynia, Gdańsk and Sopot, and their suburbs, i.e. 73% in total). Many respondents indicated other places of residence from all over Poland, including large cities and small rural areas. In general, it can be assumed that the majority of the respondents were residents of the Gdańsk – Gdynia – Sopot Metropolitan Area and large and medium-sized cities.

When describing the respondents in general, it should be noted that they were predominantly women, young people, and those with secondary or higher education. A large proportion of the respondents worked and earned an income, but they did not have significant savings or real estate, which implies potential vulnerability to crises. At the same time, most of the respondents had no children and lived in larger urban centers or suburbs, which in turn promotes greater resilience.

The social resilience survey has shown that only 22% of the respondents attended meetings held by social organizations, meetings with neighbors, town/community residents, etc. to resolve a problem in the past year (Fig. 1). This is a low percentage considering that the respondents were young and relatively well-educated. In addition, 44% of the respondents declared that they would get help from their neighbors if they had a problem. These results may indicate that the respondents have more contacts within local communities than within social organizations, and may point to a certain passivity: the respondents can rely on the support from their neighbors in case of problems, but they are less actively involved in solving problems. This suggests that the level of linking social capital was not high, which has a negative impact on social resilience.

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Fig. 1. Assessment of social and human capital
Source: own elaboration based on the survey.

The majority of the respondents (65%) reported that they participated in training or attended courses to improve their skills, or studied. This proportion is high due to the sample selection. An even higher percentage of respondents (77%) indicated that they would potentially receive support from family or friends when changing or starting a new job, and 96% of them indicated that they would receive support from family or friends in case of financial problems. This means that despite the relatively low participation of the respondents in non-family social networks, they believed that they would receive help in finding a job and financial assistance. These results indicate that bonding social capital is more important than bridging capital for the respondents' social resilience (adaptability). The first type of capital is particularly important in the short term during the crisis (Antonietti & Boschma, 2021). These findings also suggest that the respondents are more resilient in the short run, when family and social networks are more important, and less resilient in the long run, when it is important to have higher bridging social capital for employment and income.

The above survey results apply to all respondents. However, it is interesting to examine the relationships between the answers to the questions and the sociodemographic characteristics of the respondents. In order to examine these relationships, cross-tables developed with SPSS software were used. Due to the small numbers expected in some table cells, the statistical significance of less than 0.05 does not apply to all results. The results in cells for which no statistical significance was found using the Chi-square test are marked in bold. Only those tables for which differences were found between the categories of responses to the questions and the sociodemographic characteristics were included in the manuscript.

An analysis of the cross-tables revealed no significant differences between the respondents' level of education and the likelihood of receiving support in case of financial problems. Thus, education had no effect on this question. The situation was different when considering the possibility of receiving support from family and friends when changing or starting a new job (following the loss of a previous job). The survey results show that older people are slightly less likely to declare such a possibility (Table 1), suggesting that their networks of contacts are somewhat less extensive.

Table 1. Support from family and friends when changing or starting a new job across age groups (in %)

Response categories	18–24 years	25–44 years	45–64 years	65 years and more	Total
Yes	78	76	72	64	77
No	22	24	28	**36**	23

Source: own elaboration based on the survey.

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The relationship between the possibility of getting help from neighbors in case of problems and the respondents' level of education is also interesting. Although in this case the statistical significance was lower than 0.075, it can be noted that individuals with primary and vocational secondary education can more often rely on the help offered by their neighbors (Table 2). These social groups are less cut off from neighborly relations due to their importance for daily functioning as a result of relatively lower financial resources than the groups with higher education. In the present study, the members of these groups were usually older people, suggesting that the older generation is more concerned with socializing with people from their immediate environment.

Table 2. Neighbors' help in case of problems and the respondents' level of education (in %)

Response categories	Primary	Vocational secondary	Secondary	Tertiary	Total
Yes	45	63	38	47	44
No	55	37	62	53	56

Source: own elaboration based on the survey.

The respondents with higher education (as well as those with vocational secondary education, although their numbers were smaller) reported attending meetings held by social organizations or meetings with neighbors dedicated to solving problems more often than the respondents with secondary education (Table 3). This implies that the former are more likely to engage in social networks (which support social resilience) for the above purposes and, as mentioned above, are less likely to form neighborhood networks.

Table 3. Participation in meetings to solve problems and the respondents' level of education (in %)

Response categories	Primary	Vocational secondary	Secondary	Tertiary	Total
Yes	25	28	16	30	22
No	75	72	84	70	78

Source: own elaboration based on the survey.

The above issues related to participation in social life, improvement of qualifications and the possibility of receiving help from family, friends or neighbors, i.e. referring to social and human capital together with financial and material capital, determine the ability to adapt in the event of crisis phenomena. The capital possessed indicates that a large group of respondents is characterized by a relatively high level of resilience, in other words a high level of adaptability to changing circumstances. The latter term was used in the survey because of its common understanding. The respondents were directly asked how they assess their ability to adapt to various types of social and economic changes and crises. The survey results show that 9% of the respondents rate their ability as very high, 37 as high, and the largest group, i.e. 47%, as average (Fig. 2). These findings indicate a relatively high level of adaptability to crisis phenomena: many more respondents reported very high and high adaptability than very low and low adaptability. This result is in line with the general assessment of the capital held, which in a way proves the reliability of the completed questionnaires.

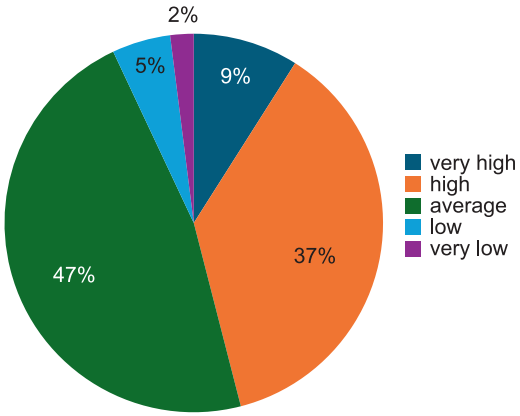

Fig. 2. General assessment of the possibility of adapting to various types of social and economic changes and crises

Source: own elaboration based on the survey.

Similarly to the assessment of social and human capital as influenced by the sociodemographic characteristics of the respondents, an analysis of the general self-assessment of adaptability as a function of these characteristics was carried out using cross-tables. The numbers of observations that are too small for the result to be statistically significant

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are marked in bold. The results of the study indicate that, compared to women, men are slightly more likely to believe that they have a higher ability to adapt to adverse crisis phenomena (Table 4). Women most often reported average adaptability, which may be associated with their lower overall self-esteem, but also with women's lower employment opportunities and lower average wages.

Table 4. Overall assessment of adaptability (social resilience) and gender (in %)

Response categories	Female	Male	Total
Very high	7	13	9
High	30	49	37
Average	56	31	47
Low	5	5	5
Very low	2	**1**	1

Source: own elaboration based on the survey.

Most respondents in the youngest age group described their adaptability as average (Table 5). On the other hand, people aged 25–44 were more likely to describe their adaptability was high. These results corroborate those of Doran and Fingleton (2016) who found that middle-aged people (and men, as also mentioned above) were more resilient. Therefore, younger people may be more vulnerable to crises due to a weaker position in the labor market resulting from less stable employment and lower occupational skills compared to middle-aged people.

Table 5. Overall assessment of adaptability across age groups (in %)

Response categories	18–24 years	25–44 years	45–64 years	65 years and more	Total
Very high	9	11	6	**7**	9
High	35	44	28	**7**	37
Average	46	40	66	71	47
Low	7	**2**	**1**	**14**	5
Very low	2	**1**	**0**	**0**	1

Source: own elaboration based on the survey.

The above hypothesis is partially confirmed by the results of the study of the relationship between the general assessment of adaptability and education. A large group (11%) of the respondents with higher education assessed their opportunities on the labor market and concluded that their adaptability was very high (Table 6). A slightly smaller proportion of those with secondary education felt the same way, while the small number of those with primary and vocational secondary education does not allow for such a clear assessment.

Table 6. Overall assessment of adaptability and the respondents' level of education (in %)

Response categories	Primary	Vocational secondary	Secondary	Tertiary	Total
Very high	**4**	**17**	8	11	9
High	37	31	35	40	37
Average	52	45	49	46	47
Low	**4**	**3**	6	3	5
Very low	**4**	**3**	3	**0**	1

Source: own elaboration based on the survey.

The respondents who did unpaid work (e.g. at home) or studied (slightly more often) rated their adaptability as average or low, compared to those who earned income from work (Table 7). Thus, income opportunities may affect the ability to adapt to health crises such as the COVID-19 pandemic, but this hypothesis could not be fully confirmed because the difference between the analyzed categories was too small.

Table 7. General assessment of adaptability and work performance (in %)

Response categories	No salary / I'm studying	Work for pay	Total
Very high	6	11	9
High	32	41	37
Average	52	44	47
Low	8	3	5
Very low	2	**1**	1

Source: own elaboration based on the survey.

An analysis of the relationship between the adaptability and work performance is consistent with the assessment of the earned income (Table 8). The respondents who found their income to be suffi-

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cient rated their adaptability as very high (11%) or high (40%). The respondents who considered their income to be insufficient evaluated their adaptability as lower, usually average (54%).

Table 8. General assessment of adaptability and the earned income (in %)

Response categories	Income is sufficient	Income is insufficient	Total
Very high	11	4	9
High	41	27	37
Average	44	55	47
Low	4	10	5
Very low	**1**	4	1

Source: own elaboration based on the survey.

However, no strong correlation was found between property ownership and the assessment of adaptability. This is due to the sample selection, where the majority of young people (the so-called millennials) do not equate tangible capital (e.g. owning an apartment) with stabilization and greater opportunities to counteract crises.

The correlation is evident when we take into account the declaration of savings and the perception of adaptability. A large group of respondents with high savings described their adaptability as very high (14%), and the largest group (44%) of the respondents rated it as high (Table 9). Thus, financial capital, which is more mobile than physical capital, has a greater impact on the perceived ability to adapt to crises and supports the social resilience of individuals.

Table 9. Overall assessment of adaptability and financial capital (savings) (in %)

Response categories	High savings	Little or no savings	Total
Very high	14	7	9
High	44	35	37
Average	39	50	47
Low	**2**	6	5
Very low	**1**	2	1

Source: own elaboration based on the survey.

The number of children affected the perception of adaptability to a small extent. The proportion of people who reported a high level of adaptability who had no children or one child was slightly lower than the proportion of people with two children (Table 10). The majority of respondents in each of the analyzed categories described their adaptability as average. Due to the small number of respondents with three or more children, no clear conclusions could be drawn.

Table 10. Overall assessment of adaptability and the number of children (in %)

Response categories	No children	One child	Two children	Three or more children
Very high	10	13	**5**	**13**
High	37	38	42	**31**
Average	45	45	53	50
Low	**7**	**0**	**0**	**6**
Very low	**2**	**3**	**0**	**0**

Source: own elaboration based on the survey.

In summary, the respondents were asked about the importance of limiting their own consumption, material use, and spatial mobility in order to counteract possible future crises resulting from the instability of natural systems. Such an approach

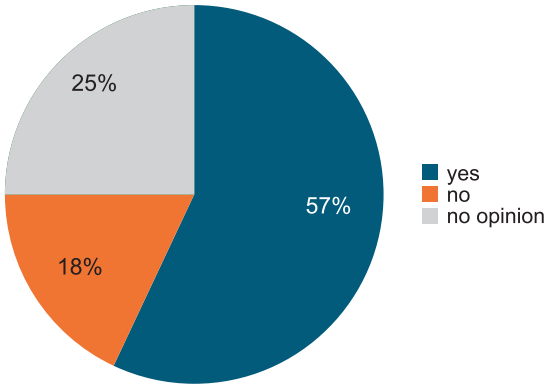

Fig. 3. Assessment that indicates an attitude, consistent with transformative activities, that one should limit one's own consumption, material use, and spatial mobility in order to prevent future crises resulting from the impact of natural systems on societies
Source: own elaboration based on the survey.

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is in line with transformative activities and policies, and represents the most far-reaching stage in the implementation of the concept of resilience (Bristow & Healy, 2020). The result of the survey is optimistic, as 57% of the respondents agreed that such activities should be undertaken (Fig. 3). Only 18% disagreed with the above statement and the remaining group (26%) did not have a specific opinion on this issue.

There were no differences between the above statement and the respondents' place of residence. Both urban and rural residents expressed the above opinions to a similar extent. Such positive attitudes towards transformative activities that contribute to reducing vulnerability to future crises are likely to be a result of the young age of the respondents and their relatively high level of education, as mentioned above. The declaration of participation in training (Fig. 1) also confirms the importance of human capital in the adoption of transformative attitudes.

CONCLUSIONS

The theoretical aim of the article was to identify the components of social resilience, as described in the literature review section. Research on social resilience in the context of the health crisis is a relatively new research field in social sciences, including socioeconomic geography. Social resilience, which refers to a society's ability to respond to disruptions and to constantly adapt to changing circumstances, results essentially from human and social capital, financial and material resources. Going further, "social capital stresses that people provide, access, and use resources embedded within their social networks" (Champlin et al., 2023, p. 3). Especially during a pandemic, enhancing social resilience requires "strengthening collectivistic values, personal responsibilities and social networks on the other" (Schubert et al., 2024, p. 1).

In the context of social resilience and social networks, the results of the current study indicate that the majority of respondents can rely on support from family and friends in case of financial difficulties or job search, while less support is expected from local authorities. This implies that the importance of bonding social capital is essential in the initial phase of the crisis. In the context of health, other studies have demonstrated that communities with stronger bridging social capital had a greater adaptive capacity during the COVID-19 pandemic. After initial peaks, stronger bridging ties led to a faster decline in infection rates, due to a willingness to adopt new health behaviors (Fraser & Aldrich, 2021).

Research results also show that younger and more educated people can rely on such support more often, which indicates their greater social resilience. However, some studies (e.g. Alizadeh & Sharifi, 2021, p. 6) revealed that "individuals with no academic education and young people (up to 20 years old) have experienced more impacts on the state of social resilience during the pandemic". In the present study, males, people who worked for pay, had sufficient income, and reported having savings were characterized by greater social resilience or adaptability to adverse phenomena. The respondents with low levels of education, the elderly and the unemployed were less resilient. Other studies have also shown that the elderly are generally vulnerable to adverse events (Kimhi, 2020). According to the respondents, support from family and friends and, to a lesser extent, help from neighbors or local authorities have an impact on increasing resilience in the event of a crisis. The results of this study contrast with other studies conducted in Switzerland and Singapore, countries with high levels of institutional capital. They indicate, referring to the linking social capital as defined by Aldrich (2012), that "cooperation with and their trust in their leaders turned to be relatively higher compared to the cooperation of residents amongst each other" (Schubert et al., 2024, p. 1).

Finally, it should be emphasized that mainly women, young people, and people with secondary or higher education participated in the survey. A large proportion of the respondents worked and earned an income, did not have children and lived in large urban centers or their suburbs, which contributed to their greater social resilience. However, the respondents generally did not have significant savings or real estate,

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which implies potential vulnerability to crises. Due to the predominance of the social group described above, further research is recommended on other more vulnerable groups, in particular: (1) the elderly, (2) those living in peripheral areas and (3) those in sensitive occupations. Such studies can guide public policy interventions to make societies more resilient to future crises.

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SOCIAL HOUSING MANAGEMENT: A LONG-TERM PLANNING PERSPECTIVE ON THE EXAMPLE OF A POLISH MUNICIPALITY

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ABSTRACT

Motives: Long-term planning and its implementation constitute the basis for effective social (municipal) housing management. Hence there is a need to monitor how these plans are drawn up and the degree to which they are implemented in municipalities so that they contribute optimally to meeting local housing needs using the existing municipal housing stock (MHS).
Aim: The research focused on assessing the implementation degree of the long-term municipal housing stock management program (MHSMP) of the city of Olsztyn in 2017–2021. The trends in social housing management in Europe, in particular regarding the introduction of strategic business planning in the social housing sector, were taken into account.
Results: In the MHS under study, there was a much faster decrease in the number of municipal dwellings than assumed in the plan and high deficits in social dwellings and temporary rooms. Sales of municipal dwellings were lower than planned, although revenues from this exceeded the plan. The operating costs of municipal facilities were determined by an over-planned increase in administrative costs while those for common properties turned out to be lower than planned. The renovation plan for municipal facilities was determined by the limited financial capacities of the municipality and covered a small percentage of the actual renovation needs. It was found that the MHSMP under study did not represent a coherent concept for the MHS management in the long run, was overly formalized, and did not take into account the actual housing needs of the local society. Moreover, it lacked the characteristics of strategic business plans, such as being market-oriented, systematic, comprehensive, and proactive.

Keywords: social housing management, long-term planning, municipal housing stock, Olsztyn

INTRODUCTION

Social housing management is defined in the literature as the set of all activities aimed at producing and allocating housing services from the existing housing stock (Priemus et al., 1999), as well as managing organizations and people to deliver housing services to clients (Walker, 2000). It covers such specific areas as technical management (e.g. conservation and repairs), social management (allocation of social dwellings, etc.), financial management (rental policy, financing), and tenure management (purchase, sale). Social housing management in this approach encompasses both an operational (day-to-day) management

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level and a strategic management level. In a more recent view, social housing management refers to a system that provides long-term housing to a group of households specified only by their limited financial resources, through a distribution system and subsidies (Hanssen & Lundgren, 2019).

Planning as a primary function of management involves conceptual activities that precede and prepare informationally realistic actions (Krzyżanowski, 1985). The most important content of planning is the formulation of the activity's objectives, the determination of the means of achieving these objectives, and the means necessary to achieve them. In terms of the level of planning arrangements, time horizon, and level of detail in an organization's planning system, a distinction is made between strategic, tactical, and operational planning. Strategic planning originated in the management of private business organizations but was later applied in the management systems of public organizations (e.g. Byrson, 1995). Selected models and procedures of strategic business planning have been transferred to management procedures in the social housing sector, where numerous examples of implementation have been found (Gruis & Niebour, 2004, e.g. Larkin, 2000; Van der Flier & Gruis, 2002).

In Poland, the predominant form of social housing consists of municipally owned rental dwellings, known as the municipal housing stock (MHS). The MHS was established by transferring housing stock from the state sector, and it is the mainstay of local housing policy in meeting the housing needs of low-income households and other vulnerable social groups (homeless, evicted, disabled, etc.). In this housing system, the roles of provider, landlord, and manager of social housing are filled directly or indirectly by municipalities and their organizational units. The basic planning instruments for MHS management in Polish municipalities include the long-term municipal housing stock management programs (MHSMPs). They are multi-annual (strategic) in nature and are mandatorily developed and implemented by municipal authorities.

The main aim of the study was to assess the degree of implementation of the long-term municipal housing stock management program (MHSMP) of the city of Olsztyn in 2017–2021. The empirical research was preceded by the presentation of development trends in European countries and strategic business planning in the social housing sector as well as the principles and methods for developing the MHSMPs in Poland. The scope of the empirical research included selected components (detailed plans) of the MHSMP in question, covering such elements as the size of the municipal housing stock, sales of municipal dwellings, and operating and renovation costs in municipal and common properties. The research was conducted using the source documentation analysis method and a face-to-face interview with employees of the Municipal Housing Management Entity (MHME) of the city of Olsztyn.

After the Introduction, this article consists of four parts. The first part presents the literature review, which gives an adequate background to the empirical study; the second part outlines the materials and methods applied to achieve the main aim of the study; the third part provides and discusses the empirical results, and the fourth part summarizes the findings and makes recommendations for further research.

LITERATURE REVIEW

Social housing management – development trends in European countries

Historically, social housing in Europe has traditionally been provided through bureaucratic mechanisms. It mainly concerned the development of new housing stock (social dwellings), which has been driven to a large extent by government finance and subsidization. The management of the existing social housing stock consisted of the day-to-day maintenance and administration of the stock under these conditions. As a consequence, social landlord organizations have operated mainly in a reactive, task-oriented way, in which the strategic decisions concerning the management of this housing stock

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were made mostly by governments, rather than by individual landlord organizations (e.g. Boelhouwer et al., 1997; Gruis & Niebour, 2004). At the same time, there was increasing pressure on social landlords to improve their efficiency and effectiveness (e.g. Walker & Van der Zon, 2000). Furthermore, the role of social housing has become more focused on the management of housing stock as development activity has declined in importance compared to the size of the existing social housing stock.

Influenced by these pressures and in response to changes in the institutional and economic context of social housing in many European countries, housing stock (assets) management in the social rental sector has begun to change (Gruis & Niebour, 2004). The management of social housing has entered a path of transition, influenced by changes in housing policy and housing markets, as well as cultural and demographic changes in many European countries (Czischke, 2009). The widespread reduction of public investment in social housing, the decentralization and deregulation of public services, as well as the privatization of social housing (since the mid-1970s in Western Europe and since the 1990s in Central and Eastern Europe) have placed more and more pressure on social landlords to become more "market-oriented" or "business-like" in order to become self-sufficient (Boelhouwer et al., 1997; Gruis et al., 2009; Hegedüs et al. 2013; Scanlon et al., 2015). As social landlords have become more dependent on the capital market they have been forced to modify their management methods and techniques to make them compatible with the principles of public service reform, which stemmed from the concept of New Public Management (NPM) (Laffin, 2019; Mullins et al., 2001). The two most important management trends in the social housing sector that occurred during the implementation of the NPM concept were externalization and managerialization (Azmy et al., 2023; e.g. Walker, 2000; Yan et al., 2021). Some other reconceptualization initiatives proposed to address the challenges of property management in public (social) housing have also been identified (Ahmed et al., 2022; Bockman, 2018; Huisman & Czischke, 2022; Muczyński, 2018; Teo et al., 2024). Following these transformations, housing organizations have been restructured and more rational management methods derived from the private sector have begun to be implemented (Walker, 2000). In addition, business solutions have started to be used in social housing management and the services provided by social housing organizations have been extended (Czischke, 2009; Mullins et al., 2012). Social landlords are increasingly faced with the need to anticipate developments in the housing market and formulate their original strategies for developing their housing stock. Thus, the basic theories and practices of the private sector that began to be implemented into the strategic housing management in the social rented sector included, in particular, theories (models) and practices associated with strategic business planning (Gruis & Niebour, 2004).

Strategic business planning characteristics and models in the social housing sector

Strategic planning is the process of developing and maintaining a viable fit between the organization's objectives and its resources. Although it originates in the private sector, this concept has also been introduced in the management of public organizations (e.g. Bryson, 1995). Advocates of strategic planning believe the process will enhance and improve systematic information gathering, clarification of organizational direction, establishment of priorities, quality decision-making, communication and understanding of strategic intent, robust organizational responsiveness, effective performance, conscientious framework, useful application of expertise, and attention to organizational learning (Fraser & Stupak, 2002). In short, strategic business planning is expected to contribute to organizational effectiveness and efficiency by following a systematic, rational, and transparent planning process (Muczyński, 2016a). In attempting to implement the principles of strategic business planning as a core component of strategic housing stock (asset) management in the social rented sector, the term of such planning was

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initially established (Gruis & Niebour, 2004). It was adopted after Ansoff (1984), that strategic planning is "*a systematic procedure for management which anticipates the challenge and prepares its responses in advance, based on examination of novel alternatives*". The characteristics of strategic business planning based on business theory (Aaker, 1998; Bryson, 1995; Kotler, 1997) in the context of the intended implementation of such planning to social housing management were then identified (Gruis & Niebour, 2004). The authors summarized that strategic business planning is to be *market-oriented*, *systematic*, *comprehensive,* and *proactive*. A *market orientation* in social housing management can be expected to emphasize analyzing market demand and opportunities. Important decision factors in strategic planning will be current rentability, future market expectations, financial return, and sale opportunities. A wide range of strategic plans will be considered and applied: diversifying the price and quality of housing in the portfolio according to housing demand will be a central theme in asset management. The specific nature of social housing management does not allow social housing landlords (managers) to behave exactly like commercial enterprises. They are limited to offering decent, affordable housing, so a financial return is not their primary aim. Nevertheless, within these constraints, increased market orientation can help these providers realize a portfolio that is effective in meeting housing demand and tenant preferences and economically efficient through using "cash cows" to finance the core social housing stock (Gruis et al., 2004). Market orientation in social housing management can be contrasted with the traditional, *task-oriented* approach that many social housing landlords (managers) have used – and still use – in which they focus solely on the provision and management of cheap and decent dwellings, with only limited variation in rents, quality, tenure, and target groups, and often without aligning these factors. In turn, a *systematically* operating social housing landlord (manager) will put much effort into rational and transparent decision-making. The process of formulating strategic plans will be well structured (Kotler, 1997; Aaker, 1998). Decision-making factors will be marked and how decisions are reached will be reported. This rational planning strategy can be contrasted with an incremental, *unstructured* approach involving a more fragmented, small-scale series of changes (Gruis & Niebour, 2004). A major characteristic of strategic business planning is that it deals with the organization's objectives as a whole, at the top management level. *Comprehensive* social housing management will therefore not only focus on individual dwellings, properties, or estates but also reflect the composition of the entire housing stock. Furthermore, different aspects of social housing stock management will be considered, for example: technical and social activities, long-term and short-term objectives, and activities at a strategic and operational level. This comprehensive (portfolio) approach helps to identify, from a wider perspective, which part of the stock should be prioritized for intensive management and investment. In opposition to comprehensive social housing management, a *partial* or ad hoc operating landlord (manager) will focus mainly on problematic properties or estates, will not formulate objectives for the development of the entire housing stock, and will not consider the synthesis of different parts of the total management approach (Gruis et al., 2004). The final characteristic of strategic business planning is a *proactive* approach (Aaker, 1998; Ansoff et al., 1984). In this approach, managers of a social housing stock will actively identify problems and opportunities stemming from developments in the housing market, housing policy, and market position of this housing stock. In addition, they will anticipate these developments in their housing stock (asset) management strategies (for example: initiating neighborhood renewal even before it has deteriorated). In contrast, *reactive* social housing managers will act after potential problems have become a reality (Gruis et al., 2004).

Most planning models in the social housing sector can be seen as a translation of general models for strategic business planning, specified for housing management. There are many different models in the literature on strategic planning. Some models comprise similar steps, but some can be considered essentially different. For example, Mintzberg (1994) distinguishes

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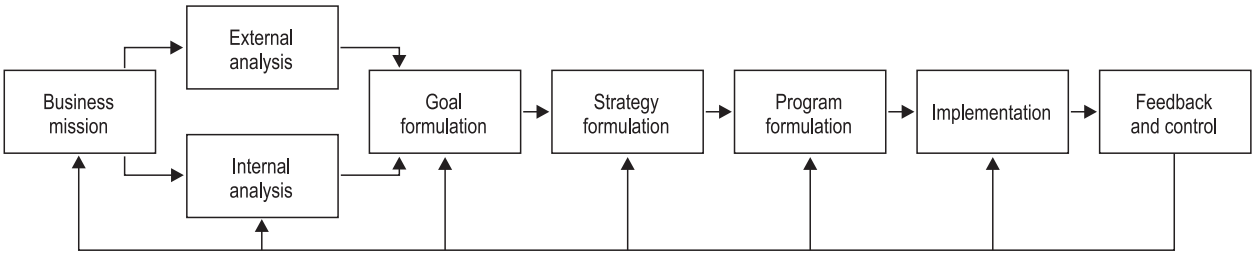

Fig. 1. The strategic business planning process
Source: Kotler (1997).

between the design school and the planning school model. While the design school model "*is built on the belief that strategy formulation is a process of conception – the use of a few basic ideas to design a strategy*" and consequently consists of only a few general steps, the planning school model places great emphasis on the formalizing the planning process and consequently leads to I detailed description. Gruis and Niebour (2004), in their search for a theoretical basis for strategic housing management, used Kotler's general representation of the strategic business planning process (Fig. 1) to describe how housing landlords (managers) can develop their social housing stock management plans in a strategic way.

The authors confined their explanation to the first four stages of this model (from business mission to strategy formulation), considered the central activities of strategic social housing management. In conclusion, they stated that Kotler's model proved useful in developing strategic plans for social housing management. However, to make the model more suitable for social housing management planning, it is necessary to extend it by adding a strategy appraisal stage.

Municipal housing stock management program (MHSMP) as a planning document

Long-term municipal housing stock management programs (MHSMPs) are the primary instrument for creating and implementing development policies in the social housing sector in Polish municipalities. According to the act (2001), the MHSMPs are planning documents developed mandatorily for at least five consecutive years, and therefore refer to the medium-term or strategic time horizon. Their content should include in particular eight components, such as:

- the forecast of the size and technical condition of the municipal housing stock (MHS) by year,
- the analysis of needs, renovation, and modernization plan resulting from the technical condition of buildings and premises in the MHS, divided into subsequent years,
- planned sales of municipal premises (dwellings) from the MHS in subsequent years,
- the principles of rent policy and the conditions for reduction of rent rates,
- the way and principles for MHS management as well as the anticipated changes in subsequent years,
- financing sources of MHS management in subsequent years,
- the amount of expenditure in subsequent years, with division into operating, repairs, and modernization costs of premises and buildings constituting the MHS, management costs of common properties in which the municipality is one of the co-owners, as well as investment expenditure, and
- the description of other activities aimed at improving the use and rationalizing the management of the MHS, including in particular, the necessary scope of exchanges of premises related to repairs of buildings and premises and the planned sale of premises.

These content components of MHSMPs are regarded as the necessary minimum which means that an individual municipa–ity – as a planning en–ity – can introduce additional elements depending on local needs. Some researchers emphasize that the

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above statutory guidelines are necessary to provide the elementary basis for proper MHS management of a typical municipality, however, they do not constitute an internally coherent whole and do not exhaust the problems to be solved (Bończak-Kucharczyk, 2008; Nowak, 2021; Salamon & Muzioł-Węcławowicz, 2015). Further, the statutory guidelines pay too little attention to the actual needs and rationality of planned activities in MHSMPs, and too much to formal issues and the need to secure the claims of persons entitled to municipal dwellings (Majchrzak, 2005).

From the point of view of comprehensive housing development in the municipality, it is necessary to ensure the coherence of the MHSMP primarily with the local housing strategy. This will allow for linkages between the municipal sector and other sectors of the local housing market (Muczyński, 2011) as well as consistency with the general development strategy of the municipality. In addition, the MHSMP should be consistent with the principles for renting and selling municipal dwellings, long-term investment plans of the municipality, housing revitalization programs, as well as spatial development studies, land use plans, and plans for the use of the municipal real estate stock. Taking into account the limitations and guidelines resulting from these documents will avoid many errors and contradictions in the MHSMP as well as the use of ad hoc or ineffective solutions. The MHSMP should be long-term, up-to-date, and efficient. It is therefore particularly important to adopt appropriate methods for its development and implementation mechanisms. In general, there are two methodological approaches for creating such types of programs, namely (Muczyński, 2016b):

a) *a classic approach* whereby the municipality board determines, in the first stage, the strategic goals and directions of the MHSMP, and then cyclically builds on them annual operational plans, the material and financial implementation of which is determined each time in the budgetary resolutions;
b) *a rolling approach* in which the originally developed program is updated and supplemented yearly (new information and tasks) at least one year ahead of time when there is a need for updating it (such as changes in housing policy or laws, change in municipal dwelling sales, increase of rents or housing maintenance costs, etc.).

In conclusion, it is important to emphasize that the MHSMP presents a well-considered concept of action, the implementation of which will ensure that the municipality can effectively fulfill its public tasks in the field of local housing, especially in the management of the municipal housing stock.

MATERIALS AND METHODS

The subject of the conducted empirical research was the municipal housing stock (MHS) of the Olsztyn city in Poland. By the end of 2021, the MHS of Olsztyn consisted of 747 buildings with 3.805 municipal housing units (dwellings) and a total usable floor area of 161,756 m^2. The MHS in question was divided into two segments. The first one (S1) included municipal dwellings located in buildings that were the exclusive property of local authority. It consisted of 113 buildings with 1,305 municipal dwellings. The second segment of MHS (S2) covered municipal dwellings located in buildings in public-private ownership that were independently managed by Homeowners Associations (HOAs). It consisted in Olsztyn of 634 residential buildings with 2,500 municipal dwellings. The age structure of the buildings in the MHS is defective and its technical condition is unsatisfactory, which is due to the negligible scale of the housing investment of the municipality and the successive build-up of the repair gap in the past (Muczyński, 2008). When reaching the assumed standards of municipal buildings and dwellings, about 70% of the stock requires renovations of varying material scope. The MHS is also characterized by the existence of around 1,700 sub-standard dwellings.

The research material enclosed the long-term municipal housing stock management program (MHSMP) of the city of Olsztyn for the years 2017–2021 adopted by the resolution of the City Council (Resolution, 2017) and the financial and substantive reports of its performance developed by

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the Municipal Housing Management Unit (MHMU) of the city of Olsztyn. The main aim of the study, which was to assess the implementation degree of this program in the aforementioned years in terms of its selected components, was achieved using the source documentation analysis method and a direct interview with competent employees of the Municipal Housing Management Entity (MHME) of the city of Olsztyn. The assessment of the implementation degree of individual detailed plans was carried out in relative terms by comparing actual quantities with corresponding quantities planned in subsequent years. The indicators obtained from the comparison were given a quotient form and their values were expressed on a percentage scale and shown in the respective charts.

RESULTS AND DISCUSSION

The first stage of the research of the MHSMP in question assessed the extent to which the plan concerning the size of the municipal housing stock (MHS) of the city of Olsztyn was implemented. It should be emphasized that planning the size of the MHS is a complex issue, as it results from several different factors relating to the management of the stock, its condition, and the level of actual demand for municipal and social dwellings in the municipality. The empirically determined implementation degree (percentage) of the size plan of the examined MHS is presented in Chart 1.

It can be seen from the chart that all three variables describing the actual size of the surveyed housing stock were below their planned level with a tendency for these discrepancies to widen over time. The relatively highest implementation degree of the plan was recorded for municipal (standard) dwellings, as the actual number of these dwellings ranged from 94.7% (in 2017) to 87.4% (in 2021) of the planned volumes. This was due to the slightly faster rate of loss of municipal dwellings from the studied stock (following privatization and decommissioning) compared to the rate of acquisition of new dwellings to the stock (through adaptation, construction, or purchase on the market). A much lower implementation degree of the plan was found for social (intervention, sub-standard) dwellings in the stock, as it ranged from 69.1% (in 2017) to 57.7% (in 2021). By far the smallest degree of implementation of the plan (from 20.0% at the beginning to 10.8% at the end of the period) was recorded in the case of temporary rooms, which are necessary for the execution of court judgments pronouncing eviction from occupied premises without the right to conclude a social tenancy agreement. The faster-than-planned

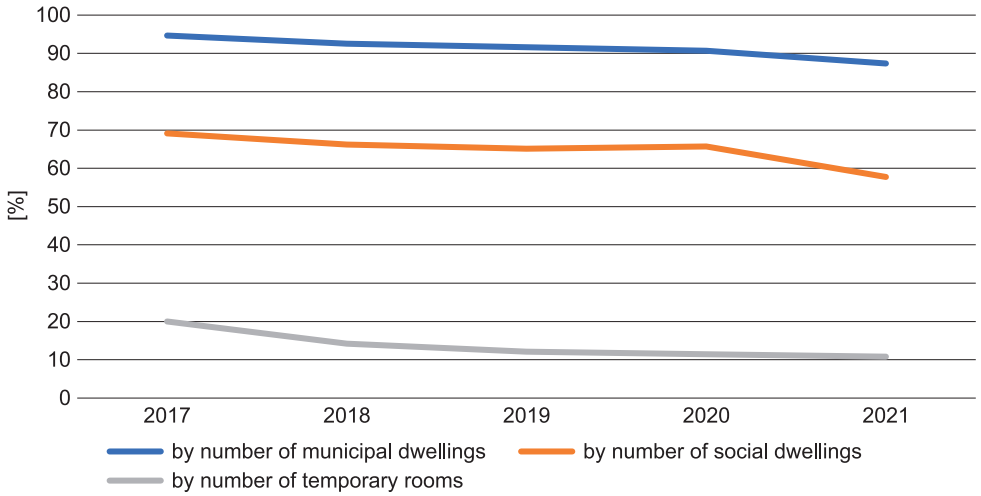

Chart 1. Implementation percentage of the plan concerning the size of the MHS of the city of Olsztyn in 2017–2021
Source: own preparation.

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rate of decline in the size of the MHS occurred during a period of acute failure to meet the actual (legitimate) needs of the local population for municipal and social dwellings and temporary rooms. The coverage rate of actual needs for municipal dwellings ranged from 20 to 30%, while for social dwellings and temporary rooms, it ranged from only 5 to 10%. In the pandemic year 2020, there was a further decrease in the coverage rate, followed by a significant increase in 2021 for municipal dwellings, which raised significantly (to 45.9%) as a result of the completion of the housing project involving the redevelopment of the building at 52/58 Niepodległości Street in Olsztyn. From the above, it can be seen that both the planned and actual volumes of the MHS surveyed deviate significantly from the level that meets the actual housing needs of the local society.

The second stage of the study assessed the implementation degree of the sales plan of municipal dwellings from the MHS in question. The assessment was made by comparing obtained and planned volumes describing the number and the floor area of the dwellings sold and the revenue the municipality received from this activity. The results are shown in Chart 2.

The Chart shows that the selling process of municipal dwellings in the period under study was marked by variable dynamics. In 2018, there was a sharp increase in the number and area of municipal dwellings sold, with the implementation rate of the sales plan of 118.6% and 111.7% respectively, while the municipality revenue from the sale of the dwellings rose to 170.9% of planned revenue. The main reason for this increase in sales was the fear that the municipality would introduce further restrictions in the sale of dwellings to tenants, including a reduction in the price discounts applied, and that the price of dwellings on the market would continue to rise. In the next few years, the number and floor area of municipal dwellings sold declined sharply, reaching only 78.6% and 72.6% of the planned volumes respectively at the end of 2021. After 2018, the level of municipal revenue from the sale of dwellings also declined, but as a result of the increase in dwelling prices in the local market, the level continued to be well above the planned revenue, reaching 140.6% of the plan in 2021. The decline in the number and floor area of municipal dwellings sold below 80.0% of the planned volumes may indicate that, on the one hand, there is beginning to be a shorttarattractive dwellings for sale in the MHS and, on the other hand, a growing shortage of willing tenants who could afford to buy these dwellings.

In the third stage, the implementation degree of the plan concerning operating (maintenance) costs

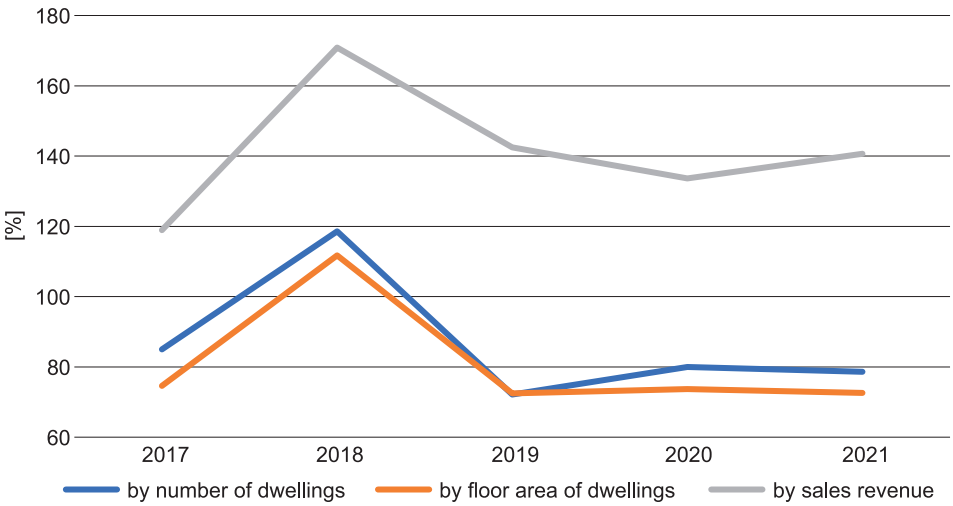

Chart 2. Implementation percentage of the sales plan of municipal dwellings from the MHS of the city of Olsztyn in 2017–2021 (by different indicators)
Source: own preparation.

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of municipal buildings and premises in the MHS under study was assessed. These costs were divided into administration, exploitation, and conservation (technical maintenance) costs. It should be noted that the total operating costs, as the sum of these three cost components, were planned quite precisely, as they ranged from 101.1% and 105.6% of the plan in the years under study. However, the implementation degree of the plan for individual component costs varied considerably, as shown in Chart 3.

The chart shows that the actual administration costs of the municipal buildings and premises, despite the faster (than planned) decline rate of the MHS, clearly exceeded the planned volumes in the following years, amounting to 109.1% in 2017 and 113.7% in 2021, respectively. The analyzed exploitation costs of municipal buildings and premises remained broadly at the planned level in 2017–2018, before declining significantly to 89.7% of the planned level in 2019 before increasing in the last years to reach 98.3% of the plan in 2021. The implementation degree of the plan for these costs was mainly influenced by the prices for services set in contracts with external providers. In contrast, the implementation degree of the conservation costs plan for municipal buildings and premises was relatively the lowest. It stood at 90.7% in 2017, rising to 93.1% in 2019 before declining to 85.1% of the plan in 2021. The degree was based on the actual conservation needs of municipal facilities, including the need for emergency maintenance in connection with emergency events and contracts with service providers securing the most urgent needs. It should be noted that the implementation degree of the plan for total operating costs of municipal buildings and dwellings was determined by the strong increase in administration costs.

In the fourth stage, the implementation degree of the plan concerning operating costs of common properties with a share of the municipality of Olsztyn in the MHS studied was analyzed. The review of the total operating costs of these common properties, which were charged to the municipality showed that they were on a declining tendency, ranging from 98.7% in 2017 to 85.4% of the plan in 2021. The results for the individual components of the operating costs analyzed are shown in Chart 4. The chart shows that the implementation degree of the plan for the exploitation costs of the common properties fluctuated around the planned level indicating a slight decline from 101.1% in 2017 to 98.6% in 2021.

In contrast, the actual administration and conservation costs of common properties under study showed a steady declining tendency over the examined period, as a result of which the implementation degree

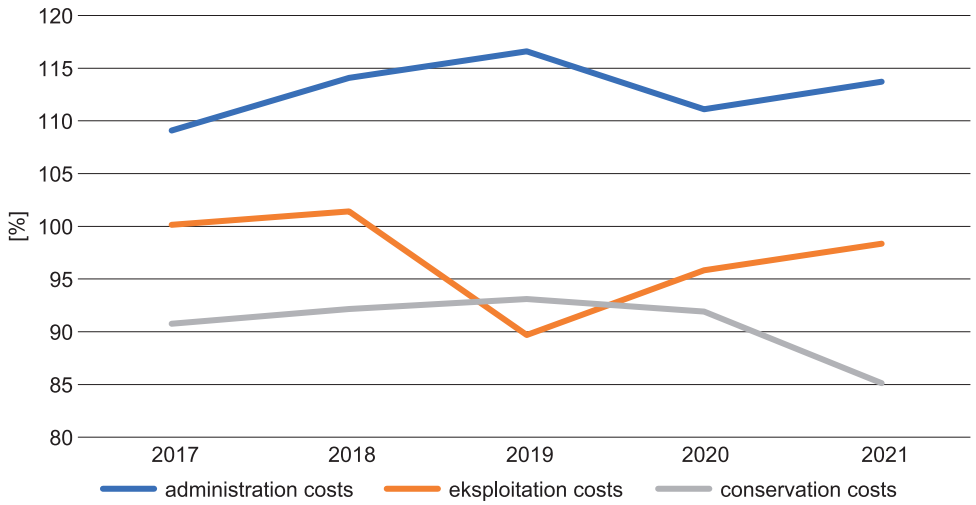

Chart 3. Implementation percentage of the plan concerning operating costs of municipal buildings and premises in the MHS of the city of Olsztyn in 2017–2021

Source: own preparation.

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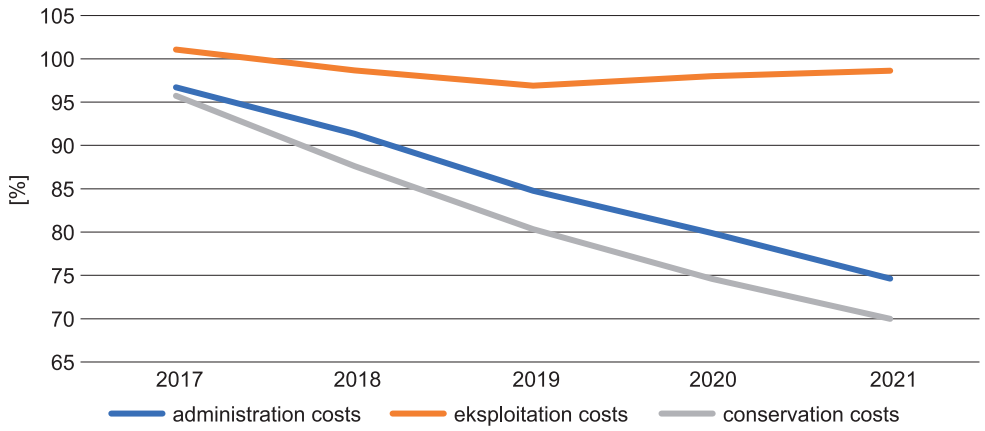

Chart 4. Implementation percentage of the plan concerning operating costs of common properties (with a share of the municipality) in the MHS of the city of Olsztyn in 2017–2021
Source: own preparation.

of the plan for these costs declined from 96.7% and 95.7% in 2017 to 74.6% and 70.0% in 2021, respectively. It should be noted that the actual implementation degree of the plan for these costs resulted from the autonomous resolutions of many public-private Homeowners Associations (HOAs). It was also a consequence of the reduction of municipal shares in common properties owned by these HOAs due to the sale of municipal dwellings to tenants.

The final stage of the study assessed the implementation degree of the renovation plan in the MHS under study. The assessment was made by comparing the actual and planned renovation costs in the three components of the MHS such as municipal buildings, municipal premises, and common buildings owned by HOAs with a share of the municipality. The obtained results of the relative (percentage) assessment are shown in Chart 5. The study shows that the renovation costs for municipal buildings in the first three years were close to the planned level reaching 97.9% of the plan in 2019. Then, in the pandemic year 2020, these costs declined drastically to around 50% of the plan and remained at this low level in 2021. In contrast, the actual renovation costs

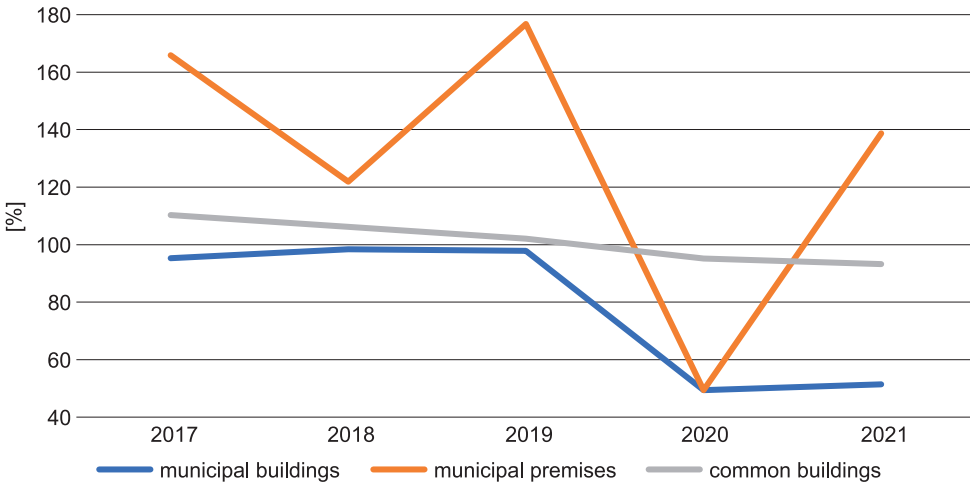

Chart 5. Implementation percentage of the plan concerning renovation costs in the MHS of the city of Olsztyn in 2017–2021
Source: own preparation.

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of municipal premises showed a variable dynamic, significantly exceeding the planned level by 21.9% in 2018 and by 76.8% in 2019. In the critical year 2020, these costs declined to 49.4% of the plan, before recovering to 138.7% of the plan in 2021.

The lack of sufficient funds for renovations and the difficult situation in the contracting market made the safety of tenants a priority for renovations in municipal buildings and premises, so priority was given to work to remove emergency conditions that threatened people's lives or health as well as the safety of property and the environment. The biggest renovation needs resulting from the periodic inspections concerned works such as repairs to installations and roads, insulation of buildings and repair of facades, repairs of roofs and chimneys, as well as repairs of staircases and replacement of window and door frames and floors in premises. It should be emphasized that, despite the relatively high implementation level of the renovation plan for municipal buildings and premises (especially at the beginning of the period), the renovations carried out covered only about 30% of the most urgent and only about 10% of the total renovation needs in these facilities. On the other hand, the costs incurred by the municipality for the renovation of common buildings owned by HOAs fluctuated around the planned level showing a constant declining tendency. Thus, the implementation degree of this plan ranged from 110.3% in the first to 93.2% in the last year of the period under study. This was due to the independent renovation decisions made by the HOAs and the decline of municipal shares in common properties owned by them.

CONCLUSIONS

In many European countries, the management of social housing has been changing from a traditional to a more market-based approach in response to the decentralization and deregulation of public services, the reduction of public funding, and the privatization of housing. These changes are particularly related to introducing planning models and instruments from the private sector into strategic social housing management. In Poland, the main planning instruments in social (municipal) housing management are municipal housing stock management programs (MHSMSs), which, as compulsory documents to be drawn up in municipalities, set out the directions, objectives, and activities of MHS management in the medium-term perspective with a comprehensive view. The empirical research on the implementation degree of the MHSMP of the city of Olsztyn allowed the following specific conclusions to be drawn.

1. The research revealed a much faster rate of decline in the number of municipal dwellings in the MHS than anticipated in the plan due to the sale and withdrawal of housing units from this stock and the lack of significant housing investments by the municipality. Much higher relative deficits against the plan occurred for social dwellings, and dramatically high for temporary rooms. The comparison of planned volumes with actual needs in each housing category shows that the plan for the size of the MHS was eminently reactive (if not purely formal) in that it was not aimed at fully meeting the housing needs of those eligible for housing assistance from the municipality.

2. Higher than planned municipal revenue from the sale of municipal dwellings has not stemmed the decline in the number of dwellings in the MHS. Sales of municipal dwellings from the MHS appear to have exceeded reasonable limits as there is beginning to be a shortage of attractive housing units for sale and tenants who can afford to buy them. In addition, the sale of municipal dwellings was conducted disregarding the actual needs for municipal and social dwellings in the MHS under study.

3. The implementation degree of the plan for operating costs of municipal buildings and premises confirmed the relatively high administration costs charged by the relevant municipal unit (MHMU) despite the declining number of these facilities in the MHS. In addition, there was a trend towards under-performance of the plan for conservation costs of municipal buildings and premises in the MHS, which may have reduced the utility values of these facilities and created greater risks for their users.

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4. The non-full and continuously declining implementation degree of the plan for administration and conservation costs in common properties may indicate more efficient property management services provided to HOAs by private property management entities than by municipal ones. In contrast, the plan for exploitation costs in common properties was almost fully realized.

5. The renovation plan for municipal buildings and premises was determined by the limited capacity of the municipality to finance them, covering only a small percentage of the actual renovation needs in these facilities and focusing on the most urgent ones. Hence, even the high implementation degree of this plan (especially in the pre-pandemic period) did not hinder the deterioration of municipal buildings and premises, which means that the long-term goal of the MHSMP, which was to improve the technical condition of the MHS, was only marginally achieved.

The results obtained from the own research and the empirical conclusions formulated lead to a rather critical assessment of the MHSMP of the city of Olsztyn in 2017–2021. This program was not a fully coherent concept of the MHS management in the long run, it did not take into account the actual housing needs of local society, and only to a small extent contributed to fulfilling the mandatory tasks of the municipality in the area of housing. Moreover, it did not meet the analyzed criteria for strategic business planning, such as being market-oriented, systematic, comprehensive, and proactive. Hence, further research should be aimed at a broader adaptation of the principles, methods, and models of strategic business planning in municipal (social) housing stock management.

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DECLINE IN THE DIVERSITY OF THE DENDROFLORA OF LUBLIN ON THE EXAMPLE OF HOUSING ESTATES BUILT AT THE TURN OF THE XXTH AND XXI CENTURY

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ABSTRACT

Motives: The need to maintain species diversity in cities has been widely reported in the literature. Among other things, it promotes plant resistance to climate change, reduces susceptibility to diseases and pests, and increases the visual attractiveness of the landscape. The proper design of tall vegetation is particularly important in residential areas, where it affects the quality of life of residents. Meanwhile, the degradation of green spaces in cities has been observed.
Aim: The aim of this study was to determine the condition of greenery in Lublin's housing estates and to describe changes in its formation in different time periods.
Results: In Lublin, a decrease in the number and diversity of tree species in residential areas was observed, and it was greatest in newer neighborhoods. It is necessary to recognize this phenomenon and take measures to stop this process, e.g. by introducing new planting standards to ensure good living conditions, protect biodiversity, and create an efficiently functioning system of green areas.

Keywords: housing estates, vegetation diversity, trees, Lublin

INTRODUCTION

Housing estates are an integral part of cities. Their beginning is related to the changes brought about by the Industrial Revolution, which took place in Europe at the turn of the 18th/19th century and resulted in a growing demand for housing. Areas of residential development with high building densities and population concentrations were created (Szafrańska, 2016). In Poland, multifamily housing developed intensively in the second half of the 20th century (Kimic, 2010; Szafrańska, 2016). Modernist settlements were being built. The principles of their formation were governed by urban planning norms, which determined the manner of development and land use (Szafrańska, 2016). The settlements were distinguished by multi-story multi-family buildings loosely distributed in the surrounding green areas, which provided appropriate sanitary conditions: the possibility to ventilate the space, light to the buildings and places for recreation (Rabiej & Tomkiewicz, 2016).

The 1990s brought changes in the creation of housing developments and the organization of settlements. The public sector withdrew from the mass construction of housing, while the market opened up to private investors, helped by the liberalization of zoning laws

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and the elimination of housing norms (Kaczmarek, 2021). The emerging development takes the form of single buildings or their complexes, the location of which, dictated by the availability of free space, is often random: they appear both among existing buildings, as infill, on the outskirts of settlements, on reclaimed or newly de-landed land. Fencing off settlements has become popular (Szarek-Iwaniuk, 2019; Trzaskowska & Adamiec, 2015). Developments created by commercial investors are characterized by arbitrariness of form and aesthetics. The lack of connection between new investments and the character of settlements results in spatial chaos (Szafrańska, 2016). Developments of the early 21st century are distinguished by the lack of preservation of proportions between buildings and green areas. Most of the land is covered with paved areas, impermeable to water. Vegetation has low natural value and does not improve the quality of residential spaces (Trzaskowska & Adamiec, 2015). The areas around buildings are used for parking and transportation purposes (Ziemiańska et al., 2019). This contributes to excessive surface heating in summer and the creation of urban heat islands (Szczepanowska, 2015).

However, greenery is an indispensable component of settlement areas, which are inhabited by almost half of the urban population in Poland (Rębowska, 2000) and around the world (Zhang & Jim, 2014), a number that studies predict will increase. According to the UN, in 2030, 60% of the population will live in cities, while in 2050, 70% (Borcuch, 2020). The role of greenery is widely recognized as important (Asanok et al., 2021; Maas et al., 2009; Sobczyńska, 2014). It has natural, microclimatic, health, aesthetic and compositional significance (Sobczyńska, 2014). In urban landscape design, the use of trees is a key element. Knowledge of their benefits has increased significantly in recent decades (Wolf, 2003). Trees absorb carbon dioxide and produce oxygen, remove pollutants (Suchocka, 2013), reduce the urban heat island (Asanok et al., 2021), and regulate local climatic conditions (Garczyńska et al., 2017; Suchocka, 2013; Wolf, 2003). By affecting the quality of the environment, they contribute to the physical health and well-being of residents (Asanok et al., 2021; Borowski & Pstrągowska, 2015; Krzywnicka & Jankowska, 2021; Maas et al., 2009; Suchocka, 2013; de Vries et al., 2003; Wolf, 2003). People who live among greenery are less likely to suffer from certain diseases, including depression and anxiety disorders (Maas et al., 2009). And being among plants has the effect of reducing nature deficit among children and adolescents (Louv, 2005). Trees improve the aesthetic quality of urban spaces, mask neglected places, enhance architecture, and create spatial order (Suchocka, 2013). Large, tall trees with spreading crowns are considered the key component of neighborhood greenery in performing the indicated functions, because the ecosystem benefits provided are related to the size of the plants, understood as the assimilative area of leaves or needles (Borowski & Pstrągowska, 2015; Ely, 2009; Morgenroth et al., 2017). The decreasing share of green space in residential areas should also be compensated for by a multi-layered vegetation structure, similar to that found in open areas (Szulczewska, 2015).

Any construction, is an unavoidable interference with the natural environment, but it can be carried out responsibly, with respect for the environment. It is worth taking care to compensate for the lost natural values by introducing diverse greenery, which used to be secured by urban planning norms for residential areas (Baum, 2018).

Urban vegetation diversity is directly correlated with human well-being. It influences aesthetic appearance, guarantees resistance to pests, diseases, climate change, including urban heat island (Morgenroth et al., 2017; Shrewsbury & Leather, 2012; Sjöman et al., 2012). However, biodiversity is threatened by increased urbanization (McKinney, 2002, 2006). This topic is readily addressed in scientific studies, which mostly focus on species richness. Few of them address species composition and traits, and how they are shaped (Liu et al., 2017).

The aim of the study was to diagnose the state of greenery of Lublin's housing estates established in the second half of the 20th century and at the beginning of the 21st century. The state of high greenery was analyzed in terms of the number

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and diversity of taxa forming it and the presence of potentially large trees in its composition. Another goal was to show the changes in the formation of the greenery of settlements established in different periods of time. Looking for the reasons for the low diversity of greenery, strategic documents were analyzed (e.g., Climate Change Adaptation Plan for Lublin and Greenery Formation Standards).

MATERIALS AND METHODS

For the purpose of the study, an inventory of woody plants of three Lublin housing estates was carried out in 2020–2022. Their selection was guided by the size of the area, similar location in the mid-western part of Lublin (Fig. 1), habitat conditions, time variation of emergence. These include the Skarpa Estate, where the survey covered an area of 27.338 ha, the estate on Kryształowa Street with an area of 26.973 ha, and the estate on Gęsia Street with an area of 24.332 ha. The area of the sites was measured using Geoportal tools (2022). The oldest is the Skarpa Estate, which was built in the 1970s–90s and is located in the North Czuby district. The buildings here were erected using large-panel technology. They are accompanied by extensive green areas (Osiedle Skarpa, 2022; Szulc & Mącik, 2017). Settlement areas on Gęsia Street and Kryształowa Street are located

Fig. 1. Location of the residential neighborhoods selected for the study against the background of Lublin

Source: own elaboration based on Geoportal Miejski (2024).

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in the Węglin Południowy district. These are developer developments. Buildings began to be constructed here after 2010 (Investmap, 2022a; b). Most of them are finished and inhabited, and the surrounding areas are landscaped, including in terms of plantings.

A dendrological inventory was carried out on each of the estates using the march method, which consists of a physical inventory of trees, shrubs and climbers. The botanical nomenclature is given after Seneta et al. (2021). For each settlement, the number of individuals of woody plants, the number of species and genera represented were determined. Large trees were also distinguished. Species that could potentially reach at least 10 m in height were considered as such (according to Seneta et al., 2021). The number of trees, species and genera were determined for them.

Planning documents for residential areas and urban greenery were analyzed. The following were considered: provisions on greenery in the 1974 Urban Planning Normative (Dąbrowska-Milewska, 2010), the Polish Architectural Policy (2011), the Regulation of the Minister of Infrastructure of April 12, 2002 on the technical conditions to which buildings and their location should conform, the Plan for Adaptation to Climate Change of the City of Lublin to 2030 Draft (2018), Standards of shaping and maintaining greenery in Polish cities: Lublin (Biuro Miejskiego Architekta Zieleni UM Lublin & Durlak, 2022), Krakow and Wroclaw (Maliszewska, 2022), Lodz (Dworniczak & Reda, 2021), Szczecin (Kubus et al., 2020), Warsaw (Borowski et al., 2016).

RESULTS

In the study areas, 9189 woody plants were inventoried. On the Skarpa Estate there were 4027 woody plants, they represented 109 species from 65 genera. On Kryształowa Street, 2875 individuals belonging to 86 species from 52 genera were inventoried, while on the estate on Gęsia Street: 2287 individuals from 90 species and 59 genera. There are fewer species and genera of woody plants in the younger settlements (Fig. 3), fewer individuals were recorded (Fig. 2).

Among the most numerous genera on the Skarpa Estate were: *Robinia, Acer, Prunus, Malus* and *Tilia* (Fig. 4). The most common species were: black locust *Robinia pseudoacacia* L., ashleaf maple *Acer negundo* L., cherry plum *Prunus cerasifera* Ehrh., norway maple *Acer platanoides* L. The most numerous genera on the Kryształowa Street estate were *Juniperus*, *Thuja*, *Spiraea*, *Acer*, *Betula*, *Prunus*, and *Sorbus* (Fig. 5), while the dominant species were american

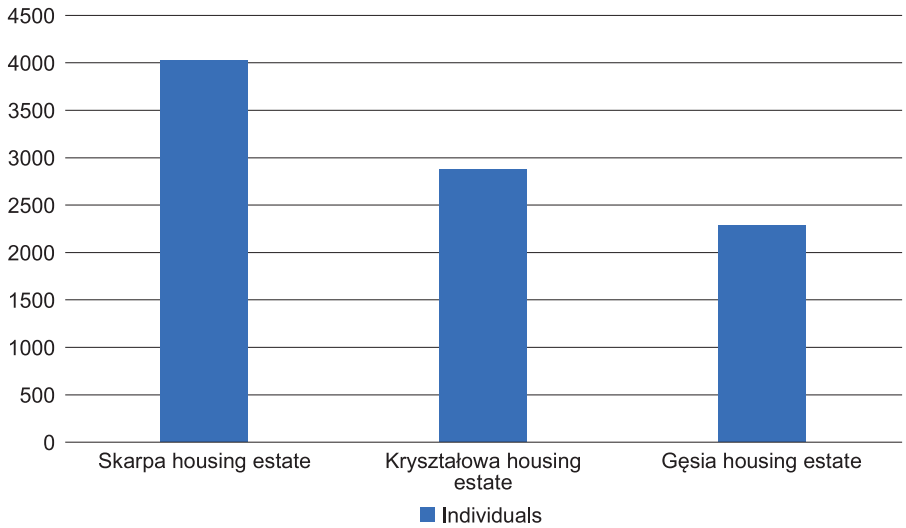

Fig. 2. Quantitative share of dendroflora (trees, shrubs, climbers) in selected residential areas of Lublin – individuals
Source: own elaboration.

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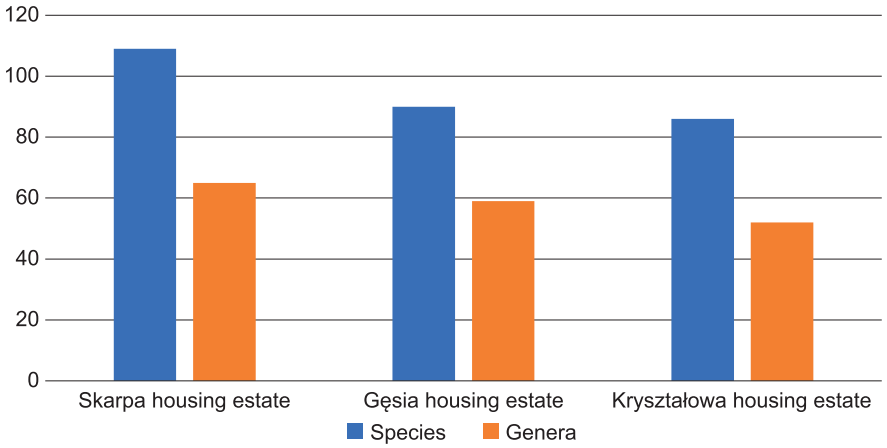

Fig. 3. Quantitative share of dendroflora (trees, shrubs, climbers) in selected residential areas of Lublin – species and genera
Source: own elaboration.

arborvitae *Thuja occidentalis* L, Japanese spirea *Spiraea japonica* L. f., common silver birch *Betula pendula* Roth and Norway maple *Acer platanoides* L. The most common genera at Gęsia Street included: *Thuja, Juniperus* and *Acer* (Fig. 6). The dominant species, however, were American arborvitae and varieties of *Thuja occidentalis* L. and Norway maple *Acer platanoides* L.

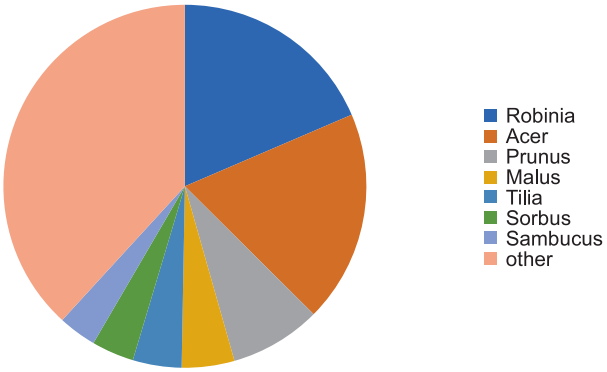

Fig. 4. Dendroflora of the Skarpa Estate – dominant genera
Source: own elaboration.

Analysis of the dendroflora of the estates in the categories of trees, shrubs and climbers shows that on younger estates the number of species and types of trees decreases (Fig. 8), and the number of specimens also decreases significantly (Fig. 7).

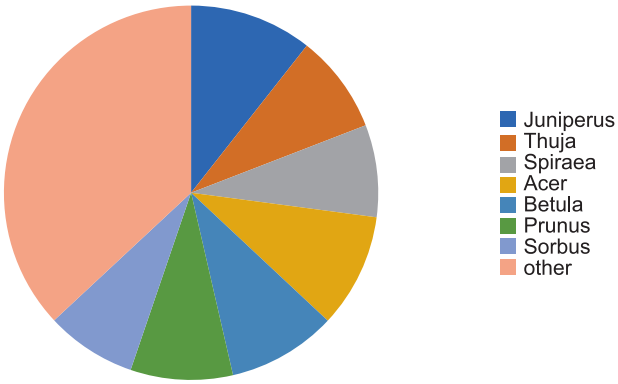

Fig. 5. Dendroflora of the Kryształowa Estate – dominant genera
Source: own elaboration.

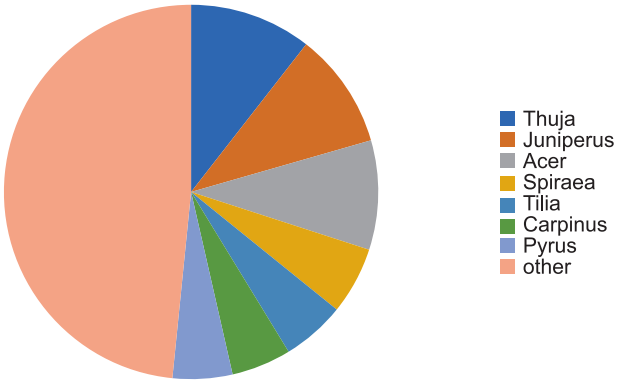

Fig. 6. Dendroflora of the Gęsia Estate – dominant genera
Source: own elaboration.

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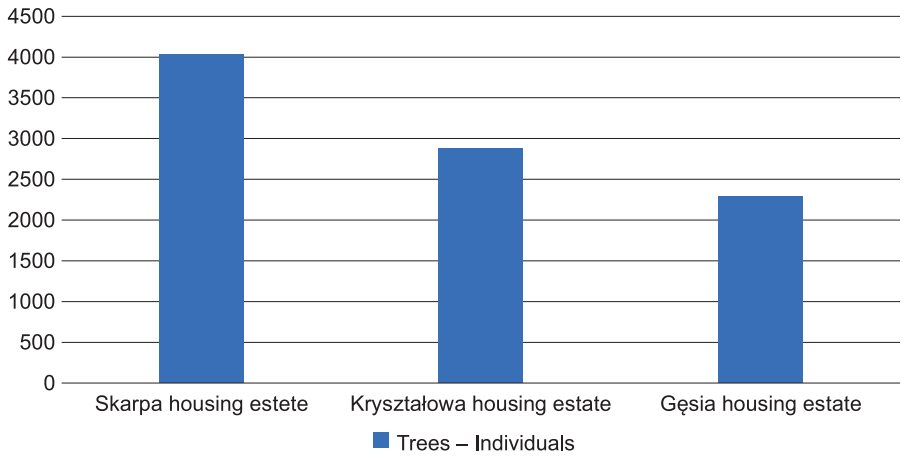

Fig. 7. The number of trees in the surveyed residential areas – individuals
Source: own elaboration.

The opposite is true for shrubs, where on younger estates the number of species representing them decreases (Fig. 10), but the number of specimens increases (Fig. 9). In the case of vines, an increase in the number of species, genera, as well as specimens is evident on younger estates.

The number of trees reaching at least 10 meters in height totaled 4771. In the Skarpa Estate, 2954 trees from 53 species and 29 genera were inventoried. On Kryształowa Street, 1003 specimens belonging to 42 species from 27 genera were found, while on Gęsia Street, 814 trees representing 90 species from 59 genera were found.

Among the inventoried trees on the Skarpa Estate, 1131 were native specimens belonging to 25 species, 882 native trees of 18 species were counted on the Kryształowa Street estate, and 528 specimens of 19 species were counted on Gęsia Street. The survey showed that in the group of woody plants, which includes trees, shrubs and climbers, the number of species has decreased: in the youngest estates, it has decreased by about 20% compared to the number recorded in the greenery of the older Skarpa Estate. The number of species of large trees has also declined, their number decreasing by 7–17%.

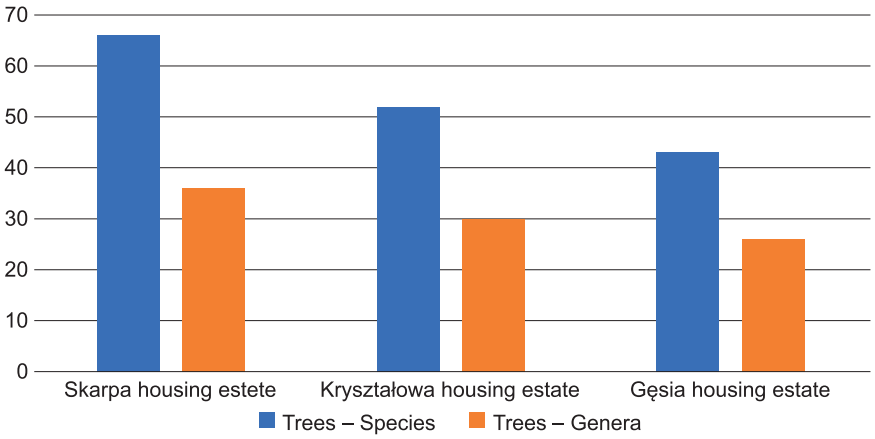

Fig. 8. The number of trees in the surveyed residential areas – species and genera
Source: own elaboration.

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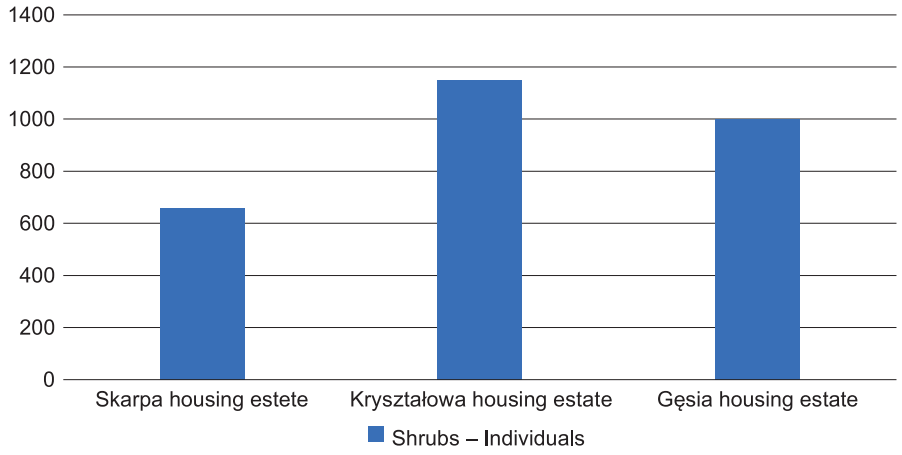

Fig. 9. The number of shrubs in the studied residential areas – individuals
Source: own elaboration.

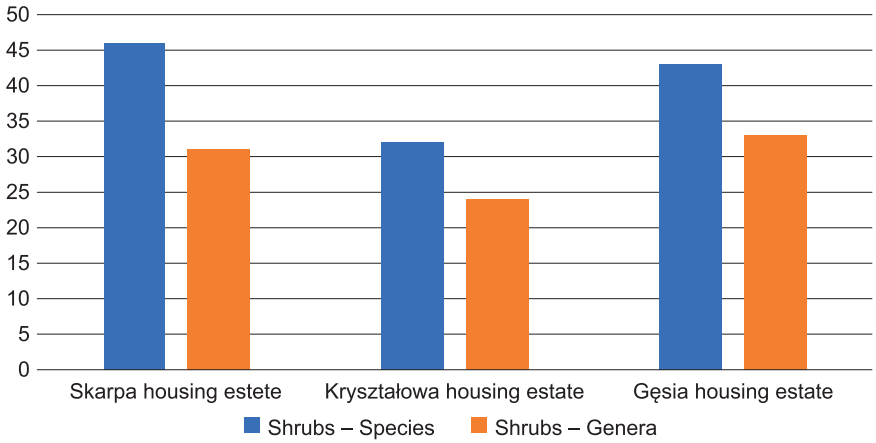

Fig. 10. The number of shrubs in the studied residential areas – species and genera
Source: own elaboration.

An analysis of greenery standards developed for Polish cities shows that they provide guidelines for implementation and maintenance work on urban trees, and can be enriched with suggestions for plant species selection. However, they do not indicate the principles of shaping neighborhood greenery or species preferred for the climatic benefits provided or ecological importance. Their observance is not mandatory. Also, the analyzed strategic documents do not indicate how settlements should be shaped in terms of planting plants, they say in general that greenery in cities is needed, it should be taken care of, new green areas should be developed, trees should be planted as a valuable component of them.

DISCUSSION

Similar changes to the young settlements in Lublin are observed in many places in Poland (Garczyńska et al., 2017; Kronenberg, 2012; Łakomy, 2011) and around the world (Jim & Zhang, 2015; Sjöman et al., 2012; Wang et al., 2014). Biodiversity is declining at global, regional and local scales (Grimm et al., 2008). This phenomenon is registered in urban areas, where land previously covered with vegetation is being developed and paved over (Kimic, 2010; McKinney, 2006; Trzaskowska, 2020). Such activities promote the formation of the urban heat island phenomenon. As reported by Kuchcik et al. (2019) and Kuśmierz

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et al. (2018), it occurs to an intensified degree in areas of high, compact development in urban centers, as well as in densely built-up neighborhoods with a small share of biologically active area (less than 25%). According to data from the map of land surface temperatures in the Lublin Functional Area (Diagnosis for the Climate Change Adaptation Plan, 2019), in Lublin, the highest maximum temperatures are recorded in the city center and also cover the areas of all the surveyed settlements: Skarpa, on Kryształowa Street and on Gęsia Street. The areas of the studied settlements have also been classified as a zone of very high risk associated with climate change (Kuśmierz et al., 2018). As areas where adverse climatic impacts are recorded, these areas require intensified mitigation efforts. Szczepanowska (2015) in mitigating the urban heat island points especially to the significant function of trees and Kuchcik et al. (2019) on the extent of green cover at 42–45%. The low number of trees also reduces the quality of the human living environment (lack of recreational areas, opportunities for contact with nature), reflects negatively on the health of residents (increase in summer temperatures), especially the sick, elderly and children (Kronenberg, 2012; Kuśmierz et al., 2018). On the other hand, it is the high level of biodiversity of green spaces in cities that is associated with physical and mental well-being of people (Carrus et al., 2015; Morgenroth et al., 2017; Nielsen et al., 2014).

Many authors report that the number of trees in urban green spaces is decreasing (Garczyńska et al., 2017; Kronenberg, 2012; Suchocka, 2013). This phenomenon has been well described in the United States, where it affects cities such as New Orleans, Houston, Albuquerque (Nowak & Greenfield, 2012), or the state of California (McPherson et al., 2016). This is also confirmed by our research, which showed that the number of trees, shrubs and climbers of the youngest estates is about 30–40% lower compared to the older Skarpa Estate, while the number of trees reaching at least 10 m in height is as much as 70% lower in the youngest estates compared to the Skarpa Estate. These data also coincide with a study by Trzaskowska and Adamiec (2015a), who point out that development estates lack places to plant trees that grow to large sizes. This seems to be the primary and main reason for the phenomenon described here.

Another disturbing phenomenon is the change in the species composition of urban greenery: trees that can reach considerable heights, develop elaborate crowns, form a large mass of foliage and provide many environmental benefits, such as the maples *Acer* spp. noted in the Skarpa Estate, lindens *Tilia* spp., rowans *Sorbus* spp., or Siberian crabapple trees *Malus baccata* (L.) Borkh., are being replaced on development estates by numerous planted shrubs, among which junipers *Juniperus* spp., arborvitae trees *Thuja* sp., and brideworts *Spiraea* spp. dominate. The trend of replacing large trees with smaller forms is also seen in other cities, with, as in Lublin, the trend being associated with new developments (Britt & Johnston, 2008). The greenery of real estate development projects presents little natural value and does not contribute to the creation of high-quality spaces for residents; it is aimed only at performing representative functions (Trzaskowska & Adamiec, 2015). Higher quality greenery performing multiple functions (climatic, ecological, natural) is characterized by older settlements, within which there is a multi-layered structure of vegetation with a high proportion of old trees (Szulczewska, 2015).

A feature of urban greenery is the presence of introduced species in its composition, the number of which is increasing from suburban areas towards the center (McKinney, 2002). The use of non-native plants is related to both their ornamental qualities and their increased resistance to many of the unfavorable conditions found here. Non-native species in cities compete with native vegetation, and their large contribution to ecosystems can impair environmental benefits (McKinney, 2006; Nielsen et al., 2014). An unfavorable phenomenon has been observed in Lublin, the number of native trees in new housing estates is 22–53% less than the Skarpa Estate, while the number of native species in new housing estates has decreased by 24–28%. The reduction in the number of native trees is also confirmed by studies

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by Bertin (2002), Chocholouskova and Pysek (2003), McKinney (2006).

The deterioration in the quality of urban greenery in Poland is related, among other things, to the abolition of urban planning norms that functioned in the past, which defined the minimum area of greenery per inhabitant as 8 m^2, and the minimum total area allocated for greenery as 50% of the site. Currently, the rate of greenery in residential areas has been limited to 25% of the biologically active area, which also includes the grassed roofs of underground garages (Regulation of the Minister of Infrastructure of April 12, 2002 on the technical conditions to be met by buildings and their location; Schneider-Skalska, 2004; Dąbrowska-Milewska, 2010; Kłopotowski, 2016). This can be improved by introducing new greenery standards. Measures that develop tree management programs and lists of taxa recommended for planting are already introduced by many cities around the world (Borowski & Pstrągowska, 2015; McPherson et al., 2000) and in Poland (Borowski et al., 2016; Dworniczak & Reda, 2021; Muras, 2016). In addition, Jim (2002, 2001, 2000) points out that the situation of urban tree planting can also be improved through measures such as: reorganizing greenery management institutions, coordinating and clarifying their responsibilities to increase the efficiency of their activities, establishing appropriate legal instruments to manage and protect trees. According to Jakubowski (2013, 2018), Bergier et al. (2018) and Jeleński (2018), it is important to conduct education and encourage local communities and NGOs to participate in greenery management, introduce tree planting and care programs aimed at increasing the quantity, quality and diversity of trees, develop local species selection guidelines that take into account native trees and species that reach large final sizes. Morgenruth et al. (2017) remind us that biodiversity should be promoted at the species, age and spatial levels, while urban tree inventories are helpful in its management. As Jim (2002) and Bożętka (2008) point out, for the preservation of good condition of trees in cities, it is also important to take care of the connections between the greenery elements inside the city and the greenery of suburban areas. It is important to preserve forest enclaves and remnants of natural greenery in cities, as well as the high content of natural elements in green structures penetrating the urban fabric and connecting the greenery of the city with the greenery of the outside world. The creation of an urban greenery system linked to the natural environment will help increase its quality and strengthen its beneficial impact on the city space.

The indicated guidelines and good practices of greenery planning and management should provide a premise for Polish cities. Their implementation will be helpful in increasing the number and improving the quality of green areas in urban areas.

CONCLUSIONS

Over the course of 40 years, unfavorable changes in the formation of the tall greenery of residential areas of Lublin are evident. Both the number of species and woody plants is decreasing. Negative changes are noticeable in the quality of greenery: formerly planted tall deciduous trees are being replaced by small shrubs, among which coniferous species have a significant share. The two younger estates were dominated by arborvitae trees *Thuja* sp., junipers *Juniperus* spp. and brideworts *Spiraea* spp. These are plants that reach small sizes and are therefore suitable for use in small garden settings. However, they are not beneficial in mitigating climate change (the occurrence of an urban heat island) in settlement areas.

The estate dendroflora includes fewer and fewer native species, which are being replaced by introduced taxa. Too high a proportion of them in the greenery can negatively affect the amount of beneficial environmental impacts delivered.

In modern cities, it is necessary to strive to halt negative changes and properly shape neighborhood greenery. The introduction of diverse plant forms, a significant proportion of tall deciduous trees, diversification of species composition and attention to native species, planting of plants adapted to climatic conditions, are measures that provide an opportunity for the vegetation cover, providing numerous

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environmental benefits, to contribute to mitigating the phenomenon of urban heat island and creating a good quality living environment for residents. To achieve this, it is necessary to introduce multifaceted measures based on guidelines being developed around the world, among which it is worth mentioning the introduction of new greenery standards, the introduction of specific data into strategic documents, educational activities, tree planting and care programs, or the development of local greenery species selections that take into account the opinions of local communities.

Author contributions: authors have given approval to the final version of the article. Authors contributed to this work as follows: E.T. developed the concept and designed the study, E.T. and J.R. collected the data, J.R. analysed and interpreted the data, J.R. prepared draft of article, E.T. and J.R. revised the article critically for important intellectual content.

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THE COURSE OF THE COVID-19 PANDEMIC IN POLAND IN RELATION TO THE LEVEL OF SUSTAINABLE DEVELOPMENT – MULTISCALE GEOGRAPHICALLY WEIGHTED REGRESSION ANALYSIS

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ABSTRACT

Motives: This article explores the relation between the course of the COVID-19 pandemic and the level of Sustainable Development of Polish counties. First, the data was collected to describe the level of Sustainable Development in terms of Social, Environmental and Economical indicators. In the second step, using data regarding the number of COVID-19 cases and the number of deaths caused by the pandemic, a regression model was built using Multiscale Geographically Weighted Regression (MGWR).
Aim: Authors decided to create a comprehensive model of the level of Sustainable Development. This approach made it possible to analyze the relations between the level of Sustainable Development and the course of the COVID-19 pandemic, as well as provided an opportunity to address the individual components of the model.
Results: The values of the coefficient of determination of the regression model indicate a high and very high fit. The MGWR model also made it possible to develop maps of local R-Squared values. These maps, by exploring spatially varying relationships between variables, further allowed to identify local anomalies of the phenomenon.

Keywords: COVID-19, pandemic, GWR, MGWR, Geographically Weighted Regression, Multiscale Geographically Weighted Regression

INTRODUCTION

The first cases of COVID-19 were reported in Wuhan, capital of Hubei province, in December 2019 (Q. Li et al., 2020; Zhu et al., 2020). Over the next few years, the disease quickly spread to every province of China and to other countries across the world. On March 11, 2020, the World Health Organization announced the coronavirus outbreak as a pandemic (Di Gennaro et al., 2020). Although today the COVID-19 pandemic is no longer the most important topic, it has already changed the world and has become one of the greatest health challenges of the 21st century.

Today, researchers have the ability to analyze the course of the pandemic from a certain time perspective. An increasing amount of data is available to allow for broader and more diverse analyses, both of the course of the pandemic and of the factors that

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may have influenced its course. In the available scientific databases, one can find many articles related to the impact of the COVID-19 pandemic on the health and lives of people (Clemente-Suárez et al., 2021; S. Li et al., 2020; Linton et al., 2020; Marom et al., 2022; Meyer et al., 2020; Shekhar et al., 2021; Solomou & Constantinidou, 2020; C. Wang et al., 2020; Zhang et al., 2020; Zhang & Ma, 2020). This topic seems to have been most extensively studied by scientists from many countries. The impact of the pandemic on both physical and mental health has been highlighted. It has been confirmed that the pandemic has changed the lifestyles and behaviors of people around the world (Castañeda-Babarro et al., 2020; Gualano et al., 2020; Lesser & Nienhuis, 2020; Mazza et al., 2020; Md Iderus et al., 2022; Stanton et al., 2020; Suzuki et al., 2020; Taff et al., 2021).

Various factors that could have influenced the COVID-19 pandemic were also analyzed. These primarily involved demographic factors (Alves et al., 2021; Kodera et al., 2020; Starke et al., 2020). Among other things, it was confirmed that an important factor in the course of the pandemic appeared to be the age structure of the population. A number of studies also addressed the impact of environmental factors on the course of the pandemic (Coccia, 2020; Comunian et al., 2020; Johnson et al., 2021; Y. Ma et al., 2020; Q. Wang et al., 2017; Xie & Zhu, 2020). The effects of temperature and air pollution on the course of the pandemic were demonstrated (Baniasad et al., 2021; Jamshidi et al., 2020). Most of the studies related to economic factors were concerned with the impact of the COVID-19 pandemic on the economic itself (Ahundjanov et al., 2020; Cao et al., 2020; Ghiani et al., 2020; Navon et al., 2021; Sharif et al., 2020).

Geographic Information System (GIS) is a computer system used to input, collect, process, and visualize geographic data, with decision support as one of its functions (Ciski & Rząsa, 2021). GIS tools have proved extremely useful for analyzing the spatial patterns of the course of the COVID-19 pandemic. Building regression models in a GIS environment allows for a thorough study of the factors influencing the course of the pandemic. Regression models incorporating spatial determinants, such as Geographically Weighted Regression (GWR) and Multiscale Geographically Weighted Regression (MGWR), appear to be particularly useful (Brunsdon et al., 1996; Comber et al., 2022; Franch-Pardo et al., 2020; Mennis, 2006; Mohammad Sham et al., 2022; Permai et al., 2021; Rząsa & Ciski, 2022; S. Yu et al., 2022; Yue et al., 2022).

The available scientific databases lack articles that comprehensively analyze the impact of factors describing the relationship between the level of Sustainable Development and the COVID-19 pandemic. This article therefore undertakes such an analysis. Thus, the main purpose of the article was to investigate whether a relation could be demonstrated between the course of the COVID-19 pandemic, as described by the number of cases and the number of deaths caused by the pandemic, and the level of Sustainable Development of an area. Poland was chosen as the study area, and detailed analyses were carried out at the administrative level of counties.

The research objective formulated in this way was carried out in two stages. In the first, data were collected to describe the level of Sustainable Development of the studied counties in terms of social, environmental, and economical characteristics. In the second step, using data regarding the number of COVID-19 cases and the number of deaths caused by the pandemic, using Multiscale Geographically Weighted Regression, a regression model was built to determine whether and to what extent the characteristics describing the level of Sustainable Development explain the course of the pandemic.

The obtained results, on the one hand can provide further confirmation of the validity of the concept of Sustainable Development, on the other hand, could serve as an important element for decision-makers to use in the fight against the possible next pandemic.

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MATERIALS AND METHODS

Study area

Determining the level of sustainable development as well as analyzing the course of the COVID-19 pandemic was carried out for the counties of Poland, the second level of the country's administrative division. Poland is divided into 380 counties. The average county area is about 822 square kilometers. Among 380 counties, there are 66 cities with county rights – municipalities with city status, carrying out county duties. The smallest county is Swietochlowice city county with an area of 13 square kilometers, and the largest county (with an area of 2,975 square kilometers) is Bialystok county. Due to the rather small area of the analyzed polygons, the chosen degree of detail of the study will allow a thorough investigation of the phenomenon, while maintaining a relatively higher administrative level, which ensures greater availability of data. Also, the number of counties in Poland meets the requirements of the GWR and MGWR (over 160) (Devkota et al., 2014). Fig. 1 shows the study area – the borders of voivodeships and counties, the highest and the second highest level administrative division of Poland.

Data source and processing

The first step in the research process was to describe the examined counties of Poland with the unified index of Sustainable Development. Polish law in the Environmental Protection Act defines Sustainable Development as "the socio-economic development integrating political, economic, and social actions, balanced with environmental protection

Fig. 1. Study area – counties of Poland
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

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and permanence of basic natural processes" (Act of 27 April 2001 Environmental Protection Law, 2001). The problem of measuring the level of sustainable development is an issue that many researchers have addressed in their studies. In previous studies, the authors have proposed a method for the classification of objects based on the natural breaks of Jenks in order to measure the level of sustainable development (Rząsa & Ciski, 2021). To study the impact of different factors on the course of the COVID-19 pandemic in this article, the authors decided to create a general statistical model. This approach made it possible, on the one hand, to comprehensively analyze the links between the level of Sustainable Development and the course of the COVID-19 pandemic, and, on the other hand, provided an opportunity to refer to and analyze the individual components of the model (three thematic groups: Social, Environmental, and Economical). The unified index was determined using data from Statistics Poland, a central government office for the collection and publishing of statistical information on most areas of public life. This data source is reliable, it is used in various scientific studies.

The level of sustainability was described with 30 factors, 10 of each related to social, environmental, and economical elements, respectively. Its selection was determined by an analysis of the subject literature (Azapagic & Perdan, 2000; Bossel, 1999; Drastichová, 2017; European Commission, 2015; Hák et al., 2016; Klopp & Petretta, 2017; Mori & Christodoulou, 2012; Morton et al., 2017; Schleicher-Tappeser, 2018; Shen et al., 2011; Spangenberg, 2015; United Nations, 2007, 2015) as well as the availability of data at the county level of detail. Sustainability studies conducted by different researchers for different case studies, such as countries, administrative parts of countries, etc., were also analyzed (Bąk & Cheba, 2018; Czermińska, 2002; Koszel & Bartkowiak, 2018; Moran et al., 2008; Mortensen, 2013; Stafford-Smith et al., 2017). Factors that relate to the level of various aspects of the development of social functions of area include: V1 – the number of housing units per 1,000 residents; V2 – the number of beneficiaries of community social assistance per 10,000 population; V3 – the number of cultural centers, houses and centers, clubs, and community centers; V4 – the number of beds in general hospitals; V5 – the number of stationary social assistance institutions; V6 – number of families granted social assistance due to poverty; V7 – average floor area of an apartment per 1 person; V8 – enrollment rate in elementary schools, defined as the ratio of the number of all residents studying at a given level to the total population of residents of the age nominally assigned to that level of education; V9 – expenditures incurred on social assistance; and V10 – infant deaths per 1,000 live births.

Factors that relate to the level of elements affecting the environment include: V11 – emission of gaseous pollutants; V12 – emission of particulate pollutants; V13 – population using wastewater treatment plants; V14 – the area of legally protected areas per capita; V15 – the amount of municipal wastewater treated per 100 km^2; V16 – the amount of total wastewater treated; V17 – the amount of industrial wastewater treated per 100 km^2; V18 – share of green areas in the total area; V19 – water consumption for economy and population; and V20 – total amount of municipal waste collected per year.

The level of economic development of the area was described by: V21 – income of county budgets; V22 – investment expenditures in enterprises per capita; V23 – number of registered economic entities per 1,000 population; V24 – number of registered motor vehicles and tractors; V25 – number of issued permits and notifications for construction of residential buildings; V26 – number of employed per 1,000 population; V27 – the amount of average monthly gross wages; V28 – the share of the area covered by valid local zoning plans in the total area (planning documents giving the right in Poland to change the zoning of area in a more intensive way); V29 – the value of housing units sold in market transactions; and V30 – expenditures of county budgets.

The next step of the research was to standardize the above indicators using Jenks' Natural Breaks classification method. Each variable has been separately classified using the Jenks optimization algorithm, with ArcGIS Pro 3.2 software. In order

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to correctly assign counties to classes, it was necessary to divide variables into stimulants and destimulants – variables whose increase in value indicates an increase in the level of Sustainable Development were selected as stimulants; and variables whose increase in value indicates a decrease in the level of Sustainable Development were selected as destimulants. Based on this division, using Jenks' Natural Breaks classification method, each variable was assigned a corresponding numerical value <0;10>. The following Table 1 lists the

Table 1. Selected factors

Thematic Group	Variable	Symbol	Impact on Sustainable Development
Social	the number of housing units per 1,000 residents	V1	Stimulant
	the number of beneficiaries of community social assistance per 10,000 population	V2	Destimulant
	the number of cultural centers, houses and centers, clubs and community centers	V3	Stimulant
	number of beds in general hospitals	V4	Stimulant
	number of stationary social assistance institutions	V5	Stimulant
	number of families granted social assistance due to poverty	V6	Destimulant
	average floor area of an apartment per 1 person	V7	Stimulant
	enrollment rate in elementary schools	V8	Stimulant
	expenditures incurred on social assistance	V9	Stimulant
Environmental	infant deaths per 1,000 live births	V10	Destimulant
	emission of gaseous pollutants	V11	Destimulant
	emission of particulate pollutants	V12	Destimulant
	population using wastewater treatment plants	V13	Stimulant
	area of legally protected areas per capita	V14	Stimulant
	amount of municipal wastewater treated per 100 km^2	V15	Stimulant
	amount of total wastewater treated	V16	Stimulant
	amount of industrial wastewater treated per 100 km^2	V17	Stimulant
	share of green areas in total area	V18	Stimulant
	water consumption for economy and population	V19	Destimulant
	total amount of municipal waste collected per year	V20	Destimulant
Economic	income of county budgets	V21	Stimulant
	investment expenditures in enterprises per capita	V22	Stimulant
	number of registered economic entities per 1,000 population	V23	Stimulant
	number of registered motor vehicles and tractors	V24	Stimulant
	number of issued permits and notifications for construction of residential buildings	V25	Stimulant
	number of employed per 1,000 population	V26	Stimulant
	the amount of average monthly gross wages	V27	Stimulant
	the share of the area covered by valid local zoning plans in the total area	V28	Stimulant
	the value of housing units sold in market transactions	V29	Stimulant
	expenditures of county budgets	V30	Stimulant

Source: own elaboration on the basis of data from Statistics Poland.

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selected variables broken down by thematic section, with appropriate symbol, and stimulant/ destimulant breakdown.

In such a way, Poland's counties were described by the unified Sustainable Development index. Such extracted data were later used for analysis using the MGWR method as explanatory variables.

From the database published by Michal Rogalski and Konrad Kalemba, the two main variables describing the course of the COVID-19 pandemic: "the number of SARS-CoV-2 cases" and "the number of deaths due to SARS-CoV-2 infection", were obtained (Michał Rogalski (@micalrg) / Twitter, 2022; Rogalski, 2022). Many studies on the COVID-19 pandemic issue in Poland use these trusted databases (Ciski & Rząsa, 2023; Duszyński et al., 2020; Kaczmarek & Mikuła, 2022; Lorent et al., 2021; Parysek & Mierzejewska, 2022; Śleszyński, 2020). These variables were used for analysis using the MGWR method as dependent variables.

Tabular data containing aforementioned variables were merged and combined with polygon data representing the administrative boundaries of counties of Poland from the polish National Register of Boundaries (NRB) (Główny Urząd Geodezji i Kartografii, 2023), an official polish spatial database.

Research method

A null hypothesis had to be established and the statistical significance of all the variables analysed had to be tested to ensure that the results were not the result of chance before the regression model was developed. ArcGIS Pro 3.2 software was used to perform a spatial autocorrelation analysis (Global Moran's I). One of the most common ways to measure spatial autocorrelation is to calculate the Moran's I index (Gao et al., 2022; Han & Sui, 2019; Lichstein et al., 2002). Moran's $I = 0$ indicates no spatial autocorrelation, Moran's $I > 0$ indicates spatial autocorrelation, with positive and negative values indicating positive and negative autocorrelation, respectively. When the null hypothesis is rejected (i.e. the results of the study are not the result of chance), it is possible to conduct the study using Multiscale Geographically Weighted Regression (MGWR), the extended and advanced version of Geographically Weighted Regression (GWR). GWR is based on the assumption that all modeled processes occur at the same spatial scale; MGWR creates a separate and optimized bandwidth for each relationship in the model, therefore indicating how different relationships perform at different spatial scales, to provide more accurate local estimates (Fotheringham et al., 2017).

MGWR is used to analyze a variety of problems in geography, urban planning and other disciplines by investigating geographically varying relationships between dependent and explanatory variables (Chen & Luo, 2022; Geddes et al., 2021). Most importantly, the validity of using this method to model the course of the COVID-19 pandemic has been proven (Ciski & Rząsa, 2023; He et al., 2023; J. Ma et al., 2022; Mohammadi et al., 2023). MGWR extends GWR by examining relationships at different spatial scales using different bands instead of a single constant band. Different bandwidths allow MGWR to model a wider range of geographic phenomena than other regression models, providing better estimates, more accurate predictions and less multicollinearity (He et al., 2023; Oshan et al., 2019). MGWRs allow for the estimation of the effect of explanatory variables on the dependent variable, and the identification of counties where the effect of variables differs, for the purpose of studying and interpreting spatial non-stationarity. MGWR is expressed as:

$$y_i = \beta_0(u_i, v_i) + \sum_k^n \beta_{bwk}(u_i, v_i)x_{ik} + \varepsilon_i \quad (1)$$

where:

y_i – the dependent variable of the i-th,
x_{ik} – the explanatory variable of the i-th,
u_i and v_i – the spatial coordinates of the i-th (i.e., the centroid coordinates of the counties),
$\beta_{bwk}(u_i, v_i)$ – the estimated coefficient of the k-th explanatory variable for the i-th with the b_w bandwidth,
ε_i – the residual at the location (u_i, v_i).

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A comparison of the magnitude of the MGWR-derived R-Squared index for all variables analyzed will allow conclusions to be drawn. RR-Squared is a measure of model performance and should be understood as the proportion of the variance in the dependent variable accounted for by the regression model, summarizing how well the estimated values match the observed values. The MGWR tool in ArcGIS Pro 3.2 enables the calculation of "Adjusted R-Squared", which reflects the complexity of the model (the number of variables) as it relates to the data. The Adjusted R-Squared value is the preferred and more accurate measure of the performance of the model (Fotheringham et al., 2006).

In addition, the maps of local R-Squared values generated with MGWR tool will allow the study of local anomalies in the analyzed phenomena, and is useful in identifying locations that have significant local parameter estimates to help focus attention on regions of interest (H. Yu et al., 2020).

A total of eight regression models were developed, all using MGWR, to assess the influence of the level of Sustainable Development of Poland's counties on the course of the COVID-19 pandemic:

1. The number of SARS-CoV-2 cases explained by the unified index of Sustainable Development (all 30 variables).
2. The number of deaths due to SARS-CoV-2 infection explained by the unified index of Sustainable Development (all 30 variables).
3. The number of SARS-CoV-2 cases explained by the Social group (V1-V10 variables).
4. The number of deaths due to SARS-CoV-2 infection explained by the Social group (V1-V10 variables).
5. The number of SARS-CoV-2 cases explained by the Environmental group (V11-V20 variables).
6. The number of deaths due to SARS-CoV-2 infection explained by the Environmental group (V11-V20 variables).
7. The number of SARS-CoV-2 cases explained by the Economical group (V21-V30 variables).
8. The number of deaths due to SARS-CoV-2 infection explained by the Economical group (V21-V30 variables).

All generated regression models were prepared using the Multiscale Geographically Weighted Regression tool in ArcGIS Pro 3.2 software.

RESULTS

The first step in understanding the studied phenomenon is to analyze its spatial distribution. For this purpose, two maps were generated using the cartographic method of choropleth map, in ArcGIS Pro 3.2 software. The results are presented on Fig. 2 below.

Even such a simple study of the spatial distribution of a phenomenon can often shed light on its character. In the case of the two dependent variables, describing the course of the COVID-19 pandemic: the number of SARS-CoV-2 cases (Fig. 2a), and the number of deaths due to SARS-CoV-2 infection (Fig. 2b), it is difficult to see any characteristic spatial trends in the distribution of the phenomenon. In order to more accurately depict the two dependent variables, a hot spot analysis was carried out using the "Optimized Hot Spot Analysis" tool in ArcGIS Pro 3.2 software. The results are shown on maps in the Fig. 3 below.

Optimized Hot Spot Analysis executes the Hot Spot Analysis tool using parameters derived from characteristics of the input data, and reflects the distribution of hot and cold spots. In the case of the variable "the number of SARS-CoV-2 cases" (Figure 3a), a significant hot spot cluster was recorded in the vicinity of Poland's capital, Warsaw. Map for the second variable „the number of deaths due to SARS-CoV-2 infection" (Fig. 3b) demonstrates, in turn, a large hot spot in the Silesian Voivodeship, and a smaller one in several counties of the Masovian Voivodeship.

Null hypothesis

The Spatial Autocorrelation (Global Moran's I) tool in ArcGIS Pro 3.2 was used for the assessment of the probability that the null hypothesis is true or false. This tool measures spatial autocorrelation on the basis of feature values and locations; and evaluates whether the pattern of the data is clustered, dispersed,

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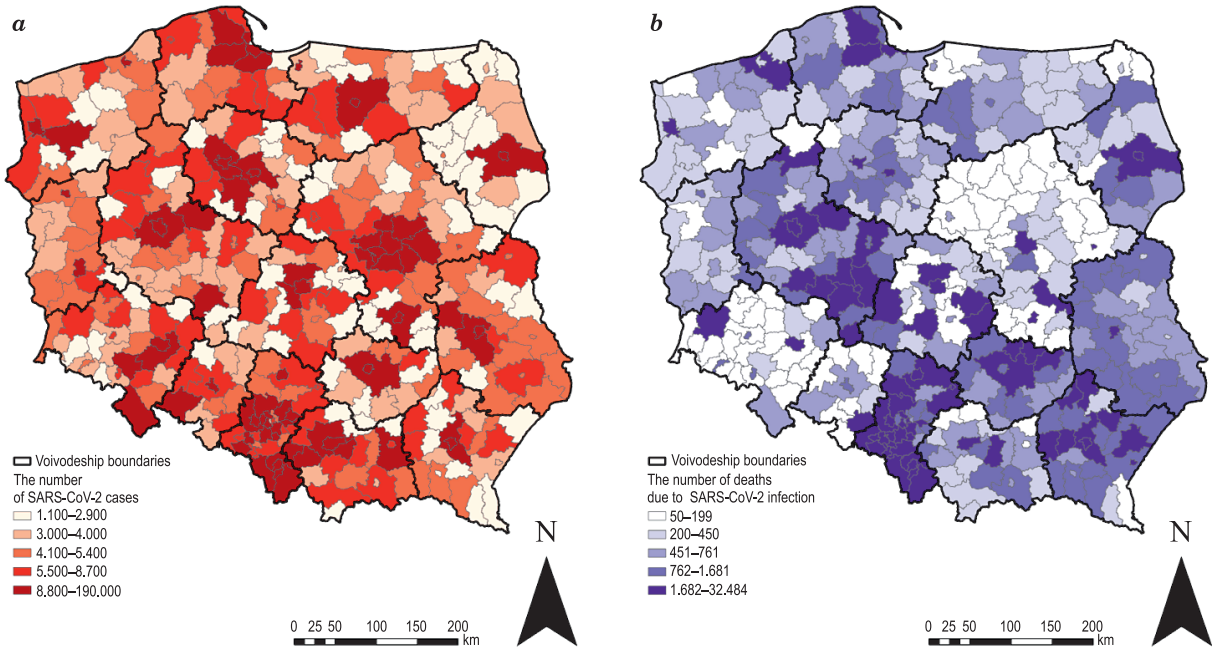

Fig. 2. Spatial distribution of two dependent variables, describing the course of the COVID-19 pandemic: the number of SARS-CoV-2 cases (a), and the number of deaths due to SARS-CoV-2 infection (b)
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

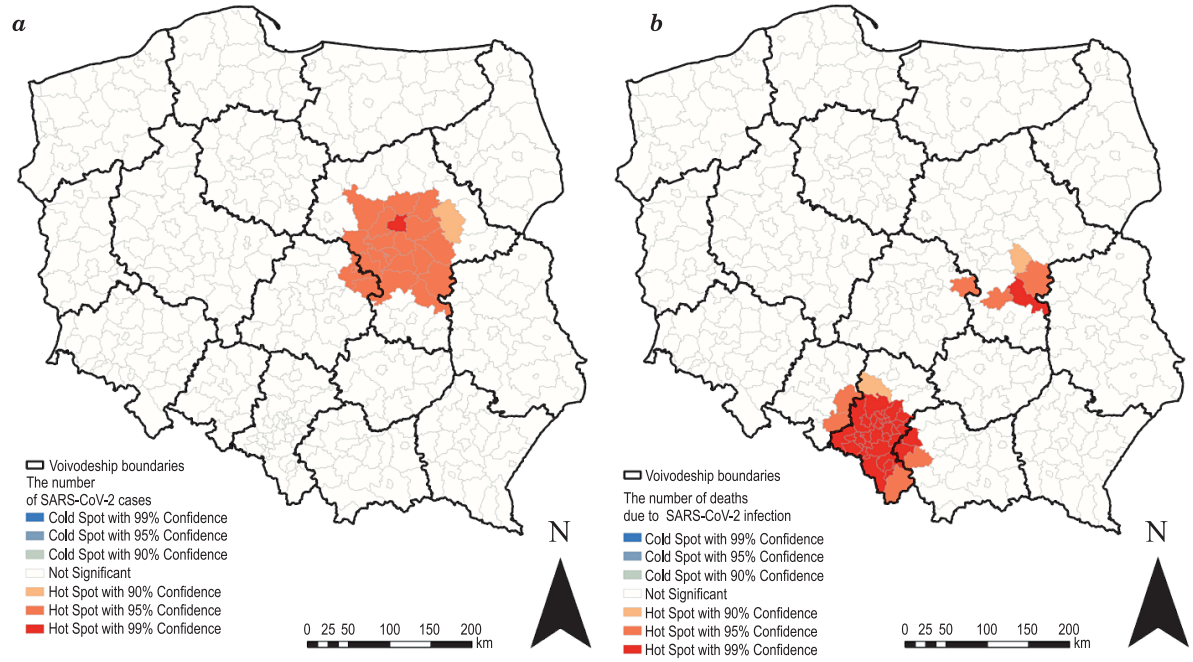

Fig. 3. Hot Spot analysis of two dependent variables, describing the course of the COVID-19 pandemic: the number of SARS-CoV-2 cases (a), and the number of deaths due to SARS-CoV-2 infection (b)
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

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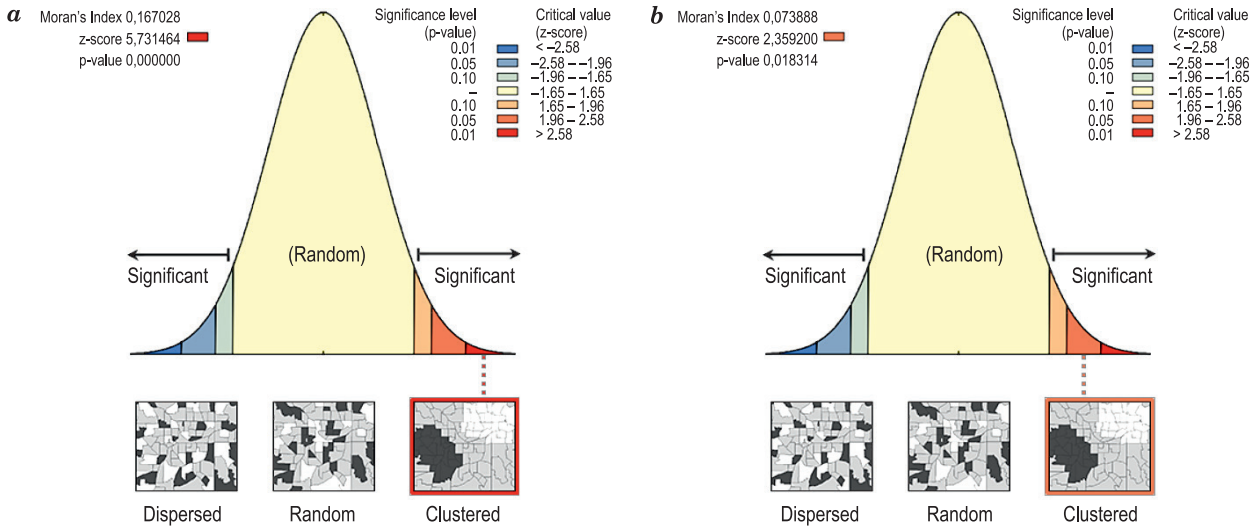

Fig. 4. Spatial Autocorrelation reports of two dependent variables, describing the course of the COVID-19 pandemic: the number of SARS-CoV-2 cases (a), and the number of deaths due to SARS-CoV-2 infection (b)
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

or random. "Inverse distance squared" was selected as the "Conceptualization of Spatial Relationships" parameter, with closest nearby neighboring counties having a larger influence on the computations for a target county than features that are far away. The chosen parameter of the tool reflects and models the analyzed phenomenon to the highest degree. All the study variables were analyzed in this way; Fig. 4 presents Spatial Autocorrelation reports of two dependent variables: the number of SARS-CoV-2 cases (a), and the number of deaths due to SARS-CoV-2 infection (b). Due to the large number of variables, reports on the explanatory variables can be found in Supplementary Materials.

Detailed analysis of the results of Spatial Autocorrelation (Global Moran's I) makes it possible to estimate the spatial pattern of the studied variables. A positive value of Moran's I indicates a clustering tendency, while a negative value of Moran's I indicates a dispersion tendency, when the z-score or p-value indicates statistical significance. The following Table 2 shows the results of this measure, with indication if analyzed data has a tendency to form clusters or to be disparate.

An autocorrelation analysis showed that almost all variables tend to form clusters (except for variables V4 and V8, "number of beds in general hospitals" and "enrollment rate of elementary schools" respectively). The p-value indicates that all variables are statistically significant. Results allow rejecting the null hypothesis and proceeding with the rest of the study.

Table 2. Summary of the spatial autocorrelation

Variable	p-value	z-score	Spatial pattern
1	2	3	4
the number of SARS-CoV-2 cases	0.00	5.73	Clustered
the number of deaths due to SARS-CoV-2 infection	0.02	2.36	Clustered
V1	0.00	4.71	Clustered
V2	0.00	14.82	Clustered
V3	0.03	2.17	Clustered
V4	0.00	-5.13	Dispersed

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cont. **Table 2**

1	2	3	4
V5	0.00	8.04	Clustered
V6	0.00	3.80	Clustered
V7	0.00	10.93	Clustered
V8	0.00	-11.66	Dispersed
V9	0.04	2.10	Clustered
V10	0.05	1.93	Clustered
V11	0.02	2.28	Clustered
V12	0.03	2.24	Clustered
V13	0.00	9.98	Clustered
V14	0.00	12.67	Clustered
V15	0.00	3.32	Clustered
V16	0.05	1.99	Clustered
V17	0.00	8.32	Clustered
V18	0.00	2.82	Clustered
V19	0.01	2.68	Clustered
V20	0.00	3.79	Clustered
V21	0.00	3.38	Clustered
V22	0.00	3.41	Clustered
V23	0.00	14.56	Clustered
V24	0.00	3.39	Clustered
V25	0.00	6.75	Clustered
V26	0.01	2.56	Clustered
V27	0.00	7.63	Clustered
V28	0.00	19.51	Clustered
V29	0.01	2.44	Clustered
V30	0.00	3.47	Clustered

Source: own elaboration with ArcGIS Pro 3.2 by Esri.

Calculating the level of Sustainable Development of polish counties, and its influence on the dependent variables

The next step of the study was to assess the impact of the level of Sustainable Development of Poland's counties on the course of the COVID-19 pandemic, represented by the number of SARS-CoV-2 cases, and the number of deaths due to SARS-CoV-2 infection. For this purpose, all the explanatory variables studied were used to build a two regression models (using the MGWR tool in ArcGIS Pro 3.2 software). In addition, six separate regression models were built from variables in the subsequent three groups (Social, Environmental, and Economical) to examine changes in the impact of specific thematic groups.

When explanatory variables are correlated, they share mutual information and the regression model cannot distinguish between the effects of the variables, so multicollinearity has a negative impact on coefficient estimation and optimal neighborhood. MGWR tool in ArcGIS Pro 3.2 highlights potential problems with multilinearity – none were found in the 8 developed regression models.

The indicator values for these models are shown in Table 3 below. Tables with complete regression results and autocorrelation reports of Adjusted R-Squared can be found in Supplementary Materials.

The values of the Adjusted R-Squared index indicate a high and very high fit of the model to the dependent variables. The explanatory variables explain the variable "the number of SARS-CoV-2 cases_ much

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Table 3. The level of goodness of fit of the 8 regression models, expressed by the coefficient of determination – Adjusted R-Squared index

	Coefficient of determination, Adjusted R-Squared	
	The number of SARS-CoV-2 cases	The number of deaths due to SARS-CoV-2 infection
Sustainable Development level	0.8737*	0.7061*
Social group	0.7469*	0.6005*
Environmental group	0.7574*	0.5708*
Economical group	0.8250*	0.6882*

Note: *—statistically significant at the $p < 0.01$ level
Source: own elaboration with ArcGIS Pro 3.2 by Esri.

better, the values of the Adjusted R-Squared index here are in the range of approximately 0.75–0.88. Less fit are the models explaining the variable "the number of deaths due to SARS-CoV-2 infection", in this case, the Adjusted R-Squared values are about 0.57–0.71. Of all the models, the highest value of the Adjusted R-Squared index was recorded for the unified level of Sustainable Development explaining the variable "the number of SARS-CoV-2 cases" – approximately 0.88.

In addition, the extracted models for each thematic group are characterized by different levels of model fit. Economical group explains the explanatory variables best, at a level of around 0.83 and 0.69. The other groups explain the explanatory variables to a lesser extent. The variable "the number of SARS-CoV-2 cases" is worst explained by the Social group model, while the variable "the number of deaths due to SARS-CoV-2 infection" – by the Environmental group model (respectively around 0.75 and 0.57).

The MGWR tool allows the creation of maps of local R-Squared values. These maps provide a better picture of such a complex phenomenon as the COVID-19 pandemic, and are useful in identifying locations that have significant local parameter estimates (H. Yu et al., 2020). Comparison of the content of maps is only viable if uniform classification is used (Ciski et al., 2019). The classification of the maps was standardized to allow comparison of the local R-Squared distribution for the models explaining the variables "number of SARS-CoV-2 cases" and "number of deaths due to SARS-CoV-2 infection". This way, each class on each map for variables "the number of SARS-CoV-2 cases" and "the number of deaths due to SARS-CoV-2 infection" matches the same values. This allows to draw the correct conclusions without any spatial classification bias, that can occur when trying to compare data visualized using different class intervals.

The following Fig. 5, 6, 7, and 8 presents the local R-Squared values for the models of Sustainable Development level, Social group, Environmental group, and Economical group.

The use of a unified cartographic classification allows the comparison of local R-Squared maps. While the impact of the explanatory variables varies (which is strongly noticeable by comparing the intensity of the symbolization of the classes of the maps), the general trend of the spatial distribution of the phenomenon is quite similar – a notable separation of the eastern and western parts of the country is evident. This trend is more pronounced in the map for the variable "the number of deaths due to SARS-CoV-2 infection" (Fig. 5b). In the case of the map for the variable "the number of SARS-CoV-2 cases" (Fig. 5a), one can see lower values of local R-Squared for counties in the eastern part of Poland, and more distinctly higher values of local R-Squared for the central part of the country.

The local R-Squared map for the "Social" thematic group for the variable "the number of SARS-CoV-2 cases" (Fig. 6a) shows a very unified picture of the phenomenon – all counties in the country are described by only two adjacent classes. A completely opposite picture is presented by the map for the variable "the number of deaths due to SARS-CoV-2 infection" (Fig. 6b) – a similar spatial trend can be observed here as in the corresponding map in Figure 5, with a stronger emphasis on the northeastern part of the country. A very unusual situation is the occurrence of counties with opposite classes (marked in red

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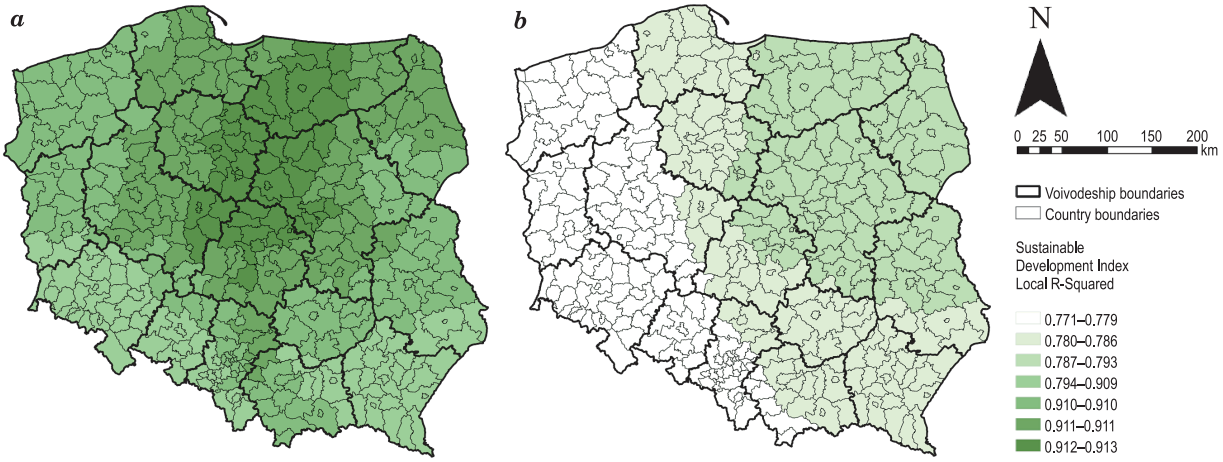

Fig. 5. Local R-Squared maps – unified Sustainable Development index for variables "the number of SARS-CoV-2 cases" (a) and "the number of deaths due to SARS-CoV-2 infection" (b)
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

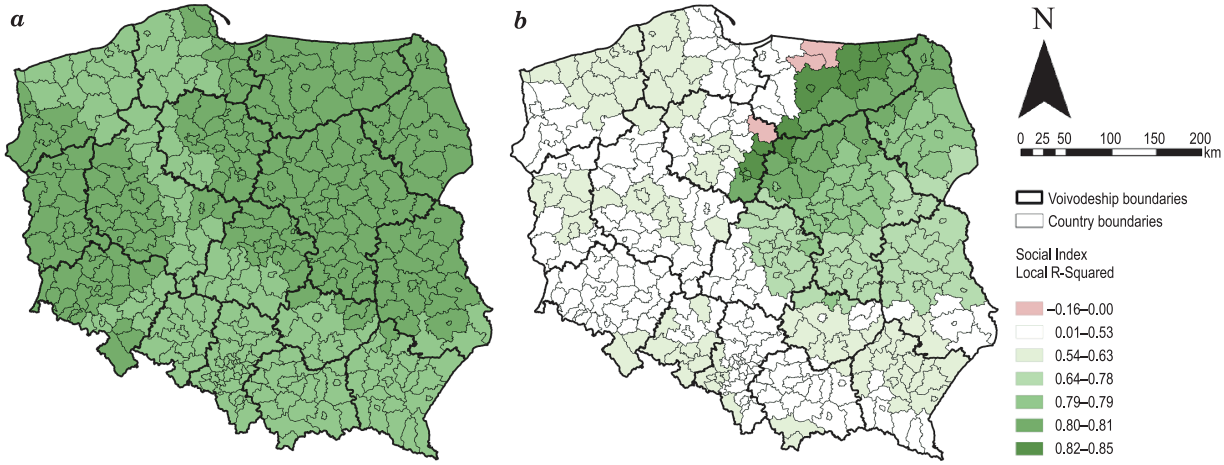

Fig. 6. Local R-Squared – Social Index for variables "the number of SARS-CoV-2 cases" (a) and "the number of deaths due to SARS-CoV-2 infection" (b)
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

and green) in close proximity. This indicates the presence of very large local anomalies in the studied phenomenon in this area, namely the northern part of the Warmian-Masurian Voivodeship and the northeastern part of the Kuyavian-Pomeranian Voivodeship.

As outlined in the previous figure, the phenomenon of the occurrence of extreme values of local R-Squared in neighboring counties is much more evident in the map for the Environmental group. Very unusual is the occurrence in a number of places of strong negative values of the R-Squared index (marked in red on all maps) alongside a strong positive values. Large clusters of such incidences can be seen in the northeastern and southwestern parts of the country.

The spatial distribution of the local R-Squared environmental group for the explained variable "the number of deaths due to SARS-CoV-2 infection" (Fig. 7b) is almost identical to that of the previous group – Social (Fig. 6b). Again, the extreme values

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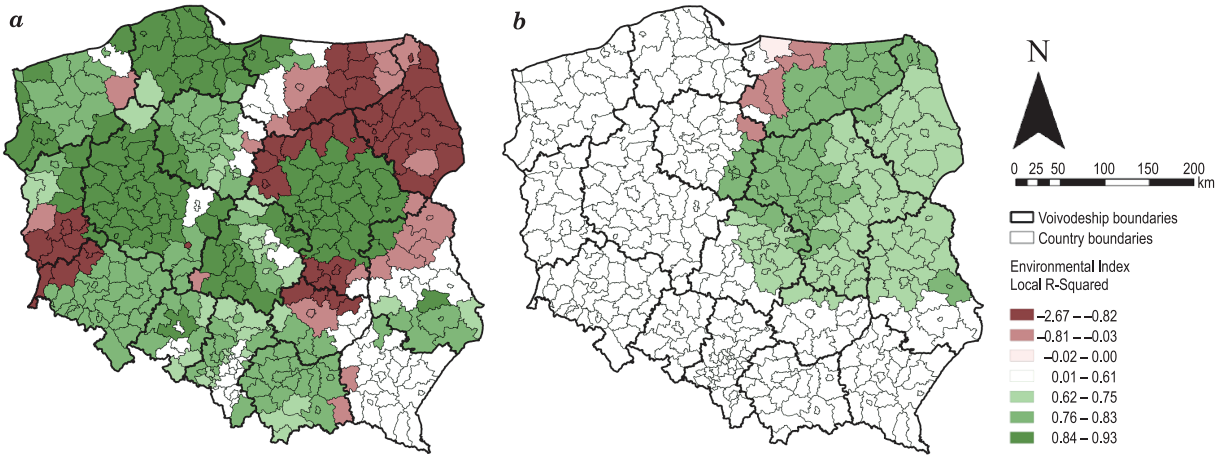

Fig. 7. Local R-Squared – Environmental Index for variables "the number of SARS-CoV-2 cases" (a) and "the number of deaths due to SARS-CoV-2 infection" (b)
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

of the local R-Squared are found in the northern part of the Warmian-Masurian Voivodeship and the northeastern part of the Kuyavian-Pomeranian Voivodeship. In the case of this group, this phenomenon is even more strongly outlined – the differences in local R-Squared class values are greater in this case than in the case of the Fig. 6b.

The spatial trends presented in Fig. 8 are remarkably similar to those observed in Fig. 7. The map describing the variable "the number of SARS-CoV-2 cases" (Fig. 8a) shows a similar phenomenon of the widespread occurrence of negative values of the local R-Squared, and the cooccurrence of extreme values. However, the large cluster of negative values in the northeastern part of the country has disappeared. As with the map for the unified Sustainable Development index, the overall trend of the spatial distribution of the phenomenon shows a significant separation of the eastern and western parts of the country.

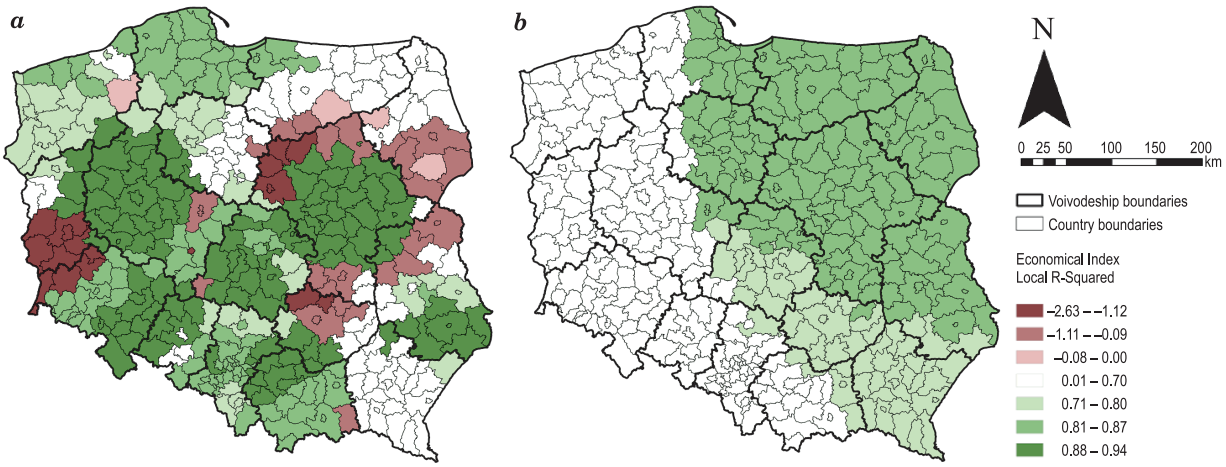

Fig. 8. Local R-Squared – Economical Index for variables "the number of SARS-CoV-2 cases" (a) and "the number of deaths due to SARS-CoV-2 infection" (b)
Source: own elaboration using ArcGIS Pro 3.2 by Esri.

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Residual spatial autocorrelation

To assess the performance of the regression model, the presence of residual spatial autocorrelation was analysed. The residual spatial autocorrelation was measured using the Spatial Autocorrelation tool (Global Moran's I). The results of this analysis are presented in Table 4 below.

Table 4. Spatial autocorrelation results for MGWR residuals

	z-score	
	The number of SARS-CoV-2 cases	The number of deaths due to SARS-CoV-2 infection
Sustainable Development level	-0.52*	0.62*
Social group	-0.25*	-0.03*
Environmental group	-1.79**	-0.10*
Economical group	0.75*	1.50*

Note: * – random spatial pattern, ** – weak dispersed spatial pattern
Source: own elaboration with ArcGIS Pro 3.2 by Esri.

The distribution of the residuals does not appear to be significantly different from random when considering the z-scores – out of the 8 regression models, only one z-score value indicate a weak dispersed pattern, confirming the validity of using the MGWR model.

CONCLUSIONS

The main purpose of the article was to investigate whether a relationship can be demonstrated between the course of the COVID-19 pandemic, as described by the number of cases and the number of deaths caused by the pandemic, and the level of Sustainable Development of an area. The study showed that such a relationship exists, and the magnitudes of the Adjusted R-Squared index indicate a high and very high fit of the model to the dependent variables. The variable "the number of SARS-CoV-2 cases" is explained to a greater extent (Adjusted R-Squared here is in the range of about 0.75–0.88) than the variable "the number of deaths due to SARS-CoV-2 infection" (Adjusted R-Squared here are in the range of about 0.57–0.70). The highest value of Adjusted R-Squared occurs for the unified level of Sustainable Development explaining the variable "the number of SARS-CoV-2 cases", and reached almost 0.88. These values confirm the very high relationship between the level of Sustainable Development of the area and the course of the COVID-19 pandemic.

Analyzing the Adjusted R-Squared values for each thematic group comprising the unified level of Sustainable Development, it can be found that all of them explain the variables "the number of SARS-CoV-2 cases" and "the number of deaths due to SARS-CoV-2 infection" to a high degree. The lowest Adjusted R-Squared value was obtained for the Environmental group explaining "the number of deaths due to SARS-CoV-2 infection" and it equaled 0.5708. The highest Adjusted R-Squared value was 0.8259, and it was recorded for the Economical group explaining "the number of SARS-CoV-2 cases" Among all three subject groups, higher Adjusted R-Squared values were obtained for the variables explaining the dependent variable "the number of SARS-CoV-2 cases". This may indicate that the variable "the number of deaths due to SARS-CoV-2 infection" was influenced by other factors (not related to the level of Sustainable Development) that were not included in the regression model.

While the article focuses on indicators related to Sustainable Development, the obtained Adjusted R-Squared values indicate that the two analyzed dependent variables may have been influenced by other factors not included in the regression models. It can be speculated that these factors could have included: climate factors (e.g., temperature), demographic factors (e.g., population density), factors related to emergency management and policy (e.g., local government decisions to fight the pandemic), and even factors related to the population's approach to the pandemic (e.g., pandemic denialism).

The development of local R-Squared maps enabled the study of spatially varying relationships between variables. In addition, further allowed to identify local

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anomalies of the phenomenon. Maps for the "Environmental" and "Economical" thematic groups, describing the dependent variable "the number of SARS-CoV-2 cases" display high concentrations of anomalies on the outskirts of the Masovian Voivodeship, and in the west of the country on the border of the Lubusz and Lower Silesian Voivodeships. Maps describing the variable "the number of deaths due to SARS-CoV-2 infection" show fewer anomalies, confined to single counties: the Bartoszyce county, the Lidzbark Warmiński county, the Ostróda county, the Iława county (in the Warmian-Masurian Voivodeship), and the Brodnica county (in the Kuyavian-Pomeranian Voivodeship).

Areas with anomalies indicated in the local R-Squared maps may require additional research due to high deviations from the regression model. This may be relevant and helpful to local authorities and decision-makers, due to the abnormalities in the results, and should pay special attention to these areas.

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POSSIBILITIES OF DEVELOPING MAPS OF SIGHT-AESTHETIC ATTRACTIVENESS OF UNDERWATER LANDSCAPES OF LAKES USING THE POINT-VALUATION METHOD AND SPATIAL INTERPOLATION METHODS

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ABSTRACT

Motives: The research investigates the feasibility of using interpolation algorithms for assessment using the point-valuation method in different types of lakes. It shows the possibilities of using the proposed methodology for underwater landscapes under various environmental and geographical conditions.
Aim: The aim of the study is to test the point-valuation method for assessing the sight-aesthetic value of lakes in terms of potential for tourist exploration. The results are presented in the form of maps, resulting from spatial interpolation methods based on a random measurement network.
Results: Maps showing the distribution of the phenomenon under study can serve as a tool for protection and planning of development and tourist use of lakes. Dedicated spatial interpolation methods for this type of assessment map were identified. The methodology is universal and can be applied, with appropriate modifications, in various types of water bodies (lakes).
Conclusion: Successful implementation of point-valuation methods and interpolation algorithms for assessing the sight-aesthetic attractiveness of underwater landscapes of lakes has been achieved. These are pioneering studies in the field of underwater landscape perception and cartographic presentation methodology. This contributes to the development of principles for protection, tourist use (qualified tourism – diving), and channelling tourist traffic in places attractive to users.

Keywords: sight-aesthetic value, underwater landscape, point valuation, interpolation, perception, Poland

INTRODUCTION

Assessment of the sight-aesthetic value of underwater lake landscapes is a relatively new issue. Until now, a comprehensive methodology addressing this topic has not been developed. Moreover, the methodology is still in the developmental phase. Often, such research works reference methods used in the assessment of sea and ocean landscapes (Dynowski et al., 2024; Musard, 2014b, 2014a; Pungetti, 2012).

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At the same time, all attempts to study underwater landscapes are based on the methodology of land landscape assessment. The aim, both in land and underwater studies, is to understand the dynamics and directions of the processes shaping landscapes. The factors causing changes and specific values are divided into anthropogenic and natural. The effects of these processes are also reflected in the sight-aesthetic attractiveness (Gosal & Ziv, 2020).

The purpose of this study is to test the possibility of applying the point-valuation method to assess the sight-aesthetic value of lakes. The proposed methodology has been developed based on algorithms used in terrestrial landscape assessment. The set of components of the assessed landscape (in this study) aims to identify landscapes particularly valuable in terms of their potential for tourist exploration. The detailed objectives concern the applicability of geometric (regular) measurement networks randomly distributed over the map base of the studied lakes. Additionally, an attempt was made to answer the question: are the interpolation algorithms available in Geographic Information Systems (GIS) suitable tools for developing and graphically presenting the attractiveness of underwater landscapes? Lakes with diverse environmental and geographical conditions were studied to compare the applicability of the described methodology to different types of underwater environments.

LITERATURE REVIEW

So far, no single definition of an underwater lake landscape has been developed for the purpose of assessing its sight-aesthetic attractiveness. Moreover, such attempts mainly focus on the underwater landscapes of seas and oceans. These definitions are often derived from those used for land landscapes. The number of such definitions is vast and depends on the purpose of the assessment (e.g., tourist exploration, residential construction, recreational development), often taking the form of classifying an area for different functions (Aretano et al., 2013; Fadel, 2016). Visual attractiveness is one of the most important factors in determining the function of a given area (Domon, 2011; Hur et al., 2010). Visual methods using point-valuation are commonly applied to assess the sight-aesthetic attractiveness of landscapes (Badouna & Fadel, 2014). One of the key trends in land landscape research is to consider the landscape as a multisensory concept, perceived through all senses (Wu, 2024). This aligns with the experience of underwater landscapes, which are perceived through all senses during exploration.

One of the first attempts to define the underwater lake landscape was undertaken by researchers in Poland (Senetra et al., 2023). The definition was based on an aesthetic approach to the assessment of land landscapes. "An underwater landscape is a heterogeneous, distinct portion of the underwater surface, composed of various ecosystems interacting with each other. These factors can be natural and/or anthropogenic" (Dynowski et al., 2024). In the case of very large lakes, schematic regionalisations of the lakebed, geological structures, distribution of fauna and flora, or biodiversity are also proposed (Karabanov et al., 1990; Potemkina & Suturin, 2008).

In the light of aesthetic theory, the most accurate assessment is based on field inventory, though it is highly labour-intensive (Barroso et al., 2012). Cartographic or photographic inventory does not yield as effective results as direct observation. Moreover, the development of modern technologies allows for increasingly time-efficient research. Firstly, the use of underwater scooters enables faster movement for diver-observers. Secondly, available underwater navigation systems optimise movement routes and increase diver safety during underwater research. Thirdly, the functionality of electronic consoles facilitates automatic, semi-automatic, and manual measurement recording, as well as taking photographs and videos documenting the underwater inventory.

Apart from the mentioned studies, no more advanced attempts to explain the phenomenon of underwater lake landscapes have been noted. Research based on marine landscape experiences, which focus on physical features as carriers of attractiveness, is thus justified. An undeniable

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aspect of this attractiveness is the development of specialised tourism related to diving (Cavallini et al., 2023), underwater photography and filming, as well as mapping and visualisation using 3D technology (Musard, 2014b, 2014a). The advancement of modern technologies, education, and awareness of the uniqueness of the underwater world ensure easier access to underwater attractions. Diving tourism is currently experiencing the highest growth dynamics (Dimmock & Musa, 2015). However, this tourism also poses a significant threat to ecosystems. Therefore, research on underwater landscapes is crucial for guiding tourist traffic and protecting the most valuable species and geological formations (Betti et al., 2019). In terms of the development of underwater landscape research, experienced divers play a decisive role. They are unquestionable experts, and their insights are invaluable in developing methodologies for assessing the attractiveness of these landscapes, including in terms of sight-aesthetic value (Johansen, 2013).

MATERIALS AND METHODS

Description of the Research Objects

Five lakes were selected for analysis: Turkusowe, Gałęziste, Muliczne, Białe, Staw (Fig. 1). These lakes are located in Poland. Four of them are situated in the northeastern part of the country, with three located in Wigierski National Park (Gałęziste, Muliczne, Białe) (Table 2, Table 3, Table 4), and one within the Natura 2000 Augustów area – Staw (Table 5). The last one, Lake Turkusowe, is located in the northwestern part of Poland, within Wolin National Park (Table 1). These lakes differ in type and origin, as shown in Table 1–Table 5 and in the descriptive characteristics. This diversity allowed for testing the proposed methodology on different objects, enabling necessary adjustments and recommendations to be made.

Lake Turkusowe (area 6.7 ha, maximum depth 21.2 m) is located on the Wolin Island (Wolin Landscape Park). It is an artificial reservoir formed after World War II in a former chalk quarry near Lubin. The lakebed is located below sea level (cryptodepression). As the name suggests, the water colour is turquoise, which arises from the reflection of sunlight off water containing calcium carbonate compounds and a white limestone lakebed. The lakebed is highly varied with numerous pits and mounds left after chalk extraction. Near the shores, the lakebed drops very steeply, in places forming small vertical walls. Visibility varies depending on the amount of precipitation and surface runoff, which brings a lot of mineral and organic suspension into the reservoir. Underwater, one can admire the post-mining landscape with remnants of equipment, fragments of a road, and trees left along the shores, serving as shelters for perch, roach, and tench. Submerged vegetation is dominated by communities of *Myriophyllum*, with some areas of *Potamogeton* and *Ceratophyllum*. Description of the lake is presented in Table 1.

Lake Gałęziste (area 3.83 ha, maximum depth 14.3 m) is located in the Wigry National Park. The visibility of this eutrophic body of water ranges from 1.5 to 3 m. Near the shores, the lakebed is steep up to a depth of about 4 m. Deeper, it is level, muddy, and gently slopes towards the deeper parts. The underwater landscape around the shores is shaped by a large number of overturned trees and fallen branches, providing natural hiding spots for perch. The submerged vegetation is mainly *Ceratophyllum* and *Myriophyllum*, with a significant presence of floating *Potamogeton* forms, as well as *Nuphar* and

Table 1. Description of Lake Turkusowe

Location	Area	Depth	Trophic type	Bottom and vegetation	Form of protection
Wolin National Park; Natura 2000 Wolin and Usedom Area PLH320019	6.7 ha	max. 21.2 m	–	Chalk quarry excavation (glacial erratic). Karst phenomena occur. The substrate is marl-limestone.	–

Source: own elaboration.

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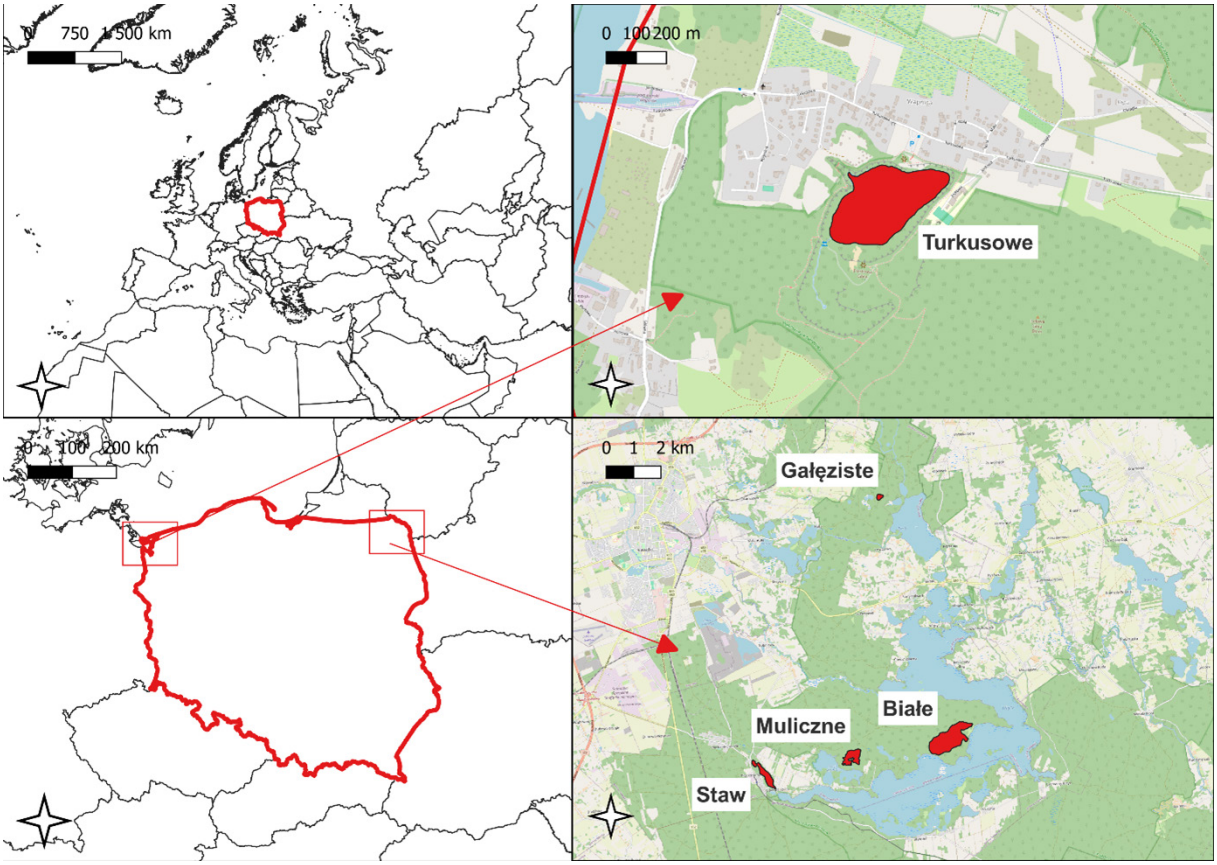

Fig. 1. Location of assessed lakes
Source: own elaboration.

Nymphaea. *Chara* is scarce – virtually not forming its own communities. Description of the lake is presented in Table 2.

Lake Muliczne (area 25.67 ha, maximum depth 11.3 m) is located within the Wigry National Park. It is a eutrophic lake. It is characterised by high biodiversity, both habitat and microhabitat. Visibility is at the level of 1–3 m. Near the shores, the lakebed is occasionally steep, and from a depth of 5 m it becomes level and gently slopes towards the deeper parts. Chara is quite common up to depths of even 5 m. Dominant among the macrophytes are *Ceratophyllum* and *Myriophyllum*, *Nuphar lutea*, and several species of *Potamogeton*. Notable are extensive communities of sea milfoil that cover large areas of the lakebed near the peninsula. The ichthyofauna mainly includes

Table 2. Description of Lake Gałęziste

Location	Area	Depth	Trophic type	Bottom and vegetation	Form of protection
Wigry National Park; Natura 2000 Augustów Site PLH200005 and Augustów Forest PLB200002	3.83 ha	max. 14.3 m	alkalitrophic	A rich phytocoenosis with high species diversity. There are both plants with floating leaves, submerged, and terrestrial-aquatic plants present.	–

Source: own elaboration.

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pike and perch. Detailed description of the lake is presented in Table 3.

Lake Białe Wigierskie (area 101.89 ha, maximum depth 34.0 m) is located in the Wigry National Park. Until recently, it had the characteristics of an oligo-mesotrophic lake. It is now classified as a well-preserved eutrophic lake. It features good visibility, occasionally reaching several meters. It is a stratified lake that mixes down to the lakebed. Vegetation covers the lakebed up to several meters deep. Chara meadows are observed down to depths of even 9 m, ensuring good oxygenation of the water. Submerged vegetation is dominated by various species of *Chara*, *Potamogeton*, and *Alopecurus*. Noteworthy is the poorly developed reed belt composed mainly of common reed and lake bulrush, which encircles the lake in a very narrow and often intermittent strip. Detailed description of the lake is presented in Table 4.

Lake Staw (area 20.75 ha, maximum depth 14.2 m) is located west of Lake Wigry, on the border of the Wigry National Park. It is a shallow eutrophic water body. Its specificity is associated with numerous seeps scattered across the entire lakebed, creating a spectacular landscape of "mineral-filled holes" within extensive *Chara* meadows. It is one of the few lakes in the country where the bottom is covered by 80% dense communities of *Chara*. Their presence ensures high oxygenation of the water and significant water clarity, often to the bottom. The lakebed is sandy and sandy-muddy apart from areas with various species of *Potamogeton*, *Alopecurus*, *Nitella*, *Ceratophyllum*, and *Myriophyllum*. Among the common species of animals other than fish, crayfish, and molluscs, extensive colonies of freshwater sponges can be found. Detailed description of the lake is presented in Table 5.

Table 3. Description of Lake Muliczne

Location	Area	Depth	Trophic type	Bottom and vegetation	Form of protection
Wigry National Park; Natura 2000 Augustów Site PLH200005 and Augustów Forest PLB200002	25.7 ha	max. 11.3 m	mesotrophic	High biodiversity, habitat diversity, and microhabitat diversity. Chara meadows.	Subject to strict protection

Source: own elaboration.

Table 4. Description of Lake Białe

Location	Area	Depth	Trophic type	Bottom and vegetation	Form of protection
Wigry National Park; Natura 2000 Wigry SitePLH200004 and Augustów Forest PLB200002	100.2 ha	max. 34.0 m	mesotrophic	Submerged vegetation is dominated by a community of Chara. Vascular plants are sparse.	Subject to strict protection

Source: own elaboration.

Table 5. Description of Lake Staw

Location	Area	Depth	Trophic type	Bottom and vegetation	Form of protection
Natura 2000 Augustów Site PLH200005 and Augustów Forest PLB200002, Augustów Forest and Lakes Area of Outstanding Natural Beauty; buffer zone of the Wigry National Park	20.75 ha	max. 14.2 m	mesotrophic	Sandy and sandy-muddy bottom densely covered with submerged vegetation. In the water column, Chara vegetation predominates.	–

Source: own elaboration.

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Development of the point valuation method

A point valuation method for the assessment of underwater landscapes of lakes was developed, with a maximum score equal to 39 points and maximum total points in each group of elements distributed according to the percentages obtained (rounded up to 1%). This is a modification of the method used for the study of the underwater landscape of Lake Muliczne, conducted as part of pilot research in 2022 (Senetra et al., 2023).

The developed point-valuation table was used for studying lakes with significant diversity. Based on a field session with a group of 20 experienced divers, minor adjustments to the scale were made. This group consisted of experts involved in the research, holding qualifications as diver ecologists. In the previous version of the method, the results showed little variation, even in areas expected to have different levels of sight-aesthetic attractiveness. The main issue in these types of water bodies is low visibility, up to approximately 6 metres. Under such conditions, the presence of even a few elements within sight significantly increases the sight-aesthetic attractiveness. In contrast to land landscapes, it is highly unlikely to observe multiple elements from each group simultaneously in lakes due to limited visibility. Therefore, the presence of at least one element received the highest score, as it is highly attractive for divers who might visit a specific lake solely to observe one particular species of animal or plant. This reasoning and approach to the research were confirmed by all participants in the field studies. Another issue was the measurement around the central points of the basic assessment grids. By using underwater scooters, which allow for very quick exploration of entire grids, an inventory of all fields was completed. The size of the basic grids was adjusted to the size of each studied water body (Table 6).

Table 6. Size of basic grids and their number for each water body

Lake	Lake surface area	Grid size	Number of grids
Białe	984.825 m^2	10.000 m^2	133
Gałęziste	37.710 m^2	2,500 m^2	27
Muliczne	261.111 m^2	2,500 m^2	136
Staw	225.525 m^2	2,500 m^2	137
Turkusowe	66.496 m^2	2,500 m^2	39

Source: own elaboration.

According to the previously adopted methodology, the results obtained during the assessment of all elements were assigned to the centroids of the basic grids and served as the basis for further calculations. Additionally, the point-valuation scale was proportionally divided into five categories of attractiveness (Table 7).

Table 7. Point valuation and categorisation of the sight-aesthetic value of the underwater landscapes of lakes

Groups of elements	Element	Score	Notes	Scales in groups of elements
1	2	3	4	5
Animals	fish	12	the total score must not exceed 12	scale 0–12
	crayfish	9		
	snails (mussels)	6		
	none	3		
	insects	0		
Submerged anthropogenic objects	wooden boat	9	the total score must not exceed 9	scale 0–9
	metal boat	9		
	obstacle made of wood	9		
	platform	9		
	car	9		

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cont. **Table 7**

1	2	3	4	5
	fixed rope	7		
	deck	7		
	plastic boat	7		
	anchor line	7		
	information board	7		
	obstacle made of plastic	2		
	fishing equipment	2		
	obstacle made of tyres	2		
	none	0		
Natural obstacles	trees	7	the total score must not exceed 7	scale 0–7
	plants	4		
	boulders	3		
	none	0		
Plants	levelled underwater *Charophyte* meadows 0.5 m in height	7	the total score must not exceed 7	scale 0–7
	none	5		
	single plants	5		
	rushes	5		
	plants growing in clumps	5		
	underwater meadows 1.5–2.0 m in height	2		
	plants growing up to the surface	0		
	filamentous algae	0		
Shape and appearance of the bottom	submerged cliffs/walls	4	the total score must not exceed 4	scale 0–4
	boulders	4		
	slope	3		
	hilly	3		
	rocky	3		
	sandy	2		
	flat	2		
	muddy	0		
Scale for the method – 0–39				
Categorisation of the sight-aesthetic value of the underwater landscapes of lakes: category I (very attractive landscapes) – 32–39 category II (attractive landscapes) – 24–31 category III (neutral landscapes) – 16–23 category IV (unattractive landscapes) – 8–15 category V (very unattractive landscapes) – 0–7				

Source: preparation based on (Senetra et al., 2023).

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Cartographic presentation of the landscape's sight-aesthetic attractiveness

The attractiveness of the above-mentioned lakes was visualised using three interpolation methods: inverse distance weighting (IDW), kriging, and nearest neighbour.

The inverse distance weighting method (IDW) method is considered one of the most intuitive and simplest methods for determining the influence of specific phenomena values measured in more or less dispersed points (Kotulak et al., 2017). It is characterised by a decrease in influence with increasing distance between the studied points. The result of interpolating each point is the weighted average of the studied values [Formula (1)]:

$$F(X,Y) = \sum_{i=1}^{n} (w_i f_i) \quad (1)$$

where:

$F(X, Y)$ – the value of the point with coordinates X, Y,
n – number of neighbouring points,
w_i – weight of the i-th neighbouring point,
f_i – value of the i-th neighbouring point,

where weights decrease proportionally to the square of the increasing distance between points (according to Tobler's law) (Bivand et al., 2013; Cichociński, 2011; Longley et al., 2005; Senetra, 2015; Urbański, 2012), according to Formula (2) (Dumitru et al., 2013; Kotulak et al., 2017):

$$w_i = \frac{d_i^{-p}}{\sum_{i=1}^{n} d_i^{-p}} \quad (2)$$

where:

w_i – weight of the i-th neighbouring point,
d_i – distance of the analysed point from the i-th neighbouring point,
p – power parameter, being a positive real number.

The number of points considered depends on the adopted approach: global (treating the entire available set of points as neighbours) or local (using only a limited number of influential nearest points, according to set criteria) (Bivand et al., 2013; Cichociński, 2011; Kotulak et al., 2017; Okabe et al., 2000; Urbański, 2012).

The resulting map resembles the results of using kriging (described below), however, unlike this method, IDW interpolation only considers distances to interpolated points with unknown values, ignoring the spatial configuration of observations, which can lead to incorrect results in the case of numerous clusters in the analysed set (Bivand et al., 2013). Moreover, the weights assigned to individual points during calculations range from 0 to 1, and the results obtained never exceed the size from the studied range (Dumitru et al., 2013; Longley et al., 2005). Despite the relative simplicity of the calculations performed, a significant problem with the IDW method is the time-consuming calculations, excessive data smoothing, and the lack of data extrapolation capabilities (Dumitru et al., 2013; Longley et al., 2005).

The second of the used methods, kriging [also known as the method of optimal prediction of random fields – see Ligas & Kulczycki (2014)], was created by one of the first scientists who began to pay more attention to spatial continuity when estimating the distribution of phenomena – becoming one of the fundamental and most frequently used tools in geostatistics (Dumitru et al., 2013).

According to Stein (1999), "at first glance, kriging is just a special case of optimal linear prediction performed on random processes and fields in space". In practice, this interpolation method involves creating optimal objective estimates of regionalised variables at locations without observed data, based on the hypothesis of stationarity and the structural properties of covariance (Kowalik, 2007). The aim of kriging is local estimation by determining a simple moving average from the studied set of points near the newly interpolated point (Bydłosz et al., 2010). The value of the variable at a point with unknown value is determined in a linear way as the weighted sum of the possessed data set, according to Formula (3) (Kowalik, 2007; Loonis & Bellefon, 2018; Scheuerer et al., 2013):

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$$Z^* = \sum_{i=1}^{n} \omega_i Z_i \quad (3)$$

where:

ω_i – weight determined for the i-th point,
Z_i – value of the variable on the i-th point,
n – number of dispersed points in the analysed set.

The weights of individual points are determined not based on the distance function, but based on the spatial ordering of points (Cichociński, 2011) and using a semivariogram and statistical criteria (Dumitru et al., 2013; Longley et al., 2005; Loonis & Bellefon, 2018), in such a way as to minimise the mean square error of estimation (kriging variance) (Bydłosz et al., 2010). Thanks to taking into account autocorrelation, it is possible to eliminate disturbances caused in the model by extreme values. Moreover, in the case of this method, the direction between the newly interpolated points and the input points is also significant, which manifests itself, for example, by assigning smaller weights to points "obscured" by others (Longley et al., 2005).

Despite the fact that this method allows data extrapolation and exceptionally flexibly adapts to the analysed set of points (especially with uneven data distribution – see Cellmer (2014)), its disadvantage is the long processing time, associated with the large number of generated equations (one for each point) and the size of the studied area (Dumitru et al., 2013). Another – and quite significant drawback – is the excessive smoothing of results compared to reality (Urbański, 2012), because, according to Cichociński (2011), "the processing algorithm respects individual data to a lesser extent, more relating to the surface trend".

A response to most problems encountered with IDW or kriging may be natural neighbour interpolation. Thanks to the use of structures in the form of Voronoi diagrams and Delaunay triangulation, describing the topology in terms of natural neighbours around each of the studied points (Kim et al., 2010; Kotulak et al., 2017), it performs very well in the case of irregularly spaced point sets (Dumitru et al., 2013). By natural neighbours, we mean points located in Voronoi cells directly adjacent to the cell containing the studied point (criterion of common boundary).

RESULTS

Application of the Method at the Assessed Site

The valuation table presented above was used to assess the individual points evenly distributed across each of the studied lakes during the underwater inventory. The fieldwork was conducted by experienced divers using high-tech underwater survey equipment. Direct measurements were made at 472 measurement points covering basic fields – squares (133 in Białe, 27 in Gałęziste, 136 in Muliczne, 137 in Staw, 39 in Turkusowe) (Fig. 2).

Each interpolation was combined with the cartogram method (colour gradation), presenting the attractiveness of the lake by means of the colour green, divided into 5 categories (Senetra et al., 2023), based on previous solutions for terrestrial landscapes: (I) very attractive (32–39 pts.), (II) attractive (24–31 pts.), (III) neutral (16–23), (IV) unattractive (8–15 pts.), (V) very unattractive (0–7 pts.). A darker shade of green on the map indicates greater attractiveness of the area.

Validation

For each lake, interpolation was performed on a selected set of measurement points, among which a group of points was chosen only for later validation of the obtained results. Each point, with a given attractiveness value obtained from direct measurement, was assigned an attractiveness obtained from the 3 interpolation methods used. The differences between the actual value and the interpolated value (Table 8) are shown on the maps (Fig. 3, Fig. 4, Fig. 5, Fig. 6, Fig. 7) using green and red points. The size of the point corresponds to the size of the difference obtained.

The average difference between the actual and interpolated values was -1.49 points for the natural neighbour method (-3.82%), -1.70 for the IDW method

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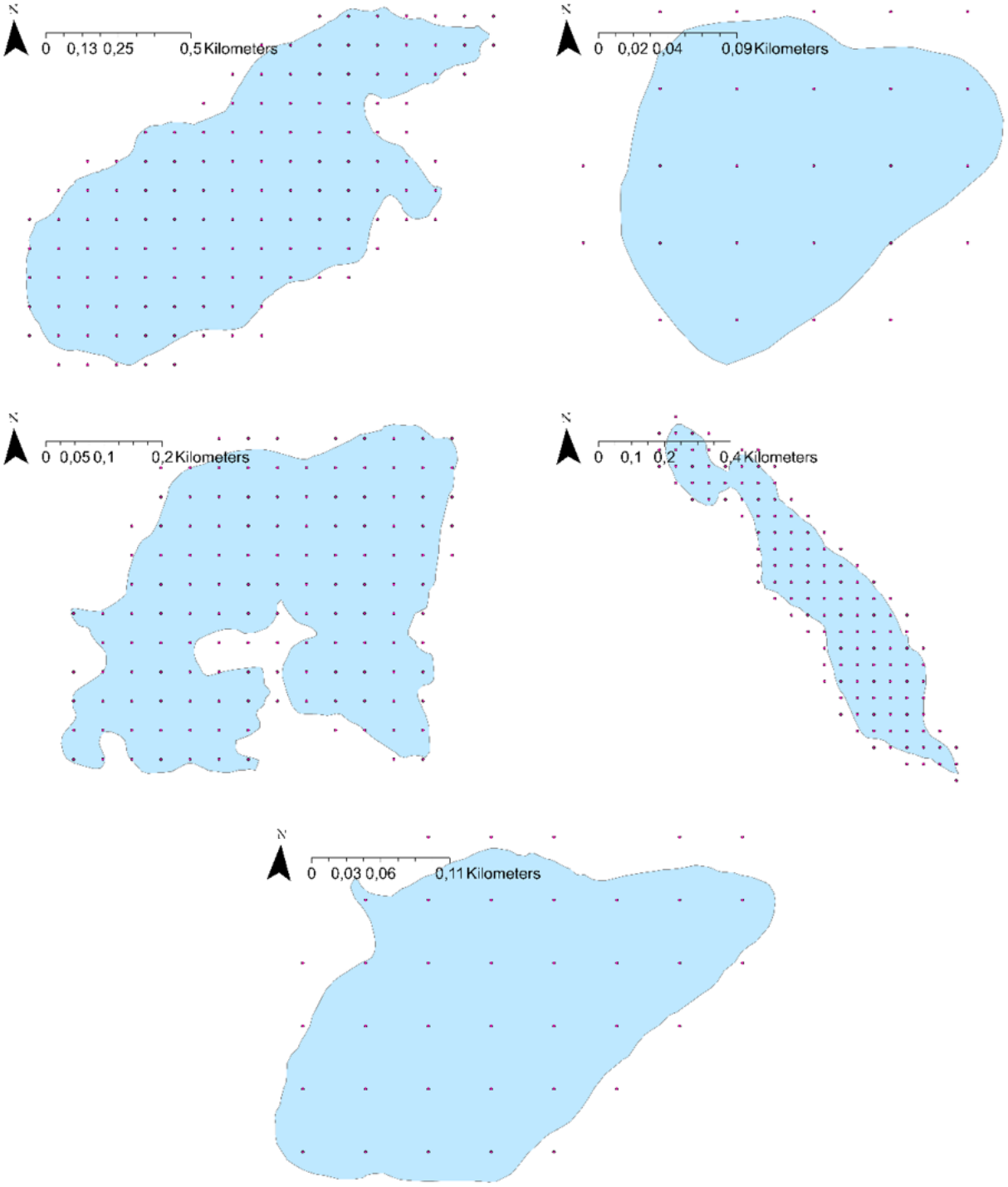

Fig. 2. Measurment points at lakes: Białe (top left), Gałęziste (top right), Muliczne (middle left), Staw (middle right), Turkusowe (bottom)
Source: own elaboration.

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Table 8. Differences between actual and interpolated values

Lake	Mean			Standard deviation			Root Mean Square Deviation (RMS)		
	Natural	IDW	Kriging	Natural	IDW	Kriging	Natural	IDW	Kriging
Turkusowe	-4.83	-4.67	-4.83	2.40	2.88	3.19	5.31	5.35	5.64
Gałęziste	-1.50	-2.25	-1.25	1.73	0.96	2.22	2.12	2.40	2.29
Muliczne	1.10	0.43	0.14	6.34	0.51	7.52	6.28	0.65	7.34
Białe	-0.76	-0.82	-0.94	2.25	2.04	1.85	2.31	2.14	2.03
Staw	-1.45	-1.21	-0.97	4.76	4.97	5.31	4.89	5.03	1.64
mean	-1.49	-1.70	-1.57	3.50	2.27	4.02	4.18	3.12	3.79
mean [%]	-3.82%	-4.37%	-4.02%	8.96%	5.82%	10.30%	10.73%	7.99%	9.72%

Source: own elaboration.

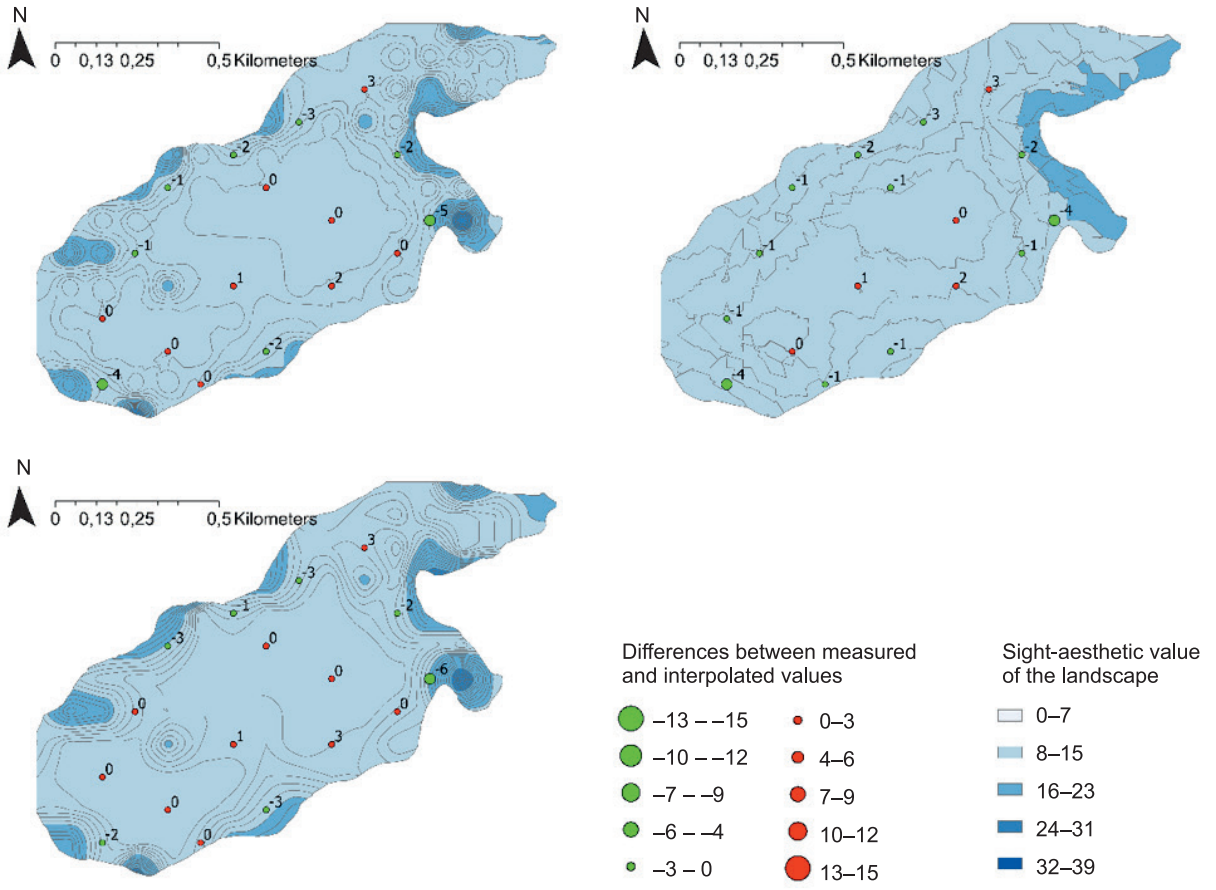

Fig. 3. Lake Białe, IDW (top left), kriging (top right) and natural neighbour (bottom) interpolation
Source: own elaboration.

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(-4.37%), and -1.57 for kriging (-4.02%). The values ranged as follows: from -4.83 to +1.10 for natural neighbour, from -4.67 to +0.43 for IDW, and from -4.83 to +0.14 for kriging. The largest differences for each method were obtained for Lake Turkusowe, and the smallest for Lake Muliczne. On average, the difference for each method was around -1.6 points (about -4%), with the best results achieved using the natural neighbour interpolation method.

In terms of standard deviation, the smallest results were obtained for the IDW method (an average of around 5.82%). In the context of individual lakes, the smallest standard deviation was observed for Lake Gałęziste using the natural neighbour method, Lake Muliczne for the IDW method, and Lake Białe for kriging. The average standard deviation was around 3 points (8%).

The lowest values of Root Mean Square Deviation (RMS) were achieved with the IDW method (an average of 3.12 points – around 8%). The lake with the best RMS score was Lake Muliczne (0.65 points). Relatively small RMS values indicate that the differences between the interpolated and actual values for the lakes studied were minor, meaning the data was modelled correctly. No significant errors in the generated data were detected for any of the interpolation methods across all water bodies.

The most results with the lowest values were obtained for Lake Muliczne, both in terms of the average difference, standard deviation, and RMS, with the IDW method being predominant.

In the case of Lake Białe, for each method, a significant portion of the interpolated values in the central part of the lake matched the actual values.

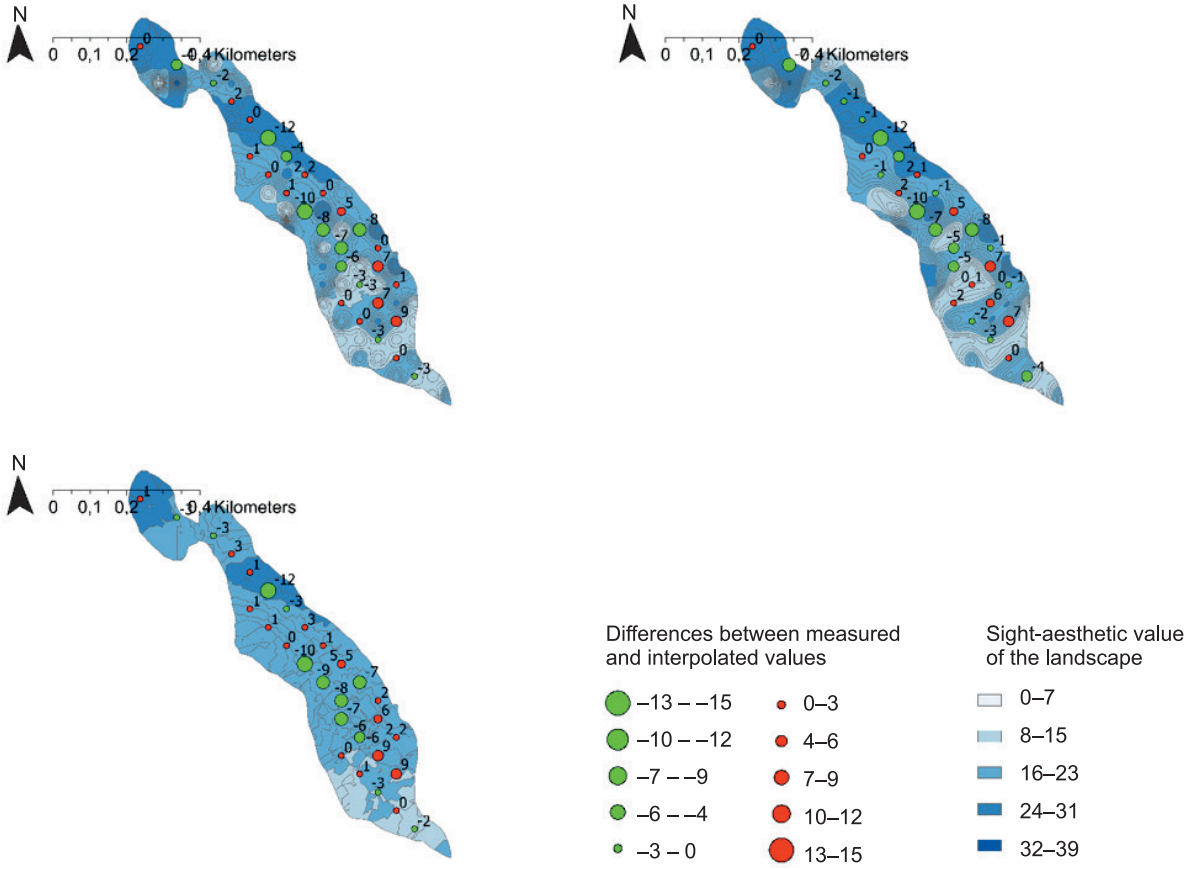

Fig. 4. Lake Staw, IDW (top left), kriging (top right) and natural neighbour (bottom) interpolation
Source: own elaboration.

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However, the majority of overestimated values were also obtained in the central areas, while on the edges, the interpolations generated values lower than the actual ones.

For Lake Staw, the interpolated values were higher than the actual ones, particularly in the central and north-western parts of the lake. Very few control points had interpolated values equal to the actual measured values.

The interpolation results for Lake Turkusowe were lower than the actual values at almost every interpolated point. Only in the northern part, using the IDW method and kriging, was there a single point where the interpolated value was higher than the actual measured value at that location.

For Lake Muliczne, the vast majority of interpolated values exceeded the actual values obtained at the measurement points. Using the IDW method, none of the points had values lower than the actual ones. In the case of kriging, there were the most underestimated values by the model, while for the natural neighbour method, the underestimated values were unevenly distributed.

For Lake Gałęziste, the IDW method resulted in all interpolated values being underestimated. The other two methods produced results where half of the points had values above and half had values below the actual ones.

The overall attractiveness of the entire reservoir in each case was determined as a weighted average

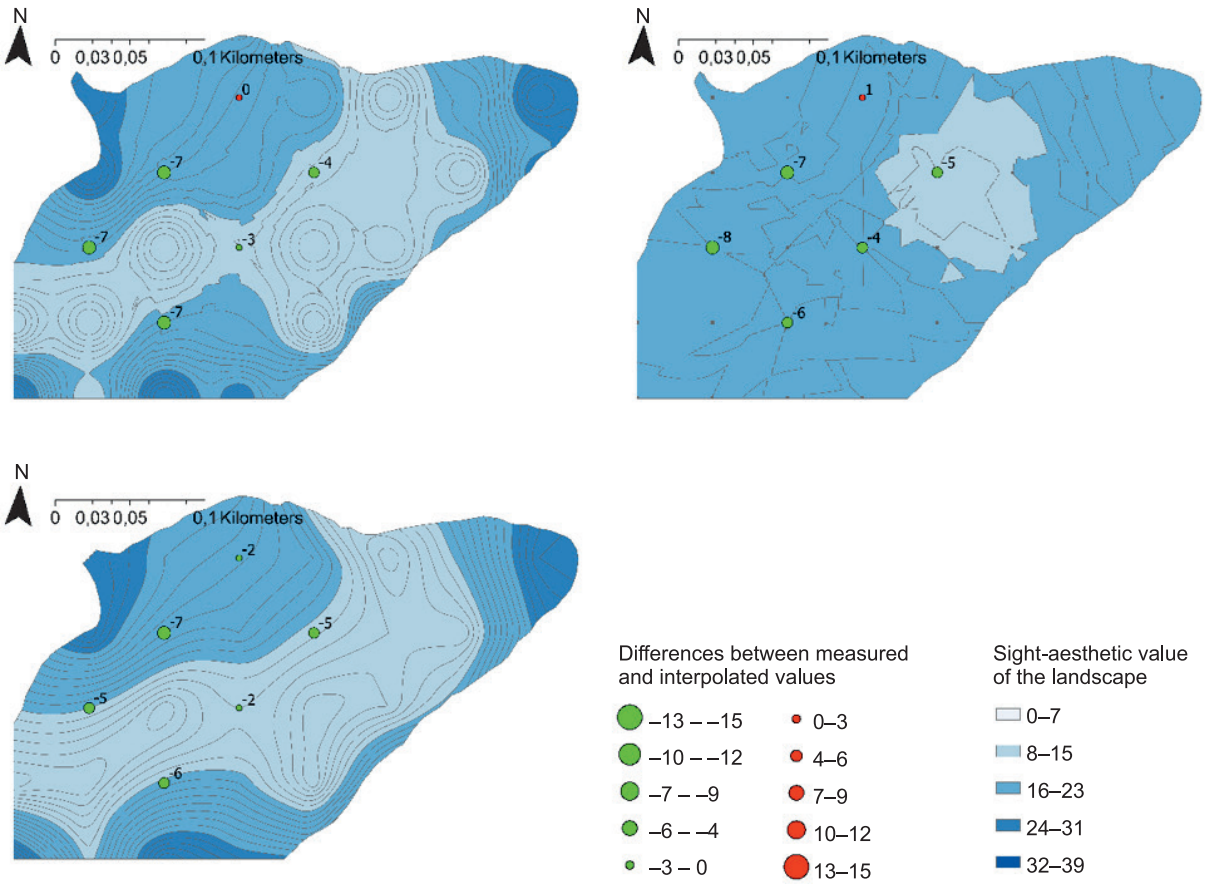

Fig. 5. Lake Turkusowe, IDW (top left), kriging (top right) and natural neighbour (bottom) interpolation
Source: own elaboration.

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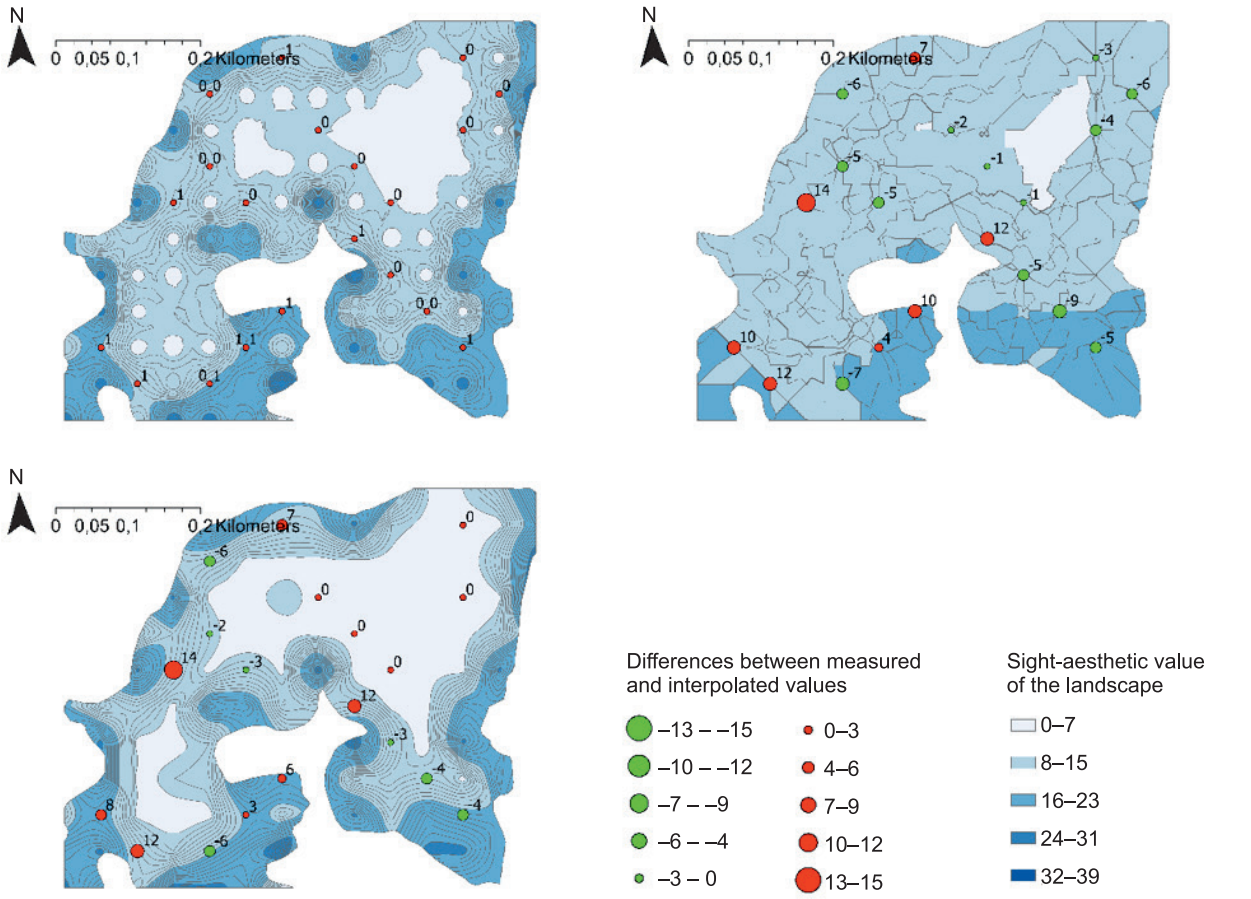

Fig. 6. Lake Muliczne, IDW (top left), kriging (top right) and natural neighbour (bottom) interpolation
Source: own elaboration.

of the areas of contour polygons for each interpolation method separately. This approach is consistent with the Thiessen method, which used this to determine average values over the studied area, typically scattered with irregular objects (Okabe et al., 2000). The results are presented in Table 9.

For each of the assessed water bodies, approximately the same results were obtained, regardless of the interpolation method used. Three of the studied lakes, according to the adopted method of attractiveness assessment, were attractive at around 35% (Lake Gałęziste, Muliczne, and Białe). Comparing the assessed lakes, the most attractive in terms of the sight-aesthetic value of underwater landscapes is Lake Staw, with 53%.

Table 9. Overall attractiveness of assessed water reservoirs

Lake	Method	Attractiveness*	Attractiveness [%]
Turkusowe	IDW	17.74	45%
Turkusowe	Kriging	18.35	47%
Turkusowe	NN	17.56	45%
Gałęziste	IDW	13.55	35%
Gałęziste	Kriging	13.05	33%
Gałęziste	NN	13.23	34%
Muliczne	IDW	13.49	35%
Muliczne	Kriging	13.55	35%
Muliczne	NN	13.27	34%
Białe	IDW	13.29	34%
Białe	Kriging	13.50	35%
Białe	NN	13.29	34%
Staw	IDW	20.56	53%
Staw	Kriging	20.56	53%
Staw	NN	20.64	53%

* out of a possible 39 points
Source: own elaboration.

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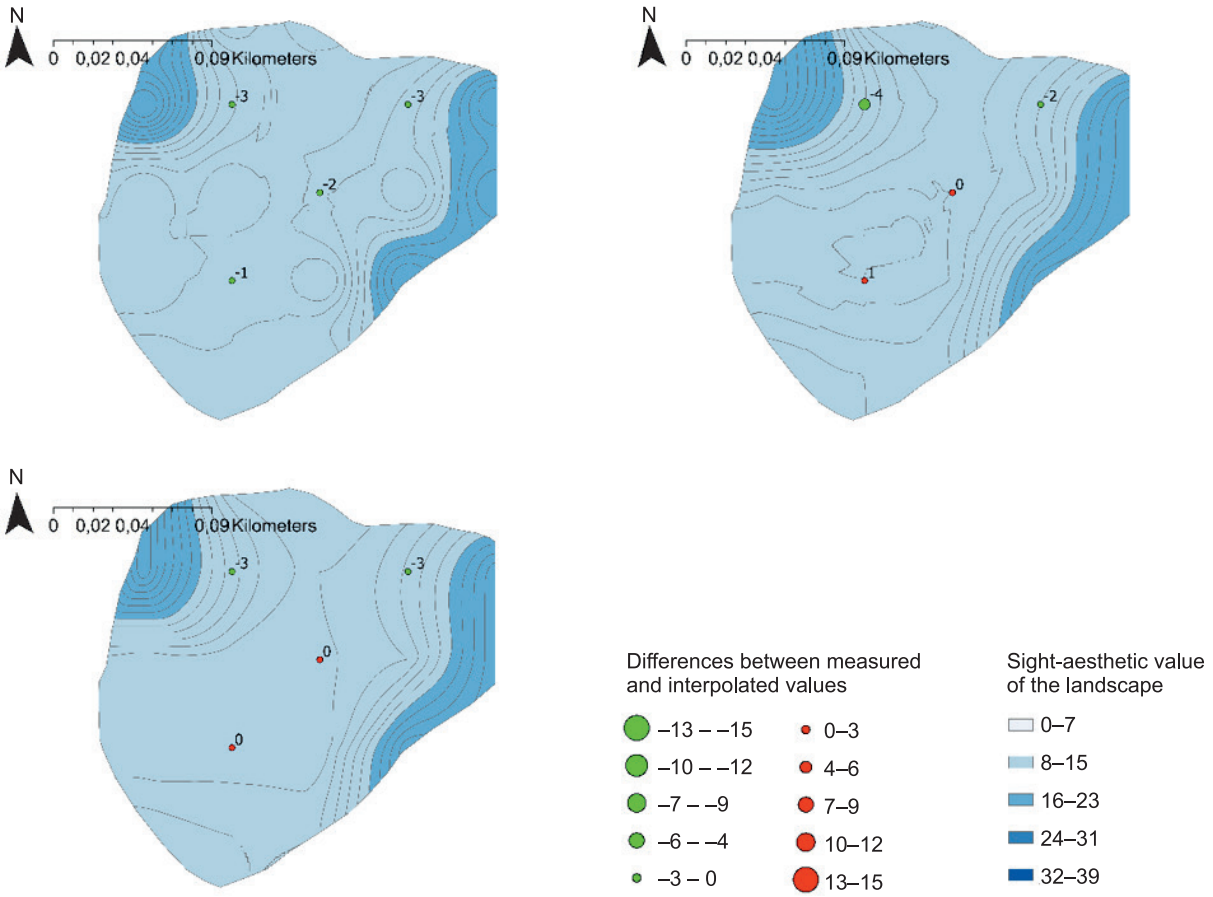

Fig. 7. Lake Gałęziste, IDW (top left), kriging (top right) and natural neighbour (bottom) interpolation
Source: own elaboration.

DISCUSSION

On average, the largest differences were obtained for Lake Turkusowe (using each interpolation method), while the largest standard deviations and mean square deviations – for Lake Muliczne. The average values of the differences were mainly negative numbers, indicating that the interpolated models underestimated the attractiveness values of the studied lakes at the selected points. Taking into account all 3 methods, the results were characterised by minor differences, with a predominance of the IDW method. Although it achieved the largest average differences (-4.37%), it gave the lowest values in the case of standard deviations (5.82% difference between actual and interpolated values), as well as in the case of mean square deviations RMS (7.99% difference).

The presented research has introduced a new quality in the assessment of the sight-aesthetic attractiveness of underwater lake landscapes by implementing the developed point-valuation method. Its usefulness in various environmental and geographical conditions was demonstrated, filling an existing research gap. The analyses conducted showed that the proposed point-valuation method allows for a precise assessment of the attractiveness of underwater lake landscapes. Moreover, the developed maps illustrate the distribution of this attractiveness, which can be used both for environmental protection and planning underwater tourism development.

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Previous research (mainly on seas and oceans) indicated the usefulness of interpolation in analysing underwater landscapes; however, similar studies for lakes were lacking. This article expands the knowledge in this field by introducing a new methodology, based on the solutions previously applied to land landscapes. It can be stated that reliable and satisfactory results were achieved. The tested methodology is related to field methods of assessing the sight-aesthetic value of landscapes and is based on groups of elements distinguished during the development of strict landscape assessment criteria. Additionally, these methods aimed at cartographic visualisation or the development of indicators for landscape attractiveness or suitability for various purposes. These methods include:

1. The LANDEP method (landscape ecological planning) (Ruzicka & Miklos, 1990).
2. The ABC method (Abiotic, Biotic, Cultural) (Bastedo, 1986; Koreleski, 2007).
3. The GEM method (General Ecological Model) (Naveh & Lieberman, 1984).
4. The MENTS method (Man-Economy-Nature-Territorial System) (Kostrowicki, 1990, 1992; Richling & Solon, 2011).
5. The Bogdanowski method (Bogdanowski, 1999).
6. The Söhngen method (Cymerman & Hopfer, 1988; Söhngen, 1975).
7. The Wejchert Impression Curve method (Koreleski, 2007).
8. The method for assessing aesthetic values of landscapes within visually perceived areas (Skarżyński, 1992).
9. The SBE method (Scenic Beauty Estimation) (Janeczko, 2011).

The examples of these methods originate from the second half of the 20th century, indicating the advancement of land landscape research. Currently, further versions are being developed to meet present needs, along with new methods largely based on existing methodological assumptions (Szefler, 2021). These facts demonstrate the significant methodological, technical, and organisational challenges in relation to the research of underwater landscapes, including underwater lake landscapes.

The results obtained were consistent with previous studies on the assessment of sight-aesthetic attractiveness. However, visibility in water (compared to air) was a significant differentiating factor, which proved to be a key influence on the assessment results. Moreover, the interpolation results varied slightly depending on the method used (IDW, kriging, natural neighbour), but the IDW method showed the highest accuracy compared to actual field measurements. In the assumptions of land landscape assessment methods, in addition to aesthetic categories, aspects of environmental function identification and its synthetic description were also perceived. All authors emphasise the need to analyse the interaction between anthropogenic elements and the environmental predispositions of the area. Quantitative evaluation elements, which are included in the sets of elements forming the landscape in a physical sense, were also applied. These methods also partially recommend the use of photographic materials in the assessment process. This approach is ensured by the point-valuation method applied to the assessment of the sight-aesthetic value of underwater lake landscapes, presented in this study.

The proposed methodology can be used as a tool for managing tourist traffic, particularly in the context of protecting water bodies of special value as part of environmental conservation. This will significantly limit tourist traffic in less visually attractive areas, which, however, possess valuable natural assets (Spyrou et al., 2022).

The results indicate the need for further refinement of the presented point-valuation method and its adaptation to the specific characteristics of lakes and underwater conditions. A significant improvement would be the expansion of research to other types of water bodies and the comparison of results obtained at different times of the year to assess the impact of seasonal changes on the sight-aesthetic attractiveness of underwater landscapes. Furthermore, the integration of modern technologies,

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such as underwater drones, seems crucial, as they can enhance the efficiency of measurements.

Another issue is the possibility of expanding the scope of research based on the tests conducted. An underwater landscape can be perceived through multiple senses, just like a landscape on land. The multisensory nature of landscapes has been a topic of research for many years (Bartkowski, 1985; Bernat, 2015; McLean, 2017). In addition to studying visual impressions, attempts should be made to determine the influence of other senses: hearing, smell, taste, and touch. Underwater, these senses play a similar role and are used in the perception of this environment.

The research results confirmed the initial hypothesis. A properly developed point-valuation method, supported by appropriate interpolation methods, can be effectively used to assess the sight-aesthetic value of underwater lake landscapes. The attractiveness maps obtained allowed for the presentation of the distribution of aesthetic values in the studied lakes, confirming that the tools used in land landscape research can also be adapted to aquatic environments. The results obtained using different interpolation methods, despite some differences, support the validity of the adopted methodology and its usefulness in planning and protecting these areas.

CONCLUSIONS

The results obtained indicate that the developed method is similar to those used for terrestrial landscapes. It relates to the field methods of landscape assessment, including the Söhngen method, Wejchert Impression Curve, and criteria for evaluating the visual amenity value of landscapes.

The presented method could in the future be used to assess the sight-aesthetic value of the underwater landscapes of lakes in order to protect the most valuable aquatic ecosystems. However, it has certain limitations, among which the most significant is the difficult perception of the underwater landscape due to visibility underwater. This depends on the type of lake, the clarity of its waters, or the kind of environment producing various pollutants. Nonetheless, it represents an innovative approach to the subject, utilising modern technologies to maximise the efficiency and automation of measurements.

Lakes, from the perspective of the sight-aesthetic value of underwater landscapes, are generally less attractive. The limited visibility in different types of water bodies, during various seasons and at different latitudes, plays a significant role in this matter. When seeking this attractiveness, it is necessary to direct tourist traffic accordingly by designating appropriate paths or underwater trails.

Author contributions: The authors have approved the final version of the article. The authors have contributed to this work as follows: Author1, Author2, Author3, Author4 developed the concept and designed the study, Author3, Author4 collected the data, Author1, Author2, Author3, Author4 analysed and interpreted the data, Author1, Author2, Author3, Author4 drafted the article, Author1, Author2 revised the article critically for important intellectual content.

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CONSEQUENCES OF THE DESTRUCTION AT THE KAKHOVKA HYDROELECTRIC POWER PLANT FOR AGRICULTURE IN THE SOUTH OF UKRAINE

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ABSTRACT

Motives: Ukraine's agricultural sector has suffered immense losses due to the Russian invasion. The situation worsened after the Kakhovka Hydropower Plant was undermined in the summer of 2023. It is essential to assess the devastating consequences of this destruction in order to plan the future development of the agricultural sector.
Aim: The aim of this study was to estimate the expected volume of agricultural production and possible scenarios of its development in the areas affected by the explosion at the Kakhovka Hydropower Plant. The study also aims to summarize the opinions expressed during the discussion on the reconstruction of the Hydropower Plant.
Results: In the medium term, agricultural activity in the region will be conducted on rainfed land at a scale similar to that of 2022. In the long term, there will be significant losses of almost all crop products due to changes in the structure of crops according to ecological requirements. Currently, there is no unified position on the restoration of the Kakhovka Reservoir and Hydropower Plant due to conflicting economic and environmental approaches.

Keywords: prospects of agricultural development, structural transformation, ecological requirements, military actions, losses suffered by farmers

INTRODUCTION

On June 6, 2023, a terrorist attack at the Kakhovka Hydro Power Plant (hereinafter – HPP) dam by russian military forces caused a catastrophic technological disaster with severe consequences. Over 30.000 hectares of fields (including those in the occupied territories) were flooded in the Kherson region and 100.000 tons of stocked crops were lost. The destruction of the dam also significantly impacted the biodiversity in the area and caused irreparable damage to the Nizhnyodniprovsky National Nature Park, the Dnipro River delta, and other Ramsar areas that safeguard the unique wetland ecosystems. The Kakhovka Reservoir previously covered an area of 2.1 thousand km^2, but as of August 2023, less than one-fifth of the surface, only 382 km^2, was still underwater. Over 1.7 thousand km^2 became dry land due to the attack.

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The areas affected by the explosion at the Kakhovka HPP are situated within Ukraine's Arid Steppe and Dry Steppe climate zones, which has a moderate continental climate with mild, little-snow winters and hot, dry summers. The destruction of the Kakhovka HPP has had a significant impact on the most vulnerable agroclimatic zone in Ukraine. Before the war, the zone was experiencing aridification of climatic conditions, i.e., a decrease in precipitation along with abnormally high temperatures that have since intensified. Domestic scientists predict that further increases in temperature and lack of precipitation in the region will lead to critical aggravation of moisture supply to biocenoses, drying of steppes, a reduction in land fertility and the total bio-productive system, and desertification of the area (Vozhegova, 2021).

The catastrophic event has had a considerable impact on Ukraine's agriculture sector, and it's essential to evaluate its effects to plan future development. The research aims to forecast the volume of agricultural production and potential scenarios of its future development in the regions affected by the terrorist attack at the Kakhovka HPP. Additionally, the study targets to summarize the discussion opinions regarding the rebuilding of the HPP.

LITERATURE REVIEW

EU's biodiversity strategy for 2030 targets to reclaim freshwater ecosystems and natural functions of rivers and aims to recover 25 thousand km of rivers in the EU (European Parliament, 2020). This will be achieved by removing unacceptable dams and artificial barriers that have been a result of human activity in the past century. Although scientific studies on river fragmentation primarily focus on large dams (over 15 m) due to security and economic reasons, not many such dams are located in Europe (only 2.8%). The majority of the barriers are smaller structures (Garcia de Leaniz, 2020). The war in Ukraine has highlighted that large dams have become targets for terrorist activities, such as the Kakhovka Hydro Power Plant and reservoir (the water level reached 16 m), which posed a catastrophic threat to the population, ecosystems, and the national economy.

According to Habel et al. (2020), Southern America and Western Europe are dismantling more dams than are being built. They mostly demolish low barriers and those between 7.5 and 15 m high. In Europe, 12 large dams have been dismantled, and those that are highly depreciated will be taken apart soon. One of the decisive criteria for dismantling dams is high costs involved in updating them. The authors of the research highlight the social and economic problems and environmental consequences of dam dismantling in different countries. They also stress the importance of developing complex plans that consider the short and long-term consequences of dismantling dams and provide local communities with new directions to develop the areas previously occupied by the water reservoirs. This can supply even greater social and economic benefits.

The researchers have highlighted the importance of effective communication with local communities regarding the dismantling and updating of dams. This will help support national political decisions. Boucher and Hudson (2023) have noted that the French state authorities' inability to include the values of stakeholders in the continuum of ecosystem services has led to opposition from the community against disassembling the 36 m dam in Vezins. Referring to Manatunge et al. (n.d.), proper planning and designing (involving the public at the early stages of the process) can minimize or eliminate the disturbance and unfavorable impact of dams. The future goal is to use dams and water reservoirs for smart management of national water resources to achieve development goals.

Agricultural ecosystems are primary suppliers of food and main users of water resources. These ecosystems use from 60% to 90% of available water depending on the climate and economic development of the region (Pedro-Monzonís et al., 2015). The global area for irrigated crops is assessed as 275 million ha, demonstrating the annual growth of 1.3% (Velasco-Muñoz et al., 2019). Although it makes up only 23% of the total cultivated area, it provides 45% of the total food.

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The researchers emphasize the need to follow the principle of sustainable development in agricultural water use and apply proper practices to improve crop yields and minimize water loss (Mancosu et al., 2015). It is essential to have water available for agricultural production to get sufficient and profitable yields. More investments in infrastructure development, such as dams and water supply systems, will help manage the growing demand for water from the population.

It is important to note that in the conditions of the climate change increasing, namely a decrease in rainfall and rising temperatures, agriculture in regions in the South of Ukraine without access to water resources will not be efficient. To achieve sufficient irrigation, surface water can be utilized after increasing the water level of Dnipro through the construction of a dam, as well as by using groundwater. A study (Su et al., 2021) has shown that rapid expansion of irrigated areas has led to a decrease in the level of groundwater, posing a threat to the stability of local agriculture and causing degradation of the ecological environment. This points clearly to the need of determine the degree of underground water over-exploitation and allowable water intake to protect the local ecosystem. Herman Bouwer also emphasizes the importance of protecting groundwater resources to ensure long-term water and food security for future generations (Bouwer, 2000).

Effective strategies for water resource management are essential for increasing water resource productivity and implementing sustainable farming systems (Mancosu et al., 2015). Therefore, Ukraine needs a reasonable choice of strategy to ensure sustainable development of its southern regions.

MATERIALS AND METHODS

The study is based on a combination of general and specialized scientific methods. By analyzing the ecological aspect, the authors aimed to summarize the opinions, observations, and predictions of experts on the natural recovery of the former area of the Kakhovka Reservoir. However, since there are no calculations available on the required funding for the reconstruction of the Kakhovka HPP and water reservoir, the conclusions reached are not fully substantiated. It is also reasonable to compare the currently available ecological and economic judgments on whether to rebuild the Kakhovka HPP and water reservoir or revive the Great Meadow National Nature Park (Velykyi Luh), which was flooded when constructing these objects.

To obtain empirical results on the transformations occurring in agricultural production in the South of Ukraine due to the destruction of the Kakhovka HPP, the authors conducted a retrospective analysis, grouping, comparative analysis, and consolidation. They analyzed the changes that have occurred in Ukrainian crop production from 2020 to 2022 based on the State Statistics Service of Ukraine data (State Statistics Service of Ukraine, 2023).

To assess effects of the Kakhovka HPP's undermining on the future development of crop production in the southern region, the authors proposed the following hypotheses:

– in the short and medium term, the production activity in the region will take place on rainfed lands, equal to that of 2022;
– in the long term, scenarios for crop production development in the area affected by the desiccation of the Kakhovka Reservoir and water outflow can be based on two options – one that prolongs the current situation that is a basic scenario, and another that considers the recovery of the irrigation system and production greening. The latter is an optimistic scenario.

RESULTS

Position on the importance of rebuilding the Kakhovka HPP and Reservoir for the Ukrainian economy

There is no agreement on the necessity of rebuilding the Kakhovka Reservoir and HPP for the Ukrainian economy. This highlights the conflict between economic, social, and ecological approaches.

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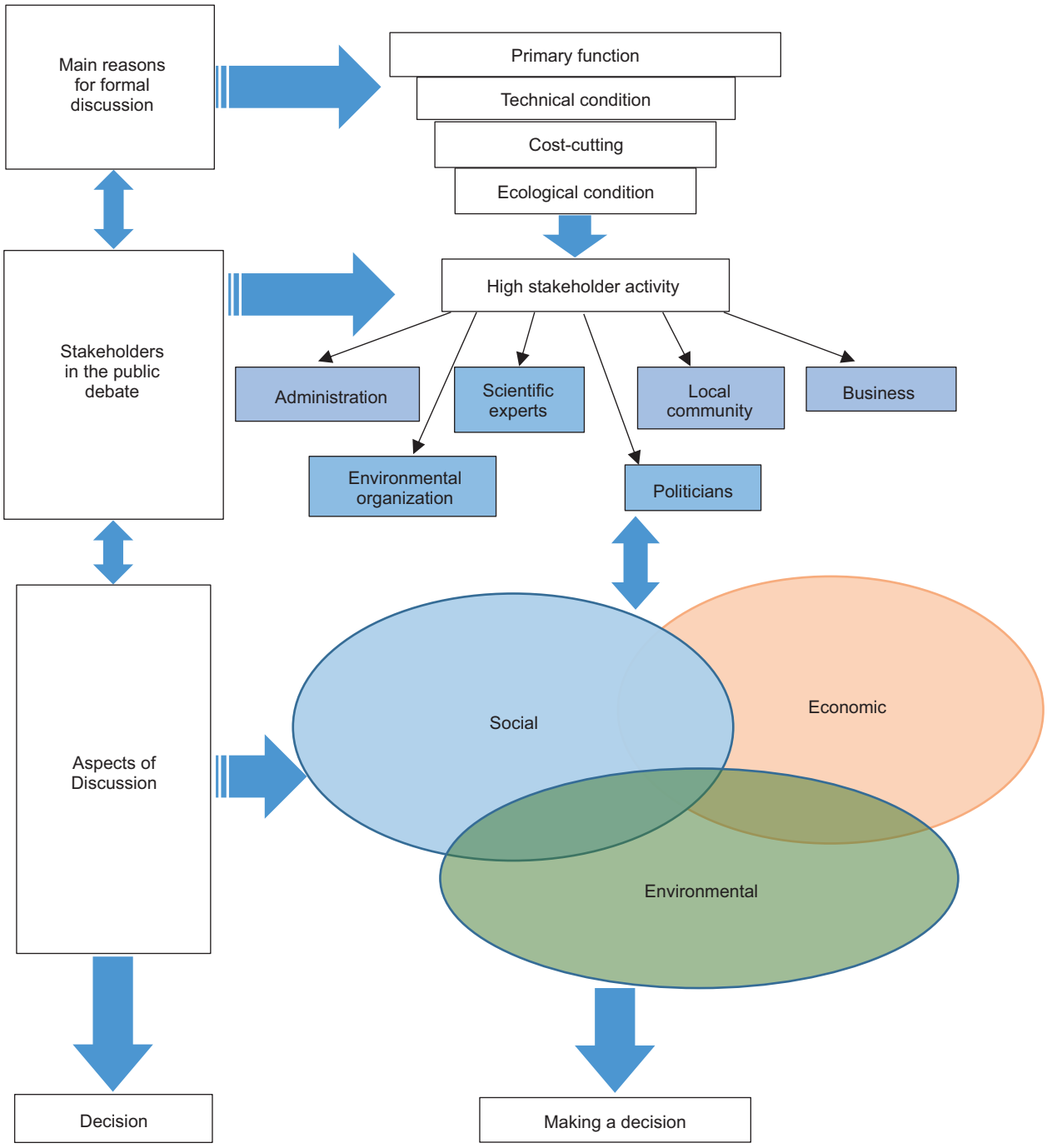

Fig. 1. Scheme of the official discussion on the decision about large dams
Source: own elaboration based on Habel et al. (2020).

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The Ministry of Agrarian Policy and Food of Ukraine believes that growing cereals using an extensive model may be an option, but it will result in significant yield losses. Vegetable growing is in a dire situation because without water from the Kakhovka Reservoir, this branch of agriculture is unsustainable. Water from the reservoir was used to irrigate 80% of the land where vegetables were grown, including almost all thermophilic fruits in Ukraine. In 2023, farmers on the right bank stated that they would switch to crops that do not require irrigation, such as wheat, barley, rape, and sunflower, and reduce their soybean production. Rainfed farming is a new prospect. Given the significant impact of the project on the ecological, social, and economic development of the southern region, a broad discussion according to the scheme shown in Figure 1 is reasonable.

The Ukrainian government is in favor of rebuilding the Kakhovka HPP and is proposing a fifteen-year ban on transfer into ownership and use of land previously occupied by the reservoir. Two draft laws have been submitted to the Verkhovna Rada of Ukraine to restore the reservoir and protect the land from misuse. The government has approved a two-year testing project to rebuild the Kakhovka HPP (Cabinet of Ministers of Ukraine, 2023).

An expert from the World Wildlife Fund emphasizes the need to partially fill the reservoir with a smaller volume of water to restore a portion of Velykyi Luh between Zaporizhzhia and Nikopol. However, most ecology specialists support the idea of completely restoring Velykyi Luh, which was flooded during the construction of the Kakhovka Hydroelectric Power Plant. This is due to the high costs required for revival, while rebuilding the reservoir would be much more beneficial. A research group from Kherson State University has concluded that creating floodplain forests in the area and reviving the Kamianka River are promising prospects. As long as no anthropogenic impact is made, groups of plants that are typical for the environment will revive. The vegetation map of the area of the dried Kakhovka Reservoir, composed by using the Normalized Difference Vegetation Index (NDVI), shows that within 2.5 months of the undermining of the Kakhovka HPP, the naked landscape has become green. The value of the index averaged 0.18, which corresponds to that of grass vegetation, according to studies by H. Kolomytsev.

It's important to highlight that rehabilitating Velykyi Luh, which was formerly part of the Kakhovka Reservoir, could greatly contribute to Ukraine's green initiative as it aligns with the country's environmental and climate goals under European Green Deal. By committing to such green projects, such as those for environmental protection and climate change, Ukraine may be able to restructure a portion of its debt through mechanisms like debt-for-climate swaps and debt-for-nature swaps (International Foundation "Vidrodzhennia", 2023). Similar agreements have been made in the past, such as the redemption of Bolivia's debt in exchange for the conservation of millions of hectares in the Amazon basin and the restructuring of Poland's debt in 1992, which allocated costs for protecting the country's biodiversity, managing waste, reducing greenhouse gas emissions, and preventing soil pollution. To encourage and attract investments in economic activities that are beneficial for ecological and climatic goals, Ukraine is advised to develop and implement a green taxonomy.

Assessment of the social and economic consequences of the Kakhovka HPP explosion for agriculture in the South of Ukraine

Economists agree that the South of Ukraine needs significant water resources for its development which proves the reasonability of, at least partial, but still rebuilding of the Kakhovka Reservoir.

Before its undermining, the Kakhovka Reservoir provided water for irrigation channels in Dnipropetrovsk, Zaporizhzhia, and Kherson regions. However, the lands in Mykolaiv region did not rely on the Kakhovka Reservoir for water. The agricultural sector in these regions mainly focused on crop production, particularly cereals and vegetables. The most commonly grown vegetables were tomatoes, cabbage, onions, peppers, and aubergines, while melons and

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stone fruits also held a significant share. Among cereals wheat, barley, rapeseed, rice, soybeans, corn, and sunflowers were grown using intensive technologies. Significant volumes of agricultural crops were grown under irrigation conditions in Kherson and Zaporizhia regions.

The data presented in Table 1 indicates that in Zaporizhzhia and Kherson regions, significant portions of arable land have been under occupation, resulting in a critical reduction in the area of irrigated land available for crop cultivation in 2022. However, in Dnipropetrovsk region, the cropping area, including the irrigated portion, has not seen much reduction. In 2022, only 8.1% of the irrigated land in Zaporizhzhia and 4.7% in Kherson regions were left for production on the government-controlled territory. This means that 80% of all irrigated land in Ukraine was not used for production activity due to military actions.

The destruction of the Kakhovka HPP by russian forces worsened the situation even further. This caused long-term and medium-term risks for agrarian production, as most of the irrigated lands in Zaporizhzhia and Kherson regions and over one-third of the area of Dnipropetrovsk region were supplied with water from the Kakhovka Reservoir.

In the short term and medium term, it is unlikely that the land in the South of Ukraine, currently is under occupation, will be available for agricultural activity. This is because it is polluted with explosive objects and degradation caused by hostilities.

The authors reached this conclusion after examining available data on the rates of recovery of agricultural lands on the deoccupied and frontline territories. In particular, January – February 2023 FAO survey showed that 95% of agricultural land in small agrarian farms (up to 250 ha) disposal are polluted in in Kherson region (KSE Agrocenter, 2023).

Landmine clearance and restoration of land fertility in areas affected by bullets and mines can be quite expensive and time-consuming. It can cost around $1780 per hectare to complete the three stages of demining. Kyiv School of Economics conducted a survey and used data from the State Statistics Service of Ukraine and FAO to estimate that small farmers alone would require over $250 million to clear their agricultural lands. High advanced costs can become a significant barrier for producers, as 72% of them have already experienced a sharp drop in income (over 50%) due to the hostilities (KSE Agrocenter, 2023).

It is currently difficult to predict the long-term impact of the catastrophic event at the Kakhovka HPP on agriculture. The reduction of cropping areas and yield capacity due to weather risks also must be taken into account. This means that negative consequences can be observed not only in the irrigated fields in Kherson, Zaporizhzhia, and Dnipropetrovsk regions directly but also in the adjacent territory due to climate deterioration.

Furthermore, there is currently no agreement on how to recover the water balance and ecosystem in the next few years. In the short and medium term, agricultural production will likely occur on drylands in a volume similar to 2022. The most significant losses will be experienced by farmers in Kherson and Zaporizhzhia regions. However, in Dnipropetrovsk region, which is less dependent on the Kakhovka Reservoir and less damaged, irrigated lands can be recovered in the medium term. Taking into account

Table 1. Loss of agricultural lands due to hostilities in the zone of the Kakhovka Reservoir

Regions	Sown area – total, thousands hectares			Irrigated lands, thousands hectares			Share of the zone of impact of the Kakhovka Reservoir in 2021 (estimation), %
	2021	2022	Index 2022 vs. 2021, %	2021	2022	Index 2022 vs. 2021, %	
Ukraine	20,198.7	16,433.2	81.4	429.2	84.2	19.6	75.1
Dnipropetrovsk	1,326.9	1,322.5	99.7	16.9	14.8	87.6	37.4
Zaporizhya	1,226.4	294.9	24.0	55.6	4.5	8.1	99.3
Kherson*	921.0	132.2	14.4	265.5	12.5	4.7	96.4

* agricultural enterprises data.
Source: calculated using the data from the State Statistics Service of Ukraine

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Table 2. The expected output of the main kinds of crops by agricultural enterprises in a short and medium period in the regions suffering from the Kakhovka HPP destruction, thousand centners

Types of crops	Production		Expected production	
	2021	2022	short term period	medium term period
Grain and legumes including	86,305.9	28,082.1	27,600	27,900
wheat	54,987.8	18,522.1	18,440	18,470
corn	14,643.1	5,623.9	5,390	5,555
barley	13,684.6	3,462.1	3,430	3,440
Soya	3,151.7	155.1	125	125
Rapeseed	6,098.7	4,153.0	4,135	4,145
Sunflower	25,070.9	10,833.6	10,805	10,810
Vegetables grown in the open	6,366.9	761.0	750	800

Source: Authors'calculation using the data from the State Statistics Service of Ukraine.

such assumptions Table 2 provides an estimate of the anticipated agricultural production in the regions affected by the Kakhovka HPP disaster in the short and medium term.

One possible solution addressing the climatic and other issues is shifting the economy of the South of Ukraine from arable farming to grassland animal breeding, which is sustainable in the current climate and justified given the progressing processes of desertification in the region. Alternatively, the costs intended for rebuilding the Kakhovka HPP could be used to build advanced pump stations to supply water for industry and agriculture directly from the Dnipro River instead of the reservoir. The application of water-saving technologies, such as drip irrigation, can also contribute to the development of intensive farming, including vegetable and fruit growing in the region.

Scenarios of agrarian sector development in the zone of the desiccated Kakhovka Reservoir

Therefore, taking into account that in order to make a decision regarding the further water supply of the three regions of Ukraine, which were part of the zone of influence of the Kakhov reservoir, specialist research is needed. As the final scenario of the region's development in the long term is currently unknown, two trends in the development of the agricultural sector can be predicted. They can be implemented regardless of the decision made about the source of water supply. At the same time it is worth noting that the agrarian sector in Dnipropetrovsk region, which was least affected by hostilities and is less dependent on water supply from the Kakhovka Reservoir (about 6 thousand ha), will maintain and even strengthen its pre-war development trends.

The first (basic) trend of development proposes:
- accessibility of agricultural lands in the three regions at the pre-war levels (including mine clearing and land recovery);
- restoration of old irrigation systems and the use of currently operating production technologies;
- strengthening of the adverse effects of climate change, which will result in further temperature rise and aridization. These trends can only be slowed down, and climatologists have long warned about them;
- conservation of the pre-war structure of cropping area and providing part of the land with irrigation.

Crop production volume can probably be maintained at the level of 2020, which was the driest in the pre-war period.

The second trend of development that is optimistic and in compliance with environmental requirements proposes the following actions:
- clearing mines and recovering land to make the total area of agricultural lands accessible at the pre-war level;
- optimizing agricultural landscapes, as stated in the Resolution of the Cabinet of Ministers of Ukraine of January 19, 2022 „On approval of the Concept of National Target Program of Use and Protection of Land", which will involve a decrease of the area

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of agricultural lands of researched regions (by up to 5560 thousand ha (63.5% of the total area), arable land by up to 3880.7 thousand ha (69.8% of the total area of agricultural lands);
- ensuring compliance with environmental requirements at enterprises, which will result in transformations in the structure of agricultural lands and cropping areas;
- implementing drip irrigation as the most efficient technology for water utilization to ensure maximum yield;
- introducing the required technological and resource decisions to increase the level of realization of the genetic potential of the seeding material productivity up to 70%.

Table 3 shows estimates based on these assumptions.

Table 3. The expected output of the main kinds of crops by agricultural enterprises in the long run in the regions suffering from the Kakhovka HPP destruction, thousand centners

Types of crops	Production 2021	Expected production	
		Basic scenario	Optimistic scenario
Winter wheat	54,750.5	43,000	50,800
Corn	14,643.1	7,700	22,000
Barley	13,684.6	11,300	15,400
Soya	3,151.7	2,550	5,700
Rapeseed	6,098.7	6,800	3,850
Sunflower	25,070.9	18,500	11,550

Source: Authors' calculation using the data from the State Statistics Service of Ukraine.

The estimates indicate that the implementation of structural changes in line with environmental requirements (optimistic scenario) could result in a significant decrease in certain crops production. For instance, agricultural enterprises may lose 7–10% in wheat production, sunflower – 45–55%, and rapeseed production may also decrease. It is also recommended to reduce the area under corn. However, its production can rise due to the increase yield if it is grown under irrigation. In recent years, the yield of corn in these regions was one of the lowest, because it, like soybeans, needs enough moisture. Therefore, in the calculations, the share of corn recommended for the Steppe zone in the structure of crops was significantly reduced in favor of wheat, which was due to the greater need for corn in water resources. This situation is essential because the current share of cropping area used by enterprises for growing industrial crops (mainly sunflower) is at an unacceptable level of 50%, depending on the region, and violates environmental requirements (Shubravska & Prokopenko, 2022). While this provides fast economic benefits, it causes land degradation and yield reduction in the long run.

The optimization of the cropping area structure of enterprises requires a ten-fold increase in the amount of land used for vegetables. This will result in a growth of vegetable production, given there is sufficient irrigation. However, it is difficult to predict the total expected volume of these products because it depends on the current market situation and the structure of vegetable production.

The losses experienced by the agrarian sector during the war had a significant impact on Ukrainian regions. Before the war, the regions mentioned accounted for 14.4% of the country's agricultural output. However, the impact of agriculture on the gross domestic product varied across the regions. For instance, in the pre-war period, the share of agriculture was 6.7% in Dnipropetrovsk region, which was less affected by the hostilities and the destruction of the Kakhovka HPP. In contrast, in Zaporizhzhia region, it was 10.5%, and in Kherson region, it was 33.1%. The agricultural production in Kherson region was heavily dependent on water supply from the Kakhovka HPP and therefore suffered the most significant impact from its explosion.

According to the authors' rough estimates, the losses suffered by agricultural businesses due to military actions and flooding caused by the destruction of the Kakhovka Hydroelectric Power Plant in Kherson, Zaporizhzhia, and Dnipropetrovsk regions amounted to at least $2.9 billion in 2022, as the value of agricultural products not received by them. In 2023, the losses of agricultural products

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were estimated to be around $3 billion. These three regions have already not received agricultural products worth $6 billion over the two years of the war. It is important to note that this figure does not include losses incurred due to damaged machinery, infrastructure (incl. destroyed elevators, irrigation facilities), livestock, poultry, buildings, mine clearing, or the cost of recovering agricultural lands. In the post-war period, it will be necessary to assess the value of land recovery and the feasibility of performing these works. There is a probability of refusing to use of the most affected agricultural lands

Based on the above expectations of a decline in production in the regions affected by the destruction of the Kakhovka HPP, the following measures should be taken:

- speed up the development of selection and increase the level of realization of the genetic potential of crop varieties and hybrids. This will have a significant impact on the agrarian sector's operation, as the amount of products obtained and the required qualities of crops for subsequent deep processing depend on proper seeding materials.
- in the medium and long run, abandon the previous systems of water supply and invest in the installation of irrigation point systems that use less water and contribute to the optimization of growing technologies.
- consider the changes in agro-climatic conditions of crop growing in the region and adapt production accordingly. In particular, fast and excessive accumulation of heat can reduce the vegetation period, stimulate premature ripening of crops, and result in a decline in yield.

CONCLUSIONS

The formation of floodplain forests in the area where the Kakhovka Reservoir used to be, as well as the recovery of Velykyi Luh, are crucial for optimizing the ecosystem and landscape in the southern part of Ukraine. These unique conditions in Europe are highly valued because the floodplain willow and poplar forests are protected under the Bern Convention. Additionally, restoring rainfed farming and transforming the structure of agricultural production in the desiccated Kakhovka Reservoir zone can have a positive impact on soil conditions, making it an opportunity for agricultural greening in the region.

At the same time, the development of agricultural production in the area requires at least a partial restoration of the Kakhovka Reservoir to provide irrigation. Obviously, this probability is extremely small even in the medium term. So, agricultural activities there will be carried out on the scale of 2022 on rainfed lands. Thus, the losses caused by the war, submergence and flooding after the destruction of the Kakhovka HPP to the agricultural enterprises of the region will increase annually. According to the authors' approximate estimates this will make almost $3 billion (as the value of not received agricultural products).

In the long run, both scenarios of development will lead to a decline in the production of traditional crops such as cereals and oilseed. This decline will be particularly noticeable in the basic scenario. However, in the optimistic scenario, the fall in production, mainly sunflower and corn, will be related to the structural transformation of agriculture in the region in compliance with the environmental requirements necessary for sustainable development.

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URBAN VISION WORKSHOP METHODOLOGY – A TOOL FOR SPATIAL JUSTICE

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ABSTRACT

Motives: Public participation in urban planning is institutionalized and generally regarded as good practice that should be promoted and implemented beyond the legal procedures for participation. A participatory approach is seen as the opposite of a hierarchical top-down approach and as a tool for achieving spatial justice. However, participatory urban planning poses numerous challenges in terms of both fundamental issues, such as superficiality and a threat to the genius loci of a place and process-related problems, such as technologies, methodology, and trust issues.
Aim: This research aims to demonstrate the importance of participatory urban planning as a means to achieve spatial justice, and to present and test participatory planning tools – the Urban Vision Creation Workshop Approach.
Results: The research has shown that the Urban Vision Creation Workshop Approach can improve citizens' participation experience, provide more comprehensive data for urban vision development, and contribute to achieving spatial justice.

Keywords: participatory urban planning, spatial justice, Urban Vision Creation Workshop Approach, Šančiai

INTRODUCTION

The understanding of space has changed significantly from a fixed context of human activities to an active force shaping human life (Pirie, 1983; Soja, 2009), with some even considering space as a social product (Pirie, 1983). As a result, public participation in urban planning has been institutionalized and is generally considered a mandatory and good practice to be encouraged and implemented beyond

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the participatory procedures required by law (Feltynowski, 2023). Public participation is defined as the involvement of individuals and groups in public decision-making on issues of importance to the community (Gawrońska et al., 2020). The participatory approach is perceived as an opposition to the hierarchical top-down approach (Kaza, 2006) and as a way to achieve a form of justice – fairness in the way people are treated (Cambridge Advanced Learner's Dictionary & Thesaurus, 2024) in terms of the distribution of resources in space and securing the opportunities to use them (Weck et al., 2022). Such spatial justice (Soja, 2009) is closely related to the concepts of equity – the situation in which everyone is treated fairly according to their needs and no group of people is given special treatment (Cambridge Advanced Learner's Dictionary & Thesaurus, 2024) and equality – the right of different groups of people to receive the same treatment (Cambridge Advanced Learner's Dictionary & Thesaurus, 2024) and to achieving them in the urban environment.

Although the participatory approach is even recognized as "as a method of good planning" (Kaza, 2006), an inseparable part of urban planning, environmental impact assessment (Gawrońska et al., 2020) and other procedures, it is constantly debated. Researchers point out that this approach inevitably excludes individuals, groups, and entities that cannot participate, such as future generations (Kaza, 2006) or non-human actors (Cook, 2018; Huston et al., 2018); that superficially understood public participation can cause damage not only to the genius loci of a place, but also to the community (Petrušonis, 2018), and that excessive attention to public participation hinders other trends of research on the urban environment, especially those related to the "genius loci's manifestations and efforts to grasp its essence" (Petrušonis, 2018). *Genius loci* is usually defined as "the unity of the tangible and intangible components of the […] environment, forming the uniqueness of the place" (Stepanchuk et al., 2020). In recent years, with the emergence of the concept of historic urban landscape, it is seen not only as a heritage preservation issue but also as a resource for urban development (Stepanchuk et al., 2020) and sustainability.

In addition to this fundamental and justified criticism, some challenges related to the participation process itself and its outcomes are mentioned in the literature. J. Åström (2020) has described such aspects related to participatory planning as technologies, methodology, and trust. The climate of mistrust in planning is often mentioned (Åström, 2020; Swain & Tait, 2007; Tait & Hansen, 2007). From one point of view, according to C. Swain and M. Tait (2007), contemporary urban planning is distrusted by citizens because of its "bureaucratic nature, its incapacity to understand and work for citizens, and its bias towards business interests". Meanwhile, J. Åström (2020) presents a different view, noting that even if most public officials support public participation in principle, they do not trust the validity of participatory planning outcomes. J. Åström (2020) emphasizes that mutual trust between collaborating actors is necessary for successful participatory planning. According to X. Wang and M. Wart (2007), citizens' positive experiences in participatory urban planning processes can increase their trust in government. As a result, technologies (Feltynowski, 2023), methods and approaches can play a significant role: they have the potential to improve citizens' participation experience and generate more reliable and useful data for decision making in planning. Moreover, the comprehensive set of participatory planning technologies and tools can generate a much more complex and broader set of data, not limited to the opinions of active community members. According to M. Feltynowski (2023), "public participation must be supported both by laws that allow residents to develop land-use policy and by technology that facilitates participation".

Šančiai, which is the territorial focus and living laboratory of this research, is a part of the city of Kaunas (Lithuania), a historic district that extends along the right bank of the Nemunas River. As in many other former suburbs of the city, the history of this district created a colorful mixture of industrial and residential objects, which over time tightly filled

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the valley in the loop of the Nemunas River, thus creating an original combination of the city and the natural environment, while still preserving a mosaic of urban subcultures that are normally more peculiar to suburban than central city zones. Upper Šančiai and Lower Šančiai are located on the upper and lower terraces of the Nemunas River, respectively (Vanagas, 2010). In this picturesque area near the city of Kaunas, the first villages were mentioned in the 17th and 18th centuries. At the end of the 19th century, Šančiai gradually became a suburb of the growing city of Kaunas. The uniqueness of this area is also given by the rather clear signs of military activity. The banks of the Nemunas River near Šančiai witnessed the beginning of the historic invasion of the Russian Empire by Napoleon's army, and since the 19th century, a large number of tsarist troops were stationed in Šančiai, and this part of the city had become a military town (Inytė, 2019). The urban structure of Lower Šančiai is characterized by narrow streets, a semi-regular layout, connections to the Nemunas River and a clearly visible contrast between large military and industrial buildings and small wooden residential houses. The rich history of the place, linked to industry, nature, and military activities, has shaped a diverse and active community, reminiscent of the everyday life of poor industrial workers' neighborhoods. The development and activities of Šančiai residents have intensified since 2011 after the creation of a modern and highly active local community, striving for a better quality and sustainability of its living environment. The modern life of this community is filled with meetings, festivals, artistic activities, and protests, which express their will to become active creators of their home and protectors of the local identity.

The aim of this study was to demonstrate the importance of participatory urban planning as a means to achieve spatial justice, and to present and test participatory planning tools that both improve citizens' participation experience and provide more comprehensive data for urban vision development.

The research process included: analysis of literature focused on the concept of spatial justice and its implementation by means of participatory urban planning; theory of spatial justice illustrated by the challenges faced by the Lower Šančiai community; presentation of the Urban Vision Creation Workshop Approach as a participatory planning tool and the experience of its application in different social groups related to Šančiai neighborhood; analysis and discussion of the results of the Urban Vision Workshop and evaluation of the efficiency of the methodology itself. The following research methods were used: literature analysis, workshop design and implementation, sociological observation, content analysis of the workshop results, SWOT evaluation of the workshop process and results from the point of view of improving citizens' participation experience, obtaining more comprehensive data for urban vision development, and contributing to spatial justice.

THEORY AND PRACTICE OF THE RIGHT TO THE CITY, SPATIAL JUSTICE, AND INJUSTICE

The theoretical foundation of the concept of spatial justice was laid by H. Lefebvre (1968) who analyzed the rights of city dwellers, and it was further developed by other scholars including D. Harvey (1973), P. Marcuse (2009, 2009a), and E. Soja (2009, 2010). In his book entitled "The Right to the City", H. Lefebvre (1968) addressed the issue of the individual's right to evaluate, know, and use urban space. Using the concept of the right to the city, H. Lefebvre (1996) created a vision of the city where the ideology of consumption is destroyed, and all social groups have the right to participate, create, and manage urban space (Lefebvre et al., 1996). H. Lefebvre (1996) argued that urban spaces are not only physical places, but also social and political constructs that shape the lives of individuals and communities. He proposed that urban dwellers have the right to participate in the decision-making processes that shape their cities, and that this right should extend to all members of society, regardless of their social, economic, or cultural backgrounds. He also argued that urban spaces should be created and managed in the way that promotes social justice,

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equality, and the well-being of all residents, rather than being driven solely by profit and commercial interests (Lefebvre et al., 1996).

Other scholars have interpreted and expanded the concept of the right to the city. According to D. Harvey (1973), through spatial consciousness, each individual is aware of the role and place of urban space in his or her personal life, and the impact of space on the relationship between the individual and the organization. Space shapes the relationship with the neighborhood, a particular territory, a local (group) language, etc. The concept of collective consciousness is also important in the context of participatory planning and placemaking. According to D. Harvey (1973), the right to the city is much more than the right to use the resources of the city. The right to the city is collective because the urban transformation of the city depends on the exercise of collective power in the processes of urbanization (Harvey, 1973). According to P. Marcuse (2009), there are two forms of spatial injustice: the involuntary confinement of any group in a limited space in order to exclude it (segregation, ghettoization), the restriction of individual freedom, and the unequal spatial distribution of resources, such as access to employment, political power, social status, income and wealth. Spatial injustice is a derivative of broader social injustice. Social injustice always has a spatial dimension that needs to be resolved in order to address injustice (Marcuse, 2009). P. Marcuse (2009a) states that the role of spatial injustice depends on social, political, and economic conditions. This means that, according to P. Marcuse (2009a), spatial justice is not only causal, but also derivative (Jankauskaitė-Jurevičienė, 2022).

The concept of spatial justice has been developed in particular by E. Soja (2009, 2010). He argued that spatial justice is the claim or right to the city, to its spatial resources, to the benefits that the city offers, the right not only to use them, but also to create them, to shape them, the right to develop them, with an understanding of social and spatial causality (Soja, 2010). The most important aspect of this concept is the granting or acquisition of a right not to the authorities but to the wider society, social organizations, and communities. E. Soja (2010) notes that most theoretical urban analyses are approached from a historical or sociological point of view, i.e. the theories focus on temporal rather than spatial analysis.

The rapid urbanization of the 20th century has raised the issue of public participation in urban processes, as urban planning cannot be just someone's individual vision of the city, but is linked to the individual experiences of many, and to the needs of society (Jankauskaitė-Jurevičienė, 2022). According to S. Fainstein (2014), the initial concern about the destruction of neighborhoods and their replacement by high-end residential or commercial structures was directed towards identifying methods of economic development. This led to the financing of wealthy real estate developers and the redevelopment of neighborhoods through gentrification (Fainstein, 2014). T. Sager (2011) argues that neoliberalism transforms the urban space into a space for market-oriented economic growth and elite consumption. It is noticeable that a large part of urban planning projects are now prepared by private developers. As a result, virtually all economic and social problems have become the domain of market solutions, and city authorities are influenced by the power of the market. N. Brenner et al. (2009) argue that the result of all these processes is the fragmentation of the city and the emergence of homogenized cityscapes that are clearly distinct and consistent with a business vision. N. Brenner et al. (2009) observe that it is in these fragmented areas that a variety of bottom-up social organizations emerge, claiming the right to the city and the opportunity to reshape it according to their new definitions. The processes of urbanization have led to the perception of urban space as both a social product and a marketplace. Public participation in urban spatial planning processes has become important and has been interpreted in different ways. It should be emphasized that the right to the city includes not only the satisfaction of the needs without which individuals cannot exist, but also the strengthening of the influence of the urban society and bottom-up organizations, and the growing desire to gather and shape the new quality and possibilities

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of the city (Jankauskaitė-Jurevičienė, 2022). Thus, public participation as a means to achieve spatial justice is of crucial importance for contemporary and future just Europe that offers perspectives for all places and people (Weck et al., 2022). Furthermore, there is a trend of thought and research that encourages expanding the scope of spatial justice to include non-human actors. According to N. Cook (2018), cities are not only the product of social relations; they are an entanglement of more-than-human worlds. As noted by D. Huston et al. (2018), much planning theory has been grounded in an ontological exceptionalism of humans; however, urban planning is an integral part of the "eco-social realities co-producing the Anthropocene". As a result, planners, researchers, and activists need to think carefully and critically about who speaks for the non-human in place making (Huston et al., 2018).

Public participation and influence in decision-making are important aspects of spatial justice along with the rights to health, safety, well-being, happiness, etc. However, the interests of several groups collide in the city: residents whose goal is an attractive space to live, work, and relax, businesses whose aim is investment and growth, and visitors who are looking for cultural and recreational facilities to spend their free time (Sager, 2011). The aforementioned "more-than-human" (Huston et al., 2018) dimension of cities makes this collision even more complex. In the urban planning processes in Kaunas, the interests of society, city authorities, and developers have often collided in recent years; in some cases, the outcomes of the planning process and decision-making tend to threaten the integrity and health of urban ecosystems. In the Lower Šančiai neighborhood, on the bank of the Nemunas River, the Kaunas Municipality started the project of new street development in 2019. This project encouraged the Association Community of Žemieji Šančiai to consolidate the residents of the neighborhood and declare their position as "no street", seeking to preserve the green riverbank and its eco-social values. In 2020, the Association started the project Genius Loci: Urbanization and Civil Community (hereinafter Genius Loci) in 2020, the aim of which was to involve the citizens of Kaunas to actively participate in the creation of an urban vision for the Šančiai area and to show that the citizens have not only the right to the city, to its spatial resources, and to the benefits offered by the city, and that they have not only the right to use them, but also have the potential to create them, to shape them, the right to develop the city. The project funded by the EEA and Norwegian Financial Mechanisms was implemented in partnership with the project promoter, Association Community of Žemieji Šančiai, and partners: Kaunas University of Technology, Vellenes Fellesorganisasjon and Bodø Municipality. The project consisted of three main stages: accumulation of historical, architectural facts, personal and collective history related to Šančiai; study of the use of public spaces of the district based on the sociotope methodology; creation of an urban vision of the Šančiai area. This article presents a part of the third stage – the creation of the urban vision of Šančiai through participatory activities. The creation of the urban vision is an action that originates from the community itself in order to legitimize its right to spatial justice.

DEVELOPMENT AND STRUCTURE OF THE URBAN VISION CREATION WORKSHOP APPROACH

Context and background of the Urban Vision Creation Workshop Approach

Before presenting the Šančiai Urban Vision Creation Workshop Approach in greater detail, its background and context need to be explained. This approach was designed as a continuation and the final element of a series of participatory workshops and mapping activities aimed at involving and empowering the population of the Šančiai neighborhood and collecting necessary data for urban analysis and modeling within the framework of the Genius Loci project. The previous stages included workshops aimed at mapping memory (Memory Map Workshop) (Zaleckis et al., 2023c) and the present use of public spaces (Present Map Workshop) (Zaleckis et al.,

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2023a, 2023b) in the Šančiai neighborhood. Each research stage included workshops with community members from different social groups accompanied by the publicly accessible interactive online maps available on the website https://sanciubendruomene.lt/en/. These digital data collection maps, developed and tested in practice during this project, have been internationally recognized as a highly effective tool for data sharing, participatory planning, and fostering a sense of place and belonging. Selected from more than 1.1 thousand applications, they were awarded the New European Bauhaus 2022 Runner Up prize in the category "Regaining the Sense of Belonging".

The interactive online maps were filled by both the workshop participants and by all interested Šančiai residents, visitors and other interested members of the society. Considering this experience, the Urban Vision Creation Workshop Approach, designed for the members of different social groups, is accompanied by a publicly available interactive online map available at https://sanciubendruomene.lt/en/vizija/pasiulymai/. Similarly to the Memory Map (Zaleckis et al., 2023c) and Present Map workshops (Zaleckis et al., 2023a, 2023b), the Urban Vision Creation Workshop Approach is based on three theories and related practical approaches (Fig. 1): mental mapping (Gieseking, 2013; Lynch, 1964), the hands-on, empathizing and ideation approach characteristic of design thinking (International…, 2019), and the sociotope methodology (Ståhle, 2006). The core of the Urban Vision Creation Approach consists of group work aimed at creating design and activity proposals for public spaces in the Šančiai neighborhood. The practices of mental mapping allow the workshop participants to trace on the maps of Šančiai the distinctive places that could be the target of the desirable planning and design proposals. The elements of the sociotope methodology are used to formulate structured proposals for potential users and activities in public spaces (Tuan, 2001) in the urban vision of Šančiai. The hands-on activities such as drawing, cutting, and gluing of collage elements are aimed at stimulating the creativity and involvement of the workshop participants. Group work must be preceded by an introductory lecture to demonstrate and explain the outcomes of the Memory Map and Present Map workshops and interactive online mapping as well as the results of the project. The main purpose of this material was to build empathy for residents of different backgrounds, familiarize the workshop participants with the unique features of the district and to understand their importance not only for local residents, but also for the wider city community.

Theoretical background and structure of the Urban Vision Creation Approach

The core of the Urban Vision Creation Workshop Approach consists of three interrelated elements:

1. Map drawing – identifying, by drawing on the map of the territory under consideration, the locations that are important for its future development and that need to be transformed.
2. Envisioning of potentially desirable users and functional typology of selected localities. To present structured proposals, workshop participants use pictographic symbolic icons representing typologies of users and activities. Icons make it easier for people to categorize what would otherwise be too many options for non-experts. In the case of the Urban Vision Workshop, typologies were adapted from the sociotope methodology (Ståhle, 2006; Vitkuvienė et al., 2019).
3. Vision collage focusing on people, activities, and the environment. The collage method is relevant because it allows people who often have limited opportunities to present their ideas visually to do so, and it also helps to make the idea more understandable for the participants themselves. Workshop participants use newspaper and magazine clippings to create visual representations of their ideas for transforming a selected place.

The Urban Vision Creation Workshop Approach is designed to accommodate possible variations in the age and knowledge (of the area under consideration) of workshop participants. For example, if the workshop participants find it difficult to identify important

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locations on the geographic map (due to young age or limited knowledge of the area), photographs of selected places that need transformation can be presented to the workshop participants. The sites to be analyzed during the workshop can be selected by experts or based on previous research. Different ways of presenting and generalizing the results can also be used depending on the above-mentioned characteristics of the participants. Figure 1 and Figure 2 present two workshop scenarios: one for adults (Fig. 1) and the other for 12–15-year-old schoolchildren with limited knowledge of the area (they study in the school located in the area under analysis, but live elsewhere) (Fig. 2).

In both scenarios, workshops are based on group work with some individual work assignments and sharing of information, experiences, and reflections. The workshop staff includes a workshop coordinator and group work supervisors. Guest lecturers may also be invited to present information about the workshop context in the introductory stage. One supervisor can work with 5–7 groups, the recommended group size is up to 6 participants (optimal group size – 4 participants, especially when working with young participants). Materials needed for the workshops include pens, markers, glue, scissors, flipchart or other type of paper, printed handout materials (symbolic icons for the tasks related to users and activities, maps or photographs of the area under analysis), collage materials (newspapers, magazines, etc.). In the first scenario (Fig. 1) adult community members work with printed maps of the area. In the first step of the group work, the workshop participants identify the places that are important for the future of the neighborhood itself and for the city as a whole by drawing on the printed map of the entire neighborhood. This promotes a better understanding of the neighborhood as a whole while using maps as

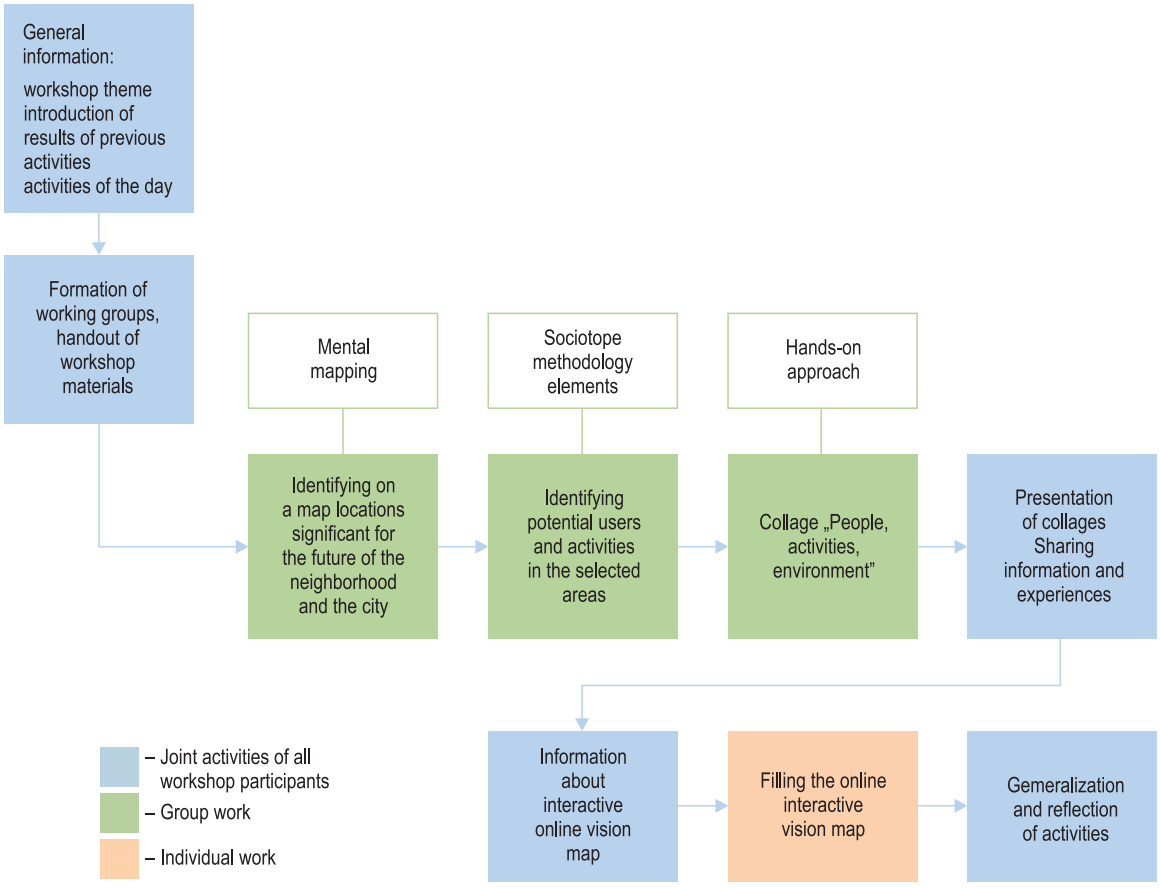

Fig. 1. Urban Vision Creation Workshop scenario for adults
Source: own elaboration.

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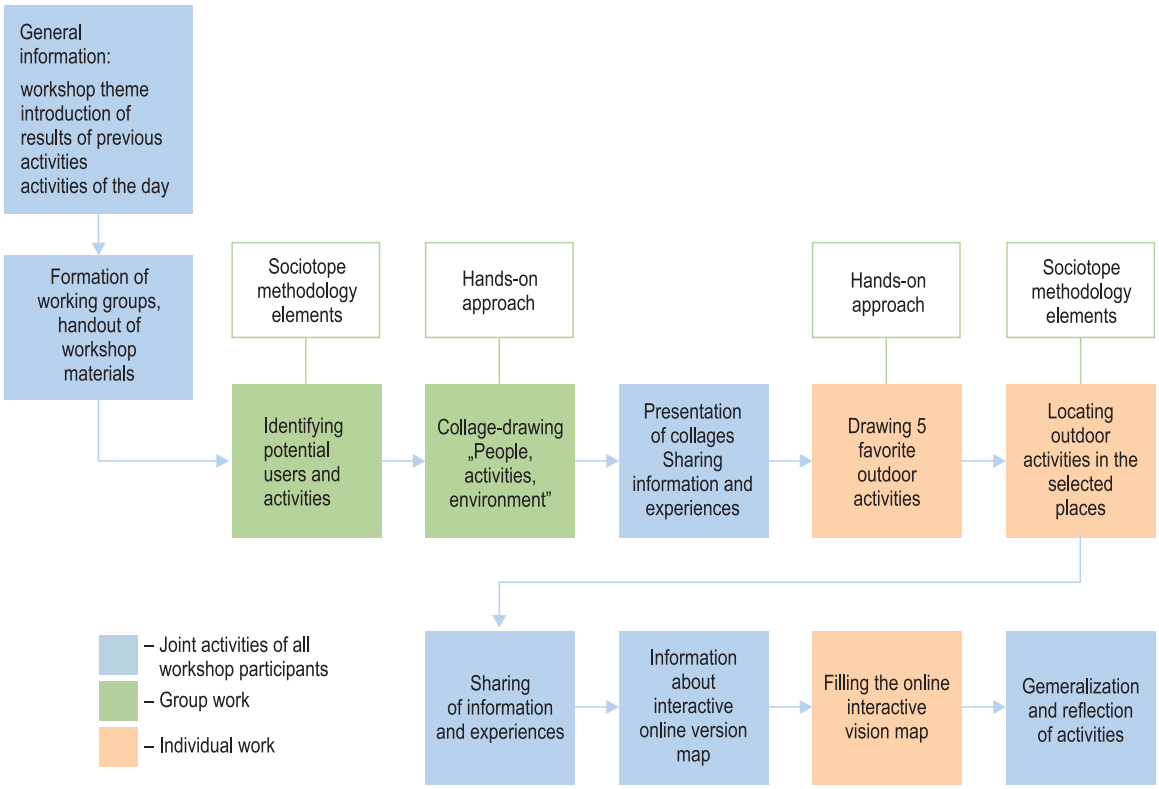

Fig. 2. Urban Vision Creation Workshop scenario adapted to 12–15-year-old schoolchildren with limited knowledge of the area

Source: own elaboration.

a non-customary tool. In further steps, workgroups elaborate selected zones of the neighborhood; each group elaborates one zone by drawing, writing comments, and gluing icons from handout materials and collage elements on the printed map of selected zones. The outcome of these activities is an urban vision collage showing potential users and activities of the elaborated locality and its potential equipment elements, and the general mood it could create. In the second scenario (Fig. 2), the workshop participants (schoolchildren) work with large-format (A3) printed photographs of selected placed in the neighborhood. The photographs are presented on flipchart paper in order to provide more space for drawing, writing and collage making. The localities can be selected by the workshop organizers based on the previous stages of research or by experts; for example, they can be places that children see on their way to and from school. In the second scenario, two types of vision collages are created during the workshops, based on the visual spaces captured in the photographs. Each workgroup of schoolchildren creates their own vision collage by drawing, writing, and gluing icons from handout materials and collage elements on and around the printed photograph of the place. Each group works on a different site. The collage reflects envisioned users and activities, as well as equipment and design elements of the public space and the mood it might create. The second collage is a collaborative result of all workshop participants. First, each participant is asked to individually draw five of his/her favorite outdoor activities on sticky notes. Once the drawing is finished, all workshop participants are invited to locate their favorite outdoor activities in one of the places under analysis. As mentioned before, each workgroup analyzes different places. In this stage, the background of the collaborative collage contains printed photographs of all the places under analysis,

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and the participants can paste their favorite activities in any of these places. Filling in the online interactive map can be the final element of both workshop scenarios. Each workshop participant can enter his/her own vision proposals for the neighborhood. The entered data includes the location on a map and the type of proposed intervention (building, public space, equipment etc.), its title and description; illustrative images (associative picture, photograph, drawing) can also be uploaded. All workshops end with a discussion and reflection on the results and a collective exhibition of the created materials.

Analysis and generalization of Urban Vision Creation Approach results

During the workshops, a lot of visual and other information is collected, reflecting not only the specific proposals of the participants in a structured form based on the sociotope methodology (using icons representing the relevant activities and users assigned to the specific place), but also a lot of emotional information expressed in the form of free creative aesthetics (drawings, associative images, notes, sentences, general mood, style, etc.). This very interesting additional information is also useful because it reflects the general attitude of the participants and the values and desires linked to specific places in the area. Such data is more original, free, and complements the sociotope methodology in new aspects, but its systematization, processing and interpretation can pose additional challenges. Thus, the work with the results (mental maps, collages, sociological observation material) of Urban Vision Creation workshops can be divided into three stages: systematization of the results in worksheets, systematization and generalization of the results on maps, and generalization of the results into the bottom-up urban vision of the place under analysis. Figure 3 presents the process of analysis and generalization of the workshop results.

Examples of the worksheets and maps used to systemize workshop results are presented in the Results section. Worksheets are created as a result of the content analysis of mental maps, collages, and recordings made during the workshops. They also help to structure and summarize the information presented in the research material in a free artistic form. Content analysis can be broadly defined as "the scientific study of the content of communication" (Prasad, 2008). In this case, content analysis is quantitative (identifying and counting categories) and aims to identify the following elements important for the creation of urban vision: potential users

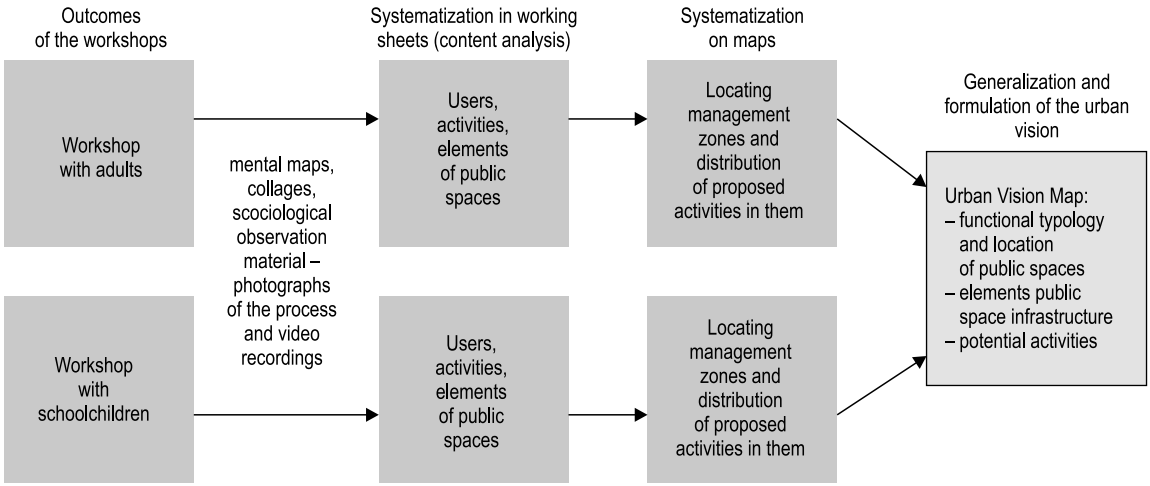

Fig. 3. The sequence and stages of the process of Urban Vision Creation workshops' results analysis and generalization
Source: own elaboration.

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of public spaces, the activities that could take place there, and the characteristics and design elements of the physical space that would create the conditions for users and activities to take place. These three components of urban vision became the categories used in the content analysis – users, activities, and elements of public spaces. Since the methodological basis of Urban Vision Creation workshops includes elements of the sociotope methodology in the form of user and activity typologies, the same typologies were applied in the processing of the results. The second step – systematization and generalization of the obtained data on maps – involved locating management zones and distribution of activities and functions proposed by the workshop participants on the topographic maps of Šančiai. The final step is the creation of a generalized urban vision map. In case of organizing several workshops with different social groups of participants, all obtained results are integrated into this map, and data from the interactive online map are also integrated in this stage. The development of urban vision maps should be creative, the use of symbols, pictograms, and drawings is recommended, but it should contain the following information: functional typology and location of public spaces, proposed elements of public space infrastructure, potential activities that take place in public spaces.

APPLICATION OF THE ŠANČIAI VISION CREATION WORKSHOP APPROACH AND ANALYSIS OF RESULTS

Methodology application

The Urban Vision Creation Workshop Approach was applied during 5 workshops with almost 200 participants (50 adult and senior members of the Šančiai community and 143 12–15-year-old schoolchildren) in the period between 2022–2023. Adult members of Šančiai community were invited to the workshop on the initiative of the Association Community of Žemieji Šančiai, using social networks and other media tools. The workshop with schoolchildren was attended by pupils from the school located in Šančiai (Kaunas University of Technology Vaižgantas progymnasium) who kindly agreed to collaborate in this project.

The workshop for adult community members was held on May 24, 2022 in Šančiai in the hall of the Kaunas University of Technology, Vaižgantas progymnasium (Fig. 4). Since the event was based on group work, during the workshop, the participants were divided into groups of 4–7 persons according to their free choice. This was done to save time for getting to know each other and to avoid possible sharp differences of opinion and conflicts within the groups, as the time available for the event was limited and additional handling of such situations would have been resource consuming and could have affected the final outcome. Given the diversity and complexity of the urban problems in the area, there was a significant potential for divergent views and conflicts of interest. The approach of the workshop was adapted to make the work as smooth as possible and to give the participants more positive emotions and relaxation in expressing their thoughts through drawings and collages. The approach of the workshop was to maximize the involvement of the participants in the practical hands-on work and to achieve a tangible result, rather than spending time in discussions. The first map of the workshop was dedicated to the identification of the most important places and common vision proposals for the entire neighborhood territory. The detailing of the vision proposals generated by the participants of the workshop with adult community members was concentrated on the bank of the Nemunas River, as this workshop focused mainly on this area due to the need to present bottom-up alternatives for the project of the street proposed by Kaunas City Municipality (Šukšta, 2022).

The event lasted 4 hours with short rest breaks. During the event, all stages of the methodology were implemented step by step and the visual material of the participants' proposals was created (reflecting the localization of the proposed interventions in the area, the type of proposed activities, potential users, possible design solutions and the mood of the desired

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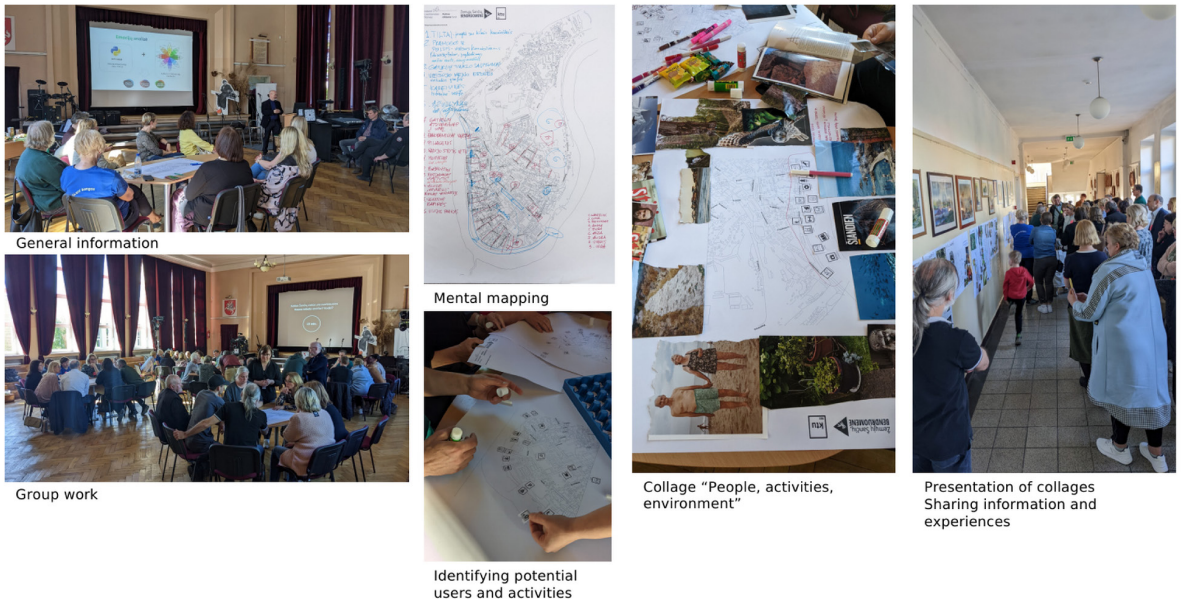

Fig. 4. Šančiai Urban Vision Creation Workshop with adult members of the community
Source: photographs by the authors.

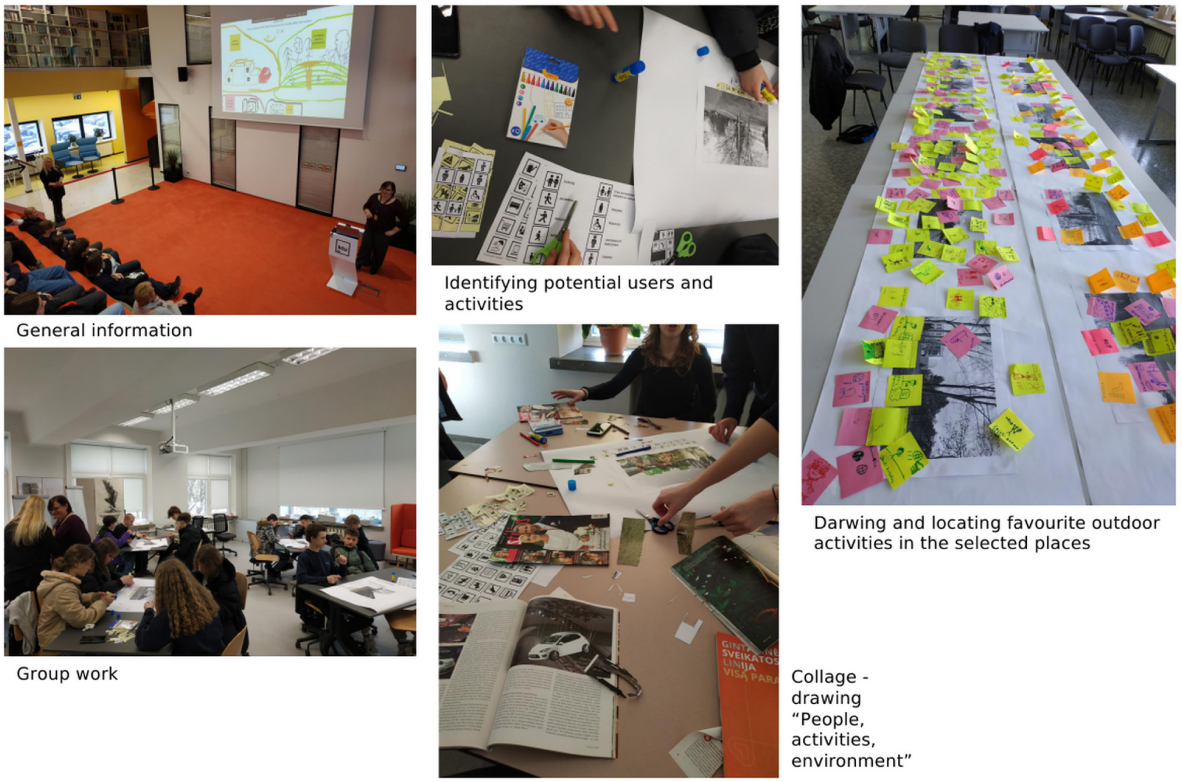

Fig. 5. Šančiai Urban Vision Creation Workshop with schoolchildren
Source: photographs by the authors.

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intervention expressed by the collage). In the course of the workshop the researchers of the project had supervised the workgroups and carried out the sociological observation of the ongoing discussions and the work process. The tangible results of the workshop were 12 vision collages and supplemental maps reflecting structured information and participants' opinions. The material identified as participatory planning artifacts (objects made by the workshop participants, of cultural or historical

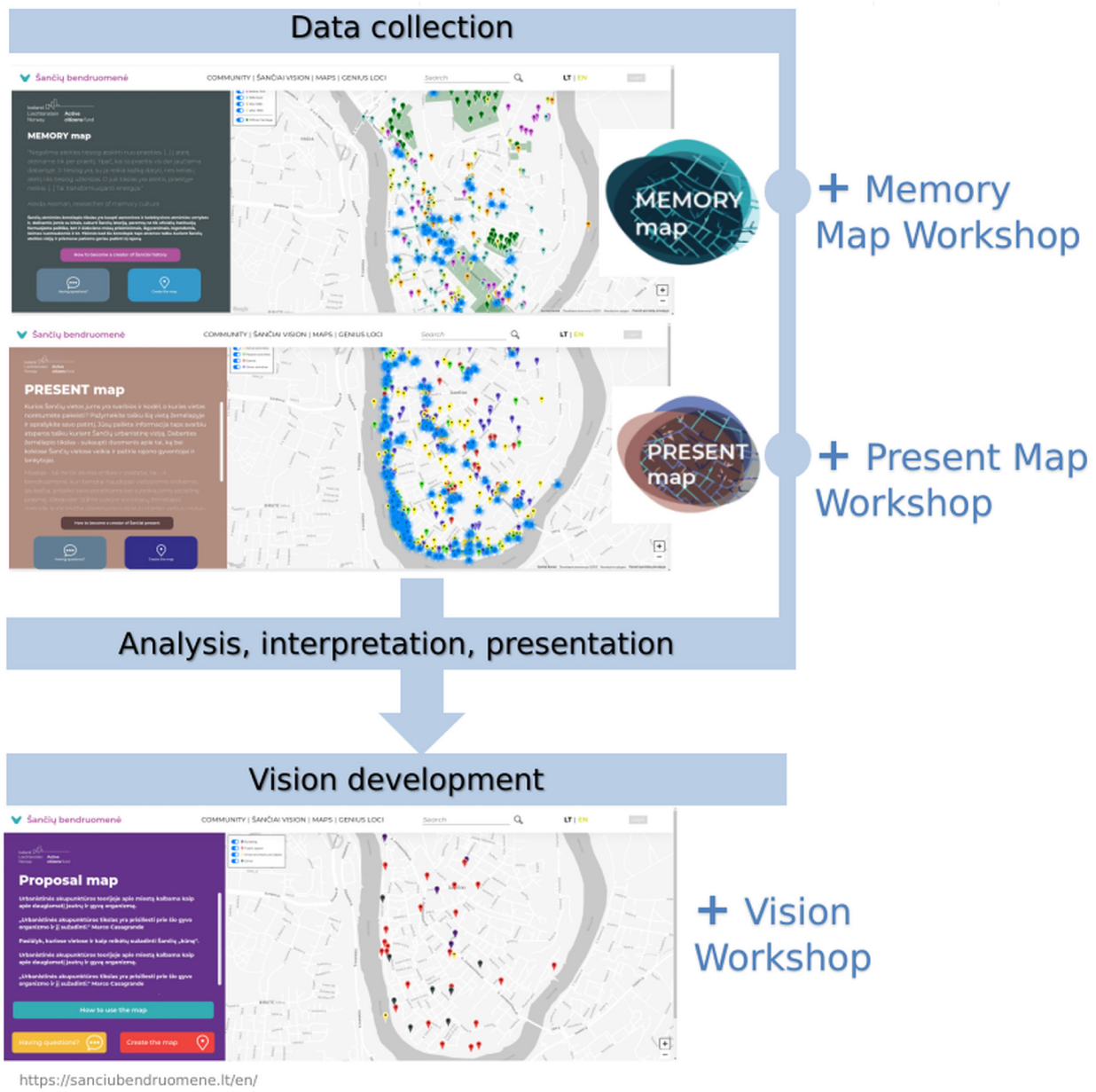

Fig. 6. Online interactive maps used in the course of the Genius Loci project. The proposal map presented at the bottom of the image was used in the Urban Vision Creation Workshop with schoolchildren. The maps are available at https://sanciubendruomene.lt/en/

Source: own elaboration based on Genius Loci (2023).

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Fig. 7. Two types of collages: a) based on the maps of the locality (plan), created in the workshop with adult members of the community and b) based on the photographs (visual spaces), created in the workshop with schoolchildren
Source: photographs by the authors.

interest) was made available to the public for viewing and commenting: it was exhibited at the Kaunas subdivision gallery "Drobė" of the Lithuanian Union of Artists, located in Šančiai.

Workshops for schoolchildren were held on March 6 and 7, 2023. During these workshops, almost the same approach was used, only the basis of the map was replaced by photographs of selected places in Šančiai (Fig. 5). This choice was made in order to avoid inaccuracies and misunderstandings when reading the maps, which could have occurred due to the participant's young age, inexperience, and limited knowledge of the area. It should be noted that some of the schoolchildren participating in the workshop did not live in Šančiai but attended the school located in this district. The participants worked in groups of 4–5 persons with up to 5 workgroups in one classroom (one class) supervised by the project researchers. The project researchers also conducted sociological observation of the ongoing discussions and the work process, and videotaped the presentations of the workshop results.

Schoolchildren focused on 6 selected locations in Šančiai representing the diversity of public spaces and their management problems in the district as well as different types of urban landscapes in Šančiai. The event lasted 8 hours (full academic school day) with short rest breaks. During the event, all the stages of the approach were implemented step by step and the visual material of the participants' proposals was created (reflecting the types of the proposed activities, potential users, possible design solutions and the mood of the desired intervention expressed by the collage); the participants also entered their ideas for Šančiai public spaces into the interactive online map (Fig. 6). The tangible results of the workshop were 36 vision collages (Fig. 7) and supplemental material reflecting structured information and participants' opinions.

Analysis of collected data and generalization of results

The material and data collected during the workshops included mental maps and collages, identified above as participatory planning artifacts and sociological observation material – photographs of the process and video recordings. Examples of participatory planning artifacts are presented

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Users of public spaces:
1. All types of users (adults, seniors, pre-school age children, school-children, teenagers, youth, uniformed officers, parents or childcarers with children, people with special needs, tourists); animals (birds)
2. All types of users except pre-school age children, uniformed officers, and tourists; animals (dog, cat, fishes)
3. All types of users except pre-school age children, seniors, uniformed officers, people with special needs, and tourists; animals (dog)
4. All types of users except uniformed officers; animals (cat, birds)
5. All types of users except pre-school age children, seniors, uniformed officers, people with special needs, and tourists
6. All types of users except adults, childcarers with children, people with special needs, uniformed officers, and tourists; animals (birds)

Elements of public spaces:
1. Trees, flowers, park, benches, merry-go-round, path, hammock, sculpture, parking, fitness equipment, pool, picnic, picnic area, art installation, solar panels, lighting, graffiti
2. Trees, decorative plants, flowers, path for pedestrians, bicycles and scooters, café, basketball court, beach, picnic area
3. Trees, flowers, benches, playground for children, swings, smoking area, picnic area, event area
4. Water, trees, flowers, location for taking photos, bicycle path, decorative plants, natural area
5. Trees, flowers, decorative plants, modern architecture, lawn, pedestrian path, café, volleyball court, bar-club
6. Building renovation, trees, decorative plants, place for litter, place for transport, personal space, billboard

Age	7th-graders	7th-graders	8th-graders	7th-graders	8th-graders	8th-graders	Total
Activity \ Group	1	2	3	4	5	6	
Gardening							
Observing the panorama	x		x		x	x	4
Folklore							
Events			x		x		2
Observing the shop windows				x			1
Taking photos			x	x	x	x	4
Other cultural activities							
Picnic	x	x	x		x		4
Exercise	x		x		x	x	4
Shipping	x						1
Bird feeding	x		x	x	x	x	5
Waiting for public transport		x					1
Resting, sitting	x		x	x	x		4
Relaxation in the greenery	x	x	x	x	x	x	6
Games/sports		x	x	x	x		4
Ball games		x	x		x	x	4
Walking the dog	x	x	x	x	x	x	6
Sitting in a cafe		x			x		2
Walking	x	x	x	x	x	x	6
Shopping							
Meetings			x			x	2
Relaxation in the greenery	x	x	x				3
Observing the flowers	x		x	x	x		4
Horse riding							
Talking on the phone				x			1
Smoking			x		x	x	3
Recreation near the water	x	x			x		3
Children's games, playing		x	x	x	x	x	5
Fishing	x				x		2
Bathing, swimming	x	x					2
Riding the bike	x	x		x	x		4

1. The most important things in the collage are relaxation and nature. It is possible to bath and do picnics here
2. Comfort – well-being. Idea for Šančiai. Benefits – relaxation, rest after works, spend weekend, have a good time
3. Any abandoned place can become popular place that everyone likes
4. The most important things are plants, humans, animals. They bring life
5. Recreation area near Nemunas
6. -

Fig. 8. Example of the worksheet used for systematizing workshop results. This sheet was used to systematize the results of the workshop with schoolchildren related to one out of the six analyzed locations – open space near the Vytautas Magnus University school

Source: own elaboration.

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in Figure 7 – drawings and collages based on the geographic map of the area created by the adult participants and on the photograph of the visual space created by schoolchildren.

As it was described in the structure of the approach in the previous section, the analysis and systematization of the results of the workshops was carried out using worksheets and maps. Figure 8 presents the systematization of the results of the workshop with schoolchildren for one location – the open space near the Vytautas Magnus University school is shown. The table on the right presents the frequency of occurrence of different types of activities in the collages prepared by different classes of schoolchildren (up to 5 workgroups in one classroom) numbered from 1 to 6. It can be seen that the most frequent activities proposed for this open green public space located near the river are relaxation in the greenery, walking, and walking the dog.

The upper panel on the left shows the potential users of public spaces identified by each class. It is important to note that the workshop participants used specific categories to identify users (adults, seniors, preschoolers, schoolchildren, teenagers, youth, uniformed officers, parents or caregivers with children, people with special needs, tourists); moreover, numerous workgroups had identified non-human actors (animals, birds, fishes) as space users by drawing them in the space or representing them in the collage using magazine clippings. The lower panel on the left lists the elements of public spaces identified by each class. The project researchers had identified these elements by analyzing workshop materials. It can be seen that natural elements and

Fig. 9. Systematization and generalization of the results of the workshop with adult and senior members of the Šančiai community revealing a bottom-up generated strategy for the Nemunas riverbank

Source: own elaboration.

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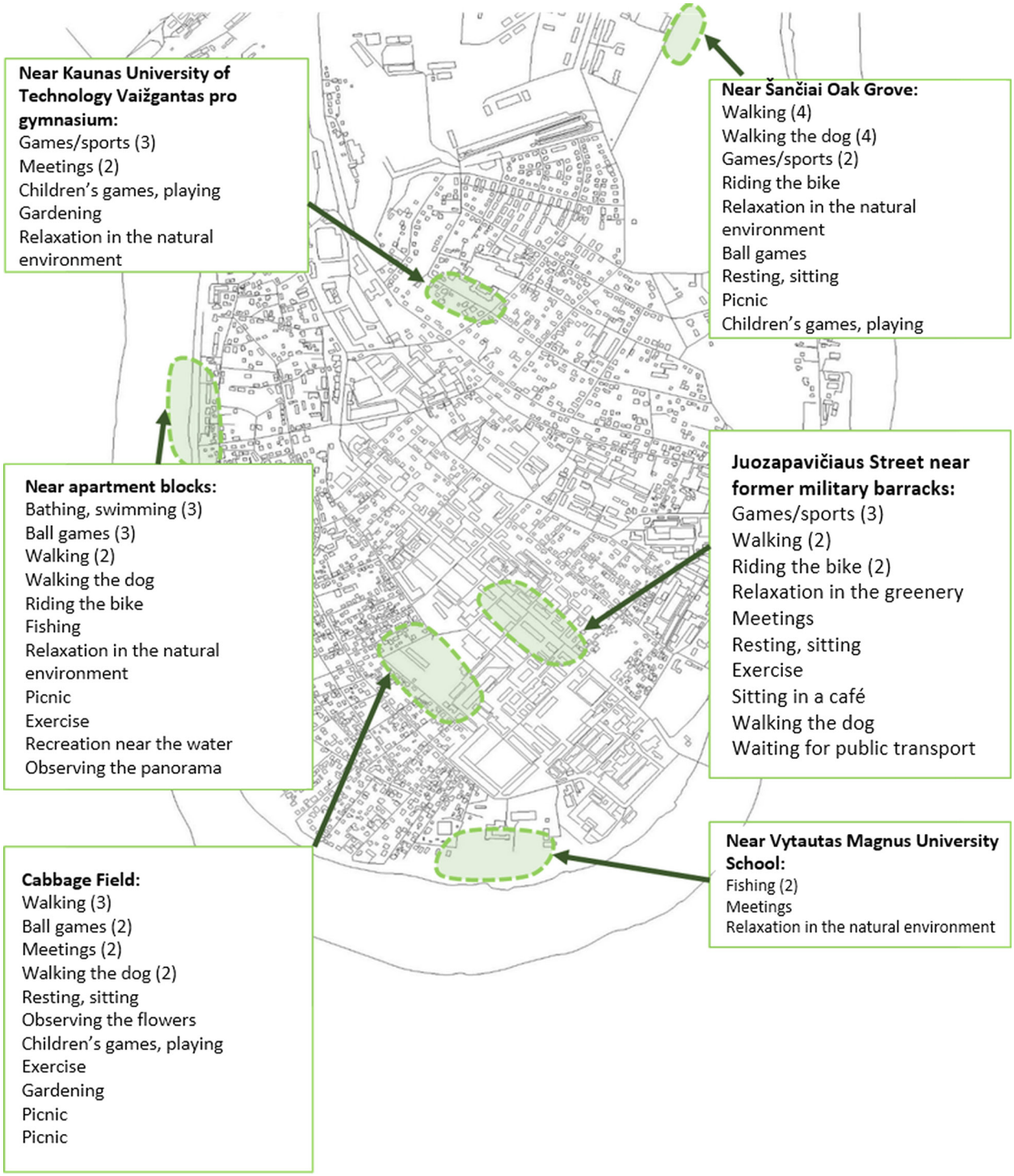

Fig. 10. Systematization and generalization of the results of the workshop with schoolchildren, demonstrating various potential activities in prominent public spaces in Šančiai

Source: own elaboration.

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ornamental decorative plantings are perceived as important elements of public space by young workshop participants. Relevant quotations from the collages are listed at the bottom of the worksheet. In this case, the workshop participants distinguish between relaxation, plants, humans, animals, Nemunas River. The quotations once again verify the results of the structured analysis of the workshop materials.

In order to get a general picture of the workshop participants' proposals, the results were systematized using maps in the second stage. Figures 9 and 10 present the systematization and generalization of the results of workshops with adult community members and schoolchildren, respectively. Figure 9 shows the functional typology and potential uses of the riverbank identified by the community members, which together reveal a bottom-up generated strategy for the Nemunas riverbank in Šančiai with localized point parking sites, boating, active and passive recreation zones. Sociological observation of discussions and analysis of workshop materials revealed the following points about the importance of locations in and features of Šančiai for the future of Kaunas city: unique non-urbanized waterfront right next to the city center, pedestrian-friendly area, natural diversity, bird wintering areas, nature observation, Nemunas riverside public space. The importance of the historic street network, which opens directly to the riverbank, was identified as important for the future of Šančiai by the community members participating in the workshop.

Figure 10 presents potential activities identified by the participants of the workshop with schoolchildren in 6 selected locations in Šančiai. This analysis revealed the functional potential of open spaces in the neighborhood from the point of view of young members of the population. It is evident that schoolchildren perceive the necessity to combine and integrate socializing (meetings), physical activities (sports, games), passive recreation (relaxation, observation) in public spaces; it is visible that selected activities correspond to the physical characteristics of the space (e.g. the presence of water and greenery). This reflects the need to find ways to combine active and quiet recreation in public spaces in a natural environment, including a wider range of activities (water recreation, children's games, picnics, fishing, boating, etc.).

It is not easy to make a direct comparison of bottom-up proposals generated by adult and senior community members and schoolchildren as the workshops focused on different locations in Šančiai. However, some general similarities and differences can be pointed out: both social groups emphasized the need for diverse passive and active activities and their integration in public spaces and the importance of nature; while the adult and senior community members put more emphasis on cultural heritage, historical street network and natural ecosystems, schoolchildren focused more on active sports activities, cultivated decorative plantings such as flowers and ornamental shrubs, and non-human actors in public spaces such as domestic animals and pets.

GENERALIZATION AND DISCUSSION OF THE RESULTS OF THE ŠANČIAI VISION CREATION WORKSHOP

Generalization of results

The urban vision workshops were aimed at generating bottom-up planning and management solutions for public spaces in Šančiai, thus the generalized results of the workshops were presented as a map of Šančiai (Fig. 13). The image of this map was deliberately chosen as a natural extension of the workshop process, prioritizing a simplified representation and visualization of the findings. Since this map, summarizing the results of the workshop, was published on the neighborhood website, this way of presenting the results made it easy to read and understand for any member of the community, not just a professional audience of urban planners. Such a decision was made to maintain and consolidate the community's trust in the results of the process and their transparency. The locations in the map were identified after overlapping the results of the workshops with schoolchildren and adult

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community members and carefully analyzing the collages, drawings, mental maps and notes of all workgroups. The generalized urban vision map presents the general functional typology of public spaces, elements of public space infrastructure, and potential users. Since the final result was intended not only as a scientific finding but also for public presentation, communication with interested subjects and the general population, the visual representation and legibility of the map were very important. For this purpose, special symbolic icons were created to represent public space infrastructure and activities. The general functional typology of public spaces includes: meeting space, educational space, sports space, active recreation space, recreation in nature space, passive recreation space, busy street space, event space, riverbank space, beach space, and cemetery space. The functional typology of public and open spaces in Šančiai is certainly not limited to this classification, as the typology was created based on the results of the workshops and the places identified and/or analyzed by the participants; nevertheless, this functional typology, consisting of 11 types of public spaces, reveals the potential for the actualization of public spaces in the district.

As shown in the map, each general functional type of public space may be equipped with different infrastructure, the equipment of the same functional type of public space may differ depending on its location, context, degree of naturalness and other characteristics. Based on the analysis and systematization of the workshop results, 12 types of public space infrastructure (Fig. 11) were distinguished in the map: wild nature, infrastructure for passive activities, infrastructure for active activities, infrastructure for water recreation, infrastructure for non-motorized transport, infrastructure for motorized transport, ornamental plantings, infrastructure for events, infrastructure for education/information, infrastructure for animal care, infrastructure for navigation, food/catering facilities. Each type is represented by a symbolic icon. Figure 12 shows 28 symbolic icons representing activities that can take place in different functional types of public spaces equipped with necessary infrastructure. This type of representation of proposals for public

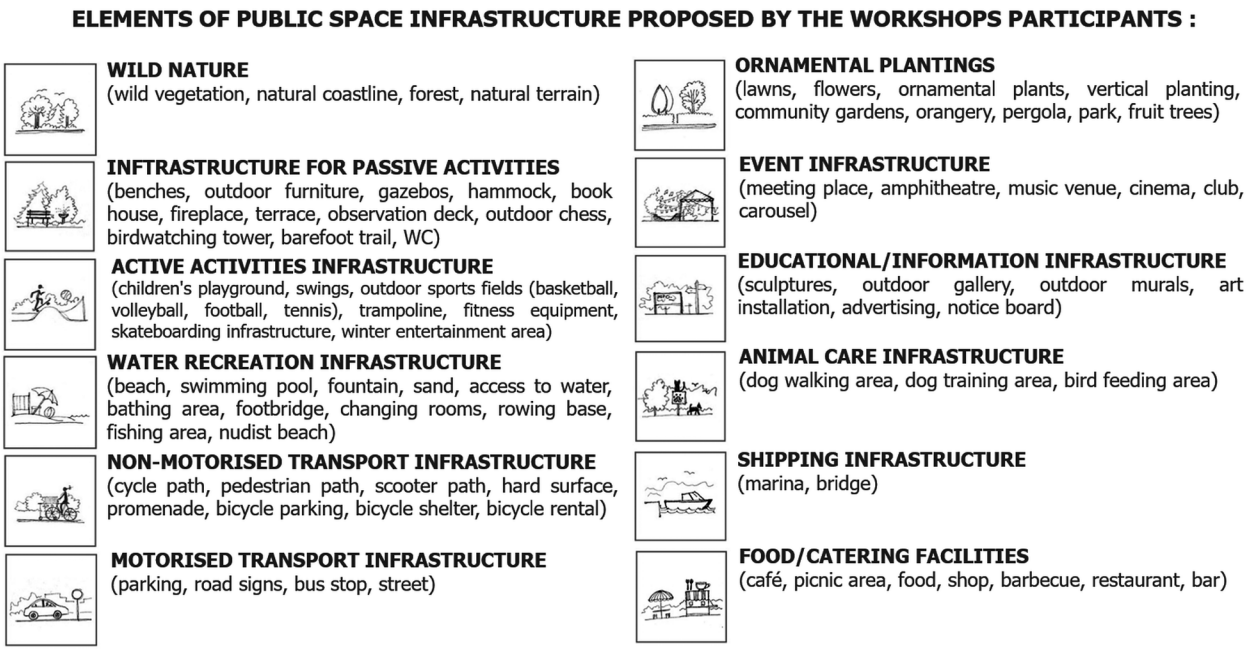

Fig. 11. Typology of public space infrastructure represented by symbolic icons
Source: own elaboration.

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Fig. 12. Typology of activities in public spaces represented by symbolic icons
Source: own elaboration based on Vitkuviene et al. (2019).

spaces is detailed in information about activities and necessary infrastructure, represents the desirable character and mood of the public space, and is also flexible in terms of planning and architectural solutions.

The bottom-up generated urban vision map of Šančiai can be complemented with the insights into the peculiarities and potential sustainable development directions of the district, synthesized from the discussions that took place during the workshops and the analysis of the workshop results:

Cultural context

1. From the architectural and urbanistic points of view, Šančiai can be seen as a unique phenomenon not only in Kaunas, but also in a much wider context and therefore it requires non-standard urban development, which should be done in a complex, not in a fragmented way.
2. The architectural and urban mosaic and history of Šančiai (panoramic views, military, wooden and interwar architectural heritage, and the network of riverside streets) should be appreciated and preserved for future generations.
3. The combination of architectural and urban diversity to be preserved and created should highlight the strengths and visual identity of Šančiai.

Social context

1. The district's environment should support the existing and create new high-quality community connections and social diversity.
2. The vision for the development of the neighborhood should focus more on ensuring the quality of the environment for existing social flows than on generating new traffic and people flows.
3. Look for ways to combine active and quiet recreation in the natural environment of the neighborhood, including a wider variety of activities.
4. Ensure that the movement and recreation of the population are completely safe and not physically separated from the Nemunas riverbank.
5. Develop the concept of a socially responsible, equitable, and sustainable neighborhood and city by initiating participatory urban development projects together with the communities, rather than simply submitting solutions for consultation or comment.

Ecological context

1. Preserve biodiversity and the natural local environment, it's not just about "roses and tulips, but also about the self-grown thistle".
2. Implement solutions based on the principles of sustainability and green infrastructure design,

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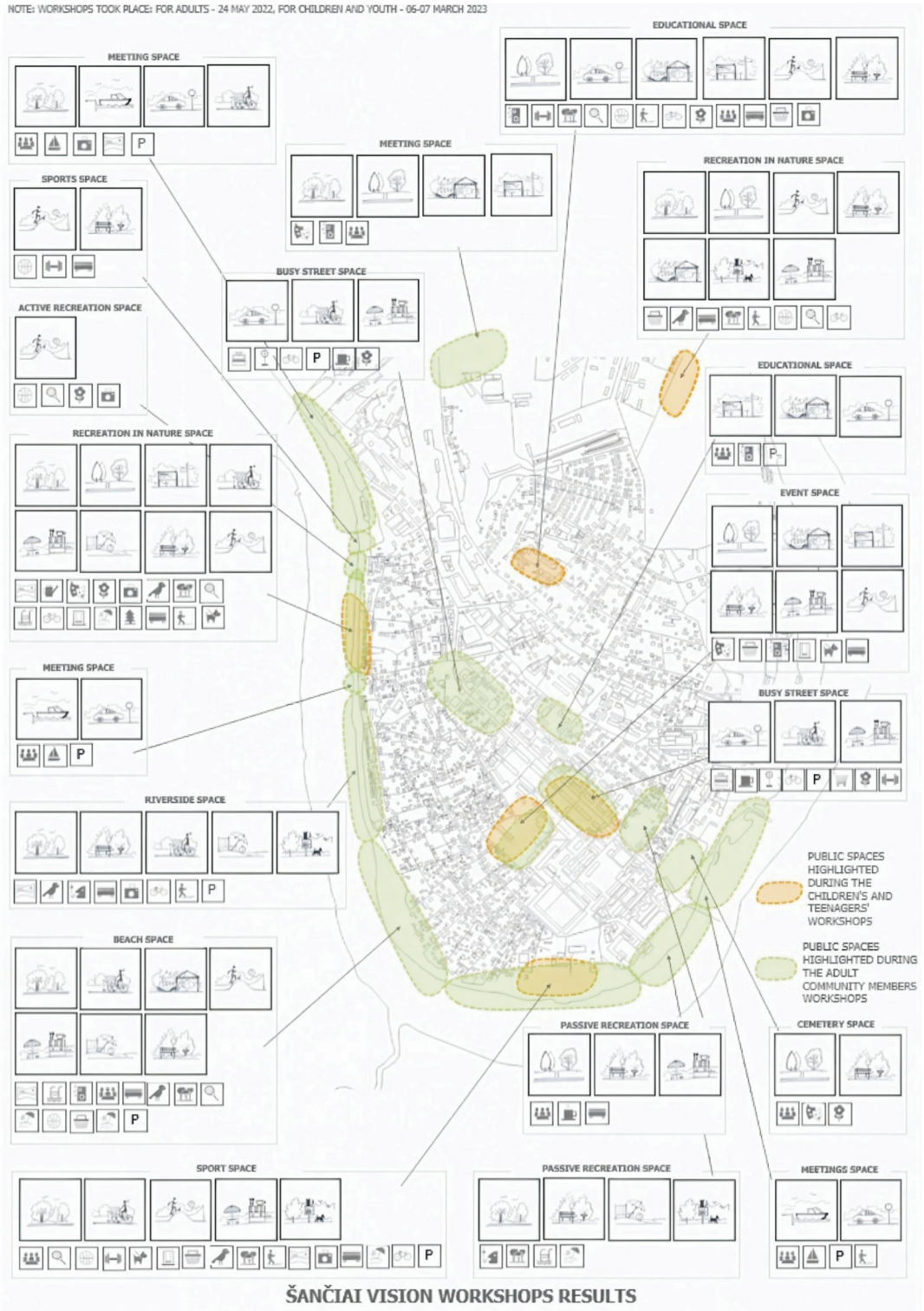

Fig. 13. Generalized results of Šančiai Urban Vision workshops
Source: own elaboration.

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developing ecosystem services, and ensuring a close human relationship with nature, plants, and animals.
3. Minimize potential pollution (chemical, visual, noise, etc.) to maintain a place for city dwellers to breathe fresh air and be surrounded by silence.
4. Maintain a local natural green environment that could serve as an educational space, a place for community gardens and urban gardening.

Economic context

1. Preserve the non-urbanized Nemunas riverbank, while maintaining the highest standard of quality of life in Kaunas – "green space under the window".
2. Preserve distinctive urban structure and local identity, creating conditions for unique educational and cultural events in the city.
3. Focus transportation infrastructure planning on access rather than passage, giving priority to pedestrian and bicycle traffic on the Nemunas riverbank, thus promoting a vibrant street culture and local small businesses.

DISCUSSION

Reflecting on the application of the Urban Vision Creation Approach, the SWOT evaluation of the workshop process and results was carried out from the point of view of 1) improving the citizen participation experience, 2) obtaining more comprehensive data for urban vision development, and 3) contributing to spatial justice. The SWOT is a qualitative analysis representing four types of factors identified on a quadrant: the strengths (internal positive characteristics); the weaknesses (internal shortcomings and deficits); the opportunities (external positive events and circumstances) that can be exploited; and the threats (external risks and barriers) that must be averted or taken into account (Stacchini et al., 2022). The SWOT analysis was conducted using a large language model (LLM) and an expert approach. The structured results of the SWOT analysis are presented in Table 1.

Table 1. SWOT analysis of the Urban Vision Creation Approach

Strengths	Weaknesses
1	2
Participation experience – Creative activities (drawing on maps and photographs, making collages) promoted active participation and engagement, and a sense of ownership of the created work – The use of visuals and non-verbal communication (symbolic icons, drawings, clippings from newspapers and magazines) helped to overcome language and expression barriers, and avoid significant conflicts of interest – Flexibility and adaptability of the approach allowed to create different participation experiences for different age groups of participants according to their social and cognitive needs	*Participation experience* – Organizing and facilitating the workshop require a significant investment of time and human effort – Some workshop participants were skeptical or felt uncomfortable expressing their ideas through drawings – Participants' experience of the workshop may depend on the skills and experience of the facilitator – Adapting the approach to different social groups requires considerable knowledge of their social and cognitive needs
Vision development – The collages and drawings produced during the workshops and the sociological observation material captured rich multifaceted data that captured the intangible aspects of the neighborhood's identity, potential, and the needs of the participants that would be difficult to express in verbal format – The content analysis of visual artifacts created during the workshops revealed the insights and preferences both in structured (through the use of symbolic icons in the process) and qualitative (through the creative nature of drawings and collages) ways, that would have been difficult to obtain using traditional survey techniques	*Vision development* – The results of the analysis of collages and drawings can be subjective and controversial – The workshop approach does not allow for recording the experiences of participants who are unable or unwilling to participate in group work. Some teenage participants in the workshops designed for schoolchildren deliberately provided ironic and contradictory results, thus requiring careful sociological observation and cross-checking – The results of the workshops may not generalize and express the preferences of the entire community of Šančiai, therefore further validation is needed

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cont. **Table 1**

1	2
– The collaborative and creative nature of the workshops encouraged discussions that took place in parallel with the creative process, providing more insightful data for vision development and revealing the genius loci – Incorporating a variety of expressions, such as drawings, the use of magazine and newspaper clippings and symbolic icons allowed for the identification of a variety of users of public spaces including non-human actors	– The skills of the facilitators are important not only for the experience of the participants, but also for the quality of the workshop results – The range of symbolic icons used in the workshop process did not seem wide enough to include relevant non-human actors
Spatial justice – Urban Vision Creation Workshops can help to ensure that the vision for Šančiai public spaces reflects the needs related to the distribution of resources and values of different social groups of community members – The use of visual tools that are accessible to people with different cognitive abilities can help to identify and express the perspectives related to spaces of different community members – The participatory practices that unite the community and the knowledge gained in the process can empower community members to take further actions related to the future and quality of their living environment	*Spatial justice* – Deeply rooted power dynamics or structural inequalities cannot be addressed through participatory workshops alone, and would require broader and coordinated efforts – It is challenging to ensure that the most marginalized or vulnerable members of the community are adequately represented among the workshop participants – Human-centered participatory workshops may not address the needs of non-human actors in the area
Opportunities	Threats
Participation experience – The workshop approach could be further developed and adapted to different cultural contexts, age groups, etc. – Further integration of technology and digital tools into the workshop process could increase engagement and participation, especially among people who may be less comfortable with traditional hands-on methods – The approach could be integrated into ongoing community development initiatives to promote long-term involvement	*Participation experience* – The creative approach of workshops and vision development may not be well received by some community members who prefer more traditional methods of participation and planning – The workshop approach may not be able to reach all segments of the community, particularly those who are less engaged in civic activities
Vision development – The approach could be combined with other data collection methods to provide a more comprehensive understanding of the neighborhood and its needs – The data generated from the workshops and the generalized urban vision could be used to inform and refine traditional planning processes, leading to more inclusive and equitable outcomes – The collaborative nature of the approach could empower community members to continue collecting and analyzing data on their own, fostering a culture of civic engagement	*Vision development* – Workshop participants may not represent the entire community of Šančiai, thus the developed urban vision may be biased towards certain social groups – The subjective nature of interpreting collages and drawings could lead to the misinterpretation of the results, thus affecting vision development – The workshop data, especially the sociological observation material, may contain sensitive information about individuals, thus requiring careful handling and data protection
Spatial justice – The workshop could encourage or be linked to broader efforts to promote spatial justice at the city level – The approach and its outcomes could be used to develop a community-based planning process in the city – The approach could improve the culture and climate of trust in the urban planning field – The participatory approach could be further developed and used to monitor and evaluate the implementation of the Šančiai urban vision	*Spatial justice* – Workshop facilitators, organizers or researchers who analyze and generalize the results may influence the outcomes, potentially marginalizing the voices of some participants – The participatory process does not automatically translate into the effective implementation of the urban vision, which can lead to unfulfilled expectations and needs, and disappointment with participatory practices – The cohesive impact of the workshops on the community may diminish over time without continuous engagement and leadership

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The SWOT analysis of the Urban Vision Creation Approach revealed that it was effective in terms of both the workshop process and generated results. The workshop process ensured the use of participants' creative imagination and artistic expression through attractive, simple, and engaging activities, creating a group work atmosphere, community engagement, and social cohesion, enhancing the quality, artistic expression, visual communication, and relevance of the created mental maps – participatory planning artifacts. The assessment of the workshop results demonstrated that the use of mental mapping, the sociotope methodology, and design thinking allowed to capture and structure the ideas and expectations of the workshop participants in relation to public spaces, and provided insights into the needs of the community. The application of user and activity typologies characteristic of the sociotope methodology in the workshop process and the initial focus on users, activities, and the environment allowed to analyze structurally quite diverse workshop material and to synthesize the results of the analysis and sociological observations into bottom-up generated urban vision proposals for Šančiai. Moreover, it is possible to conclude that the application of the Urban Vision Creation Approach can contribute to spatial justice from both a procedural and distributive point of view (Maiese, 2003; Weck et al., 2022): to a fair spatial distribution of resources and opportunities in the neighborhood and to more fair and transparent decision-making regarding the distribution of spatial resources. However, it should be noted that in order to take full advantage of the benefits of the Urban Vision Creation Approach it should be integrated into urban planning processes at the municipality level. According to S. Weck et al. (2022), the European Union is moving towards a place-based approach, which is expected to create a strategic shift towards more place-sensitive, cross-sectoral, and socially inclusive development. They state that the "place-based approach is key to territorial cohesion and to the overall efforts towards a just Europe" (Weck et al., 2022). The application experience and evaluation results of the Urban Vision Creation Approach allow it to be identified as a potential contributor to place-based development.

CONCLUSIONS

1. Spatial justice is an important justification for participatory urban planning. Currently spatial justice challenges are experienced by numerous urban communities, including the community of Šančiai historical neighborhood in Kaunas. The development of participatory planning tools including the Urban Vision Creation Approach was encouraged by the spatial justice challenges faced by the Šančiai community.

2. The Developed Urban Vision Creation Approach consists of working in groups organized in a sequence of tasks aimed at developing proposals related to users, activities, and design elements for public spaces in Šančiai district. The approach is based on the integration of well-known urban theories – mental mapping (working with maps and visual spaces), the sociotope methodology (using typologies of users and activities), and the hands-on approach. Modifications and adaptations of the methodology are possible depending on the age of the participants, their knowledge of the area and other characteristics.

3. The analysis and generalization of the results of the Urban Vision Creation Approach involves a quantitative and qualitative content analysis using worksheets and maps. The categories used in the content analysis are users, activities, and design elements of the public space. The final outcome of the analysis and generalization is an urban vision map that reflects the functional typology and location of public spaces, the proposed elements of public space infrastructure, and the potential activities that take place in public spaces.

4. The Urban Vision Workshop methodology was applied during 5 workshops with almost 200 participants (50 adult members of the Šančiai community and 143 12 to 15-year-old schoolchildren) in the period between 2022–2023. The workshops for adults and schoolchildren have proved the flexibility of the methodology as well as the possibility to accumulate

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comprehensive data sets. In addition, mental maps and collages created during the workshop with adult community members were exhibited as participatory planning artifacts.

5. The generalized results of the workshops were presented as a map of the urban vision of Šančiai, revealing bottom-up planning and management solutions for public spaces consisting of distribution and functional typology of public spaces, their infrastructure elements and activities that can potentially take place there. Such urban vision proposals are sufficiently detailed from the point of view of functions, activities, and the general character of the place, but leave a lot of flexibility in terms of spatial arrangement.

6. The SWOT analysis of the Urban Vision Creation Approach and the results of this application have shown that this approach can enhance participants' experience in the participatory planning process, can provide comprehensive and diverse data for urban analysis and decision-making, and can contribute to procedural and distributive aspects of spatial justice when integrated into broader efforts of place-based development. The approach in its current form is useful for collecting data and engaging citizens in urban planning, although further steps are needed to adapt it to formally integrate the citizens' right to the city into urban planning decisions. Further research directions may include: adapting the approach to different age groups, testing it in different cultural contexts, further elaborating the tools used during the workshops to better reflect the more-than-human dimension of the area under analysis.

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ORIGINAL PAPER
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CITIZEN FORESTS – A NEW MANAGEMENT APPROACH FOR STATE-OWNED FORESTS

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ABSTRACT

Motives: There is a growing emphasis on assessing the value of forest social functions. There are no objective measures of the intensity and attractiveness of recreational forest use. It would be beneficial to obtain an independent expert opinion on the social value of forest complexes, based on a reliable methodology. It is imperative to ascertain how to objectively determine a forest's social function and factors influencing it.
Aim: The main objective of the conducted research was to indicate the types and sequence of activities necessary to designate areas of natural value and social importance in forest districts.
Results: The authors' procedure for designating socially important forest areas (called citizen forest) was presented and discussed.

Keywords: forests with enhanced social function, forest space management, Local Cooperation Team, public influence on forest management

INTRODUCTION

A forest is a highly organised assemblage of plants, especially woody species, growing in close proximity and playing the role of the main edificators within it. Together with the animals that inhabit forest areas, they form forest phytocoenoses. The high diversity of life in the forest is related to the growth conditions of the woody species, which are a result of the habitat and parameters such as moisture content, average annual temperatures, or amount of precipitation. Under natural conditions, these factors determine, among other things, the vertical structure of the stands as well as their species composition and age structure. The forest fulfils three fundamental functions, which are inextricably linked and mutually reinforcing, and subject to constant change over time and space (Govedar, 2022; Führer, 2020; eg. Pilli & Pase, 2018). These functions are:

1. Protective – pertaining to the stabilising effect of the forest on the natural environment, including the preservation of biodiversity and the beneficial effects on climate, soil, and water relations.
2. Productive – the forest provides society with raw timber as well as other non-timber products, including forest fruits, herbs, and wildlife meat.

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3. Social – the forest creates an environment conducive to enhancing the quality of life for local communities. It influences the local labour market and contributes to the creation of places for rest and recreation, including opportunities for the population to expand their ecological knowledge. The forest is also a cultural asset with which many communities identify, shaping their heritage.

The economic value of production functions has been the subject of considerable research and is relatively well documented. Wood has now been identified as a material with applications in more than 30.000 different contexts worldwide. The timber sector in Poland, according to the Polish Economic Chamber of the Timber Industry, generates approximately 2.5% of the national GDP, provides budget revenues in excess of PLN 30 billion per year, and directly employs approximately 350.000 individuals. Additionally, the wood industry indirectly employs tens of thousands of people in related sectors, including transportation, trade, and the manufacturing of wood harvesting and processing machinery and equipment (Newseria Biznes, (Zac), 2020).

It is challenging to assess the non-productive functions of forests. This has led to significant discrepancies between studies on this topic. Depending on the approach, mainly scale and area, some studies emphasise that the total value exceeds the value of the effects of the productive functions. However, it should be emphasised that the primary function of commercial forests is timber production, with the most sustainable approach possible (Kriström et al., 2001; Sikora & Wartecka-Ważyńska, 2017; Snarski, 2023).

Modern forest management is therefore based on the concept of multifunctionality. It is of paramount importance to identify a reasonable compromise between the aforementioned functions in order to achieve a balance that is based on parameters that are constant and clear to all stakeholders. The objective should be to develop a method that determines the value of social forests as objectively as possible. Furthermore, the method should be universal and feasible regardless of the climatic, topographical, and social conditions of the study area.

Consequently, in recent years, there has been a growing focus on the development of methodologies for the assessment of the social functions of forests (eg. Bańkowski et al., 2019). Firstly, it is necessary to establish a procedure for the designation of this type of forest. Given the novel nature of the issue pertaining to forests with particular social functions, objective measures of the intensity and attractiveness of recreational forest use have yet to be developed. It would therefore be beneficial to obtain an independent and objective expert opinion on the valuation of the "social value" of individual forest complexes within a given forest district, based on a known and reliable methodology.

It is therefore necessary to consider how the increased social function of a forest can be objectively established and what elements may influence it.

These considerations suggest that the main challenge in efforts to designate and manage forests with enhanced social function on land under the management of State Forests is to strike a balance between forest management and social expectations.

The research was conducted with a focus on two research theses that were formulated.

1. The management of forests with enhanced social function on land under the management of State Forests represents a significant social, economic, and scientific challenge in the context of biodiversity conservation and sustainable development of areas.
2. There is a need to develop specific guidelines for the designation of forest areas with enhanced social function. Furthermore, the study aimed to illustrate the potential challenges that may arise for those developing local conservation action programmes and the institutions responsible for implementing them.

The author's proposed approach to the designation of socially important forest areas was outlined, accompanied by an examination of the potential difficulties that could occur at each stage of the process. Additionally, suggestions were put forth for addressing these challenges.

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LITERATURE REVIEW

In light of the accelerated pace of societal development observed in recent decades, coupled with the constraints imposed by the recent pandemic, there has been a discernible shift in societal attitudes towards a renewed appreciation for the natural environment. This phenomenon is associated with the rising incidence of civilization-related illnesses, including allergies, respiratory insufficiency, and mental health disorders. These conditions are prompting individuals to seek respite from the demands of modern life by immersing themselves in the natural environment and even relocating to less populated areas. It is paradoxical that the fulfilment of these needs is facilitated by advances in civilisation. For example, the possibility of working remotely or a good network of communication links enables quick contact with culture or medical care. Furthermore, the best place to live is on the outskirts of large cities, which offer the possibility of daily contact with nature and at the same time enable a quick return to the benefits of civilisation. The current trends in the property market indicate that the optimal locations for establishing a settled residence are developed plots situated within approximately 20 km of the administrative boundaries of cities. These locations are characterized by good communication, proximity to housing estates or other single-family developments, and a topographical feature that allows for an unobstructed view of fields, lakes, or forests. It is anticipated that the surrounding area will comprise accessible green spaces and recreational facilities, offering a respite from the urban environment (Ciesielski et al., 2022; Immich & Robl, 2023; Źróbek et al., 2015; Źróbek-Różańska et al., 2017).

Over time, areas that have such functions are often regarded by local communities as "their place and property." As a result, these communities assert their right to determine the trajectory of developments in areas that are not de facto theirs, yet to which they frequently feel emotionally attached. It is pertinent to recall the promotion of the concept of "civil society" in European Union countries (Vandor et al., 2017). Article 15 of the Treaty on the Functioning of the European Union recognises the importance of civil society for the good governance of European Union. Article 11 of the Treaty on European Union stresses the need for regular, open and transparent dialogue with civil society organisations, for example when drafting proposals for European Union legislation. These activities are reflected in the content of numerous legal instruments pertaining to spatial management and nature protection, which stipulate the obligation to conduct public consultations on planned activities and investments. Polish society is becoming increasingly aware of the significance of these provisions and the opportunities they offer. This may be the reason for the increased number of public actions and "protest committees" observed in recent years, aimed at blocking, or at least moving linear or cubic investments away from their property boundaries. However, it is important to emphasise that in places where the density of development is high (especially around large cities), it is practically impossible to carry out an investment that would not cause changes to the landscape. This also applies to forest space. The implementation of forestry operations in close proximity to human settlements frequently gives rise to public controversy and opposition. Currently, the public associates forestry work associated with timber harvesting with the term "felling", which is perceived as the destruction of walking routes and a significant alteration of the landscape (Cidrás, 2022; eg. Lawrence et al., 2021; Niedziałkowski & Chmielewski, 2023; Nieto-Romero et al., 2023).

The instrument that defines the forest is sustainable forest management. In accordance with Article 6.1a of the Forest Act of 28 September 1991, sustainable forest management is defined as an "activity aimed at shaping the structure of forests and their use in a manner and at a rate ensuring the permanent preservation of their biological richness, high productivity and regeneration potential, vitality and capacity to fulfil, now and in the future, all important protective, economic and social functions at local, national and

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global levels, without detriment to other ecosystems." Forests owned by the State Treasury, subject to Articles 26(2) and 26(3) of the Forest Act, are open to the public, thereby allowing for the utilisation of over 7 million hectares of land for recreational or tourist purposes. The growing significance of forests in urbanised areas underscores the necessity for the implementation of suitable environmental policies and the modification of forest resource management practices.

The State Forests are implementing a systematic approach to address the challenges associated with forests in urban areas and other locations where there are expressed concerns about reduced timber harvesting, the development of recreational infrastructure, or the organisation of mass events. Consequently, on 14 December 2023, the Director General of the State Forests, by virtue of the pertinent Order No. 116, amended the Forest Management Instruction, thereby establishing the principle of public participation in the preparation of forest management plans on a permanent basis. In accordance with the Forest Act, the forest management plans represents the fundamental planning document within the State Forests, delineating the economic objectives to be pursued by the forest district over a ten-year economic period. In the context of the economic division of forests under the administration of a given forest district, the designation of a "citizen forest holding" is a possibility. This designation entails the implementation of special management methods, defined in collaboration with a Local Cooperation Team comprising representatives of local communities, with the objective of prioritising the social function. The Order in question provides the heads of the State Forests' organisational units (in this case, the Forest District Managers) with the necessary tools to develop a social dialogue in cooperation with the Local Cooperation Team, with the objective of determining the extent of the "citizen forests". The Local Cooperation Teams are officially established, and their findings are legally binding for the management of forests in the selected areas. In essence, the category of "citizen forests" is designed to encompass areas that are intensively utilized by individuals for recreational, sporting, health-related, and other social activities. The management principles of these forests, situated in close proximity to resorts, spas or urban agglomerations, prioritise sustainability, visitor safety and the maintenance of landscape values. It is important to note that these forests will not be reduced to the role of suburban parks or inaccessible reserves for recreation. Forestry work will still be carried out in such forests, but in a highly individualised manner with a minimum of logging. It is also important to highlight that the developed solutions will be granted the status of local legislation, as each forest management plan undergoes a process of strategic environmental impact assessment and is ultimately approved by the minister responsible for environmental matters.

The new regulations will be implemented gradually, with the introduction of new forest management plans. On an annual basis, plans are devised for approximately 40 forest districts, which collectively represent 10% of the country's total forest area. Nevertheless, in justified cases related to public necessity, "forests with enhanced social function" may be established by forest districts during the 10-year management cycle, thus circumventing the necessity to await the expiration of the current plans.

The Ministry of Climate and Environment is currently engaged in efforts to exclude 20% of the most valuable forest areas from felling. On 26 April 2024, the Ministry issued instructions to the Director General of the State Forests to enhance the protection of forests with a leading social function in approximately a dozen Polish cities. The following cities are included in this designation: The cities of Warsaw, Kraków, Gdańsk – Sopot – Gdynia, Wrocław, Łódź, Poznań, Katowice, Bydgoszcz, Toruń, Szczecin, Kielce, and Bielsko-Biała have been identified as requiring particular attention. Concurrently, the formulation of comprehensive proposals for forests with a leading social function has commenced .

As announced on 30 July 2024 by Minister Paulina Hennig-Kloska and Deputy Minister Mikołaj Dorożała, the initial point of reference for the

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establishment of social forests is the so-called Map of Disputed Forests, which was created by non-governmental organisations. The map illustrates the areas where, in previous years, local communities and environmental activists have exerted significant pressure for the protection of forests, while logging operations have elicited the strongest public opposition (Lasy i Obywatele, 2024).

In accordance with the schedule adopted at the National Council on Forests (a forum comprising all relevant stakeholders, from non-governmental organisations to state forests and the timber industry), the results of the Citizen Forests project are to be produced by 31 October 2024. By that time, a map of citizen forests is to be created, indicating the specific locations and areas in question.

European legislation does not prescribe uniform regulations for forest land management across all member states. Consequently, the responsibility for formulating forest policy resides with the member states. Nevertheless, the European Union has established a European Forest Strategy and provides substantial support for activities that exert a considerable influence on forests within the European Union and beyond. In the year 2021, The European Commission has adopted a new European Union Forestry Strategy for the year 2030. It constitutes one of the flagship initiatives of the European Green Deal, building on the European Union Biodiversity Strategy 2030. It is anticipated that the Forestry Strategy will contribute to the achievement of the European Union's biodiversity targets by reducing greenhouse gas emissions by a minimum of 55% by 2030 and achieving climate neutrality by 2050. The strategy acknowledges the pivotal and multifaceted role of forests, which, in collaboration with stakeholders in the forest and timber industries, will facilitate the development of dynamic and prosperous rural communities. The objective is to achieve this goal by 2050. The European Parliament, in collaboration with the Council of the European Union, plays a pivotal role in shaping the European Union's developmental trajectory across a multitude of domains, including those pertaining to forest areas. In this context, the Parliament resolved to produce two own-initiative reports: one on the intensification of European Union action to protect and restore the world's forests (European Parliament resolution of 16 September 2020 on the European Union's role in protecting and restoring the world's forests) and the other on a new European strategy on forests (European Parliament resolution of 8 October 2020 on a European forestry strategy – the way forward). In conjunction with the aforementioned report, the Parliament also adopted an own-initiative report on legislative issues pertaining to global deforestation (European Parliament resolution of 22 October 2020, which sets forth recommendations to the Commission on an European Union legislative framework to halt and reverse European Union-induced global deforestation). Furthermore, on 13 September 2022, In response to the Commission's 2021 adoption of the European Union Forest Strategy 2030, the Parliament has adopted a resolution on the new European Union Forest Strategy 2030 – Sustainable forest management in Europe.

The concept of forests with an enhanced social function is also recognised internationally.

In the context of international forestry, the term "citizen forests" is primarily associated with urban and suburban forests, as well as the concept of the "tiny forest", which is exemplified by the forest in Poland (Cárdenas et al., 2022; Egerer & Suda, 2023; Galati et al., 2023; Greenleaf & Ries, 2020). In this particular case, citizen forests and urban forests are distinct categories of forests. By contrast, the defining feature of these various forms of community forestry is the involvement of the public in the protection and management of a forest that is important to a particular social group.

MATERIALS AND METHODS

A critical literature review was conducted in accordance with the methodology set forth by Pickering & Byrne (2014) and Gruas et al. (2020). The method is in accordance with the Preferred Reporting Items for Systematic Review Recommendations (PRISMA) guidelines.

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A review of the literature, legislation, websites dedicated to forests with enhanced social function, and environmental reports by the authors of the article confirmed the validity of the research theses formulated. Furthermore, interviews conducted by the article's authors with forest land managers and their own observations and experience in the field of spatial management and nature conservation served to corroborate the lack of formal guidelines for the designation of forest areas with enhanced social function. It was discovered that, with regard to their designation, in a multitude of countries, only general recommendations (termed "good practices") are typically in place, without consideration of the particularities of this type of forest function in relation to the sustainable development of the areas (Bańkowski, et al. 2019; Landry, 2022; eg. McElhinney et al., 2018; Order No. 58 of the Director General of the State Forests of 5 July 2022). This observation has prompted the authors to put forward a set of guidelines to assist those responsible for the designation and management of forests with enhanced social functions.

The objective of the literature analysis was to illustrate the economic, social, and scientific relevance and timeliness of research on the designation of forests with enhanced social function in the context of biodiversity conservation and production functions and their sustainability. Furthermore, it aimed to demonstrate the necessity for systemic actions aimed at preserving all forest functions. In addition to English-language sources, studies published in Polish were also consulted. The selection of pertinent sources of information was conducted through the utilisation of keyword searches within publicly accessible library catalogues, electronic publication databases (e.g. Science Direct, Scopus, Web of Knowledge; Google Scholar, Research Gate), printed bibliographic studies, internet repositories and digital libraries. The principal focus of the search was on recent papers published over the past 10 years. The content of scientific and practical items, European Union law and Polish law (including regulations, conventions, etc.) was analysed in order to ascertain their relevance to the issue of creating and managing forests with enhanced social functions.

The websites dedicated to the issue of social forests were visited and subjected to analysis.

The collected material was subjected to a process of verification and interpretation of the content of individual sources in accordance with the thesis and research hypotheses.

RESULTS AND DISCUSSION

Proposed guidelines for the development and implementation of criteria for the designation of forest areas with enhanced social function

The study's findings provide a framework for the designation of forest areas with an enhanced social function. The requisite actions for the implementation of an appropriate selection process are illustrated in Figure 1. Should the Local Cooperation Team be able to reach an agreement on the boundaries and location of the citizen forest proposed by the public party, the decision-making process will proceed in an orderly and efficient manner. Subsequently, the Forestry Commission accepts the proposal. Following approval by the Regional Directorate of State Forests, an appropriate entry is made in the taxation description of the Forest Management Plan, accompanied by economic indications. In the event that the Local Cooperation Team is unable to reach a consensus on the proposal, the team may elect to support the proposal with the analytical evidence outlined in the comprehensive algorithm (Fig. 2). In the event of further disagreement and disagreement on the proposals within the community proposal, it would be advisable to invite an independent auditor to contribute to the process. This could be a team of specialists not associated with the Local Cooperation Team. It is recommended that the independent auditor be an academic with interdisciplinary research experience in the disciplines of social and economic geography and spatial management, forestry and biological sciences, and Earth and related environmental

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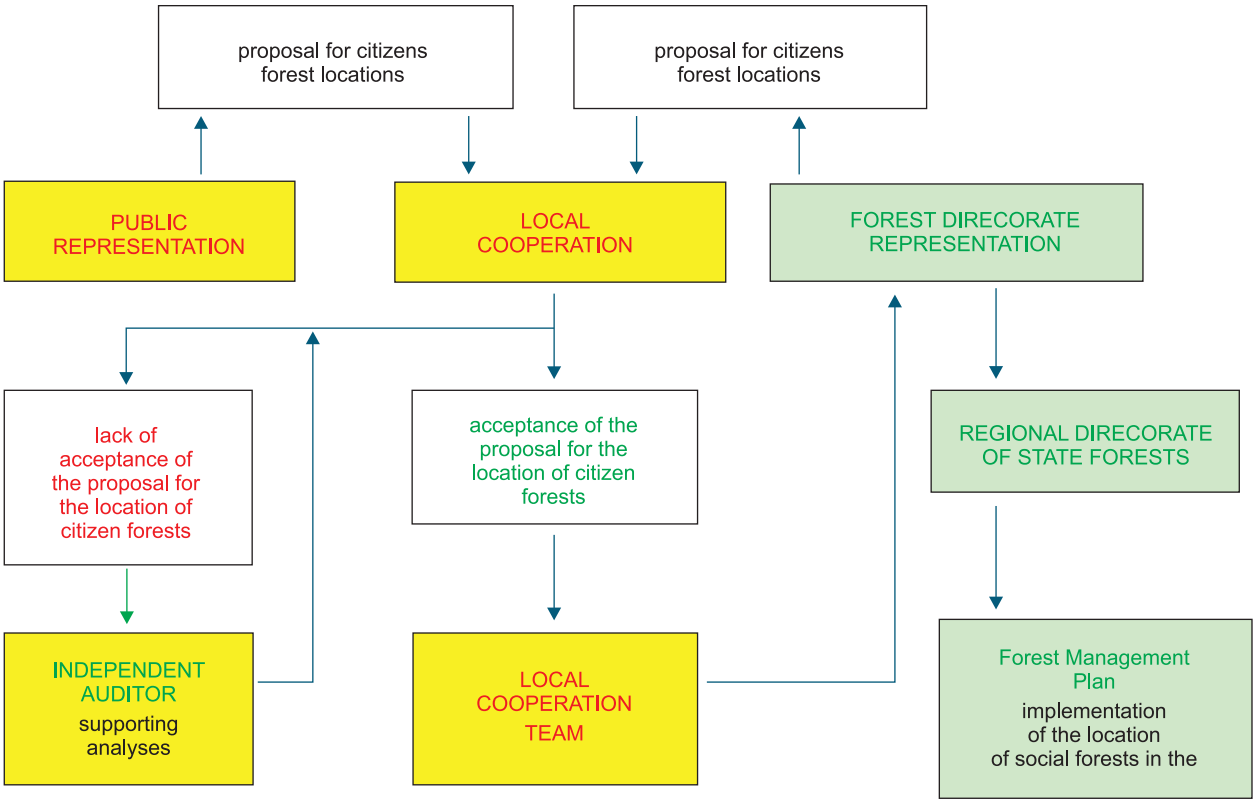

Fig. 1. General outline of entities and activities leading to the establishment of the citizen forest
Source: own elaboration.

sciences. The findings of the independent auditor should be accepted by the Local Cooperation Team and agreed upon by the Regional Directorate of State Forests, in accordance with the relevant provisions set forth in the Forest Management Plan.

The following section presents a comprehensive algorithmic approach to the designation of forest areas as citizen forests. The proposed algorithm of activities was divided into four stages (Fig. 2). Stage I concerns preparatory work, namely a preliminary selection of forest areas for further analysis. Stages II and III concern inventory and analytical work, enabling an assessment and valorisation of the selected areas to be carried out and a decision to designate all areas in the forest district or in the analysed area that could be converted into community forests. Stage IV includes legal and technical activities related to the final selection of the location of the forest with increased social function.

STAGE I – preparatory work

The preliminary stage of the preparatory work entails the identification of a preliminary location, which may be one or more areas within the forest district that are characterised by an increased level of social functionality. The precise algorithmic approach to be employed at this stage of the decision-making process is illustrated in Figure 1. The initial stage is a social proposal, wherein society (comprising local communities and non-governmental organisations) requests the creation of such an area. Additionally, the State Forests may act as the applicant, conducting an analysis of the indicated areas within the Local Cooperation Teams. In the event of discrepancies in the categorisation of forest areas of particular social value, it would be prudent to conduct a more comprehensive consultation process, utilising geomatics tools where appropriate. In specific

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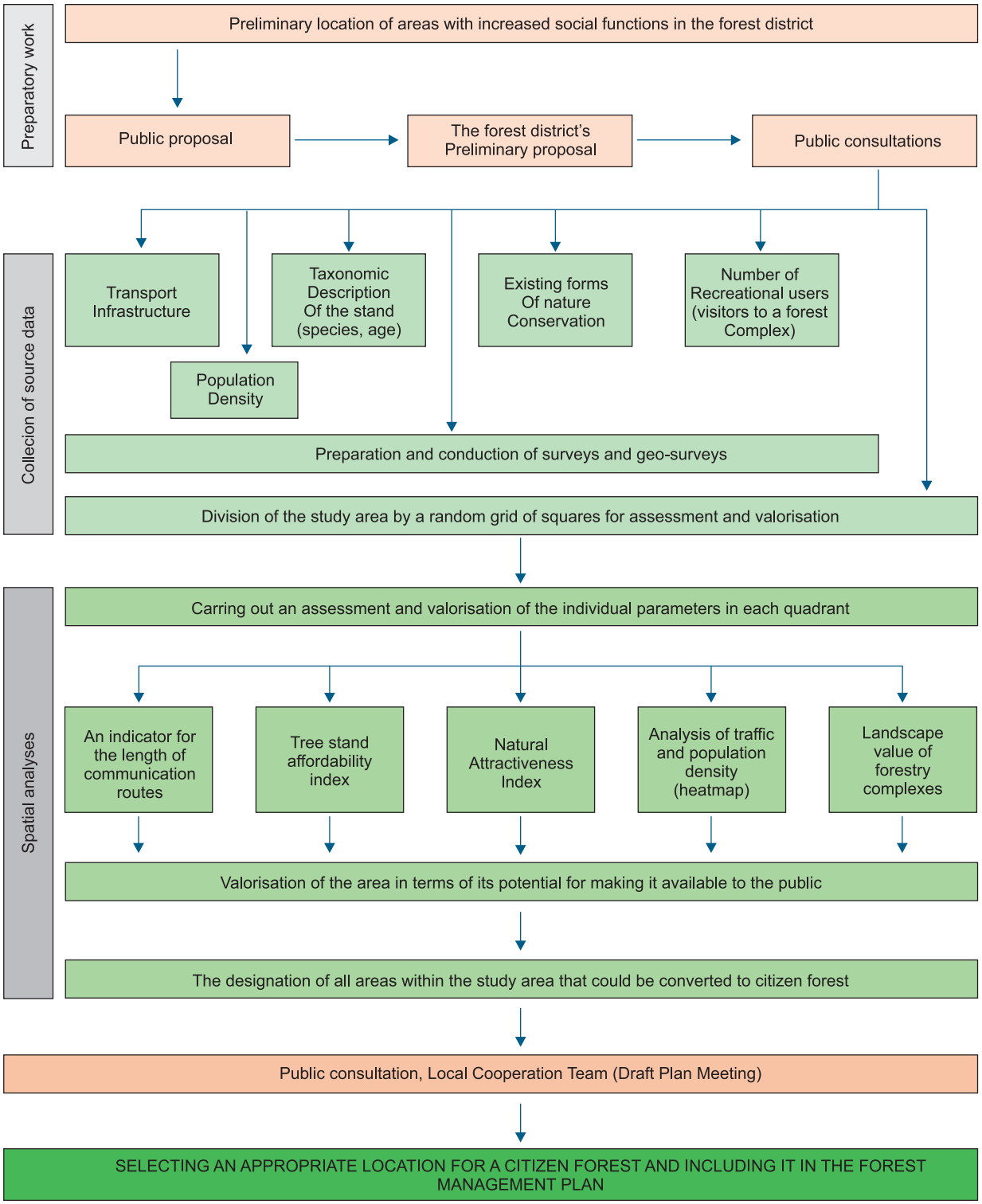

Fig. 2. Guidelines for demarcating potential areas for establishing citizen forests
Source: own elaboration.

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instances, it may also be necessary to conduct surveys or a series of meetings with the local community. The data gathered on the social requirements is then collated into a proposal for a specific area or multiple areas, which are then subjected to further analysis for potential designation as this type of forest.

STAGE II – collection of source data

It is important to note that the designation of socially important areas is a more complex process, as it requires the use of data from a variety of sources, including those outside the information system of the State Forests. It is therefore evident that the implementation of spatial information systems (GIS) will facilitate the delineation of areas where social expectations and forest management may conflict. These systems are capable of rapidly conducting a multitude of analyses based on existing data, which can be identified in geographical space. Furthermore, this solution will facilitate the visualisation of areas that meet specific criteria. It would be beneficial to integrate the communication infrastructure into the GIS as a layer, thereby establishing a foundation for the monitoring of tourist traffic. This would constitute a further, significant piece of information regarding the actual scale of public penetration of a given forest area. Furthermore, the issue of population density is also pertinent in this context. The presentation of the concentration of both the local community and those periodically staying in the area (tourists) on the background of the forest area map will provide a basis for further spatial analyses of potential or existing conflict sites.

The delineation of socially significant zones could be founded upon the valuation of the area in question, employing a grid of squares with dimensions of 500 metres by 500 metres (equivalent to 25 hectares). The initial anchor point could be selected at random to guarantee objectivity.

Surveys represent a valuable tool for the collection of reliable data pertaining to the public's preferences and expectations regarding community forests. It would be beneficial to precede the distribution of surveys with an information campaign, disseminated via social media and websites, in order to reach a vast array of stakeholders and gauge the extent of interest in the subject matter addressed in the survey. A survey constructed on a geo-server, wherein each individual would be afforded the opportunity to delineate on a map a square that they consider "attractive/important" with a brief justification selected from a list of options, would facilitate the precise identification of the most attractive areas. Such surveys could be created by the relevant bodies within the State Forests, for example the Information Centre or the Department of Information Technology. Additionally, the public should be queried regarding their expectations regarding the type of forest they desire. In conclusion, this will provide insight into the extent of the requisite changes in management and the "adjustment" of the provided forest fragments to align with the expectations of the majority of respondents. Furthermore, the open dialogue would serve a PR function, thereby demonstrating the openness of the State Forests to the needs of the public.

STAGE III – Spatial analyses

A value would be attributed to each square, calculated as the sum of the individual components. A grid of squares with sides of 500 x 500 m provides sufficient precision in determining the attractiveness of an area and is capable of capturing its variability, particularly in densely populated areas. The analysis may thus be conducted at the municipal, county, or forest disrtict territorial level, with the grid of squares appropriately designed to avoid the so-called "boundary effect". This entails enlarging the study area to account for the impact on squares located beyond the boundary of the analysed area.

As previously stated, each quadrant would have numerical component values in the attribute table, derived from the individual analyses. The average of these values would represent the value of the asset, determining the recreational potential of the area.

In order to ascertain the component values for each quadrant, it is necessary to consider at least the following:

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1. An indicator for the length of communication routes

It is established that the recreational appeal of forest complexes is contingent upon the presence of primary and secondary transportation routes. An area devoid of visible and passable roads, for instance those suitable for cyclists, is unlikely to garner significant public interest. Accordingly, the parameter of the density of roads and existing hiking trails (the indicator of the length of communication routes) defined for a given forest complex and then replicated in each quadrant would serve as an authoritative value indicating the accessibility of the area to the public.

The number of people utilising a specific forest complex for recreational purposes can be ascertained through the analysis of the road network. In this instance, the utilisation of so-called traffic counters (pedestrian, bicycle) situated at the point of ingress to the principal traffic arteries could prove an efficacious methodology for the determination of the number of individuals utilising the route. There are companies on the market that are specialised in the installation of such devices and the subsequent analysis of the data they provide. Furthermore, the data can be correlated with so-called heat maps, which visualise the attractiveness of traffic routes for people practising sports activities (e.g. Strava). Furthermore, it is important to note that in order to obtain a reliable estimate of the number of individuals utilising a specific forest complex for recreational purposes, the survey must be conducted throughout the entire calendar year. During the summer months, there is a tendency for a concentration of people in specific locations, such as along the shores of lakes or in the vicinity of resorts. Conversely, these areas may be visited with less frequency during the off-season. In such cases, the annual average can serve as a valuable indicator of the typical usage patterns.

2. Tree stand Affordability Index

The inclusion of stand parameters in the taxonomic description created for the purposes of forest management plans (e.g. dominant species, forest site type, stand age and others) when appropriately correlated would provide a meaningful indicator of the "attractiveness" of a stand. However, it is possible that the public's expectations in this respect may differ and be mutually exclusive, potentially due to personal preferences and ideas of a "picture forest". It is evident that oak-hornbeam habitats are incompatible with pine or spruce as the dominant species, which may give rise to certain expectations. The public's awareness of the impact of the habitat on the shape and appearance of the stand is a significant factor in shaping expectations. Therefore, at any stage where the public has the opportunity to articulate their preferences, efforts should be made to increase knowledge of broader ecological relationships.

3. Landscape value of forest complexes and Natural Attractiveness Index

The numerical terrain model data for each square allows the terrain roughness to be determined, thereby providing information on the terrain diversity of the study area. This process has already been completed as part of the establishment of valuation points for management works. In this context, the terrain diversity coefficient has been defined for each forest district in Poland in accordance with the provisions set forth in the DGLP Order 41/2012. This value can be further recalculated with a specific value resulting from the presence of additional "landscape values" in the area, such as lakes, high-aged forests, or forest habitat types "attractive" for human presence (fresh coniferous forest, fresh mixed coniferous forest, fresh mixed deciduous forest, fresh broadleaved forest). By correlating this parameter with the natural attractiveness of the area, based on information obtained from the Regional Environment Protection Directorate, it will be possible to describe each of the analysed squares in terms of landscape and nature value.

4. Traffic and Population Density Index

The aggregation of data for the European Commission permits the download of population density data (GHSL – Global Human Settlement Layer). The data are provided in raster format, with a resolution of 100 x 100 m, and contain information on the

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number of people residing in a given area. A value is attributed to each pixel, representing the population density.

The final stage of the spatial analysis process is to perform a summary valuation of the site in terms of accessibility, taking into account all of the elements that have been analysed in the individual grid boxes. A variety of spatial analyses may be employed to identify the areas exhibiting the highest values, including the Jenks method, natural dividing boundaries, and the distance-weighted average (IDW).

The outcome of the concluding spatial analyses will facilitate the identification and commendation of all areas that may satisfy the prerequisites for social forest status. The collated analytical and cartographic material will serve as an invaluable resource in the final stage (**IV STAGE**) of the algorithm, namely the public consultation.

CONCLUSIONS

The appropriate decision-making process for determining the location of citizen forests is a complex one that necessitates the collection of sufficient source data.

An error in the spatial analyses or the omission of any of the steps may result in an erroneous location that will fail to fulfil its functions. Consequently, certain sections of the forest will be excluded from effective forest management, despite their social functions.

In citizen forest areas, forest management must be carried out in a manner that takes into account the expectations of the public, which will often diverge from one another. The priorities of those advocating broad nature conservation, which most often takes the form of reserve protection, differ from those of those with sporting preferences and from ordinary walkers wishing to travel a short distance from a vehicle stop in safety and comfort. Furthermore, it is important to consider the forest as a workplace for various professional groups, including forest service companies, foresters, and those employed in other sectors directly or indirectly related to the timber industry. For these parties, a reduction in the area to be harvested will be associated with professional challenges and potential income opportunities. Furthermore, it is important to acknowledge that the implementation of economic procedures associated with the maintenance of stands and their reconstruction in a more socially beneficial manner is conducted through the utilisation of harvesting equipment. In many instances, the mere appearance of such equipment in the area gives rise to concerns and protests.

It is thus evident that a suitable procedure for determining the location of citizen forests (Fig. 2) should be preceded by a preliminary analysis of the application for the establishment of such areas by each forest district (Fig. 1). Involving the local community in consultations on the shape and extent of forests of special social value will facilitate a more nuanced understanding of the multifaceted aspects related to the public perception of forest functions.

This will facilitate the ability to respond to the public's expectations regarding the visual presentation and character of the forest areas visited, while simultaneously educating the public and promoting a positive image of the State Forests as a responsible and environmentally conscious administrator of state forest areas.

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