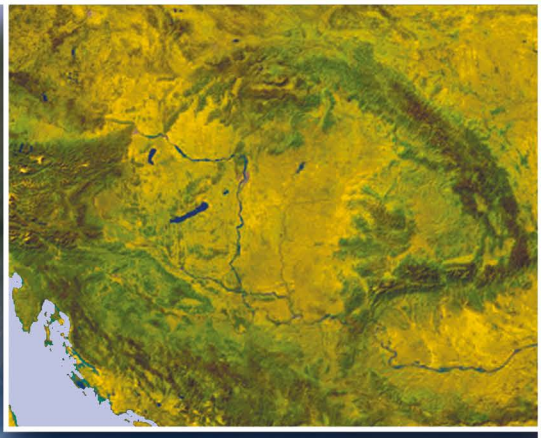
Hungarian Geographical Bulletin



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CONTENT

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Lithological mapping with pseudo-labelling: Promise or overestimation in data-scarce settings?

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Abstract

Reference data are the most crucial points in model building. In geoscience, a scarcity of sufficient reference data is common. Pseudo-labelling (PL), i.e. incorporating high-probability data in the model-building process, offers a potential solution. We aimed to reveal the efficiency of PL in lithological mapping in a vegetation-free arid region of Sudan. Multiple Adaptive Regression Splines (MARS) and Random Forest (RF) were used to classify a Landsat 9 image. Reference data were collected during fieldwork and through visual interpretation. Image processing yielded classified maps with associated probability layers, from which 1000 additional traditional samples (PL data) were extracted at a 95 percent probability. A detailed accuracy assessment was conducted, and accuracy measures were evaluated using statistical analysis and visual inspection. MARS was found to be an ambiguous classifier because the probability was too optimistic related to the overall accuracy (OA) (81% of samples had above 99% probability, OA = 98.2%) compared to RF (21% above 99%, OA = 98.1%); that is, despite the high probability, the accuracy improvement was only 0.1 percent. At the class level, the correlation between probability and the F1-score was low (0.21%). The original and PL-based models resulted in different maps with improved accuracy, although the new model version showed lower probability values for both the classifiers. Visual inspection proved essential for better insights into the spatial patterns: expert knowledge is crucial for controlling the occurrence of rock types and identifying false classifications. The main finding is that probability should be handled carefully, as it does not guarantee high model performance in classification, although the PL approach can lead to more reliable maps.

Keywords: Multiple Adaptive Regression Splines (MARS), Random Forest (RF), self-training, probability, data augmentation

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Introduction

Lithological mapping is the process of identifying different lithological units (rocks) within a given area and represents a fundamental step in most geological investigations, including mineral exploration, groundwater assessment, petroleum studies, natural resource

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evaluation, and environmental management (Amusuk, D.J. *et al.* 2016; Abrams, M. and Yamaguchi, Y. 2019). Consequently, obtaining an accurate lithological map is crucial for mineral exploration. Traditionally, lithological mapping is executed mainly through interpretation of aerial photographs, followed by extensive field-based investigations in which geologists collect samples, register observations, measure geological structures (such as dip and strike), identify mineral composition and textures, or interpret field relationships (Szaniawska, L. 2018). However, this traditional mapping approach can be challenging because it requires skilled field geologists, is time-consuming, and requires a suitable budget to cover costs, especially in harsh environments and inaccessible or isolated places. These difficulties have recently decreased through the integration of cutting-edge technologies, such as remote sensing and machine learning, in the lithological mapping process (Bachri, I. *et al.* 2019; Abdelkareem, M. *et al.* 2021; Shirmard, H. *et al.* 2022).

Geological features can be identified using extensive datasets of remote sensing technology (El-Omairi, M.A. and Garouani, A.E. 2023). Valuable insights can be drawn from the geographic data obtained by sensors, based on the distinctive properties of the local area (Nair, P. *et al.* 2023). Machine learning offers an efficient way of processing remote sensing data. After the training phase, algorithms can identify rock types, faults, or mineral deposits if the spectral resolution of the images makes it possible. These algorithms can handle large datasets, allowing the discovery of plausible patterns in complex geological datasets (Han, W. *et al.* 2023). However, machine learning requires high-quality training data to build a reliable model. Additionally, independent testing data (known as reference data) are essential for validating a model's performance (James, G. *et al.* 2013).

Reference data is the most crucial constituent of all models. Training subsets are used for model building, while testing subsets are used to assess accuracy. In remote sensing, we may have millions of pixels (i.e. data points), which may give the impression that the delineation of reference data is easy, however, this is not true for all tasks. For example, in land cover mapping, the traditional approach is to classify surface objects into simple classes such as forests, grasslands, and water bodies. These classes can include thousands of pixels as reference data because simple visual interpretations of the images can provide sufficient information. However, when the aim is a more specific problem, such as identifying plant or tree species, detecting plant diseases, or classifying roof types, reference data collection requires field observations and/or ground measurements, which makes this step labour-intensive and time-consuming. Lithological mapping faces the same problem: Field observations are essential for a reliable reference dataset. If the number of labelled instances is insufficient, the model cannot be adequately trained because of the insufficient size of the reference dataset.

The question of how much reference data is needed depends on the algorithms and is widely discussed in the literature. While there are basic rules, generally, the more the reference data, the better. Studies have shown that accurate, balanced, and large training datasets are often more important than the choice of algorithms in terms of the output (Li, C. *et al.* 2014; Maxwell, A.E. *et al.* 2018; Collins, L. *et al*. 2020). There is no universally accepted minimum number of training data points. However, Foody, G.M. (2009) defined a method for calculating the minimum amount of testing data based on the desired overall accuracy, acceptable standard error, and classification error. For example, for four categories with an 85 percent target accuracy and a standard error of 0.02 (2%), at least 1275 testing data samples are required, which is approximately 320 per class. Class imbalance also can be a crucial point when the target class or some classes are underrepresented causing false accuracy metrics (Luque, A. *et al.* 2019), which is common when the target features are limited owing to unique characteristics (e.g. rare species, specific roofing types, or uncommon rock types or plant species), collecting a sufficient number of data

points may be infeasible, while easy to collect non-target classes. Even with fewer reference data than the optimal, accurate outcomes are still possible depending on the data distribution and representativeness of the data which introduces a higher risk of uncertain results.

An alternative method, known as self-training or pseudo-labelling (PL), involves selecting high-probability data from the predictions of an initial model conducted with fewer data points, and the model training is repeated with data from a classified map with the highest probability. The effectiveness of this method has been proven to improve the classification results, including soil class mapping (Zhang, L. *et al.* 2021), detection of geochemical anomalies (Chen, Y. *et al.* 2023), prediction of invasive species distribution (Cruz, C. *et al.* 2023; Kim, E. *et al.* 2024), and identification of sporadically distributed species (Likó, Sz.B. *et al.* 2024). However, PL does not always improve classification accuracy or even result in worse predictions. Although PL appears to be a good solution for overcoming the issue of limited reference data, users cannot assume that the outcome will be better than that of the model output based on the original data. Geological mapping presents a unique challenge, as both natural and anthropogenic processes (e.g. physical and chemical weathering and mining) can alter rock characteristics. However, the spatial pattern can easily be validated by visual interpretation (e.g. the given rock type can occur at a given location).

We aimed to determine the effectiveness of PL in geological mapping. The selected study site was in an arid environment, where the lack of vegetation made it possible to observe rock types in satellite imagery. We had the following questions related to the probabilities and PL: (i) what was the probability of the related rock type and how did it change with the increased training data; (ii) what was the standard deviation (SD) of classes in the changed areas, and how large areas were influenced; and (iii) what was the direction of the changes in terms of probability? Accordingly, we formulated the following hypotheses: (i) high probability values ensure high model performance and (ii) pseudo-labelling improves map quality by providing additional training data for the modelling process.

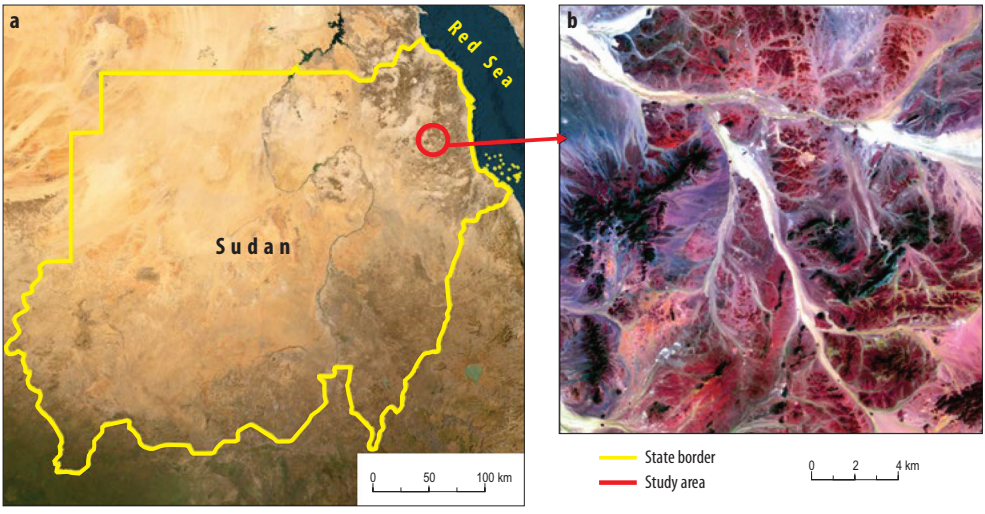

Fig. 1. Location of the study area: Sudan and study area location (a), and Landsat 8 colour composite of the study area in 7, 5, and 2 bands (b). *Source*: Authors' own elaboration.

Data and methodology

Study area

The study area was located in the Red Sea State, northeast Sudan, 90 km from Port Sudan *(Figure 1).* Geologically, the area is part of the Red Sea Hills (RSHs), the Sudanese section of the Arabian Nubian Shield, which is a juvenile continental crust formed between 900 Ma and 550 Ma (Abdelsalam, M.G. *et al.* 2000; Hamimi, Z. *et al.* 2021; Abdelrahman, S. *et al.* 2024). These rocks are highly sheared and deformed, and their geology is complex (Abdelsalam, M.G. and Stern, R.J. 1993). The study area is part of the Gebeit terrane, and the major lithological units include highly sheared low-grade meta-volcanics (meta-basaltic andesite, meta-andesitic basalt, and meta-dacite), meta-sediments (marble), sheared granitoids, and superficial deposits. Accordingly, we identified and mapped the following six rock types: artisanal (art), granite (gra), marble (marb), meta-volcanic rocks (mtvo), ophiolite (ophi), and wadi deposits (WDi).

Applied data

A Landsat 9 image (LC09_L2SP_172046_20231014_20231015_02_T1, US Geological Survey) was used in the analysis on a cloud-free date. Through a thorough review of current geological maps, close visual inspection, and analysis of processed Landsat data, as well as high spatial resolution imagery from Google Earth, we carefully produced reference data. In addition, extensive fieldwork was conducted along regularly planned traverses.

Image processing

Machine learning

Multivariate Adaptive Regression Spline (MARS) and Random Forest (RF) and algorithms were tested in this study because both provide a probability layer that indicates the reliability of the classification pixel-by-pixel regarding the classes.

MARS is a nonparametric, robust algorithm that efficiently manages a large amount of input data and nonlinear relationships between the target and explanatory variables with no assumptions (Friedman, J.H. 1991). The feature space is split into regions based on knots, which define the boundaries of the piecewise linear basis functions that contribute to the overall prediction. Each basis function votes on a class for the data instances, and finally, the function with the majority votes is selected as the prediction. Probability calculation for classification tasks are similar to the procedure of logistic regression (logistic transformation to convert the continuous values to 0 and 1 probabilities), but the main difference is that the MARS, instead of using linear terms, calculates the weighted sum of the basic functions (Friedman, J.H. 1991; Boehmke, B. and Greenwell, B.M. 2019, 2020). In the R implementation, the earth package (Milborrow, S. *et al.* 2024), the 'degree' should be specified, which is the degree of interaction among the input variables, 'nprune' refers to the number of basic functions. The performance of MARS models is high; however, a grid search of hyper-parameters is important.

RF is a widely used and robust algorithm (Breiman, L. 2001), and its efficiency has been proven in several fields such as land cover mapping, soil science, and geology (Belgiu, M. and Drăguț, L. 2016; Shahare, Y.R. *et al.* 2024; Simarmata, N. *et al.* 2025). RF does not assume normal distribution, homoscedasticity, or multi-collinearity due to its calculation method, and classification is based on hundreds of decision trees (DTs) using randomly chosen data (36.8% subset of the training dataset) and variables. The number of trees (ntree) parameter is usually set between 100 and 500, and we used the default setting of the 'caret' package (Kuhn, M. 2022), which is 500. The number of variables (mtry) is chosen at each split of a single DT, the default is the square root of the number of all variables, and hyper-parameter tuning testing can be tested between 1:20.

Models were developed and conducted in R 4.4.2 (R Core Team, 2024) with the 'caret' package (Kuhn, M. 2022). Both models resulted in two outputs: prediction of the classes (classified map) and calculation of the related probabilities (probability map). Probabilities were calculated by classes, but in the analysis, we used only the maximum values, i.e. instead of having six values (for the six classes) with the related probabilities in six raster layers, only the highest values were extracted to a single raster layer. It was important, because the maximums determined the resulting classified output, and we were able to pair and evaluate the classes with the probabilities by pixels: for six classes 16.67 percent (100/6 = 16.66) of maximum probability was enough to classify a pixel, whereas the maximum was 100 percent.

Accuracy assessment

Model testing is a crucial step in all predictions (Bui, D.H. and Mucsi, L. 2022). We used our previously developed module, programmed for an automated accuracy assessment, the Classification Assessment Tool (Szabó, Sz. *et al.* 2024), which calculates accuracies using advanced solutions by taking random subsamples from the entire testing dataset based on a predefined ratio obtained from the testing data (0–1) and the number of repetitions of random sampling. We applied 0.6 for the fraction (60% of data were used at a time with stratified random sampling), and for repetitions, we applied 10. Boxplot diagrams were used to visualise the differences among the classes. The following class-level metrics were calculated: Precision (or User's Accuracy, UA), Sensitivity (Producer's Accuracy, PA) (Congalton, R.G. 1991; Barsi, Á. *et al.* 2018), Specificity (True Negative Rate), F1-scores (or Dice Similarity Coefficient), Jaccard Index (or Intersection over Union, IOU) (Willem, 2017; Grandini, M. *et al.* 2020), and Matthews correlation coefficient (MCC) (Cao, C. *et al.* 2020; Chicco, D. and Jurman, G. 2020).

Pseudo-labelling and statistical evaluation

For pseudo-labelling, users must choose a probability map based on an accuracy assessment (e.g. the highest accuracy). A threshold value should be set to define pixels with a minimum probability to delineate the area where the newly labelled classes will be collected. Although the threshold can be between 1 and 100 percent, only higher values (e.g. 0.9 [> 90%]) are useful; accordingly, we chose 95 percent. This step assigned the relating area to the probability maps. We selected 1000 spatially random data points from the assigned area as PL-data (abbreviated as PL1000), involved in the new training phase, merged with the original training data; possible duplicates were removed. Next, the classification step was repeated with an accuracy assessment.

Furthermore, we compared the class-level accuracy metrics (independent variables: Precision, Sensitivity, Specificity, MCC, F1, IOU) of the original maps with the map where the model was trained with the largest number (1000) of pseudo-labelled, resampled data (PL1000) (i.e. input datasets as dependent variables). A multivariate method, Hotelling's T-squared test, was used to test H_0 (group means for all independent variables were equal). The analysis was conducted with R 4.4.2 with the Hotelling package (Curran, J. and Hersh, T. 2012). Besides the p-values, effect sizes of partial η^2 and Mahalanobis Distance Squared (D^2) were also determined to express the magnitude of the differences between the two values of the dependent variable. For partial η^2, 0.01–0.06 is considered as small, 0.06–0.14 as medium, > 0.14 as large effect; for D^2, 0.25–0.50 is considered as small, 0.50–1.00 as medium, and > 1.00 as large effect (Cohen, J. 2013; Matcharashvili, T. *et al.* 2019; Shaker, A. 2023).

Maps produced with the original training and PL1000 data were compared using cross-tabulation and quantified by cross-entropy and visual analysis. Cross-entropy is a robust index for identifying hotspot areas of change (the higher the value, the larger the

change) (Shim, J.W. 2024). Values below the upper quartile were blanked to enhance the relevant differences between the two maps, and the differences were quantified in comparison (agreement) tables. The two maps were also compared using the Interspersion and Juxtaposition Index (IJI), which showed the isolation of the intermixing of patches (i.e. rock types) (Mead, R.A. *et al.* 1981). Cross-entropy was determined using the 'spatialEco' package (Evans, J.S. *et al.* 2023), and IJI with the 'landscapemetrics' package (Hesselbarth, M.H.K. *et al.* 2025).

We also performed a difference analysis between the original and PL1000 maps, focusing directly on changes and probabilities. We determined the probabilities of the classifications and the relationship between the accuracy metrics and probabilities at the class level by rock type. We focused on the areas where the classification was different in the two approaches, and investigated the probability of the pairs (e.g. in the original approach, a pixel was "art", and in the PL1000 it was "WDi"). Finally, we compared the F1-scores and mean probabilities by rock type using Spearman correlation.

Results

Geological maps with original training data

The MARS and RF algorithms provided seemingly similar maps of rock types, but there were also significant differences. The main difference was in the case of WDi: MARS considerably overestimated WDi and underestimated all the other types *(Table 1)*. Considering the possible occurrence of WDi, the RF model was more reliable, as MARS indicated the deposits at irrelevant locations as well (NW and NE corners of the area, *Figure 2*).

Table 1. Estimated area of rock types by two classification models: Multiple Adaptive Regression Spline (MARS) and Random Forest (RF)

Rock type	Area based on	
	MARS model, km²	RF model, km²
art (astisanal)	54.09	58.98
gra (granit)	133.08	150.57
marb (marble)	47.56	60.64
mtvo (meta-volcanic)	54.93	64.81
ophi (ophiolite	29.60	22.88
WDi (wadi deposits)	139.59	100.96

Source. Compiled by the authors.

However, the class-level accuracy metrics showed different results: WDi had the best performance with MARS *(Figure 3)*. In the case of other rock types, the accuracies were similar (or at least slightly, 2–3%, better with the RF), and the RF had a narrower range based on the repetitions of the testing procedure, that is, it acted more reliably with the existing testing data.

Classification accuracies and probabilities

Regarding the probabilities, maps showed that MARS was supposed to be more accurate as 371.56 km² of the area had > 99 percent probability (considering the maximum probabilities of all classes by pixels), whilst in the case of RF it was only 94.85 km² *(Figure 4)*. Although the near-100 percent pixels dominated the MARS model, it did not perform better; only the probabilities were overoptimistic, and the accuracy measures were only slightly better than RF (*Figure 5*, a). The median (derived from the accuracy assessment data) differences between the two models in the case of the robust F1 and MCC did not demonstrate the superiority of any of the models: for art, marb, and ophi, the RF performed better than the MARS with 4.6–2.2–6.6 percent (MCC) and 4.0–1.8–5.9 percent (F1), whereas the MARS was shown to be a better model for gra, mtvo, and WDi with 2.9–1.4–12.2 percent (MCC) and 2.7–1.0–10.9 percent (F1).

Class level accuracy and the F1-score had no connection with the two classifiers; the Spearman correlation coefficient was 0.21 ($p = 0.51$, i.e. not significant). In half of the rock types, the RF performed better, and in the other half, the MARS performed better based on the F1-scores (*Figure 5*, b). Although the values theoretically followed a linear relationship,

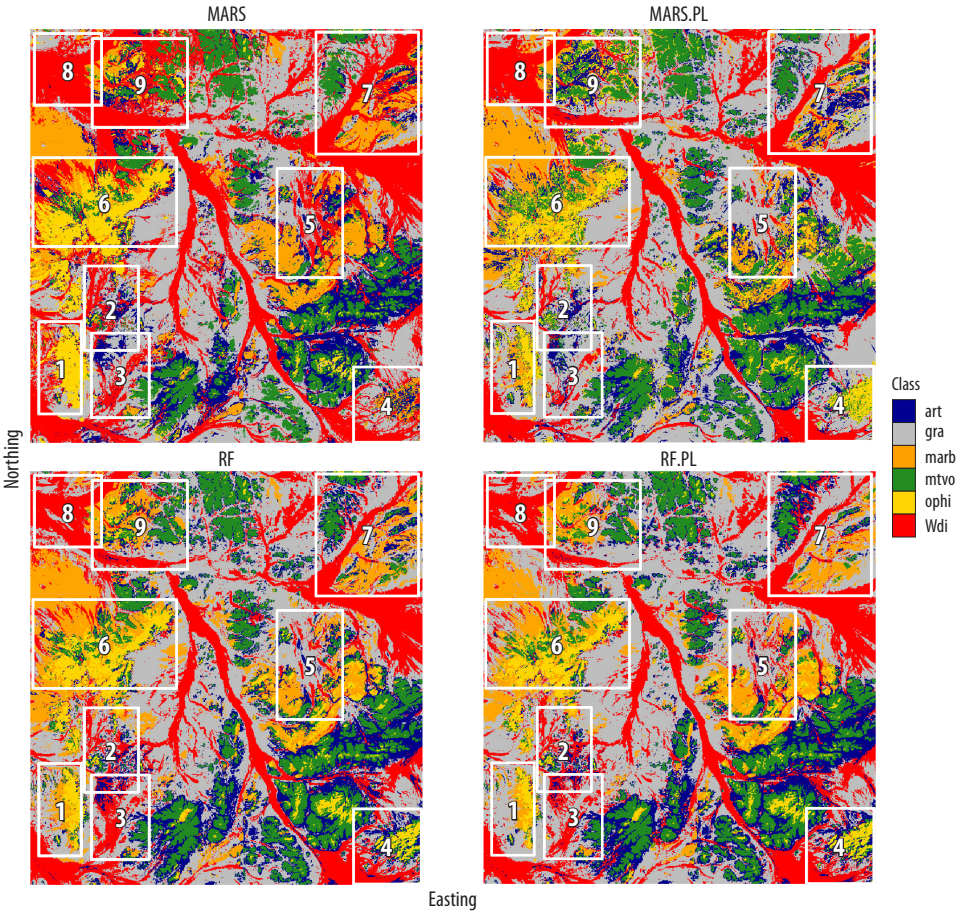

Fig. 2. Geological maps of the Multiple Adaptive Regression Spline (MARS), and Random Forest (RF) models and their pseudo-labelled (PL) versions. Rock types: art = artisanal; gra = granite; marb = marble; mtvo = metavolcanic; ophi = ophiolite; WDi = wadi deposits. (PL = 1000 pseudo-label data with 95% probability; white rectangles and numbers: evaluated areas). *Source*: Authors' own elaboration.

there were outliers in both models: in the case of $MARS_{art}$, the mean accuracy (F1) was one of the lowest (0.81), while the probability was 92 percent, and RF_{marb} had a large F1-score (0.98) with the lowest probability (58%).

Models trained with original and pseudo-labelling

We compared the maps produced with the original and PL1000 (95% probability) training datasets and found that the original training set performed similarly to the case with an additional 1000 data points, at least on the level of accuracy metrics. Comparison matrices showed smaller agreements for MARS (art, marb, and ophi had < 50%, WDi 58%) and slight differences for the RF (all rock types had > 80% agreement, except marb, having only 65%).

Visual analysis brought controversial observations: although both the RF and MARS maps differed by 25 percent from the PL versions regarding the hot-spot changing areas (in addition to the simple expres-

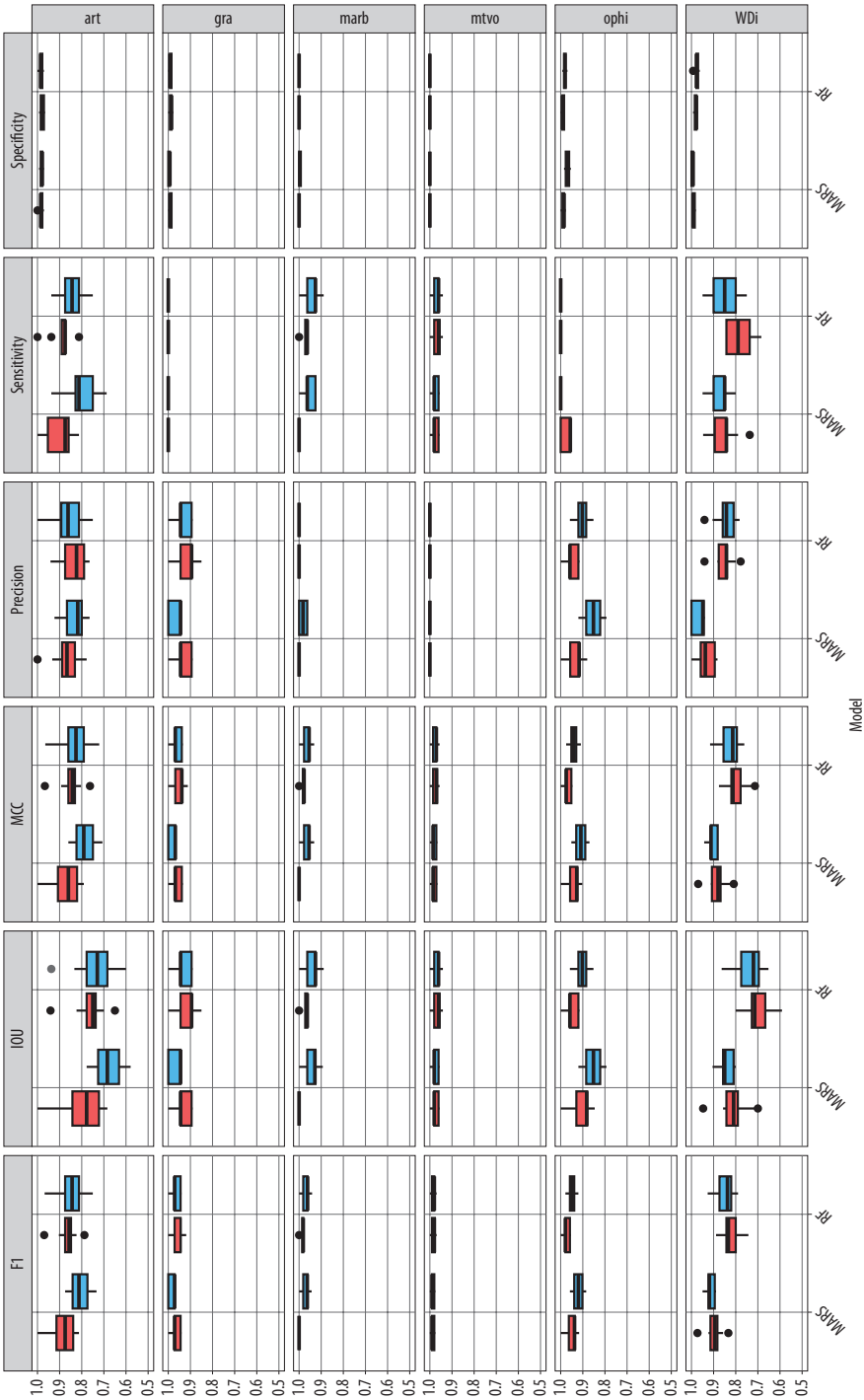

Fig. 3. Accuracy metrics of the MARS and RF classifications. Original = Models trained with the original training dataset; PL1000 = Models trained with an additional 1000 pseudo-labelled data sampled from 95% probability pixels; IOU = Intersection over Union; MCC = Matthews correlation coefficient. For rock types see *Fig. 2*. *Source:* Authors' own elaboration.

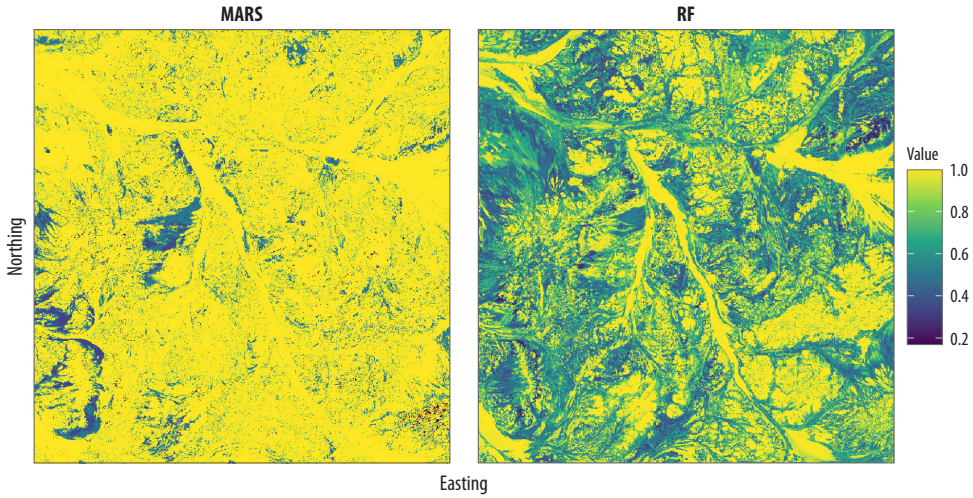

Fig. 4. Probability layers of classification models of the MARS and RF models, visualising the maximum probabilities *Source*: Authors' own elaboration.

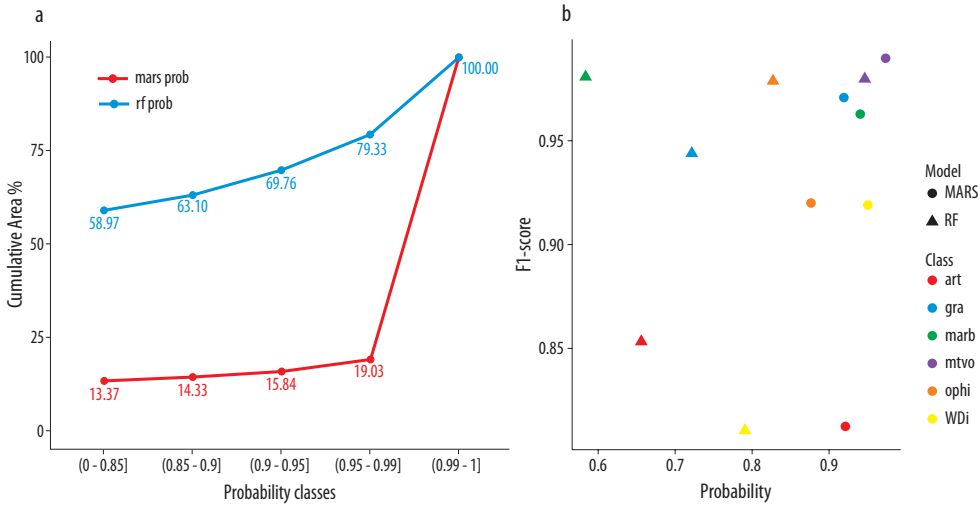

Fig. 5. Cumulative probabilities and accuracies of the MARS and RF models. Proportions of pixels by probability thresholds (a); Probabilities and F1-scores by rock type (b). For rock types see *Fig. 2. Source*: Authors' own elaboration.

sion of the area, the cross-entropy levels differed significantly), the changes caused by the additional data improved the maps *(Table 2).* In area 1, the PL versions outperformed the original classifications for both RF and MARS; in area 2, RF.PL outperformed all other versions, and MARS.PL outperformed the original MARS. For area 3, MARS.PL provided the best outcome, but RF.PL was also better than the original version. In areas 4

*Table 2. Summary of best models based in visual inspection of spatial patterns**

Area	Characteristic rock type	Rock type	Best model
1	ophi, WDi	generally	RF.PL and MARS.PL
2	gra, WDi	generally	RF.PL
3	gra, mtvo, WDi	generally	MARS.PL and RF.PL
4	art, ophi, WDi	generally	RF.PL
5	ophi, marb, gra	generally	RF.PL
6	marb, mtvo, ophi	ophi	RF.PL
6	marb, mtvo, ophi	marb	MARS.PL
7	art, marb, mtvo, WDi	mtvo	MARS and MARS.PL
7	art, marb, mtvo, WDi	WDi	RF.PL
8	gra, WDi	generally	RF.PL
9	art, marb, mtwo, WDi	art	RF.PL
9	art, marb, mtwo, WDi	WDi, mtvo	MARS.PL

*Area codes depicted in *Figure 2*. RF = Random Forest; MARS = Multiple Adaptive Regression Spline; PL = pseudo labelled; art = artisanal, gra = granite, marb = marble, mtvo = meta-volcanic, ophi = ophiolite, WDi = wadi deposits. *Source*. Compiled by the authors.

and 5, the RF.PL was the most reliable solution. For area 6, MARS was the least accurate, and RF.PL provided the best solution for ophi, and MARS.PL for marb. MARS and MARS.PL mapped mtvo better than the other models, and RF.PL mapped WDi the best in the case of area 7. Generally, RF.PL was the best for area 8. In case area 9, RF.PL had the best classification for art and MARS.PL for mtvo and WDi. Accordingly, the PL model versions performed well, and based on the visual analysis, the spatial patterns were determined in several cases as the best outcomes.

Although cross-entropy showed that the hot-spot areas of differences were 25 percent for both model pairs (original vs. PL), in the case of RF, the values were higher, indicating that there was a difference in sparse pixels; that is, the level of mixing of standalone pixels had changed *(Figure 6)*. IJI confirmed that

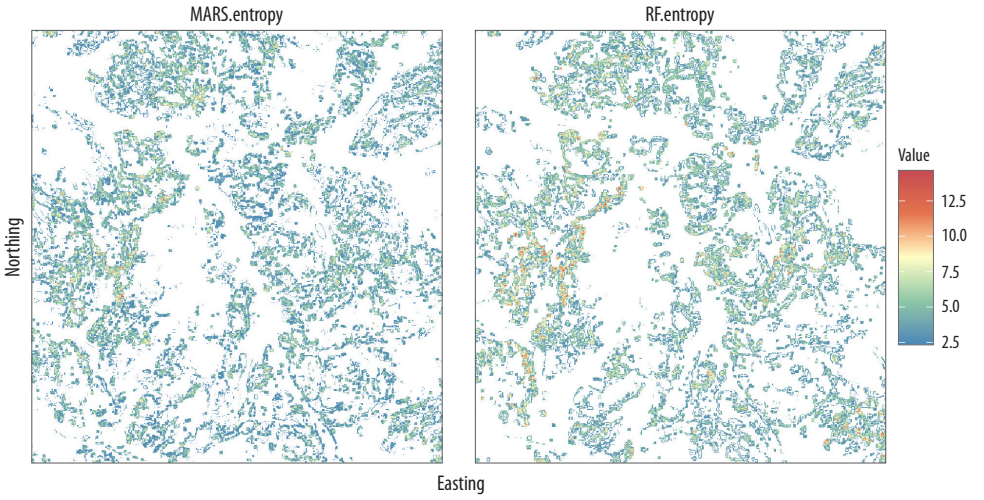

Fig. 6. Differences of the pseudo-labelled model (PL1000) to the original models using the cross-entropy of MARS and RF (values < 2.5, i.e. upper quartile, were blanked). *Source*: Authors' own elaboration.

interspersion became more uneven with the RF.PL with 2.0 percent (77.2) related to the RF (79.2), while in the case of MARS it was 86.2, and for MARS.PL it was 89.5.

The class-level evaluation of the probability levels in the two classification approaches showed that the classifiers reacted differently. In the case of MARS, the probabilities were initially high in the changing pixels of the rock-type pairs, and usually, the larger probabilities had lower SDs. A small decrease in the mean probability levels caused an increase in SD (*Figure 7*, a). The relationship between the mean probability and SDs was almost perfect (e.g. as a second-order polynomial), but the marb-WDi pair was an influential data point with a low mean and SD. Although the changes in probabilities were not significant according to the Wilcoxon test, they exceeded 10 percent in 14 of 30 cases (*Figure 7*, b). In 12 instances, the probability increased. The results were different for RF; typically, lower mean probabilities had lower SDs and followed a linear relationship (*Figure 8*, a). The probabilities of the original approach were lower than those of MARS, and the probabilities of the PL versions were even lower, with significant differences (*Figure 8*, b). The number of cases in which the change was > 10 percent was nine, and the number increased by only five. The magnitudes of the changes also differed; the maximum increase was 62 percent in the case of MARS, and 0.09 for RF (additionally, the largest change regardless of the direction of changes was only 0.27).

Multivariate comparison of the traditional and pseudo-labelling methods

Multivariate comparison of the MARS models

The MARS models performed better with PL1000 than with the original training data, except for three out of 36 cases (without specific rock types). The original data provided more accurate results, and among the three exceptions, the mean differences were below 2 percent (mostly < 0.5%). The decreases in F1, IOU, and MCC were up to 18.8 percent, with a maximum increase of 1.8 percent. For RF models, PL1000 was not very useful; nevertheless, it provided better metrics in 17 out of 36 cases, particularly for gra and WDi rock types *(Figure 9)*.

The difference between the models based on the original and PL1000 training data was significant according to the Hotelling test ($T^2 = 447.77$, $F[6, 593] = 74.63$, $p < 0.001$). $\eta^2 = 0.4302$ indicated a very large effect size and accounted for 43.02 percent of the multivariate variance by group differences in the independent variable. The large effect size was also justified by $D^2 = 0.746$. Both indicated a strong association between the grouping variables and the set of dependent variables. Effect sizes suggested that there were substantial differences in how the models performed across different datasets, considering all performance metrics simultaneously. Accordingly, the groups were well-separated in the multivariate space defined by the dependent variables.

Multivariate comparison of the RF models

For the RF models, the accuracy metrics showed varied results related to the MARS, and the PL1000 training dataset provided better accuracy measures than the original in 15 out of 36 cases. The increase was 5.5 percent and the maximum decrease was 4.8 percent (see *Figure 9*). The Hotelling test revealed a significant difference ($T^2 = 35.31$, $F[6, 593] = 5.89$, $p < 0.001$), but the effect sizes were not as large as in the case of MARS, indicating less pronounced differences between the groups. $\eta^2 = 0.056$ was close to the threshold for a medium effect (0.06), suggesting moderate significance of the group difference. $D^2 = 0.0588$ indicated a relatively small separation between the groups; accordingly, the difference was statistically significant, but the effect was not large.

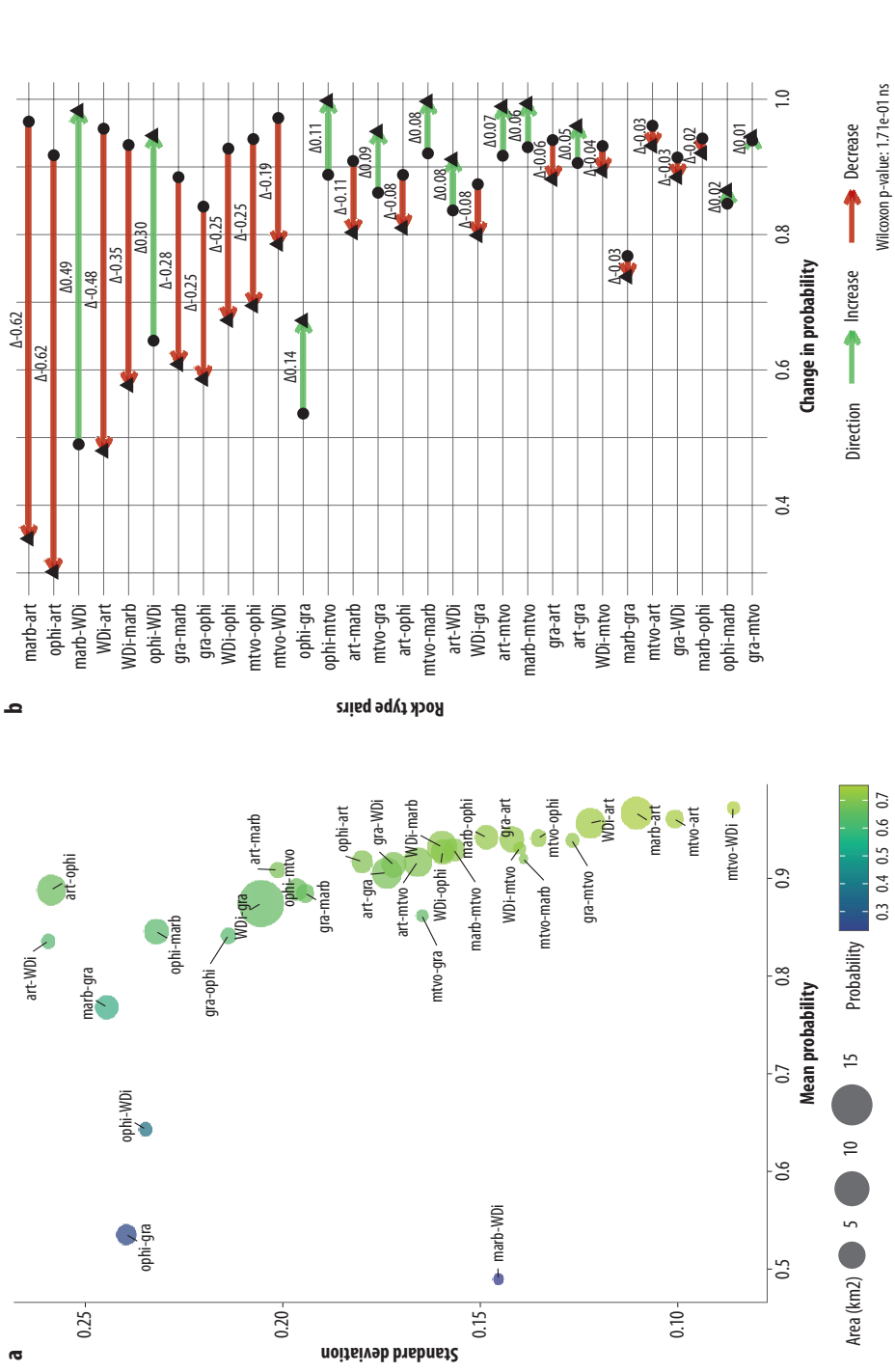

Fig. 7. Changes of rock type classifications in light of probabilities in the case of MARS classifier. Original probabilities by changing rock types (a); Magnitudes of probabilities of rock type pairs (b). For rock types see *Fig. 2. Source*: Authors' own elaboration.

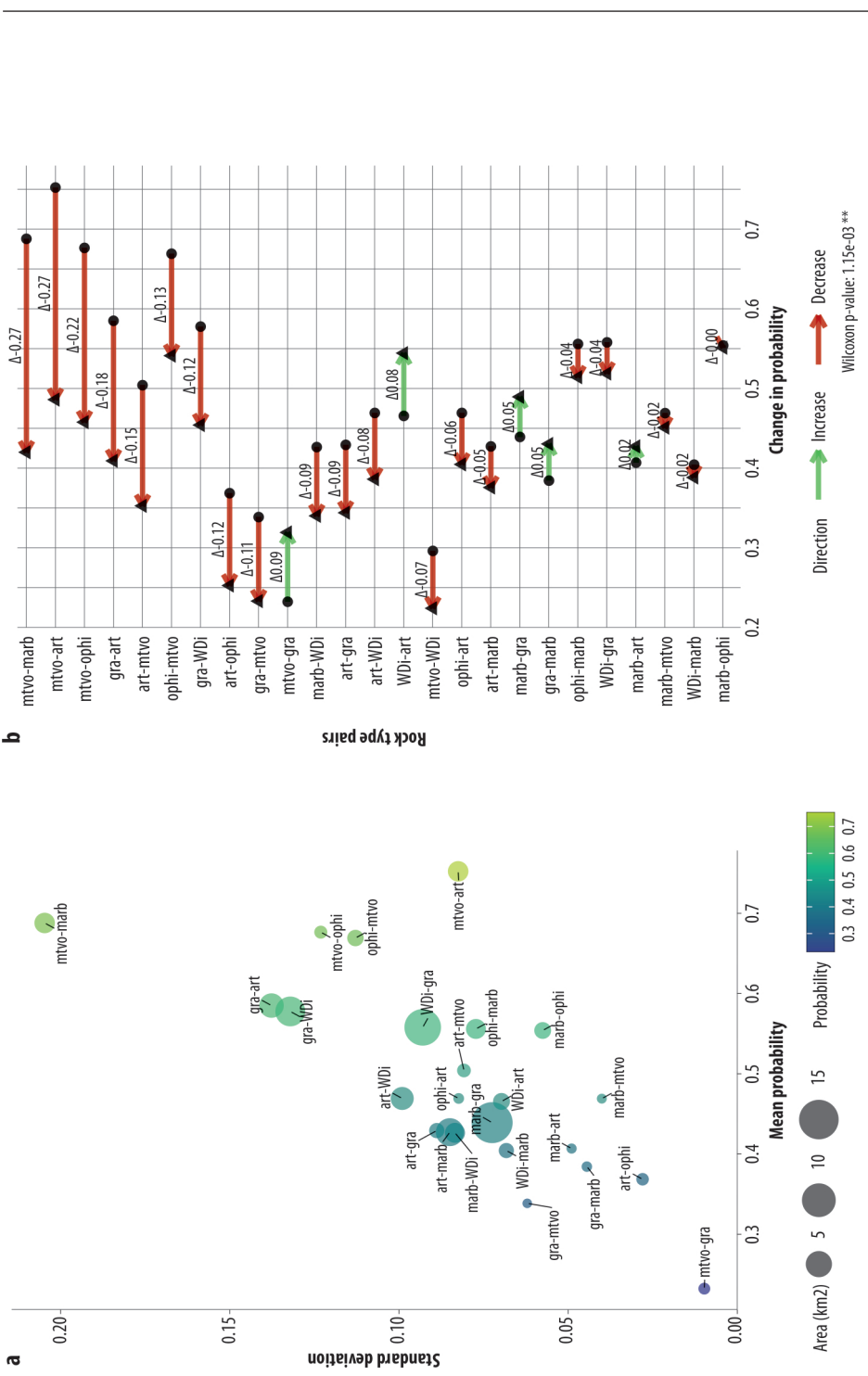

Fig. 8. Changes of rock type classifications in light of probabilities in case of RF classifier. Original probabilities by the changing rock types (a); Magnitudes of probabilities of the rock type pairs (b). For rock types see *Fig. 2. Source:* Authors' own elaboration.

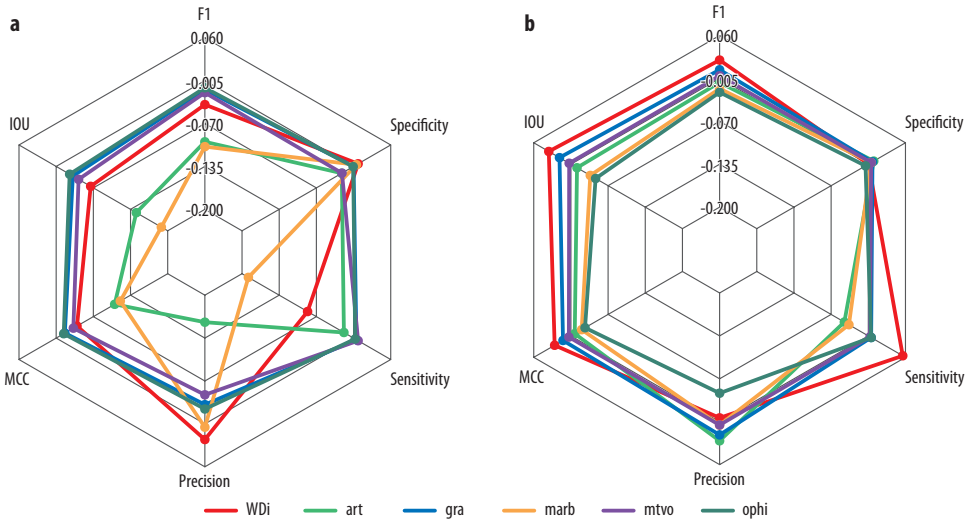

Fig. 9. Difference in model accuracies (Original – PL1000 training data) by rock type and accuracy metrics MARS (a), and RF (b). IOU = Intersection over Union; MCC = Matthews correlation coefficient. For rock types see *Fig. 2.* *Source*: Authors' own elaboration.

Discussion

Insights on classification algorithms

Studying the probability maps alone could lead to misjudging the real performance of the algorithms, as MARS provided unreliably high values, and one could state that RF has poor accuracy. Although probabilities provided new insights, MARS indicated almost perfect reliability (i.e. > 99%) for 81 percent of the study area; however, this was not validated by the accuracy metrics, and RF was not worse than MARS. The OAs only slightly differed between the MARS and RF models; at the class level, there were differences in the misclassification. The reason for the high probabilities of MARS can amplify small spectral differences through its model calculation procedure, whereas RF naturally moderates its probabilities through vote averaging. The key point of this result is that, although MARS seems to be a better classifier based on the probabilities, RF was not worse when considering the accuracy metrics. Even with class-level comparisons regarding the medians, MARS performed only 1–2 percent better than RF in half of the cases. The general issue with confirming the results is that MARS, unlike RF, SVM, XGB, or KNN, is not frequently used. Quirós, E. *et al.* (2009) found that MARS was the best classifier related to Maximum Likelihood and Parallelepiped methods in 13 of 17 test zones in Spain. Nagpal, A. and Singh, V. (2019) used MARS and RF and found that RF was better in six out of 10 datasets. Based on the study by Rotigliano, E. *et al.* (2018), MARS outperformed binary logistic regression for landslide identification, which is consistent with our finding. Harvey, A.S. and Fotopoulos, G. (2016) found that RF was the best classifier; however, in their study, MARS was not applied. Thus, although direct comparison is not a common practice, because MARS is not as popular as RF, we can conclude that both classifiers can generally perform well.

Common misclassifications were caused due to the complexities of geological features, high inter-class similarity, and difficulties presented by remote sensing data. Misclassifications are frequently encountered in lithological mapping, especially when employing this type of data (El-Omairi, M.A. and Garouani, A.E. 2023). In our study, the rock type classification focused on marble, meta-volcanic, ophiolite, altered rock, and wadi deposit units. Discriminating these lithologies is inherently challenging because of their spectral similarities (Othman, A.A. and Gloaguen, R. 2014). Misclassifications occurred primarily among granitoids, wadi deposits, and altered rocks owing to their heterogeneous nature and overlapping spectral characteristics. Specifically, wadi deposits are largely influenced by the weathering of granitoids, whereas altered rocks, often the result of traditional mining activities, are typically associated with these deposits. In contrast, marble, metavolcanic, and ophiolite units predominantly comprise iron (Fe) and magnesium (Mg) minerals, which are less prone to weathering and, thus, less likely to be misclassified. These observations are consistent with Liu, H. *et al.* (2021), who reported common misclassifications between similar lithologies such as granitoids and alluvial sediments owing to their spectral similarities.

Evaluation of pseudo-labelling

PL is generally regarded as a promising method for model-based predictions and focuses on geosciences (e.g. well-log classification: Dunham, M.W. *et al.* 2020; seismic facies classification: Asghar, S. *et al.* 2020). In remote sensing, PL also ensured better models, and several authors have proven its relevance (Aydav, P.S.S. and Minz, S. 2018; Li, J. *et al.* 2022). However, in our study, the outcomes were not always straightforward in terms of usefulness, as reflected by the F1 and MCC values (see *Figure 9*). We evaluated the results both quantitatively (based on accuracy metrics) and qualitatively (based on visual inspection), and the final judgement was not obvious.

A comparison of the original and PL approaches showed that 25 percent of the study area was affected by the changed training data, and the accuracy metrics were affected by the differences between the two approaches, although the improvement was not consistent across all rock types. Focusing on the areas where rock types were classified differently using the two approaches, we found that the consequences differed for the MARS and RF maps. The reason is the initially high probability of the MARS model, which was the opposite of the results experienced in case of RF: the areas of differently classified pixels had high probability with low SD in case of MARS where a small decrease of probability caused the increase of SD; while in case of RF followed a more common trend, having a linear relation with low SDs for low mean probabilities, and high SDs for high probabilities by rock pairs. The main observation was that the probabilities did not improve in the case of MARS and had significantly lower values with RF. Although the MARS was dominated by > 99 percent probabilities, in the areas of change, these values were lower, and the PL approach ensured a higher probability. In the case of RF, the probabilities were lower and could result in lower values with PL, but this did not mean that the performance would have been lower.

Multivariate analyses showed that using 1000 additional data with 95 percent probability changed the accuracy metrics according to the Hotelling test. Furthermore, visual analysis justified these differences. However, PL1000 resulted in conflicting results with several rock types; in these circumstances, PL1000 was useless, and training the model using the original data was more adequate. A summary of the visual analysis results showed that RF.PL was more useful than MARS. The PL was not as successful as the metrics suggested. This seems to be a contradiction, but the explanation can be simple: the amount of testing data was not sufficient to reveal the accuracy in detail. A geologically complex area, such as the study area, would require a higher amount of testing data, but testing only

validated spots is recommended to avoid false accuracy metrics (Meyer, H. and Pebesma, E. 2022; Gao, M. *et al.* 2023). Accordingly, we did not use pseudo-labelled data for testing, but only for training; therefore, the testing points did not cover the entire area. Furthermore, spatial patterns cannot be captured using points, and visual inspection with specific geological knowledge is more important. The main question is, based on analogies, whether there are reasonable (i.e. geologically possible) occurrences of rock types. The artisanal small-scale mining exploits certain rock types (meta-volcanics), and occurrences can be excluded when they are identified on marble, ophiolite, and granite. Wadi deposits (WDi) also have typical areas where wadis can be found, corresponding to the topography.

Limitations

Training data is always the main question of all models, and in our case, we provided a possible approach by augmenting the available training data. Testing is another important point, and we had only a limited amount of data, 256 records that were collected during extensive fieldwork, and rock samples that were investigated and registered. This was sufficient to conduct an accuracy assessment; however, visual inspection of the spatial patterns was useful. Accordingly, further testing is needed with more testing data and other datasets where probabilities can be tested as well.

Conclusions

Our aim was to study the efficacy of pseudo-labelling in the geological mapping of an African area. We applied the RF and MARS classifiers, which provided classified maps and probability maps, and evaluated the results using an accuracy assessment and visual analysis. RF provided more reliable probability levels, whereas the MARS probability map was too optimistic; 85.7 percent of the classified pixels were above 90 percent probability and 81 percent above 99 percent probability, which did not correspond to the accuracy assessment. MARS performed only slightly better than RF, and as the PL data were obtained within the 95 percent range of probability, PL was useful for MARS (with 1000 PL data of 95% probability). For RF, PL helped to obtain better accuracies, but its relevance was smaller owing to its robustness. Visual analysis enhanced the relevance of specific knowledge of the area by confirming or excluding the outcomes of the best and impossible occurrences of rock types. We revealed the relevance of PL in geological mapping for both RF and MARS, and the additional data helped to gain better maps. Based on class-level accuracy metrics, PL provided better maps in the case of MARS (33 out of 36) and fewer cases with RF (17 out of 36), considering 1000 additional samples of 95 percent probability.

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How extreme precipitation in 2010 altered urban heat island behaviour in Debrecen

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Abstract

Earlier examinations of the urban heat island (UHI) characteristics in Debrecen revealed unusual behaviour in the years 2010 and 2011, while the following years exhibited characteristics expected according to the literature. The year 2010 in Hungary was characterised by anomalously high precipitation with several extreme events, including two Mediterranean cyclones in the spring, numerous convective systems in the summer, and several slow-moving frontal passages in the autumn. These led – both country-wide and in Debrecen – to record-high annual precipitation, and significant deviations in other meteorological elements like soil moisture and near-surface humidity characteristics. It is possible that the development of the urban heat island (UHI) in Debrecen was also affected. This study investigates the unusual behaviour of the UHI in 2010 and early 2011, focusing on how the excessive precipitation influenced the urban climate. Data from 2010 to 2015 were analysed, originally including temperature, humidity, wind, precipitation, cloud cover and soil moisture measurements from a city and a rural station. The current analysis shows that the high precipitation caused significant changes in soil moisture and relative humidity in the rural area, possibly leading to an increased latent heat flux at the expense of sensible heat. This might have reduced the UHI intensity during both day-time and night-time. With this, the study proposes a potential explanation for how long-term high precipitation can have lasting effects on UHI development, which may contribute to a deeper understanding of the interactions between extreme weather events and urban climate dynamics, which is crucial for urban planning and climate adaptation strategies in the context of climate change.

Keywords: urban heat island, precipitation anomaly, Debrecen, extreme weather, climate dynamics, energy balance

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Introduction

Urbanization and climate change are two major factors influencing local and regional weather patterns, particularly in urban environments. One of the most studied phenomena in urban climatology is the Urban Heat Island (UHI) effect, where urban areas exhibit higher air temperature than their rural surroundings, primarily due to modifications in surface characteristics such as reduced vegetation, increased impermeable surfaces, and altered energy balance (Oke, T.R. 1973). This effect is especially pronounced during clear, calm weather conditions, but its behaviour under extreme weather, such as excessive precipitation, remains less understood.

The year 2010 presented an opportunity to investigate the effects of extreme precipitation on UHI behaviour in Debrecen, Hungary. The city, located on the Great Hungarian Plain, experienced significantly

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higher than average rainfall throughout the year, with some months recording up to three times the normal precipitation (Móring, A. 2011). This raised the question of how such excessive rainfall might influence UHI development, given that high precipitation events can alter urban and rural environments' thermal and moisture characteristics.

While the UHI phenomenon has been widely documented, most studies focus on its development during heatwaves or stable, dry weather conditions, and specific impacts of extreme weather, for example a long-lasting high-precipitation event, on UHI dynamics remain largely unexplored. This study aims to address this gap by analysing the unusual UHI behaviour observed in Debrecen during the extreme precipitation year of 2010. The focus is on understanding how excessive rainfall affects the energy balance in both urban and rural areas and how this, in turn, influences UHI development. We compare air temperature, humidity, cloud cover and wind data from 2010 to 2015 from two meteorological stations: one in the urban centre of Debrecen and the other in a nearby rural location. We aim to provide some insights into the mechanism behind UHI modulation in response to a prolonged high-precipitation event.

Ultimately, this research contributes to the broader understanding of urban climatology by highlighting the role of extreme weather in shaping UHI dynamics. The findings are particularly relevant in the context of climate change, where extreme weather events, such as heavy rainfall, are projected to become more frequent and intense. Understanding the interplay between urbanisation, precipitation, and UHI can help inform urban planning and climate adaptation strategists, ensuring that cities are better prepared to cope with the impacts of a changing climate.

Literature review

While the UHI phenomenon has been widely documented in various urban settings, most studies focus on its development during heatwaves or stable, dry weather conditions (Szymanowski, M. 2005; Kovács, A. and Unger, J. 2014; Unger, J. *et al.* 2017). In such cases, urban areas experience enhanced heating due to the prevalence of heat-absorbing materials like concrete and asphalt, reduced vegetation, and lower evapotranspiration compared to rural areas (Oke, T.R. 2002). These factors contribute to a temperature contrast between the city and its surroundings, often peaking during the night when heat release from urban surfaces is slower (Kłysik, K. and Fortuniak, K. 1999). While the literature extensively discusses how UHI affects precipitation (e.g. Han, J.-Y. *et al.* 2014; Marelle, L. *et al.* 2020; Öztürk, S.P. *et al.* 2025), there is limited understanding of the case vice-versa, that is, how prolonged high-precipitation events influence UHI intensity and dynamics, especially when considering the energy balance in urban and rural areas.

In recent years, climate variability has caused a growing frequency of extreme weather events, including both heatwaves and heavy rainfall (Bartholy, J. and Pongrácz, R. 2013). The year 2010 serves as an example of an extreme precipitation year in Hungary and much of Central Europe, where several significant rainfall events contributed to record-breaking annual precipitation totals. Among these events, two Mediterranean cyclones, named Zsófia and Angéla, were particularly impactful, bringing intense and prolonged periods of rainfall (Ujváry, K. 2010; Teknős, L. 2012). These weather anomalies led to flooding in many areas and significantly altered local climatic conditions (Senevirante, S.I. *et al.* 2010; Husain, S.Z. *et al.* 2014; Vereecken, H. *et al.* 2022), including urban areas such as Debrecen.

Typically, in rural areas, heavy rainfall increases soil moisture, leading to enhanced latent heat flux due to higher evapotranspiration rates, which in turn can reduce surface temperatures (Altermann, M. *et al.* 2005). In urban areas, however, much of the precipitation is rapidly drained from the surface due to the prevalence of impermeable surfaces and storm water management systems (e.g. Dobai, A. *et al.* 2024; Kubiak-Wójcicka, K. *et al.* 2025),

meaning that the moisture content in the urban environment may not increase to the same extent as in rural areas. This discrepancy could lead to a modification of the UHI effect, as the thermal response of urban and rural areas to precipitation differs. Understanding these dynamics is critical for developing accurate models of urban climate and planning for the impacts of extreme weather events in an era of increasing climate variability.

Several studies have examined the relationship between UHI and weather patterns (Morris, C.J.G. and Simmonds, I. 2000; Beranová, R. and Huth, R. 2005; Hoffmann, P. and Schlünyen, K.H. 2013), but few have focused on the impact of prolonged precipitation on UHI intensity (László, E. and Weidinger, T. 2014; László, E. and Salavec, P. 2018). Research by Schlünzen, K.H. *et al.* (2010) highlights the regional differences in temperature and precipitation in metropolitan areas, suggesting that local climatic conditions can significantly influence UHI behaviour. Similarly, Gedzelman, S.D. *et al.* (2003) observed mesoscale variations in the UHI effect around New York City, showing that localised weather conditions can modulate the intensity of UHI. However, the specific impact of long-lasting high-precipitation weather on UHI dynamics, particularly in smaller cities like Debrecen, remains largely unexplored.

The UHI's general behaviour in Debrecen resembles those of other similar towns on plain areas without large water bodies in the vicinity (Peng, S. *et al.* 2012). Only a few slight differences were found which seem to express more-or-less unique features for Debrecen (Szegedi, S. 2000; Kircsi, A. and Szegedi, S. 2003; Szegedi, S. and Kircsi, A. 2003; Szegedi, S. *et al.* 2010; László, E. *et al.* 2016). These are reflected in our data as well, in the years from 2012 to 2015, when there were no modifying effects caused by either large precipitation or high soil water content.

General characteristics of absolute humidity difference between urban and rural areas is less frequently studied (Kuttler, W. *et al.* 2007; Sherwood, S.C. *et al.* 2010). Due to convective transfer processes typical of the summer half-year, this difference decreases following the afternoon maximum, as convection lifts moisture from the surface to higher layers of troposphere, hence, vapour pressure drops in the surface layers.

Soil moisture data can show how saturated the soil is, which determines the intensity of evaporation. As such, the energy balance can be largely different just by the difference in soil moisture content, while other meteorological elements are the same. For example, the latent heat flux can dominate the sensible heat flux when the soil is saturated. Around an urban environment, the different storage capacity of the urban and rural soils – for example, the existence of drainage systems in the town – causes differences in the modification of latent heat flux in an extreme precipitation event (Starke, P. *et al.* 2010; Huang, X. and Song, J. 2023; Luo, Z. *et al.* 2023). With this, the urban heat island development is also affected (Altermann, M. *et al.* 2005).

We will show that the characteristic behaviour of the UHI in Debrecen was different in the years 2010 and 2011, which is attributable to the permanent high precipitation and the long-lasting saturation of the soil with liquid water. Total precipitation in 2010 reached 964 mm at DVK and 994 mm at AMO. More than half of this was recorded during the period between May and September, causing inland floods around the town. For comparison, Hungarian Meteorological Service reported 546 mm average yearly sum in the period 1991 to 2020 in Debrecen.

Data and methods

The measurements, basis of the results detailed below, were carried out at two sites simultaneously: inside the city of Debrecen (DVK, LCZ-2) and 4.9 km to the northwest at the Agrometeorological Observatory near Kismacs (AMO, LCZ-D), at a distance of 1.8 km from the edge of the urban area (*Figure 1*). The difference between their elevation does not exceed 2 metres. Debrecen, populated by 200,000, is located in the Great Hungarian Plain inside the Carpathi-

Fig. 1. Location of Debrecen Urban Climate Station (DVK, bottom right) at the Institute for Nuclear Research (MTA ATOMKI) and the Agrometeorological Observatory (AMO) of the Centre for Precision Farming R&D Services, University of Debrecen (bottom left) within the satellite map of Debrecen (top). *Source:* Compiled by the authors.

an Basin at an elevation of 120 m above sea level (approx. N 47.5°, E 21.6°). The flat land and the lack of nearby large water bodies favour the development of an urban heat island (UHI).

The urban climate station (DVK) is situated in a densely built-up (78%) zone of Debrecen, within the area of the Institute for Nuclear Research (HUN-REN ATOMKI), 1 km to the north of the city centre. According to classification scheme of local climate zones (Stewart, I.D. and Oke, T.R. 2012), it is classified as LCZ-2 with rather compact, mid-rise buildings and scattered woody vegetation. Data collection was carried out with a Davis 6152 Vantage automatic weather station in the period between 1 January 2010 and 31 December 2015, with very few intermissions. Instruments have been placed at 2 m a.g.l., which meets the recommendations; data obtained during the measurement campaign will well represent the ambient climate (Oke, T.R. 2006). The type of the station is suitable for studies of urban climate as it is

equipped with adequate precision temperature (±0.1 °C), humidity (±2%) and wind velocity (±0.1 m/s) sensors.

As a reference, 10-min resolution and high precision data of the Agrometeorological Observatory (AMO) were used, representing the natural climate of the surrounding area (Rácz, Cs. *et al.* 2013).

Since both stations represent the local climate zone in which they are situated, the temperature of the DVK station subtracted from that of the AMO station serves as an appropriate measure of the intensity of urban heat island intensity.

UHI intensity is defined as the difference between the urban and rural temperatures. In our case, only one station was available in both areas, so the actual UHI intensity is defined as the difference $T_{DVK} - T_{AMO}$. However, this is a time series with a resolution of 10 minutes. Since the UHI exhibits a daily course, we define the following UHI intensity indices for each day:

– F-UHI: Full-day averaged UHI intensity (from 0 to 24 CET),
– D-UHI: Day-time averaged UHI intensity (from 5 to 18 CET),
– N-UHI: Night-time averaged UHI intensity (from 18 to 5 CET),
– M-UHI: Maximal daily UHI intensity.

The difference in relative humidity (RH) between the city and rural areas is less commonly studied (Hage, K.D. 1975; Ackermann, B. 1987; Unger, J. 1999; Unkašević, M. *et al.* 2001). The main reason is the need for high-precision sensors, as RH measurements require a more complex technique than that of temperature. In addition, because of the dependence on temperature of relative humidity, differences in the values do not usually mean the same difference in the absolute amount of moisture. For this reason, it is more suitable to involve vapour pressure or other absolute humidity data to highlight absolute differences. Here, vapour pressure was calculated using the 10-min temperature and relative humidity data for both stations.

Measured data of soil moisture was available only from the Agrometeorological Observatory where two sensors measured soil moisture. Both represent approximately the average of the uppermost 30 cm. The soil type is a typical calcareous chernozem. Normally, the volumetric soil moisture content lies around 20 percent, but it is mostly in the range of 15 to 30 percent. Values outside this interval occurs during extremely dry or wet weather.

Results

Urban heat island intensity

In the summer of 2010 and 2011, we observed a weaker development of the urban heat island compared to the following years, which may be explained by the excessive precipitation (Móring, A. 2011). UHI appears during the dawn and day-time hours as well *(Figure 2).* Day-time negative heat island was detectable in September and October, which can be explained by the decrease of precipitation in these months. An unusual pattern was also observable during the drought period in 2011 (see *Figure* 2), so we conjecture that the amount and intensity of precipitation can determine the daily dynamics of UHI. It appeared mainly in late spring to early summer (May: 55 mm, June: 49 mm, July: 266 mm, August: 42 mm) as high precipitation was measured (see Appendix 6 in László, E. 2017), while the course of dawn and day-time UHI deviated from the normal.

Relative humidity and vapour pressure

During the day, high differences may occur in the course of relative humidity *(Figure 3).* The night-time humidity deficit in the city occasionally dropped as low as 38 percent in comparison with the AMO, however, the most typical values range from -10 to -22 percent. In the day-time, relative humidity was generally 10 to 15 percent higher at the DVK, except for the very low (-6%) difference in the cold season. The highest differences were found during the warm and the transitional seasons, clearly pointing out the seasonal characteristic of the parameter. Furthermore,

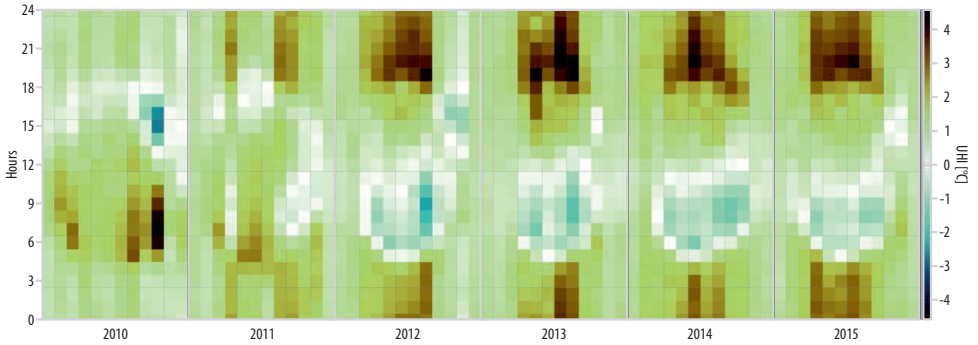

Fig. 2. Monthly averaged daily course of UHI from January 2010 to December 2015. Time of day is on the vertical axis, and one column represents one month. *Source:* Compiled by the authors.

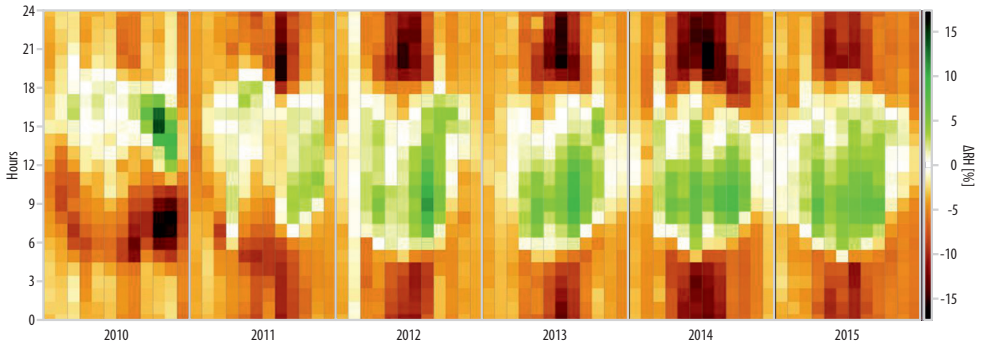

Fig. 3. Monthly averaged daily course of the difference of relative humidity ($RH_{DVK} - RH_{AMO}$) from January 2010 to December 2015. Time of day is on the vertical axis, and one column represents one month. *Source:* Compiled by the authors.

the pattern of differences in relative humidity in 2010 differs from that of an average year, mainly driven by the extreme rainfall measured that year.

Vapour pressure difference (Δe) between the city and the countryside rarely reaches 1 hPa in winter, while it may exceed 5 hPa in the summer months *(Figure 4).* The effect of convection on vapour pressure can be seen on both the DVK and AMO station data. The absolute humidity curve peaks later inside the city. During the winter half-year convective transfer is less typical, thus, absolute humidity does not show a daily course and only a slight difference is observable between the urban and rural environment.

As a general summary, the contrast between city and countryside may as well be significant and negligible, depending on both the season and the time of day, which is reflected in our data as follows:

Only a slight difference of relative humidity can be measured day-time, while during the night it is less humid in the city.

During the day-light hours, vapour pressure is higher in the rural area. Similar to relative humidity, the daily course of vapour pressure peaks in the afternoon hours (at about 14 CET) in the summer half-year.

After sunset, vapour pressure rapidly drops, causing a vapour deficit in urban areas compared to the surroundings.

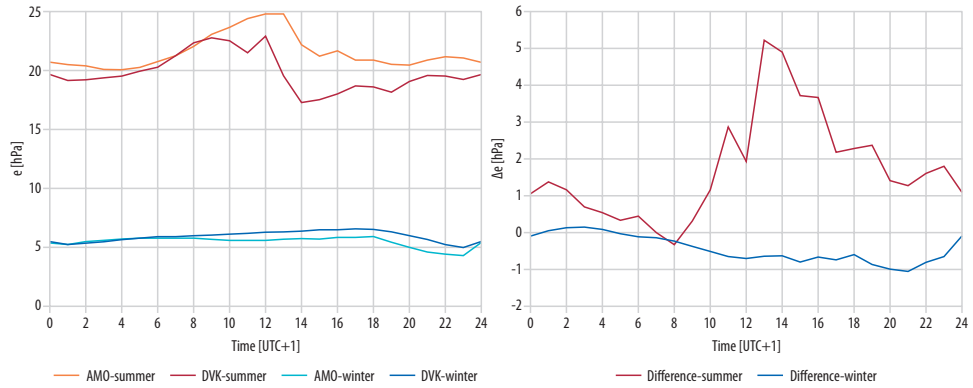

Fig. 4. Vapour pressure course on a typical winter (16.01.2015), and summer (04.08.2015) day at the AMO and DVK stations (left), and their difference ($e_{AMO} - e_{DVK}$) (right). *Source:* Compiled by the authors.

From the dawn hours, vapor pressure rapidly grows at rural locations, which is driven by the intense evapotranspiration and weak convective processes.

The RH difference daily course (see *Figure 3*) shows the normal behaviour between 2012 and 2015. In 2010 and 2011, a similar pattern can be seen as in *Figure 2* for the UHI. The day-time difference between the city and the rural area vanishes. At night, the usual deficit in the city compared to the rural area is less pronounced. In the autumn of 2010, a morning deficit appeared in the city, while in the afternoon, the RH in the city became higher. This is also similar to the UHI pattern in September and October. The slow transition to the usual behaviour in 2011 also appears similar to that of the UHI.

Soil moisture

As can be seen in *Figure 5*, the volumetric soil moisture content is generally in the mentioned interval; higher values occur on days when higher precipitation occurred. Considerably, the water content in these periods can be permanently high, over 30 percent, but these are short periods compared to that lasting until around the middle of 2011. The water content in 2010 and early 2011 is usu-

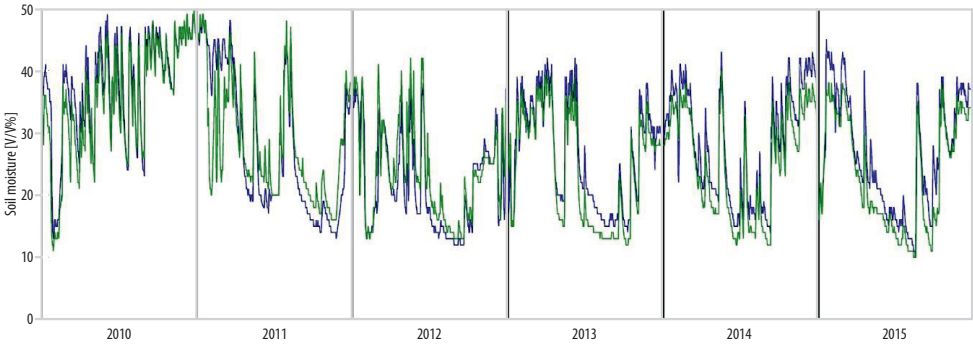

Fig. 5. Soil moisture content time series at the AMO station from two sensors in the upper 30 cm layer. *Source:* Compiled by the authors.

ally higher than in the usual wet periods, around 45 to 50 percent, about the pore space (46.2%, according to Table 9 in Altermann, M. *et al.* 2005). This means that inland flooding should be present in the vicinity before the middle of 2011.

Discussion

The investigation of the urban (DVK) and rural (AMO) measurement data revealed the anomalous behaviour of the urban heat island in 2010 and 2011 in Debrecen, Hungary. In normal years, the night-time urban heat island development is usually strong in summer, while the city is usually cooler in the day-time. In winter, the urban heat island development is weak and nearly the same in the night- and in day-time. In 2010 and early 2011, the urban heat island development was nearly equal or even stronger in day-time than at night. In the dry year of 2011, the transition to normal was smooth, meaning that the urban heat island reacted slowly to the return to normal weather which happened in January 2011. This effect is also revealed by the daily course of the UHI (see *Figure 2*).

Elements which are considered determining factors in advantageous conditions for urban heat island development were briefly analysed earlier, but in this case, only the course of relative humidity difference was modified in 2010 and 2011. The difference in wind and cloudiness cannot change much due to the relatively short distance between the two stations. As such, macro-synoptic changes in weather patterns cannot directly alter the urban heat island development, so extreme precipitation and its consequences are assumed to cause the modification of urban heat island development.

In a typical summer day, the building structure in the city causes the temperature to rise more slowly in the morning than in rural areas, due to shadowing. Thus, the relative humidity remains higher as the absolute humidity is not affected. After the maximum temperature – which is determined by the nearly constant PBL height in a typical fair weather summer day – is reached at the rural area, which is earlier than in the city, the relative humidity difference begins to vanish. As the temperature remains higher in the city at night, the relative humidity becomes lower there. This is true if the vapour pressure has few spatial differences. That spatial difference appears in the afternoon when stronger evapotranspiration makes the vapour pressure rise more in the rural area, as seen in *Figure 4*.

In a high precipitation situation, the high runoff in the city caused by the drainage system and the non-porous surfaces causes the loss of groundwater content. In the rural area, the water is kept in the soil and the high groundwater causes high evapotranspiration which leads to a higher absolute humidity than usual, keeping the relative humidity higher as well. This can make rural RH values equal to, or even in excess of, those of the city. The high RH and the decreased radiation caused by the often cloudy weather can also make the daily course less pronounced.

The similarities of the monthly-averaged daily courses of RH and UHI in 2010 and early 2011 are probably related to the similar patterns in UHI in September and October, the latter can be related to the longer dry period amongst the high precipitation events. However, an explanation of this feature with the available data is uncertain.

In the following winters, the dominating synoptic scale patterns (zonal, meridional, frequent cold pillow situations, etc.) cause complications. The RH difference seems to be more sensitive to synoptic patterns, and one synoptic situation can cover a large part of one winter. As such, the average daily course can be more different from one winter to another, while in the summer, the effect of daily radiation course exceeds that of the synoptic patterns. Thus, the daily course of the RH difference cannot be used to explain UHI behaviour in winter without considering synoptic-scale weather patterns. For example, the apparent inhomogeneity in February 2012 is caused by cold and dry continental air mass lying over the Carpathian Basin for approximately 20 to 25 days.

The effect of high precipitation on humidity can be examined in terms of any humidity characteristic. Relative humidity reveals the difference more pronouncedly because, for example, high relative humidity difference means less difference in absolute humidity in a colder period. Thus, absolute measures are important when considering the energy balance because the absolute humidity is included in the latent heat. When the precipitation, and accordingly the absolute humidity, is high, the latent heat flux rises in the rural area at the expense of the sensible heat flux. The lower sensible heat flux with a similar wind course, however, is only possible if the temperature is lower. This lower temperature can be set up not only by the decreased radiation but also by the higher evaporation of groundwater.

The wet period notably increased the soil moisture and vapour transfer (evapotranspiration) towards the lower layers of the atmosphere at the AMO station. In an urban area, the drainage system removes most of the water content of an excessive precipitation event. The groundwater, in turn, can remain unusually high after a high precipitation period, for a longer time. As the weather returned to normal in January 2011, inland floods were still common in the Great Plain. These survived until spring, partially in the form of ice, and evaporation of these water bodies began only after melting. The ground soil remained saturated until summer, and the evapotranspiration began to decrease in the summer. Soil moisture content measurements at the AMO station are in accordance with this observation, as they show permanently high soil moisture content in 2010 and early 2011, and significantly lower periods afterwards are interrupted with only intermittently occurring high values (see *Figure 5*).

The effect of the high precipitation and the higher humidity on the energy balance is thought to be less in the city because of the loss of groundwater caused by the drainage system and higher surface runoff. This loss of groundwater results in less modification of the vapour pressure. Because of shadowing, the radiation has an effect on the roughness sublayer in the city, meaning that the decreased radiation also has a little effect on the energy balance under the roughness sublayer. That is, the overall modification caused by high precipitation weather is minor. Consequently, the modification of the UHI effect by large precipitation is caused by the modified state of soil, and with that, the PBL, in the rural area. A strong conjecture is, thus, that the modifications in the energy balances caused by the rural soil water anomalies are the key factor in the development of the UHI during (and somewhat after) a high precipitation event.

Hypothesising these modifications of the rural and urban energy balances, it could be concluded that the increased humidity can significantly alter the rural energy balance. As mentioned, this is via the increasing latent heat flux at the expense of the sensible heat flux, leading to a lower maximum temperature and a slower rise of the temperature. This results in a temporal shift in the daily rural temperature course, and this shift is greater in average than the shift between the rural and urban daily temperature courses in normal weather. This explains that the urban area remained warmer in 2010 and early 2011. In the night, the frequently high cloudiness caused higher minimum temperatures at both stations. In rural areas, cloudiness also prevented continuous dew formation, and these two features prevented a stronger temperature decrease in the morning. These lead to more balanced temperatures, i.e. lower UHI intensities at night.

Moreover, a temporally local effect in October of 2010 can be considered on *Figure 2*. The weather then was less cloudy which resulted in increased diurnal amplitude in temperature in the city, causing high UHI values mornings and high negative UHIs evenings.

Conclusions

Examining the urban heat island intensity of Debrecen revealed unusual behaviour in 2010 and early 2011. Anomalous daily courses were observed in which urban heat

island was more developed day-time than in the night. Unusually high precipitation characterised the weather of 2010, which often caused inland floods in the vicinity. These survived the winter, and the soil moisture content returned slowly to normal in early 2011, and the normal state of the urban heat island was set up in the summer of 2011. A link between the high precipitation weather and high humidity, and the unusual behaviour of the urban heat island is examined. Measurement datasets of temperature, relative humidity and soil moisture in the city of Debrecen and the nearby Kismacs rural site from 2010 to 2015 are evaluated with the aim of proving the hypothesised link, and to reveal its causes. A possible explanation of the link is provided based on these data. The most possible effect of high precipitation weather is that the unusually high humidity and soil moisture content causes the latent heat flux increase significantly, at the expense of the sensible heat flux, at the rural area in day-time. A more complex effect in the night is probable, tending to be similar to the effect of wet weather in general. In the city, however, these effects are little because of the loss of groundwater caused by the drainage system. This modification of the rural energy balance, thus, resulted in the unusual behaviour of the Debrecen UHI.

Direct measurement to prove the modification of energy balances is difficult to carry out. Difficult on its own because of the expenses of the required measurement technique: a long-term complex micrometeorological measurement campaign is needed at both the rural and urban areas, to track long-term courses of the energy balance components. Furthermore, a similarly exceptional year with high precipitation is needed during which the energy balance is measured as well, but such years occur once in several decades or even centuries. Energy balance measurements may be carried out with continuous control and durable working equipment. Shorter high precipitation weather events, lasting for at least some weeks or months, are not as rare as complete years, and with these measurements available, the effects of this weather on the energy balances and the urban heat island can be examined. Results from such an event of the energy balance can be compared with our hypothesis on the energy balance modification.

While the measurements were carried out before 2016, when urban heat island research was a bit less developed, the techniques nowadays are much more suitable to check these results. As such, a plan might be formulated to develop a measurement network around Debrecen or other town with similar features. If the sensors are readily accessible, the build-up if such a network could be fast enough to capture at least much of the high-groundwater period, as well as the time range when conditions return to normal. This network would include 5 to 10 stations in and around the town, where sensible and latent heat flux could also be measured. The storage of the high-frequency turbulence data seems to be the most problematic in a technical sense.

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Cultural adaptation and validation of the water attitude scale: Insights from Hungarian student responses

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Abstract

Education plays a crucial role in shaping future generations. This is also the case for the formation of environmental attitudes. Hungary is a country with abundant water resources; however, fostering students with a strong water attitude is especially important for the future, even in such nations. The objective of this study was to adapt and validate the Water Attitude Scale (WAS) questionnaire for use with primary school students in Hungary. A total of 964 students from grades 5–8, enrolled in twenty schools located in Southern Transdanubia, completed the questionnaire. The results of the confirmatory factor analysis indicated that the original factor structure was not an optimal fit for the data, prompting the development of a new four-factor model through exploratory factor analysis. The revised factors were: 1) The Value of Water and Responsibility, 2) Awareness and Education, 3) Water Usage at Home and in Society, and 4) Responsibility and Intervention. Analysis across grade levels revealed that fifth graders showed high initial awareness, which gradually declined in higher grades, while attitudes toward water use improved with age. Responsibility peaked in grade 6 but decreased slightly thereafter. The adapted questionnaire proved to be a reliable and valid tool for assessing water-related attitudes among Hungarian students, making it applicable for both diagnostic purposes in environmental education and as a foundation for longitudinal studies.

Keywords: water attitude, environmental education, diagnostic tool, questionnaire validation

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Introduction

Relevance of the research

Water is one of the most essential resources on Earth and plays a pivotal role in several life processes and in the functioning of diverse ecosystems. Water is indispensable for all living organisms, because it is involved in fundamental biochemical processes, including the transport of nutrients and the removal of metabolic waste. Furthermore, numerous human activities, including agriculture, industry, and energy production, are also significantly dependent on water. Freshwater resources are limited, making up only 2.5 percent of the Earth's water supply, with much of this – in a form not directly usable – stored in ice caps and glaciers. Climate change, population growth, and pollution are worsening the growing demand for freshwater and potentially leading to a global

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water crisis. Sustainable water management, including water conservation, pollution reduction, and recycling, is critical to ensuring water availability for future generations. On 28 July 2010, the United Nations General Assembly adopted Resolution 64/292, which declared access to safe and clean drinking water and sanitation facilities as a human right, essential for fully enjoying life and all other human rights (United Nations, 2010).

In recent decades, it has become clear that freshwater is a limited resource that is significantly impacted by human activity. The effects of population growth are not as immediately apparent on freshwater consumption, as the regions with the fastest-growing populations often have the lowest per capita water usage (United Nations, 2023). In lower-income countries, the primary cause of poor environmental water quality is inadequate wastewater treatment. In contrast, in higher-income countries, agricultural runoff represents the most significant environmental challenge (United Nations, 2024). As reported by Seelen, L.M.S. *et al.* (2019), Europeans use an average of 3,550 litres per person per day, a quantity that continues to rise with increasing incomes. Their findings showed that European respondents significantly underestimated their daily water usage, particularly regarding the indirect water use associated with the production of goods and services. Environmental awareness, societal attitudes, behaviour, and knowledge play a significant role in enabling sustainable socio-economic processes (Bodó, A. and Alpek, B.L. 2024).

In addition to the above, climate skepticism is also a critical issue that affects Hungarian society too (Jankó, F. *et al.* 2018). Therefore, the role of education is invaluable. The primary educational goals concerning water resource issues should be to foster long-term changes and nurture conscious citizens ready to act on water-related matters. This will require a shift in focus toward attitudes, knowledge, and behaviours (Hurlimann, A. *et al.* 2009; Gopinath, G. 2014; Amahmid, O. *et al.* 2019). It is crucial to acknowledge that young people can establish the fundamental elements for lifelong learning and awareness at an early stage of their education. This enables them to make more informed decisions about water-related concepts based on accurate knowledge (Rejeski, D.W. 1982; Dieser, O. and Bogner, F.X. 2016). The early educational stages thus present an opportunity to model public education on water conservation. The children of today will eventually make decisions about the future use of water resources. The most effective way to equip the next generation with the knowledge and attitudes that promote wise water use and proper behaviour is through school education (Schaap, W. and van Steenbergen, F. 2001; Global Water Partnership, 2003; Kovačević-Majkić, J. *et al.* 2022).

Water Attitude Scale

This study is based on a questionnaire package developed by Yeap, C.H. *et al.* (2007), known as the Water Attitude Scale (WAS), which was validated by the authors on a primary school-age sample. Yeap, C.H. *et al.* (2007) designed this questionnaire to assess four key components. The four components are: (1) Water and Environmentally Sustainable Development; (2) Water for Health, Hygiene, and Recreation; (3) Water, Social Equity, and Human Dignity; and (4) Cultural, Traditional, and Religious Practices Related to Water. The original objective of the questionnaire was twofold: firstly, to serve as a diagnostic tool for measuring changes resulting from water-related pedagogical interventions introduced by the research group, and secondly, to function as a formative assessment tool.

Despite undergoing multi-stage testing, the questionnaire was conducted with relatively small sample sizes. The initial pilot testing was conducted with 43 participants (across three groups of teachers), followed by a second round with 39 participants (science and mathematics teachers). Following these tests, the final version was established through confirmatory factor analysis. The

original five-point Likert scale was reduced to a four-point scale, eliminating the neutral option. The starting 102 items were gradually refined to a final 29 items. The questionnaire was administered in a small-sample study comprising 24 participants in a science class and 27 in a mathematics class, both before and after the HVWSHE intervention (see subchapter "*The HVWSHE curriculum*"). Yeap, C.H. *et al.* (2007) grouped the questionnaire items as shown in *Table 1.*

Research objectives

At the outset of this research project, our objective was to develop a standardized questionnaire package that could be used to diagnose attitudes toward water among primary school-aged students. A review of the literature revealed the WAS questionnaire, as previously outlined. However, it became clear that the questionnaire, in its original form, could not be directly transferred as a diagnostic tool into Hungarian educational practice. This was due to its use of terms and expressions unfamiliar to students in this age group, who often lacked the background knowledge necessary for proper comprehension and evaluation of certain concepts. Consequently, we made preliminary adjustments to the original WAS questionnaire, clarifying terms like water meter, water theft, and sanitation by providing explanations in parentheses.

Literature review

Environmental education and its aspects in Hungary

The concept of environmental education has undergone significant evolution since its initial appearance, rendering a precise definition challenging due to its changing content (Neal, P. and Palmer, J. 1994). One of the most influential international interpretations emerged at the Tbilisi Conference 1978, defining environmental education's aim "to succeed in making individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic and cultural aspects, and acquire the knowledge, values, attitudes, and practical skills to participate responsibly and effectively in participating and solving environmental problems, and the management of the quality of the environment." (United Nations, 1978, 25).

In recent decades, the scope of environmental education has transformed. Initially, it was narrowly focused on environmental protection and primarily conveyed by biology teachers and conservationists. Over time, however, the concept expanded to include human and social dimensions. The principle of sustainability has also taken on an increasingly prominent role within environmental education over the past few decades. Consequently, this field of educa-

*Table 1. Cronbach's alpha coefficients and average inter-item correlation for the factors of the WAS**

Factor	Items	Cronbach alpha	Mean correlation
Water and Environmentally Sustainable Development	1, 2, 10, 11, 12, 18, 22, 26	0.99	0.45
Water for Health, Sanitation and Recreation	3, 13, 14, 17, 19, 25, 27	0.99	0.34
Water, Social Equity, Human Dignity	4, 5, 6, 16, 23, 28, 29	0.98	0.44
Water in Culture, Tradition and Religious Practice	7, 8, 9, 15, 20, 21, 24	0.99	0.43

*N = 51. *Source*: Yeap, C.H. *et al.* (2007) p. 7.

tion is now often designated as "education for sustainability", rendering it pertinent not only for biology instructors but for all educators (Kónya, G. 2019). One of the fundamental tenets of environmental education is the instruction of students through an interdisciplinary approach, with an emphasis on the development of skills across a range of contexts. Teachers and educational professionals need to develop curricula and programs that emphasize integrated skill areas, including practical applications (e.g., interpersonal collaboration, problem-solving, and analysis) (Vincent, S. and Focht, W. 2009).

The current Hungarian National Core Curriculum (NCC), which has been in effect since 2020, plays a foundational role in the Hungarian education system. In analysing the NCC 2020, Varjas, J. (2021, 2022) demonstrated its alignment with the 17 Sustainable Development Goals (SDGs), two of which are directly water related. Goal 6, Clean Water and Sanitation, addresses the provision of water, drinking water, and associated global challenges, while Goal 14, Life Below Water, focuses on the protection of oceans, seas, freshwater organisms, and water pollution. In his 2021 analysis, Varjas, J. observed that environmental education goals in the NCC 2020 are now presented more as a list, contrasting with the previous versions' detailed approach. This format affords teachers greater autonomy but provides less detailed guidance.

The NCC 2020 no longer identifies sustainable development as a principal objective. The concept of sustainability is referenced in social science disciplines, including history, civic education, and ethics, and is addressed in all natural science subjects. However, only in biology and ethics is sustainability designated as an independent learning outcome group, while in geography, this is not the case. In the primary school version, approximately 16.9 percent of the overall text is related to sustainable development, increasing to 20.5 percent in secondary school. In primary schools, this represents a decrease to approximately half the word count seen in previous versions.

The HVWSHE curriculum

The study by Yeap, C.H. *et al.* (2007) relates to the HVWSHE curriculum, which aims to impart knowledge and values associated with water use to foster environmentally conscious behaviours among students. The curriculum, developed for use in Southeast Asian schools through the SEAMEO–UN-HABITAT project, encompasses not only water and hygiene education but also places significant emphasis on the essential human values necessary for sustainability, including honesty, peace, truth, love, and non-violence. The HVWSHE curriculum is structured around four main thematic strands, which address key topics in a way that enables students to gain insight into the multifaceted role of water in society and nature. This approach fosters the development of valuable attitudes toward sustainable water use.

a) Water and Environmentally Sustainable Development

In the first module, students examine the importance of water and its limited availability, as well as strategies for contributing to its long-term preservation, which is vital for sustaining life and human well-being. This theme incorporates social, environmental, and economic perspectives that facilitate students' comprehension of the value of water and the concept of environmental sustainability. The educational objective is to instill in students a commitment to conserving water for future generations through the implementation of methods such as water conservation and recycling.

b) Water for Health, Sanitation, and Recreation

This theme posits that water is a foundation for a healthy life, essential for human functioning and meeting fundamental hygiene needs. The curriculum encompasses instruction in water-related hygiene practices and the use of appropriate facilities, as well as an examination of the role of water in recreational activities. The concept encourages students to recognize the health significance of clean water and to engage actively in water-related activities, such as sports or recreation, thereby enhancing their quality of life.

c) Water, Human Dignity, and Social Equity

In this theme, the proposition is advanced that equal access to water and sanitation facilities is a fundamental human right. Students are introduced to the concepts of social justice and human dignity, alongside the necessity for social equality regardless of gender, ethnicity, economic status, or geographic location. The objective of this theme is to cultivate a sense of justice and fairness in students and to equip them with the ability to critically examine and advocate for the equitable distribution of water resources, such as through the implementation of water metering and cost calculation.

d) Water in Culture, Tradition, and Religious Practice

In the last module, students will gain an understanding of how water is integrated into the practices of diverse cultures, traditions, and religions, and the impact this has on people's lives. The curriculum offers students the chance to gain a deeper comprehension of their own and others' cultural, traditional, and religious practices, thereby fostering social cohesion. Furthermore, students gain insight into the significance of water-related festivals and ceremonies, such as water festivals, and learn to express water-related human values, including respect and cooperation, through creative activities.

Each of these themes includes a variety of indicators that can be used to assess students' knowledge, cognitive abilities, and values. The experiences and attitudes that are cultivated through these themes encourage students to commit to the sustainable use and conservation of water, while also fostering an appreciation for water's role in their health and community well-being. Researchers have validated the WAS questionnaire, which is used to measure students' attitudes toward water, using indicators that have been developed based on these themes.

Comparison with related scales

Measuring environmental and water attitudes is cardinal to understanding and promoting sustainable behaviours, especially in educational and policy contexts. Validated questionnaires such as CHEAKS, EAI, the New Water Culture instrument, and Yeap, C.H. *et al*.'s (2007) values-based water education tool provide structured means to assess knowledge, attitudes, and behaviours related to environmental and water issues. Their comparative analysis reveals both methodological strengths and persistent gaps, particularly in cross-cultural applicability and the linkage between attitudes and real-world behaviours. To situate the development of the Modified Water Attitude Scale in context, this section reviews several existing instruments for assessing environmental and water-related attitudes. The focus is on three prominent scales – the Children's Environmental Attitudes and Knowledge Scale (CHEAKS), the Environmental Attitudes Inventory (EAI), and a recent New Water Culture questionnaire – and how they compare with the WAS. A summary of key characteristics is provided in *Table 2.*

The Children's Environmental Attitudes and Knowledge Scale (CHEAKS), developed by Leeming, F.C. *et al.* (1995), is a widely used instrument for assessing children's environmental orientations. It consists of 66 items divided into a 36-item Attitudes subscale – covering verbal commitment, actual commitment, and affect – and a 30-item Knowledge subscale, addressing domains such as animals, energy, pollution, recycling, water, and general environmental issues. Responses are measured on a 5-point Likert-type scale, with higher scores indicating stronger pro-environmental attitudes and greater knowledge. Originally validated on U.S. children aged 6–13, CHEAKS has demonstrated acceptable reliability ($\alpha \approx .68–.85$) and validity, though cross-cultural applications (e.g. in Ireland, Brazil, Spain) reveal differences in factor structures and item relevance, necessitating cultural adaptation (Walsh-Daneshmandi, A. and MacLachlan, M. 2006; Moreno, I. *et al*. 2016; Galli, F. *et al*. 2018). While robust for evaluating environmental education interventions among children and adolescents, CHEAKS is a general ecological instrument

Table 2. Comparison of environmental and water attitude scales: focus, structure, and cultural adaptation

Questionnaire (Source)	Target population	Focus / Main constructs	Structure (Items and scales)	Theoretical foundation	Cultural adaptation	Key limitations
CHEAKS (Leeming, F.C. *et al*. 1995)	Children, adolescents (6–13)	General environmental *attitudes* (affective, behavioural, cognitive) and *knowledge* (ecological topics: animals, energy, pollution, recycling, water, general issues)	66 items: *Attitudes* (36 items, 3 subscales: verbal commitment, actual commitment, affect) + *Knowledge* (30 items). 5-point Likert (attitudes), correct/incorrect (knowledge).	Socio-ecological and educational frameworks	Moderate – constituent elements and factor structures vary across contexts (e.g. US, Ireland, Brazil, Spain)	Limited to younger students; cross-cultural reliability varies; not designed for adults
Environmental Attitudes Inventory (EAI) (Milfont, T.L. and Duckitt, J. 2010)	General population, university students	Broad environmental attitudes (e.g. enjoyment of nature, support for conservation, ecocentrism, human dominance, personal behaviour, confidence in science)	120 items (12 scales, 10 items each); shorter 72- and 24-item forms available. 7-point Likert with balanced items. Yields 12 scale scores + 2 higher-order dimensions: *Preservation* vs. *Utilization*.	Multidimensional, hierarchical, deliberative attitudinal models	High – validated in multiple languages (e.g. Portuguese, Spanish, Brazilian, European samples)	Less sensitive to short-term educational effects; some subscales less relevant in certain cultural contexts
"New Water Culture" (NWC) Questionnaire (Benarroch, A. *et al*. 2021)	General public, students, trainee teachers (Spain)	*Water-specific* attitudes: scarcity, sustainability, governance, personal actions	27 items (final version, 4-point Likert without neutral option). Organized into 4 sections: (1) scarcity/quantity/distribution, (2) water's multiple dimensions, (3) management/governance, (4) personal water-saving behaviour.	Integrated water education paradigm (KAPP: knowledge, attitudes, perceptions, practices); sustainability and participatory governance frameworks	Low – validated only in Spain, culturally grounded in Iberian water policy	Limited explicit integration of broader cultural/educational dimensions; not adapted beyond Iberian context
Water Attitude Scale (WAS) (Yeap, C.H. *et al*. 2007)	University students, employees (Malaysia)	*Water-specific* values and attitudes; links cultural orientation (e.g. collectivism, power distance) to water conservation behaviour	29 Likert-type items; items reflect cultural values, personal responsibility, and conservation behaviours	Cultural/behavioural theories (Hofstede's cultural dimensions, theory of planned behaviour)	Low – limited cross-cultural validation outside Malaysia	Heterogeneity in cultural attitudes; limited psychometric validation; not widely adapted internationally
Modified Water Attitude Scale (mWAS) (Adapted in present study)	Students (Hungary, secondary level)	*Water-specific* values, attitudes, and behaviours (e.g. conservation)	25 Likert-type items, adapted from Yeap, C.H. *et al*. (2007). Items probe values, responsibility, and awareness regarding water conservation.	Educational and values-based water conservation framework	Current study provides *first Hungarian validation*	Novel instrument in Hungarian; further testing needed to confirm cross-cultural stability

Source: Compiled by the authors.

rather than domain-specific and is less suitable for adult populations.

The Environmental Attitudes Inventory (EAI), developed by Milfont, T.L. and Duckitt, J. (2010), is a multidimensional measure designed to assess the complexity of adult environmental attitudes. The full version consists of 120 items (12 subscales with 10 items each), capturing diverse dimensions such as Enjoyment of Nature, Ecocentric Concern, Support for Conservation Policies, Personal Conservation Behaviour, Human Dominance, and Confidence in Science and Technology. Responses are rated on a 7-point agreement scale, with balanced (half reverse-scored) items to minimize acquiescence bias. Psychometric analyses consistently support a hierarchical structure in which the 12 subscales load onto two higher-order dimensions: Preservation (reflecting pro-environmental orientations) and Utilization (reflecting anthropocentric and exploitative orientations). Shortened versions (e.g. 72- and 24-item forms) have been developed for practical use while maintaining acceptable reliability and validity (Sutton, S.G. and Gyuris, E. 2015). Originally validated with university students in New Zealand, the EAI has since been adapted and applied across numerous cultural contexts (e.g. Brazil, Spain, Australia, North America, Europe), though certain subscales (e.g. environmental movement activism) show variable cross-cultural relevance (Ajdukovic, I. *et al*. 2019; Andrade, E. *et al*. 2021). Despite its broad applicability and strong psychometric robustness, the EAI is not tailored to specific domains such as water-related issues, is less sensitive to short-term educational interventions, and to date lacks a validated Hungarian adaptation – highlighting a gap this study's WAS seeks to address.

The "New Water Culture" (NWC) Questionnaire, developed by Benarroch, A. *et al*. (2021), was designed to assess knowledge, attitudes, perceptions, and practices (KAPP) consistent with the NWC paradigm, which conceptualizes water as an eco-social resource requiring sustainable, participatory, and demand-oriented management in contrast to traditional supply-driven approaches (Ramírez-Segado, A. *et al*. 2023). The instrument was initially composed of 20 Likert-type items (1–4 scale, with no neutral option) generating 51 variables and was subsequently refined through expert panel review – including contributions from the New Water Culture Foundation – into a validated 27-item scale. These items are organized into four thematic areas: (1) perceptions of scarcity, quantity, and distribution; (2) recognition of water's multiple dimensions (environmental, social, cultural, economic); (3) preferences for participatory and sustainable management strategies; and (4) personal water-saving actions. The final version demonstrated high internal consistency (Cronbach's $\alpha \approx .91$) and strong content validity (Aiken's $V \approx .84$). Developed and validated in Spain, the NWC questionnaire has been primarily applied to the general public, students, and pre-service teachers in formal education contexts (Ramírez-Segado, A. *et al*. 2023). Unlike broader ecological instruments such as CHEAKS and EAI, the NWC questionnaire is explicitly water-specific and education-oriented, though its cultural grounding in Iberian water policy discourse means adaptation is required for other contexts, including Hungary.

Conceptual distinctions and measurement of knowledge, beliefs, and attitudes

In the literature on environmental and water education, knowledge, beliefs, and attitudes are commonly conceptualized as distinct yet interrelated constructs. Knowledge is treated as factual or conceptual understanding of environmental and water-related issues and is typically assessed with objective instruments such as factual quizzes, structured tests, or knowledge subscales (Walsh-Daneshmandi, A. and MacLachlan, M. 2006; Rosa, C.D. *et al*. 2022; Mostacedo-Marasovic, S.-J. *et al*. 2023). Beliefs refer to convictions and symbolic or cultural meanings attached to environmental and water phenomena; these are examined with belief subscales, the New Eco-

logical Paradigm (NEP) and its child version, and – critically – qualitative or ethnographic approaches that surface culturally embedded meanings (Kopnina, H. 2011; Rosa, C.D. *et al*. 2022; Mostacedo-Marasovic, S.-J. *et al*. 2023; Berze, I.Z. *et al*. 2024). Attitudes capture affective evaluations and predispositions, often including behavioural intentions, and are measured with well-established scales such as CHEAKS, the EAI, and the Two-Major Environmental Values (2-MEV) instrument (Musser, L.M. and Malkus, A.J. 1994; Wilfong, M. *et al*. 2023; Vucetich, J.A. *et al*. 2024).

Validated tools like CHEAKS, EAI, and 2-MEV rely on factor-analytic procedures and, increasingly, Rasch modelling and Item Response Theory (IRT) to sharpen construct separation and improve item performance (Musser, L.M. and Malkus, A.J. 1994; Walsh-Daneshmandi, A. and MacLachlan, M. 2006; Milfont, T.L. and Duckitt, J. 2010; Mamat, M.N. and Mokhtar, F. 2012; Liefländer, A.K. and Bogner, F.X. 2018; Vucetich, J.A. *et al*. 2024; Ngan, S.F. and Li, C.S. 2025). Disciplinary emphases, however, differ: pedagogy and curriculum studies stress experiential and transdisciplinary integration (Palozzi, J.E. *et al*. 2025), educational psychology advances identity-based explanations (Freed, A. 2018; Pagano, L.P. *et al*. 2025), sociology situates orientations within social-demographic contexts (Newman, T.P. and Fernandes, R. 2016), and anthropology foregrounds symbolic beliefs, local knowledge, and inequities related to water (Jackson, S. 2011; Lahiri-Dutt, K. 2020; Wilfong, M. *et al*. 2023). Despite these advances, several challenges persist – most notably the conceptual ambiguity of "beliefs", the limitations of NEP with children, cross-cultural validity concerns for "Western"-developed scales, and the enduring gap between self-reported attitudes and behaviour (Moore, S. *et al*. 1994; Grob, A. 1995; Zhu, Z. *et al*. 2019; Yu, J.-H. *et al*. 2021; Hundemer, S. *et al*. 2022; Rosa, C.D. *et al*. 2022).

In water-specific contexts, water knowledge centres on objective understanding of cycles, conservation, and management and is increasingly anchored in standards and water-literacy frameworks (Yu, J.-H. *et al*. 2021; Mostacedo-Marasovic, S.-J. *et al*. 2023). Water beliefs encompass both factual beliefs and symbolic meanings – such as sacredness or identity value – often documented in indigenous or traditional settings and associated with preservation behaviours (Sindik, J. and Araya, Y.N. 2013; Freed, A. 2018; Lahiri-Dutt, K. 2020). Water attitudes cover evaluative tendencies and willingness to engage in water-saving practices, with recent child/adolescent instruments and composite water-literacy measures extending the toolkit (Aysu, B. *et al*. 2025). In addition, the Water Attitude Scale (WAS) has been specifically developed to capture students' perceptions and values in water education, further broadening the range of validated instruments available for water-related research (Yeap, C.H. *et al*. 2007). Demographic heterogeneity is common: gender, age, education, place, and broader contextual factors systematically shape knowledge, attitudes, acceptance, and behaviour (Braun, T. *et al*. 2018).

Identity-based pathways frequently outperform attitude-only models in explaining behaviour: structural models show environmental knowledge acting as a distal driver via attitudes and intentions, while values and emotions exert comparatively strong direct effects. Classroom-embedded, dialogical approaches and theory-based formative assessment broaden the lens beyond knowledge–attitude–behaviour by capturing relevance, responsibility, and identity exploration (Ligorio, M.B. 2010; Granit-Dgani, D. *et al*. 2017).

Materials and methods

Sampling

The primary area for questionnaire sampling was the South Transdanubia region in SW Hungary *(Figure 1)*. This region is characterized by a high number of small schools with few students, which have undergone continuous transformations: "Over the past

seven decades, education policy measures have left a profound impact on the school network, including institutional restructuring, closures, and occasionally the establishment of new schools" (Andl, H. 2023, 259). In many small settlements, these educational facilities have been shut down, necessitating that students commute to other locations. A total of seventy-two primary schools were contacted for this survey. Of these, twenty granted permissions to administer the questionnaire. The schools are situated in fifteen different towns within the region. The institutions encompass rural primary schools (notably small schools) in the villages of Látrány and Szőlősgyörök, as well as institutions in cities like Nagykanizsa and the regional centre, Pécs.

The statistical representativeness of the population is evident in the region, as demonstrated by the chi-square tests, which indicate a statistically significant relationship between the legal status of the settlements, the response rates, and the number of respondents relative to the total number of primary school students in each grade level *(Table 3).*

The total number of participating students was 964. Of these, 20 percent were in fifth grade (197 students), 25 percent in sixth grade (237 students), 26 percent in seventh grade (253 students), and 29 percent in eighth grade (277 students). The grade distribution by municipality demonstrates that certain grades are more homogeneous in certain municipalities, as only a limited number of schools agreed to administer the survey across all upper grades. Full grade-level data collection was only conducted in Látrány, Nagykanizsa, and Pécs *(Figure 2).*

Questionnaire adaptation

As previously noted in the introduction, the original WAS questionnaire included a multitude of terms and expressions that were either unfamiliar to the target age group or beyond the scope of their background knowl-

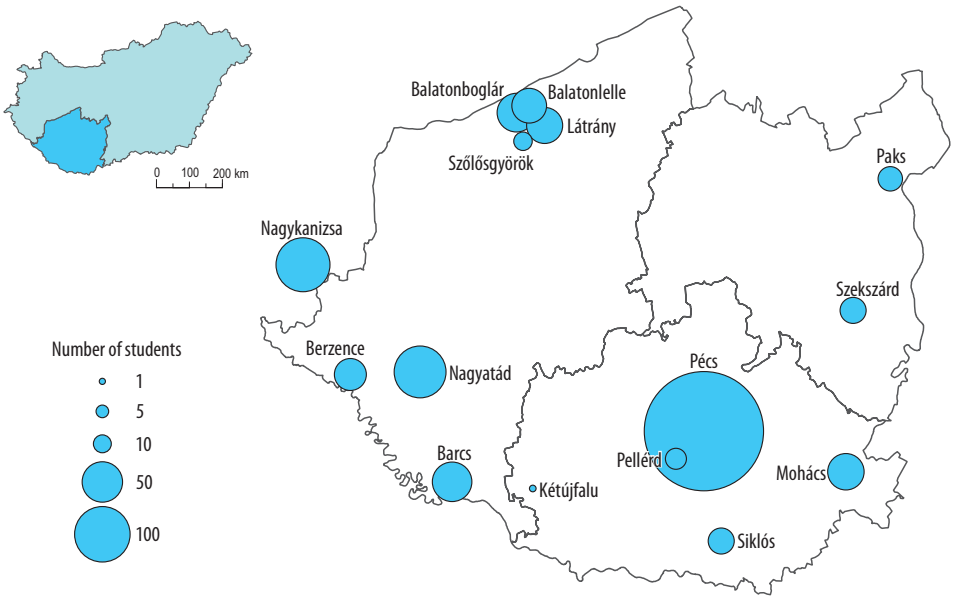

Fig. 1. Spatial dimensions of the population by settlements of school. *Source:* Authors' own elaboration.

*Table 3. Statistical representativeness of the participants based on Chi-square test of independence**

Attribute 1	Attribute 2		Df	χ^2 value
Legal status of settlement	All respondents		30	607.43
	Non-respondents		472	1,314.00
Legal status of settlement	Fifth grade	Respondents	122	424.86
		Non-respondents	14	138.66
	Sixth grade	Respondents	120	419.32
		Non-respondents	20	199.55
	Seventh grade	Respondents	116	406.48
		Non-respondents	18	140.96
	Eight grade	Respondents	120	420.04
		Non-respondents	14	133.88

*p-value <0.001, Fisher exact <0.001. *Source:* Authors' own elaboration.

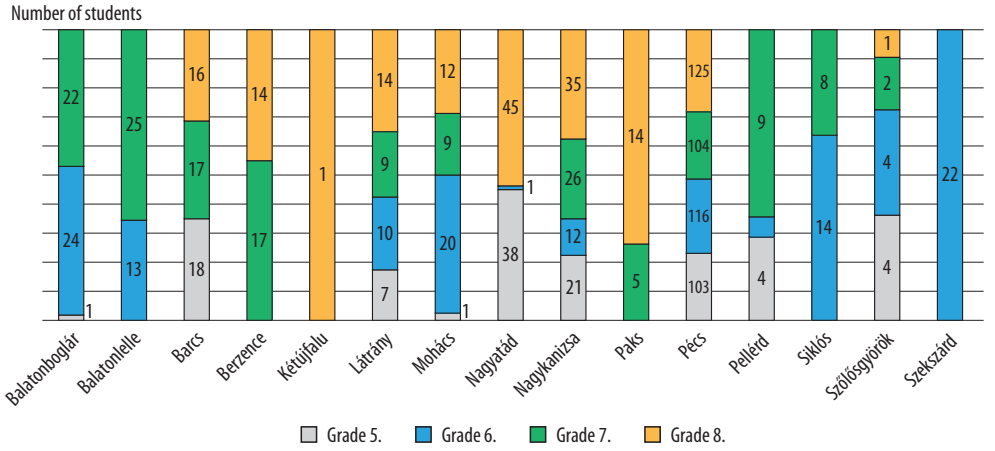

Fig. 2. Distribution of age groups in the population by settlement of school. *Source:* Authors' own elaboration.

edge for assessment purposes. Accordingly, the initial version of the WAS questionnaire was modified to provide clarification regarding certain terms. For example, regarding the phenomenon of water theft, we provided an illustrative example, stating, "e.g. someone uses a neighbour's water without paying for it". Concerning the objective of a water conservation campaign, we offered a clarification, stating, "The purpose of this would be to encourage people to save water". In the context of sanitary items, we offered a definition, stating, "sanitary = faucets, showers, bathtubs". For instance, the term "water meters" was clarified as "a water meter measures water consumption in a house/apartment". Additionally, the concept of the water cycle was elucidated as "without the water cycle, the ecosystem would be harmed". Furthermore, the term "erosion" was defined as "erosion = the degradation of land surfaces". Following these initial modifications, a large-scale survey was conducted.

However, additional issues emerged with certain statements, as most students encountered difficulty in understanding questions 2, 14, 21, and 28. Regarding question 2, a considerable number of students encountered difficulties in interpreting the term "drinking water at the garden faucet". Question 14 did

not resonate with the age group in question, as students frequently reacted with excessive humour. Questions 21 and 28 presented interpretation challenges, as students lacked sufficient background knowledge to grasp government responsibilities or the phenomenon of water theft, despite the added explanations. These concepts were largely unfamiliar, especially for this age group.

Data processing

Confirmatory factor analysis: Purpose and application in the research

The concept of reliability concerns the consistency of measurement outcomes. It encompasses test-retest reliability, internal consistency, and inter-rater reliability, which are essential for identifying random and systematic errors in measurements (Streiner, D.L. *et al.* 2015; Mohajan, H.K. 2017). Although reliability pertains to the precision of test scores in representing an attribute, it does not confirm the attribute measured or the test's effectiveness. This is the realm of validity (Slaney, K. 2017). Validity pertains to the accuracy of measurement tools in capturing the intended construct (Buckingham, B.R. *et al.* 1921). The link between factor analysis and construct validity has been recognized since Thompson, B. and Daniel, L.G. (1996). The mid-twentieth century saw a shift in focus towards the assessment of validity through the structural configuration of test variables, often employing factor analysis. This shift was observed by Goodwin, L.D. and Leech, N.L. (2003) and represented a departure from the previous emphasis on correlating test scores with external criteria.

Confirmatory factor analysis (CFA) is a statistical technique employed to confirm the factor structure hypothesized by researchers. It is widely employed to bolster construct validity in measurement tools (DiStefano, C. and Hess, B. 2005). Researchers utilize CFA to furnish evidence of validity for a measurement instrument, drawing on its factor structure and the item-to-factor relationship patterns (Rios, J. and Wells, C. 2014). Typically, researchers provide evidence in support of this in the subsequent formats. For data analysis, we used JASP[4] and RStudio[5] software.

Fit indices: Use and significance in CFA

This study utilizes CFA to validate a modified version of the WAS. The key model fit indices – including the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Residual (SRMR) – are employed to evaluate the congruence between the revised model and observed data. These indices facilitate a comprehensive understanding of the model's suitability and ensure that the scale's constructs are appropriately measured within the new demographic.

Both the CFI and the TLI are indices that range from 0 to 1. A CFI value above 0.90 is indicative of an acceptable fit, whereby the proposed model is evaluated in comparison to a null model. The TLI is analogous to the CFI, yet it also considers model complexity. Values exceeding 0.95 indicate an appropriate fit. Additionally, the RMSEA and SRMR are important. An RMSEA value below 0.06 suggests a good fit, although it should be noted that caution is advised in models with limited degrees of freedom, as this value may be misleading in such cases. SRMR is less sensitive to model complexity, with values under 0.08 considered acceptable (Shi, D. *et al.* 2019; Khademi, A. *et al.* 2023). This approach allows the study to assess model fit while addressing the challenges and nuances in cross-cultural adaptation of attitudinal measures, thereby contributing to more accurate and generalizable findings in educational and environmental research.

[4] JASP Team (2024). JASP (Version 0.18.3) [Software]. JASP Team (Revelle, W. 2018).

[5] RStudio Team (2023). RStudio: Integrated Development for R, Version 2023.06.1 (Software). Posit, PBC.

Exploratory factor analysis

Empirical methods such as exploratory factor analysis (EFA) reveal patterns within the correlations of items in a measurement tool and their unknown domains (factors) (Tavakol, M. and Wetzel, A. 2020). EFA clarifies the relationship patterns among assorted items and constructs (Knekta, E. *et al.* 2019). Furthermore, it identifies items that do not align with the anticipated construct, suggesting their exclusion from the assessment (Knekta, E. *et al.* 2019). The EFA provides evidence to support the validity of a construct, which in turn informs decisions regarding its factor structure. In particular, the factor solution derived from the EFA demonstrates the relationships between the constructs of interest and indicators such as behaviours and attitudes. This offers a basis for validating the construct's measurement and for supporting theoretical frameworks (Brown, T.A. 2015), As a result, the empirical and theoretical understanding of the measure is enhanced (Knekta, E. *et al.* 2019).

In EFA, we used Promax rotation to facilitate the identification of underlying factor structures within the scale. Promax rotation, a type of oblique rotation, allows factors to be correlated, which is often more representative of real-world data where constructs may not be fully independent. This approach allowed us to achieve a clearer and more interpretable factor solution by maximizing the variance of the factor loadings and providing insight into the relationships between the identified factors (Finch, H. 2006).

Results

Modification of the questionnaire

To assess the reliability of the research data, a confirmatory factor analysis was conducted to ascertain the validity of the original factor structure proposed by Yeap, C.H. *et al.* (2007) within the context of the current sample. The structure developed by Yeap, C.H. *et al.* (2007) exhibited at least one negative eigenvalue in the covariance matrix, indicating deficiencies in the model specification. The data structure became interpretable when the condition for the program to search for correlations between factors was removed. However, even with this adjustment, the resulting model lacked statistical reliability, even at the component level *(Table 4).*

Utilizing our dataset with a larger sample size, we developed a novel model based on the original WAS questionnaire (*Appendix A*). After exploratory factor analysis, we removed questions 2, 14, 21, and 28 due to their low factor loadings and issues observed during completion (see subchapter "*Questionnaire adaptation*"). This resulted in a more coherent model *(Table 5*, *Appendix B).* The original number of factors was retained, but their content composition changed *(Table 6).*

The content of the four new factors has been modified, necessitating adjustments to their grouped labels. The correlations between the factors are displayed in *Figure 3*.

The first factor, designated as Fc1, is entitled "The Value of Water and Responsibility".

Table 4. Reliability analysis of the original WAS factor structure

Reliability model	Factor 1	Factor 2	Factor 3	Factor 4
McDonald's Omega (ω)	0.569	0.708	0.445	0.240
Cronbach's Alpha (α)	0.522	0.669	0.412	0.234

Source: Authors' own elaboration.

Table 5. Reliability analysis of the modified WAS

Reliability model	Factor 1	Factor 2	Factor 3	Factor 4
McDonald's Omega (ω)	0.880	0.790	0.664	0.670
Cronbach's Alpha (α)	0.876	0.786	0.646	0.658

Source: Authors' own elaboration.

Table 6. Model fit and test summary of the modified WAS

Test	Results
Chi-Square Test	Baseline Model: $\chi^2 = 7769.331$; Df = 300; $p < 0.001$ Factor Model: $\chi^2 = 868.393$; Df = 269; $p < 0.001$
Bartlett's Test	$\chi^2 = 7687.393$; Df = 300; $p < 0.001$
Fit indices	CFI = 0.920 TLI = 0.911 RMSEA = 0.048 SRMR = 0.044

Source: Authors' own elaboration.

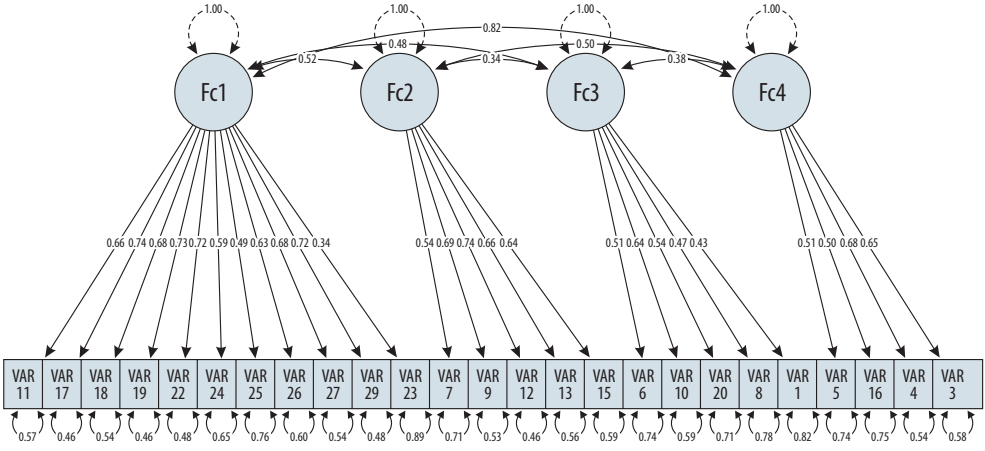

Fig. 3. Structure of the modified WAS. *Source:* Authors' own elaboration.

This factor emphasizes students' acknowledgment and assumption of accountability for the significance and preservation of water. It includes items addressing themes such as the responsibility associated with water conservation, the appreciation of water's aesthetic qualities, the stabilizing effects of the water cycle, and the significance of water for human health.

The second factor (Fc2), "Awareness and Education", is centred on educational initiatives and awareness-building, encouraging students to disseminate information regarding the importance of water conservation to others. The items included in this factor are organized around three primary areas: personal development regarding water-related issues, intention to participate in water-saving campaigns, and sharing of knowledge about water conservation.

The third factor (Fc3), "Water Usage at Home and in Society", encompasses questions related to personal and societal water-use habits and attitudes. This encompasses the willingness to conserve water, the individual's responsibility in its usage, and the social equity of access to and the maintenance of hygiene through its use.

The fourth factor (Fc4), "Responsibility and Intervention", addresses individual responsibility, intervention intentions, and ethical concerns. It examines students' attitudes toward avoiding water pollution, reporting leaks and water theft, and the ethical perception of water meter tampering. The number of items within each factor is provided in *Table 7.*

Table 7. Items of the modified WAS factors

No.	Factor	Items of scale
1	The Value of Water and Responsibility	11, 17, 18, 19, 22, 23,24, 25, 26, 27, 29
2	Awareness and Education	7, 9, 12, 13, 15
3	Water Usage at Home and in Society	1, 6, 8, 10, 20
4	Responsibility and Intervention	3, 4, 5, 16

Note: In the modified version of the WAS, the following items were categorized: *Knowledge* – 7, 18, 19, 26; *Beliefs* – 6, 8, 10, 20, 22, 23, 24, 29; *Attitudes* – 1, 3, 4, 5, 9, 11, 12, 13, 15, 16, 17, 25, 27. This classification reflects the different pedagogical implications of the items: knowledge relates to factual understanding, beliefs reflect normative or value-based assumptions, while attitudes capture emotional and behavioural orientations toward water. *Source*: Authors' own elaboration.

Development of Water Attitudes by grade

In the following phase of the research, an investigation was conducted to ascertain whether the grouped factors of the questionnaire, calculated for each student, demonstrated any correlations when analysed by grade. Based on the Welch-ANOVA test (*Table 8* and *9*), the second and third factors exhibited significant correlations, while the fourth factor, though above the significance threshold, was close to it.

With regard to the "Awareness and Education" (Fc2), the observed decline in the mean value indicates a potential reduction in students' awareness and commitment to education as they progress through the grade levels. The fluctuation in standard deviation indicates changes in the differences of opinion among students, though no significant discrepancies are evident. The minimum value remains constant, except for a slight increase observed in one grade level. The maximum value remains constant, indicating that the highest level of commitment remains unaltered.

The slight increase in the mean value for "Water Usage at Home and in Society" (Fc3) indicates a positive trend, suggesting that students' water-use habits and attitudes tend to improve with grade level. The observed fluctuation in standard deviation indicates an in-

Table 8. Welch's ANOVA Test – Correlations between grade levels and water attitudes

Attitude	Df	Sum Sq	Mean Sq	F value	p-value
The Value of Water and Responsibility	3	68.0	22.5300	1.3681	0.250
Awareness and Education	3	208.7	69.5570	16.1970	0.000
Water Usage at Home and in Society	3	21.0	7.0026	4.1846	0.000
Responsibility and Intervention	3	13.5	4.5090	2.5086	0.051

Source: Authors' own elaboration.

Table 9. Descriptive statistics for factors 2–4

Factors	Factor 2				Factor 3				Factor 4			
Grade	5	6	7	8	5	6	7	8	5	6	7	8
Number of students	197	237	253	277	197	237	253	277	197	237	253	277
Mode	9.81	9.81	9.81	9.81	2.59	2.59	2.59	2.59	9.36	9.36	9.36	8.35
Mean	9.13	8.23	8.29	7.79	4.02	4.30	4.16	4.42	7.55	7.75	7.44	7.48
SD	1.97	2.13	2.00	2.15	1.22	1.34	1.24	1.35	1.35	1.08	1.52	1.36
Min	3.27	3.27	3.81	3.27	2.59	2.59	2.59	2.59	2.34	3.67	2.34	2.34
Max	13.08	13.08	13.08	13.08	8.41	10.36	8.16	10.36	9.36	9.36	9.36	9.36

Source:Authors' own elaboration.

crease in the diversity of opinions among students. The minimum value remains constant, indicating that the lowest level of commitment remains unaltered. The fluctuations in the maximum value indicate that the highest level of commitment varies between grade levels.

Finally, regarding "Responsibility and Intervention" (Fc4), the fluctuations in the mean indicate that students' sense of responsibility and intention to intervene vary across grade levels, without a clear trend. The changes in standard deviation suggest that differences in opinions do not follow a distinct pattern. Variations in the minimum value show that the lowest level of commitment differs across grades. The maximum value remains constant, indicating that the highest level of commitment is stable.

In general, it can be stated that the values of the factors in question undergo a change as students' progress through the various grade levels. Regarding the factor "Awareness and Education" (Fc2), fifth-grade students demonstrate the greatest commitment, although this commitment then declines gradually in subsequent grades. The data indicate that responses from fifth graders exhibit less variability, whereas variability in responses increases in later grades. As indicated by the "Water Usage at Home and in Society" (Fc3) factor, students demonstrate enhanced awareness and commitment across grade levels, particularly in eighth grade. The distribution data demonstrates a notable positive skewness and a pronounced peak, indicating that a subset of students attain higher scores than the remainder. Regarding the "Responsibility and Intervention" (Fc4) factor, fifth and sixth graders evince a heightened sense of responsibility and intention to intervene. However, this declines slightly in seventh and eighth grades. The distribution data indicate a reduction in dispersion, with a few notably high values.

These changes reflect developmental processes associated with age, which influence students' water-related attitudes and commitment within and across grade levels. Significant differences are evident in students' water-related attitudes and commitment when comparing academic levels. Fifth graders typically demonstrate a less developed awareness of water conservation and management practices. At this age, the primary objective of education should be the establishment of awareness and the imparting of fundamental knowledge. By the eighth grade, students typically demonstrate a heightened level of awareness and a more nuanced understanding of the personal and societal implications of water use. Consequently, their sensitivity to water management issues increases, enabling them to view water consumption habits and their societal impact with greater criticality.

The capacity for assuming responsibility and engaging in intervention also undergoes a transformation as students progress through the academic grades. Fifth and sixth graders typically demonstrate a heightened sense of responsibility and more active involvement in environmental matters. However, this attitude may exhibit a slight decline among seventh and eighth graders, potentially influenced by social norms, age-specific traits (such as adolescence) and evolving interests.

Beyond these developmental patterns, we also examined whether settlement type was associated with differences across the four extracted factors. Four one-way analyses of variance (ANOVAs) were conducted, with the assumption of homogeneity of variances met in each case, as indicated by non-significant Levene's tests (all $p > .31$). The omnibus ANOVAs revealed no statistically significant differences between settlement types on any of the factors (Factor1: $F(2, 961) = 0.350$, $p = .705$; Factor2: $F(2, 961) = 1.986$, $p = .138$; Factor3: $F(2, 961) = 0.654$, $p = .520$; Factor4: $F(2, 961) = 0.680$, $p = .507$). Robust Welch tests yielded the same pattern of non-significant results. Effect sizes were consistently trivial ($\eta^2 < .01$), suggesting that settlement type did not account for meaningful variation in students' responses on the four factors. These findings indicate that while developmental differences across age groups are apparent, the influence of settlement context is negligible in shaping students' water-related attitudes.

In sum, the analyses indicate that age-related patterns exert a more consistent influence on students' water-related attitudes than settlement context, a finding that sets the stage for the subsequent discussion of educational implications.

Discussion and conclusions

The study findings provide insight into how Hungarian students' attitudes toward water and environmental sensitivity evolve with grade level, shedding light on age-related shifts in both awareness and engagement. In terms of "Awareness and Education" (Fc2), fifth-grade students displayed the highest awareness and commitment to water-related issues, but this commitment appeared to decrease slightly in higher grades. This trend suggests a potential need for sustained or enhanced engagement strategies as students' progress to maintain and deepen their understanding of water conservation. The variability in responses also increased, indicating a growing diversity of perspectives with age. For "Water Usage at Home and in Society" (Fc3), there was a gradual increase in positive attitudes and practices, particularly noticeable by eighth grade. This trend suggests an overall improvement in students' water-conscious behaviour over time. The distribution of responses, showing a skew towards higher scores, points to a subset of students who display notably elevated levels of commitment. With the "Responsibility and Intervention" (Fc4) factor, fifth and sixth graders showed a stronger sense of responsibility and intervention in water issues. However, this commitment slightly decreased in seventh and eighth grades, possibly due to adolescent developmental factors, shifting interests, and peer influence. This observation highlights the importance of reinforcing responsibility as students grow older, countering potential declines in environmental engagement during adolescence.

The observed decline in awareness from grade 5 onwards resonates with international findings that environmental sensitivity often diminishes during early adolescence, when cognitive demands increase and peer influences strengthen (Liefländer, A.K. and Bogner, F.X. 2018; Otto, S. *et al*. 2019; Grønhøj, A. and Hubert, M. 2022). This highlights the importance of sustained educational reinforcement: early gains in awareness need to be consolidated through age-appropriate activities that connect abstract knowledge with practical action. At the same time, the increase in positive attitudes toward daily water use by grade 8 suggests that older students can translate abstract principles into personal habits, provided that curricula emphasize experiential and participatory approaches. The temporary peak in responsibility observed in grade 6, followed by a slight decline, points to a window of opportunity for interventions that foster civic responsibility and ethical reflection before adolescence reshapes motivational orientations.

Yeap, C.H. *et al.* (2007) identified a positive shift in perceptions among lower secondary students following the integration of the HVWSHE curriculum. In comparison, the present study reveals notable variations in attitudes among Hungarian students as they progress through their educational trajectories. This observation lends support to the conclusion of Yeap, C.H. *et al.* (2007) that targeted educational strategies can effectively foster improved water-related perceptions among specific age groups. Moreover, the findings of Yeap, C.H. *et al.* (2007) emphasize the importance of continuous educational initiatives to maintain students' engagement and awareness about water-related issues. The present study corroborates this notion, as it reveals a decline in students' sense of responsibility and willingness to intervene in environmental matters during the seventh and eighth grades. This trend underscores the necessity for sustained educational programs that aim to reinforce positive attitudes toward water conservation as students mature. However, it is crucial to underscore that the findings of Varjas, J. (2021, 2022) point to a decline in the level of expectations regarding environmental education within

the National Core Curriculum 2020. This decline presents a challenge in the context of Hungary, potentially impeding the efficacy of environmental education initiatives aimed at fostering positive attitudes and awareness about water among students.

The value of the revised and validated questionnaire lies primarily in its potential to advance research on environmental and water-related attitudes in Hungary and other European contexts. As a robust instrument, it enables systematic assessment of students' attitudes toward water and environmental issues, offering reliable data for academic inquiry. The scale also supports longitudinal investigations, allowing researchers to track developmental changes across age cohorts and to evaluate the long-term impact of specific educational interventions. Furthermore, its adaptability to diverse European contexts ensures that it can be modified to reflect regional environmental challenges and cultural specificities, thereby contributing to comparative studies and cross-national educational research.

Beyond its research value, the revised Water Attitude Scale provides direct pedagogical benefits. It can function as a formative tool, offering feedback that supports curriculum development and instructional design aimed at strengthening environmental education. Teachers may use the instrument to better understand students' perceptions, to identify opportunities for integrating water-related issues into everyday teaching, and to foster critical awareness of sustainability. In teacher training, the questionnaire can help future educators develop strategies for meaningful student engagement, while in practice it may encourage reflective pedagogy and evidence-based decision-making. By enabling comparative insights across different school contexts, the scale not only informs classroom practice but also contributes to broader educational policy discussions.

One important omission concerns the dimension of indirect water use, which refers to the hidden water footprint of energy production, food consumption, and material goods. This construct was not included in the original WAS developed by Yeap, C.H. *et al*. (2007), and therefore it was not part of the Hungarian adaptation either. While pedagogically relevant, its assessment poses challenges with students aged 10–14, as the concept requires abstract reasoning about production and consumption chains that exceed their everyday experience. Nevertheless, introducing indirect water use through project-based or experiential learning may represent an important future direction in environmental education, and future questionnaire adaptations might incorporate simplified items targeting this dimension.

Some items, such as reporting leaks, tampering with meters, or questions of social equity, may appear to exceed the immediate experience of 10–14-year-old students. We acknowledge this potential limitation. At the same time, our findings suggest that students were able to provide consistent responses, indicating that they can engage with such issues at an attitudinal level even if not all of them encounter these situations in practice. As with many attitude measures, responses may be influenced by socially desirable norms, which is itself relevant in understanding how civic and environmental expectations are internalized during adolescence.

In order to further contextualize the Hungarian findings, it is useful to draw on related research from Central and Eastern Europe. Although these studies typically relied on different instruments rather than the Water Attitude Scale, they nonetheless reveal comparable regional dynamics. In Serbia, for instance, validation work identified a three-factor structure that emphasized the rejection of anthropocentrism and the salience of ecological crisis perceptions (Vdović, M. *et al*. 2024). A Czech study likewise confirmed that pro-environmental orientations among young people were present, but their internal consistency varied depending on the applied measurement tool, underscoring the challenges of transferring scales across contexts (Laníková, S. and Zíka, V. 2025). In Greece, the internal consistency of the NEP scale proved unsatisfactory, raising ques-

tions about its applicability in this cultural setting (Matsiori, S.K. 2020). Polish findings, by contrast, suggested a two-factor solution reflecting an ambivalence between economic development priorities and environmental responsibility (Dyr, W. and Prusik, M. 2020). Taken together, these results highlight that environmental attitudes in the region are strongly conditioned by socio-cultural and economic contexts, which not only reinforces the relevance of the Hungarian findings but also underscores the necessity of context-sensitive approaches in cross-cultural attitude research. Consequently, given that Hungarian public education traditionally places strong emphasis on lexical knowledge (i.e. the transmission of factual content), it is likely that students are relatively well equipped to understand even those items that may initially appear remote from their everyday experience—such as questions about water meters.

It should be noted that the findings of this research are subject to certain limitations that may affect their generalizability. Primarily, the study was conducted exclusively in the Southern Transdanubia region of Hungary, which may limit the applicability of the results to other geographic areas with differing environmental education contexts. In addition, the lack of responses from certain grades in some schools may introduce some bias and limit the robustness of the data. Another limitation is that socioeconomic variables (e.g. parental education, household resources) and finer-grained urban–rural distinctions were not available. These factors could have provided additional explanatory power and should be incorporated in future research.

Further research could be conducted in the form of longitudinal studies, tracking students' attitudes and awareness regarding water conservation throughout their educational trajectories. Such investigations would provide deeper insights into the evolution of these attitudes over time and the effectiveness of educational interventions. Additionally, expanding the study to encompass multiple regions across Hungary would enhance the generalizability of the findings and allow for comparative analyses of environmental attitudes in diverse educational settings. This approach could yield valuable data on regional differences in environmental awareness and inform the development of targeted educational strategies to address specific community needs.

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Appendix A

The modified WAS scale. (Questions to be deleted by CFA are marked in red)

Grade: _____ **Gender**: _____(boy/girl)

Circle where you live!

a.) Municipality
b.) Village
c.) City

Circle what type of living environment you live in!

a.) Single-family house
b.) Apartment building (panel)
Other:

Decide whether you agree or disagree with the following statements! Mark the box with an X!

Strongly Disagree	Disagree	Agree	Strongly Agree

	Statement	Strongly Disagree	Disagree	Agree	Strongly Agree
1	It is alright to keep tap water running when brushing teeth.				
2	Using high quality water or safe water for gardening is wasteful.				
3	It is important not to dirty drains, rivers, lakes, sea, or catchment area.				
4	I should report cases of water pipe leakage, water pump or any sanitation facility defects to my teachers or parents.				
5	I would report water theft if I saw it. (e.g., someone uses a neighbor's water without paying for it)				
6	Only people who cannot afford to pay water bill should try to save water.				
7	I read books or follow news about water issues.				
8	It is not necessary to discuss the values of water in school.				
9	I like to share my knowledge about how to save water.				
10	Water is cheap, we do not have to try hard to save it.				
11	I have the responsibility to save water even there is enough for use.				
12	I would like to participate in a water-saving campaign. (The purpose of this would be to encourage people to save water)				
13	I would like to work together with others to clean wells, sinks or other sanitation facilities. (sanitary − faucets, showers, bathtubs etc.)				
14	Maintaining the cleanliness of the toilet is too difficult. I can leave it to my parents or family to do that.				
15	I would persuade others to save water even though I must try very hard.				
16	Tempering with water meter is wrong. (a water meter measures water consumption in a house/apartment)				
17	I appreciate the beauty of lakes, rivers and sea.				
18	The water cycle stabilizes our environment. (without the water cycle, the ecosystem would be harmed)				
19	Water is important to health.				
20	Since there is no shortage of water in my school or home, I do not have to take much care about saving water.				
21	Supplying water to homes is the responsibility of the government only.				
22	Even there is enough water now, we should save water for future use.				
23	Rich and poor people should be charged the same water tariff.				
24	It is important for girls to have proper water supply and sanitation facilities as for boys.				
25	I often make facilities clean for the next users.				
26	Cutting down too many trees causes more erosion. (erosion = the degradation of land surfaces)				
27	I like to walk along streams, rivers or beaches.				
28	It is better not to report cases of water theft. One theft case does not cost much to the authority concerned.				
29	It is as important for the poor to have proper water supply and sanitation facilities as for the rich.				

Thank you very much for filling this out! If you have any additional comments, you can share them with us below:

Appendix B

The modified WAS scale (Final version)

1	It is all right to keep tap water running when brushing teeth.	14	Tampering with a water meter, or manipulating it, is wrong (a water meter measures household water use).
2	It is important not to dirty drains, rivers, lakes, sea, or catchment area.	15	I appreciate the beauty of lakes, rivers, and the sea.
3	If I see leakage in water pipes or at the toilet, I should tell my parents or teachers.	16	The water cycle stabilizes our environment (without the water cycle, ecosystems would be harmed).
4	I would report water theft if I see it (e.g. someone uses a neighbour's water without paying).	17	Water is important to health.
5	Only people who cannot afford to pay water bill should try to save water.	18	Since there is no water shortage in my school or home, I do not have to care much about saving water.
6	I read books or follow news about water issues.	19	Even if there is enough water now, we should still save water for future use.
7	It is not necessary to discuss the values of water in school.	20	Rich and poor people should be charged the same water tariff.
8	I like to share my knowledge about how to save water.	21	It is important for girls to have proper water supply and sanitation facilities just like boys.
9	Water is cheap, we do not have to try hard to save it.	22	I usually clean the sanitary facilities after use for the next user (sanitary facilities: taps, bathtubs, showerheads, etc.).
10	I have the responsibility to save water even when there is enough for use.	23	Cutting down too many trees causes more erosion (erosion: the degradation of soil/land).
11	I would like to participate in a water-saving campaign (whose goal is to encourage people to save water).	24	I like to walk along streams and rivers, and along lake shores.
12	I would like to work together with others to clean drinking fountains, sinks, or other sanitary fixtures (e.g. taps, showerheads, soap dispensers, etc.).	25	It is just as important for the poor to have proper water supply and sanitation facilities as for the rich.
13	I would persuade others to save water even though I have to try very hard.		

Note: The original Hungarian version of the validated questionnaire (mWAS) is available in *University of Pécs Institutional Repository* under http://doi.org/10.15170/modifiedwasscale-2025

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Human-forest relationship in the Budapest agglomeration: an urban-rural divide among forest visitors

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Abstract

This paper conducted 1000n survey comprising 27 questions at five urban and semi-natural sample sites to analyse the human-forest relationship in Budapest and its suburban areas. The study examines the relationship between the respondent residence types – the urban-rural divide – forest use, human-nature connectedness (HNC), environment-related well-being, and activities categorized under pro-environmental behaviour (PEB). The present study employed statistical analysis with the R statistical program. The results revealed significant differences between respondents living in Budapest, suburban areas, and rural areas. Budapest residents and suburban dwellers spend less time visiting forests but hold more positive views of Hungary's environmental status. People living in Budapest also had a significantly lower nature dependency score determined by living conditions (-) and education (+). Moreover, pro-environmental habits were slightly higher among city dwellers but lower among suburban newcomers. Education levels also proved to be a more significant variable in determining whether respondents supported green policies. A further finding indicates surveys conducted in natural settings may also influence and fortify respondents' forest valuation, HNC, and PEB.

Keywords: forest, Budapest, suburbanization, pro-environmental behaviour, human-nature connectedness

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Introduction

Natural environments serve various social functions in cities and provide fundamental ecosystem services to urban populations. Related research has increasingly addressed environmental attitudes and climate change adaptation involving nature-based solutions or green infrastructure in cities (Szkordilisz, F. *et al.* 2018; Čorejová, T. *et al.* 2021; Kolcsár, R.A. *et al.* 2022; Cerovečki, M.T. and Stiperski, Z. 2024; Pröbstl-Haider, U. *et al.* 2024). Forests within and in the vicinity of urban agglomerations have faced a larger environmental load since the COVID-19 pandemic (Weinbrenner, H. *et al.* 2021; Ciesielski, M. *et al.* 2023; Pichlerová, M. *et al.* 2023). Although some research on the environment-related urban-rural divide has

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been conducted (Arcury, T.A. and Christianson, E.H. 1993; Berenguer, J. *et al.* 2005; Yu, X. 2014; Dąbrowski, L.S. *et al.* 2022), few studies have focused on how various geographical factors, such as distance from forests and residence types, influence forest use. Furthermore, knowledge in this field is still incomplete, particularly concerning how forest use influences environment-related well-being and activities (Bowler, D. *et al.* 2010; Oh, B. *et al.* 2017). The role of forests in human-nature connectedness (HNC) and pro-environmental behaviour (PEB) is underrepresented in the literature (Häyrinen, L. and Pynnönen, S. 2020). Filling this gap is vital and contributes to the research questions in the present study on forest use in Budapest and its suburban zone. The research questions are: (1) How does residence type influence forest use habits and environmental consciousness? (2) How do residence type and forest use behaviour influence environment-related well-being and activities? (3) What is the role of forests in HNC and PEB?

Budapest and its suburban zone are vital, continuously monitored areas where the post-socialist (sub)urban transformation has been intensely analysed since the country's political transition (Barta, Gy. 1999; Kok, H. and Kovács, Z. 1999; Kovács, Z. and Tosics, I. 2014; Kocsis, J.B. 2015; Kovács, Z. *et al.* 2019; Egedy, T. *et al.* 2024). Many environmental aspects have been raised, including environmental conflicts, ecological footprint comparisons, and others (Illyés, Z. *et al.* 2016; Kovács, Z. *et al.* 2020, 2022); however, research has not addressed urban or peri-urban forest use.

Theoretical background

Environmental studies have developed various concepts to grasp the essence of the human relationship with nature and human behaviour related to the environment. Concepts like human-nature-connectedness (HNC, sometimes as "connectedness to nature") and pro-environmental behaviour (PEB) form the theoretical signposts of our study. In a psychological sense, HNC could be understood as how close humans feel towards nature and how we include our relationship to nature in our identities. Relatedly, the way humans think about nature's values and utilities also modifies the human-nature relationship (Lengieza, M.L. and Aviste, R. 2025). Under pro-environmental behaviour, we include many actions that mitigate environmental impact via consumption, mobility, energy use, green activism, or foster adaptation to environmental challenges (Lange, F. and Dewitte, S. 2019). A central issue behind these concepts is whether and how the natural environment affects our daily lives, routines, activities, and thinking, as well as our direct behaviour towards nature. Consensus in environmental psychology literature indicates that our relationship with nature impacts our environmental behaviour (Lengieza, M.L. and Aviste, R. 2025), and stronger connectedness aligns with greater engagement in PEB (Whitburn, J. *et al.* 2019). There is also evidence that socio-economic and geographical factors (place of residence) impact HNC and PEB (Macias-Zambrano, L. *et al.* 2024); however, whether and how environmental education reinforces our ties to nature and motivates PEB remains under debate (Fletcher, R. 2017).

Another theoretical concept of the present study is the human–forest relationship (HFR), which is a particular formulation of HNC since forests play a determining role in our relationship with nature. Interestingly, only a few studies address forests in this sense (Häyrinen, L. and Pynnönen, S. 2020). HFR "depicts a reciprocal relationship between humans and forests that is formed through personal experiences, life histories, as well as cultural and societal backgrounds and environmental settings" (Halla, T. *et al.* 2023). A strong HFR entails understanding the vital roles of forests that extend beyond technical and economic tools for effective sustainable forestry and address the cultural and spiritual values of forests (Ritter, E. and Dauksta, D. 2013; Hafenscher, P. and Jankó, F. 2022).

Forest functions and types must also be considered to ensure a better understanding of HFR and form our perceptions about nature. Notable differences in human utilization, attitudes, and ecosystem services exist between urban forests, semi-natural forests, and forest reserves. Urban forests are part of the urban ecosystem and are ecologically, economically, and socially essential to sustainable urban development. Consequently, their main roles are anthropocentric and include climate change acclimatization, water purification, flood control, carbon storage, and recreation services (Solomu, A.D. *et al.* 2018). Semi-natural forests, which include secondary forests, also possess these capabilities; however, biodiversity preservation or economic interests play a far more prominent role in semi-natural forests (Biró, M. *et al*. 2022). Tourists are usually banned from entering forest reserves to protect the self-regulating, natural ecosystems that are vital for gene preservation. Nevertheless, perceptions of natural forests might depend on residence locations and other factors (Lutz, A.R. *et al*. 1999).

Perceptions about forests and nature depend on numerous factors, such as residence, media consumption habits, education, quality of life, cultural heritage, and individual experiences about being in nature and climate change impacts (Halla, T. *et al*. 2023; Lengieza, M.L. and Aviste, R. 2025). A European project revealed differences in local views of forests and their impact on the quality of life between macroregional rural regions. People who live in declining but forested areas, especially in Atlantic countries, view forests as a disadvantage. In contrast, Central European and Mediterranean countries with traditional forest areas hold positive views about forests (Elands, B.H.M. *et al*. 2004). Similarly, residents in timber-dependent rural regions are more informed, concerned about forest outputs, and regard forests from a practical perspective (Goula, M. *et al*. 2015). Conversely, people in urban and non-timber-dependent rural areas are more concerned about maintaining recreational opportunities for personal use (Racevskis, L.A. and Lupi, F. 2006). Living conditions and education are also key factors in HFR (similarly in HNC and PEB). Higher socio-economic status enhances the willingness to pay for forest protection or sustainable forestry. However, in urban areas, opportunity also plays a role in the frequency and duration of forest visits (Kc, A. *et al*. 2014; Zhang, M. 2022). On the other hand, demographic and employment factors might be insignificant for HNC (Cartwright, K. and Mitten, D. 2017). Finally, exceptional events, such as bushfires, energy crises, or epidemics, also affect perceptions of forests. For instance, people visited forests more frequently but for shorter durations during the COVID-19 lockdown (Wunderlich, A.C. *et al*. 2023).

Although the literature has investigated social differences in environmental concerns, awareness, and PEB, it presents no unified method. Thus, findings are often controversial and difficult to compare (Lange, F. and Dewitte, S. 2019). For instance, Gifford, R. and Nilsson, A. (2014) found that PEB or environmental concern is usually greater among urban residents, whereas anthropocentric ecological views and sustainable practices are more common among rural people. Using a Polish sample, Dąbrowski, L.S. *et al.* (2022) also claimed that settlement type significantly influences the PEB of Generation Z. National cultural conditions are also decisive. Countries themselves may have a more pronounced effect than regions within a country. A survey in Chinese and Japanese cities found that Japanese people were satisfied with the state of the environment, while Chinese residents focused more on local problems (Yingchao, L. *et al*. 2011; see also Yu, X. 2014).

Recent research also highlights distinct factors. Some studies demonstrated that the education factor and urban-rural differences are better indicators of climate change attitudes and skepticism (Jankó, F. *et al.* 2018; Weckroth, M. and Ala-Mantila, S. 2022). However, based on a national survey in England, Alcock, I. *et al.* (2020) reported that time spent in nature counted much more than residence in PEB. DeVille, N.V. *et al*.

(2021) reinforced this assumption in a narrative review but cautioned against the lack of longitudinal studies, since personal and social factors may also be important (see also: Duroy, Q.M. 2005; Gifford, R. and Nilsson, A. 2014). Overall, the literature reveals that research on how exposure to nature affects long-term attitudes toward nature and PEB is still incomplete.

Differences within the agglomeration population may stem from migration status, i.e. whether residents are newcomers or locals. For example, wealthy newcomers expressed the strongest environmental attitudes in Idaho, suggesting that newcomers from big cities could improve the environmental state of rural areas, but their proportion was negligible compared to the low-income, poorly educated locals (McBeth, M.K. and Foster, R.H. 1994). However, this should not be the case in other neighbourhoods. Other studies used the urban gradient approach to identify varying attitudes toward urban forests but reported only slight value changes between urban and rural dwellers (Su, K. *et al*. 2022). Another open question is how suburban migration changes the environmental attitudes in urban agglomerations. Another research study from a vastly different place and time found that environmental and climate change concerns and pro-environmental norms are stronger in urban areas, independent of socio-economic status or political orientation (Larson, L.R. *et al*. 2015).

Hungarian studies also demonstrate the crucial role of socio-economic background in determining environmental awareness (Mónus, F. 2019); however, a gap between environmental concern and PEB also exists as the correlation between the two is weak (Jankó, F. *et al.* 2018). Kónya, Gy. (2016) reinforced this weak correlation by concluding that studying environmental problems shaped emotions rather than behaviour. The "justification of non-behaviour" concept highlights the gap between positive environmental concern and lack of pro-environmental behaviour, i.e. lack of actions (Kollmuss, A. and Agyeman, J. 2002). For example, one study investigating Americans and Hungarians discovered that the concept was valid for Americans, who justified their non-behaviour by dismissing individual actions as insignificant and claimed that recycling consumes more energy and creates more pollution than landfilling. Hungarians refused to justify non-behaviour despite high environmental concerns. Thus, the cognitive dissonance remained unresolved. Moreover, Hungarians had higher environmental concern and PEB, but these findings were gender-independent (Kovács, J. *et al.* 2014).

Methods

Questionnaire survey

The present study is based on a 1000n questionnaire survey conducted in forests (urban and semi-natural forests), i.e. hot spot venues with touristic-recreational relevance. More broadly, the study area is part of the designated Budapest agglomeration area with 80 settlements, which more or less covers the area of suburbanization. Our basic aim was to address forest visitors and investigate their forest attitudes. Hence, the sample could not be representative of the entire population. Furthermore, it was also methodologically significant for us to survey within forests because we believe that respondents' environmental engagement and response abilities are better if the interviews occur *in situ* (Lakkonen, A. *et al*. 2018).

Among the survey locations, two were in semi-natural forests in the Budapest surroundings, i.e. *Dobogókő* (200n, Pilis Mountains) and *Királyrét* (200n, Börzsöny Mountains). There were also three urban forest locations, one in the Buda Mountains closer to the city (200n, *Normafa*), and two on the Pest side of the Danube in outer quarters with strong local significance (*Naplás-tó* and *Farkas-erdő*, 200–200n). The paper-based survey was conducted in person with the help of BA university students, who were trained beforehand, in the autumn months of 2023.

The questionnaire included 27 questions and required about 20 minutes for respondents to complete. It covered diverse topics, but we tried to keep it brief to avoid a low response rate and interrupted fillings. Questions addressing socio-economic status were single-choice and open-ended. The 10-point Likert-scale questions were designed on Hungary's environmental state, respondents' mental and physical health, and nature dependency (connectedness). Single choice questions addressed forest-use habits on the goals, frequency, duration of, and travelling modes to forests. Another two questions focused on environmental valuation of forest use, and three focused on pro-environmental behaviour. Instead of using the travel cost method, we asked the respondents to choose from pre-given, market-based non-forest activities (in order from the cheapest to the most expensive) to determine the usefulness and enjoyment value of forest visits. Also, taking an opposing viewpoint, we asked the respondents to rate the environmental value of forests through their willingness to volunteer in forest maintenance. Finally, a group of 19 5-point Likert-scale questions addressed forest-related environmental knowledge (4 questions), the mindset about climate change (2), the support of green policy (10), or orthodox energy policy options (2).

The raw data were digitized in MS Excel, and the database was processed (filtering, categorization of open-ended questions, classification of respondents' residence types). Statistical analysis was conducted using the R statistical program.

Statistical analysis

The present study applied two grouping variables in the statistical analysis. It classified the respondents based on their situation and migration status in the Budapest area. Residence type distribution (Budapest, natives, and newcomers in the suburban zone, countryside) was highly uneven among the respondents. Still, the statistical analysis was reliable due to the vast sample size *(Table 1)*. Lines where residence was inapplicable were excluded from further analysis. The percentages of further variables were calculated separately for every residence type.

In line with our endeavours to conduct the survey *in situ* in forest locations, the second grouping variable was the location where the questionnaire was completed. Riechers, M. *et al.* (2021) also noted that landscape complexity and sense of place may influence HNC. Other explanatory variables were also used where relevant. Demographic features may affect behaviour and ideology; however, time spent in forests may have been decisive in some cases. Concerning the latter, a forest visit intensity index was calculated (*Appendix 1*).

Dependent variables were present at different scales: nominal, ordinal, Likert-scale, and numeric variables. Nominal variables were analysed with Fisher's exact test, which assesses whether the proportions of one variable are different depending on the value of the other variable. Ordinal variables were analysed with the Kruskal-Wallis H test, a nonparametric method (thus, appropriate for ordinal variables) for testing whether samples originated from the same distribution.

Variance analysis was applied to numeric variables (ANOVA). A further pairwise comparison was conducted when needed with Tukey's Honest Significant Difference test (Tukey HSD).

The 5-point Likert-scale data were examined using the special Likert-package from R (https://CRAN.R-project.org/package=likert). Here, the relevant Likert-scale question scores were summed to create a Green policy support score index (see *Appendix 1*).

Table 1. Distribution of residence types, %

Capital (Budapest)	Suburban (native)	Suburban (newcomer)	Countryside	No answer
61.13	21.76	7.12	7.91	2.08

Results

Environmental awareness and forest use

Assessment of the *environmental status of Hungary* varied widely between and within residence types. The most frequent scores on a 1 to 10 scale were 5, 6, and 7. However, 20 percent of the Budapest residents only gave a 4. At the same time, Budapest residents were the only ones who did not give less than a 4 on this question. Rural residents were the most likely to think that the environmental condition of Hungary was poor. Hungary's environmental status assessment was independent of the time and frequency of forest visits; most people scored middle values (4–6).

Relatedly, assessment of the *most serious local environmental problems* showed similarities between the residence types, as *Waste/dirt* was considered the most severe problem. In the capital and the suburb, the second most severe problem was *Air pollution*, while the third was the lack or scarcity of *Green areas*. Countryside residents thought vice versa, while they also mentioned *industry* more. Other problems received only a negligible number of votes *(Figure 1)*.

Forest activity was independent of residence type and forest visit intensity. Countryside respondents used forests for *food gathering* at a higher rate than others, but the difference was not significant. Similarly, time spent in the forest was not connected to residence type. Most noted "more than half of the free time" and "approximately half of the free time." If we consider forest visit frequency and free time activities other than forest visits together, we see that countryside dwellers visit forests to the greatest extent followed by native dwellers in the suburb (*Figure 2*). "Close to nature" activities (including implicitly forest related hiking, fishing, but also gardening etc.) were chosen to a greater extent by suburban residents, independent of whether they are native or newcomers. Third, urban habits like s*port/training* and *hobbies* showed higher rates among capital residents and suburban newcomers.

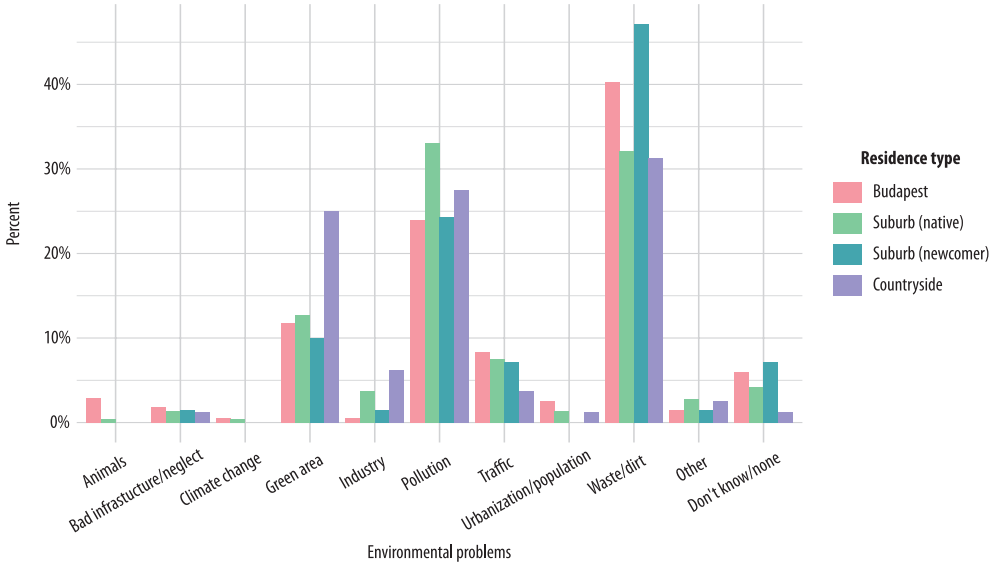

Fig. 1 The most serious environmental problems in the respondents' locality. *Source:* Authors' own elaboration.

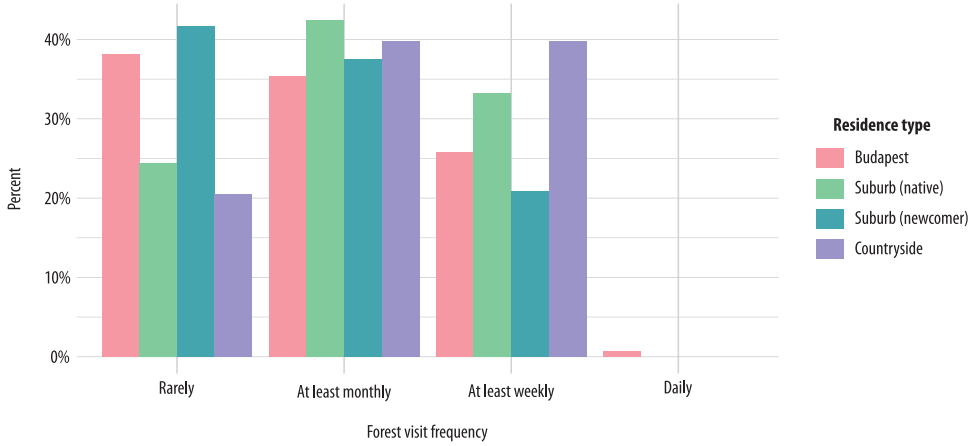

Fig. 2. The frequency of forest visits. *Source:* Authors' own elaboration.

Environment-related well-being, and nature connectedness

It was also vital for our research to address the respondents' environment-related well-being in connection with forest use and related activities. Our data showed that *mental health* was independent of residence type and *forest visit intensity*. Those living in the capital or the suburban zone (native) had better *physical health*, but *physical health* was independent of *forest visit intensity*. Many factors affect physical and mental health; however, residence type and forest visit intensity were not significant.

On the other hand, residence type was a decisive factor in nature dependency. Budapest residents had a significantly lower *nature dependency* score (ANOVA F = 22.5, p < 0.001) (*Figure 3*). *Forest visit intensity* also significantly affected the strength of nature dependency. Those who barely visited forests had a much weaker nature dependency score (ANOVA, F = 24.56, p < 0,01). However, those who rarely visited the forests were nearly as dependent on nature as those who spent much time in the woodlands.

Concerning demographic factors, nature dependency decreases with living condition improvement (Kruskal-Wallis chi-squared = 24.666, df = 9, p-value = 0.003) and increases with education level (Kruskal-Wallis chi-squared = 30.979, df = 9, p-value < 0.001). The place where people completed the questionnaire also had a significant effect. The highest nature dependency score was observable at *Dobogókő*, which is a spiritual place for many. Interestingly, *Farkas-erdő*, an urban forest, was in second place, while *Királyrét*, a semi-natural woodland, had the least nature-dependent visitors (Kruskal-Wallis chi-squared = 22.048, df = 4, p < 0.001) (*Figure 4*).

Role of forests in HNC and PEB

Some questions addressed the environmental valuation of the forests. The results showed that adding value to the forests was independent of residence type. People choose mostly the cheapest option (fitness, gym, yoga, dance, etc.) Suburban dwellers – both natives and newcomers – chose the medium-price option (having coffee or a beer with friends) at a slightly higher rate compared to capital and countryside residents. On the other hand, the frequency of forest visits had an inverse effect. Those who spent less time in forests were more willing to choose a more expensive option for a forest value equivalent. The venue

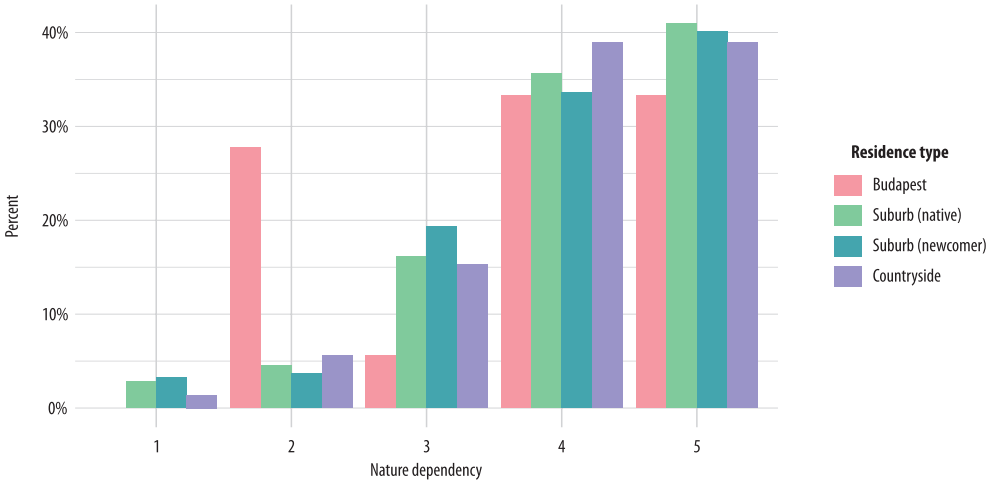

Fig. 3. Self-reported nature dependency of the respondents by residence types. *Source:* Authors' own elaboration.

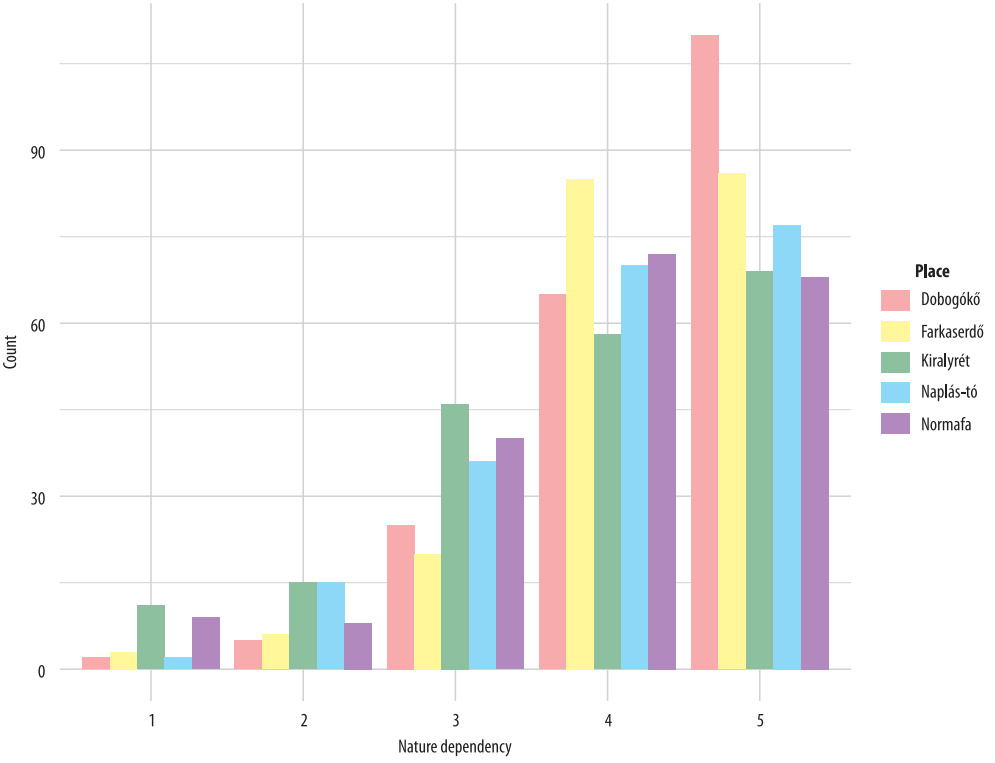

Fig. 4. Self-reported nature dependency of the respondents by the location of the survey. *Source:* Authors' own elaboration.

where questionnaires were completed also affected the value people assigned to forests. Although people chose the cheapest option at a higher rate at every location, this rate was the highest at *Királyrét*. At *Naplás-tó*, people were more willing to opt for slightly higher-priced options, followed by *Farkas-erdő* and *Normafa*. *Dobogókő* hikers most often chose the two most expensive forest value equivalents (*Figure 5*).

In the case of willingness to volunteer for forest maintenance and the questions addressing PEB, there were only slight, insignificant differences. Suburban newcomers garden the least and buy the least unpackaged goods. In volunteering, most respondents picked the choice that they would contribute to forest maintenance financially. However, if we consider the four questions on volunteering, food shopping, and gardening as a PEB index, the difference would be significant; Budapest respondents have the highest and suburban newcomers have the lowest scores (see *Appendix 1*).

Knowledge and green policy support

As mentioned in the methods section, forest-related environmental knowledge, climate change, and willingness to support green policy/orthodox energy policy were addressed with 5-point Likert-scale questions (*Figure. 6*). Knowledge about Hungarian environmental issues was good; however, it was independent of all the explanatory variables (residence type, education, forest visit frequency).

Most respondents were willing to support green policy options. The green policy

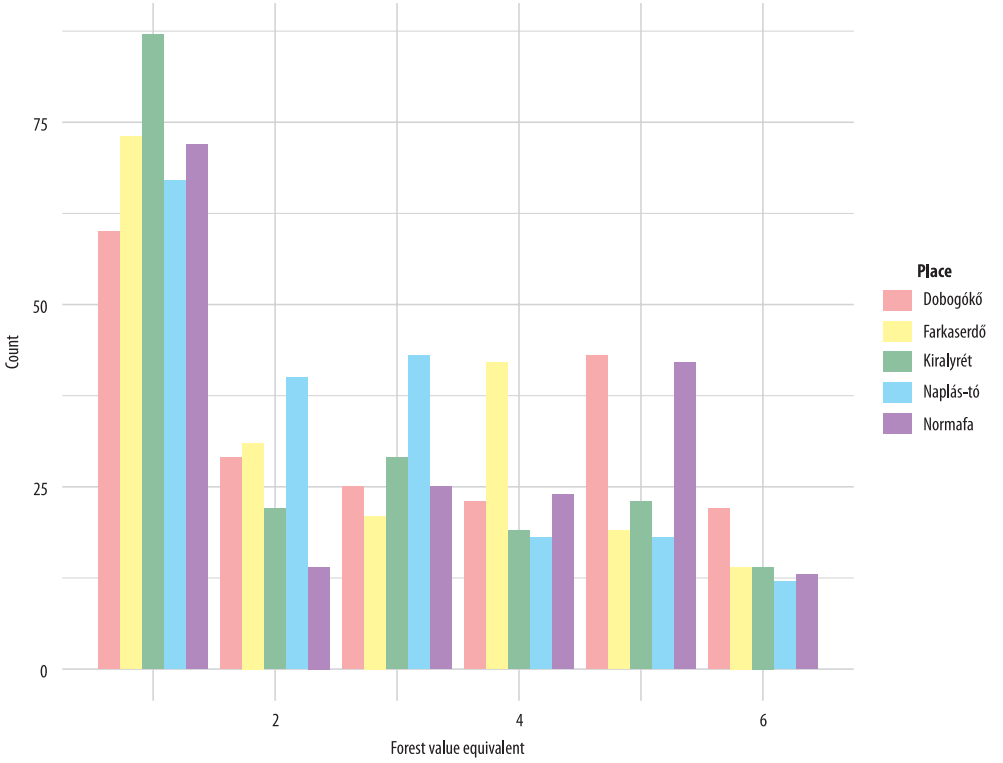

Fig. 5. Forest value equivalent scores in the light of the venue of the survey. *Source:* Authors' own elaboration.

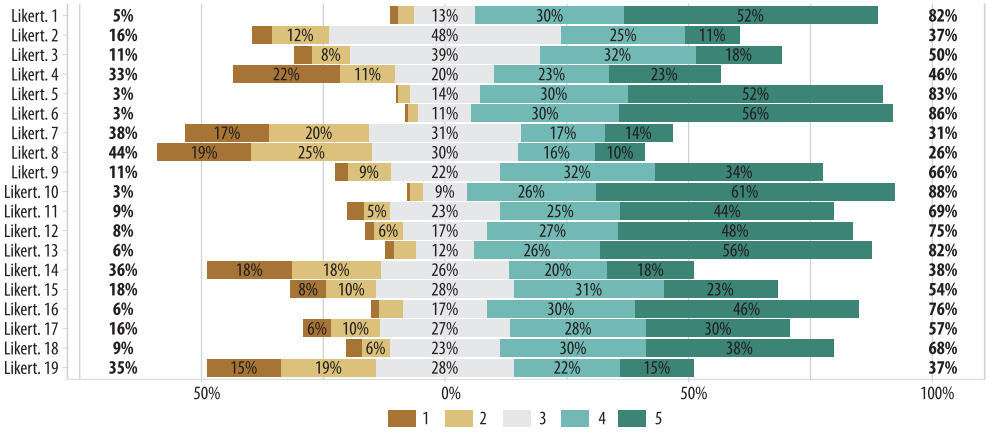

Fig. 6. Answers to the Likert-scale questions. *Source:* Authors' own elaboration.

support score index was independent of the residence type and forest visit frequency; however, education level affected it positively. People with high school graduation and higher levels of education were more likely to support green policy initiatives (e.g. green area development, enlargement of nature conservation areas, wetland rehabilitations, wind energy developments, etc.) than those with only an elementary school degree (ANOVA $F = 4.64$, $p = 0.003$; Tukey HSD: *Appendix 2*). However, the reintroduction of large predators (wolves, bears, lynx) was a highly divisive issue. But again, the location of the survey had a significant effect on green policy support (*Figure 7*), as respondents expressed stronger green policy support at *Dobogókő* and *Farkas-erdő* (ANOVA $F = 13.41$, $p < 0.001$; Tukey HSD: *Appendix 3*).

Discussion

While the respondents were in general uncertain about the environmental status of the country, countryside respondents tended to regard the environmental situation in Hungary more negatively, perhaps due to so-called environmental amnesia (Miller, J.R. 2005), i.e. urban residents have looser tights to nature and experience the visibility problem (Jankó, F. *et al.* 2018; Hafenscher, P. and Jankó, F. 2022; Vinnari, E. and Vinnari, M. 2022), which could be factors in not seeing air pollution as a problem. However, it should be noted that the rural residents surveyed do not represent the whole countryside population of Hungary. Notably, climate change is not visible from bottom-up perspectives and only received a few mentions by the respondents.

Unsurprisingly, our data showed that (sub) urban residents have fewer opportunities to visit forests. Relatedly, those who moved

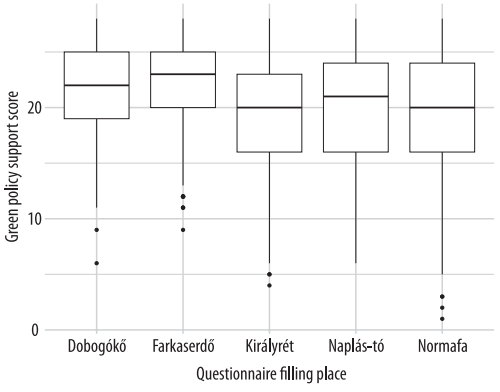

Fig. 7. Green policy support score in light of the venue of the survey. *Source:* Authors' own elaboration.

to the countryside from Budapest were not motivated explicitly by the proximity to forests but rather by other nature-related activities like gardening, which supplements the findings of the existing literature (Kok, H. and Kovács, Z. 1999; Bajmócy, P. *et al.* 2011). However, suburban newcomers have fewer opportunities to practice gardening. Time-use patterns could explain these differences.

Although the literature provides evidence that nature exposure significantly contributes to physical and mental health (Jimenez, M.P. *et al.* 2021; Schönbach, D.M.I. *et al.* 2022; Wicks, C. *et al*. 2022; Nguyen, P.-Y. *et al*. 2023), our sample only partly supports this. The respondents' subjective self-scoring could explain these discrepancies.

Nature connectedness and dependence are at the forefront of research in environmental education. Our basic results using only one 10-point Likert-scale question correspond with the main arguments that countryside respondents feel closer to nature and depend more on it (Navarro, O. *et al.* 2022). Our data also showed that financial security reduces feelings of nature dependence. Education level revealed the opposite. People with higher education levels were more sensitive to environmental concerns. The frequency of forest visits also fortified feelings of nature dependency. Those who barely visited forests had a much weaker nature dependency score. This result concords with Schönbach, D.M.I. *et al.*'s one (2022); therefore, forests play a vital role in HNC; however, other factors are also meaningful, like socio-economic factors, living conditions, and education. These findings offer an interesting area for development in communication. The more prosperous should understand that the long-term maintenance of prosperity depends on natural resources. However, the relationship between HNC and demographic factors is uncertain in the literature (Cartwright, K. and Mitten, D. 2017; Whitburn, J. *et al.* 2020; Marcias-Zambrano, L. *et al*. 2024).

The effect of the surveying locations on responses is also under investigation (Chiang, Y.-C. *et al*. 2017). Our positive results here on HNC could be explained by the fact that *Dobogókő* is a historic and transcendental place of the Hungarian hiking movement, while *Farkas-erdő* is a venue of natural beauty in contrast with the large housing estate nearby. *Normafa* and *Királyrét* are over-urbanized "forest gates" with added infrastructures. The surveying locations showed a notably similar pattern in the case of forest valuation and green policy support. However, our findings here are incomplete, and the issue should be investigated more fully in the future.

Furthermore, it is not surprising that respondents mostly chose the cheapest option in forest valuation. Also, it seems that those who spend less time in the forest tend to value the occasions more. When the valuation was modelled with the respondents' contingent volunteering action, respondents showed only a bit more willingness, hence a bit higher valuation. Concerning the pro-environmental indicators, there was only a slight difference, where Budapest residents showed higher engagement. These results are somewhat contradictory with their low nature connection; however, together with all our results, they strengthen the opinion in the reviewed literature that supports the existing urban-rural divide in environment-related attitudes. Infrastructure differences could be institutional barriers that hinder PEB (see in review: Dioba, A. *et al.* 2024), i.e. people in Budapest have more opportunities to buy packaging-free products or fruits and vegetables from farmers' markets, while gardening is more accessible in the agglomeration and rural areas.

Our results raise the question of whether background factors like education, socio-economic status, ages of residents in residence types, and migration status explain the connections between HNC and PEB. To address this question, we applied an interaction and an additive model. Although the interaction between settlement type and income level (living conditions) proved to be statistically significant (e.g. Suburb.Q: Living.conditions^5, p = 0.0289), the interaction model

resulted only in a modest improvement in explanatory power compared to the additive model (e.g. a minimal increase in R^2). This suggests that while some interaction effect may be present, the more complex model does not offer substantially better predictive accuracy. Therefore, the additive model was kept as the primary analytical framework.

The present paper faced some study limitations. First, Budapest residents comprise a more heterogeneous population compared to the other subsamples scattered across a wide spectrum according to livelihood, local environments, etc. The study could not control these in its sample. Second, our survey ignored the effects of politico-environmental ideologies on respondents' thinking about the topic; Hungarian political circumstances hardly contribute to meaningful dialogues in an explicit form. Third, our survey addressed forest visitors and not the entire population. Thus, the study is non-representative; however, the sample size made it possible to analyse some correlation in the suburban area of Budapest.

Conclusions

The present study aimed to fill a research gap concerning the role of forests in environment-related well-being and activities and better understand how residence type and related factors affect forest use, HNC, and PEB in the Hungarian capital and its suburban area. Our results showed that there are some significant connections; the urban-rural divide was most visible in the case of environmental awareness and problems, self-reported HNC, and some PEB measures; however, other cases did not offer clear explanations in this direction. What is more, our results not only underscore the importance of socio-demographic factors that could have a role in considering some issues, but the venue of the survey could also have a decisive effect in some cases; thus, this problem should be addressed with more focused research.

Beyond the explanatory factors, the perception of the Hungarian environmental situation is positive; however, the visibility-invisibility issues and ecosystem services benefits should be addressed and highlighted through environmental communication efforts. Similarly, the localization of climate change is an urgent task for environmental experts and politicians. Relatedly, urban development should use the newest, nature-based initiatives, not only for climate change adaptation, but also to engage and reconnect local people with nature, i.e. the environment. Forests are vital, especially in and around urban areas with high environmental impact and visitor expectations. Developing their public relations and mutual recognition is an urgent issue for forestry professionals and environmental educators.

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Appendix 1

Variables of the analysis

Variable types				
Grouping variables	Residence type	Venue of questionnaire survey	Demographic features	Forest visit intensity*
			Education	Q10 + Q11
			Income	
			Age	
			Gender	
Dependent variables	Nominal	Ordinal	Numeric	Likert-scale***
	Q2	Q1	Q17–20: PEB**	Environmental knowledge: L2–4, L7–8
	Q8	Q5		Green policy support: L5–6, L9–13, L16, L18
	Q9	Q6		Other
		Q7		
		Q10		

* The index was created by summing two questions. The first one was "How often do you visit forests?" (Q10). The choices were scored based on frequency: daily (score: 5); at least weekly (score: 4); at least monthly (score: 3); less often (score: 2); never (score: 1). The second was "How much time do you usually spend in the forest per occasion?" (Q11) The choices were scored based on duration: more than two hours (score: 5); 1.5–2 hours (score: 4); around 1 hour (score: 3); around half an hour (score: 2); around 15 minutes (score: 1). The new variable was created by summing the scores of the two questions.

** Pro-environmental behaviour (PEB) index was derived from ordered variables (Q17, 18, 19, 20). Answers for question 19 – "Where do you usually get your vegetables and fruits from?" – were converted to scale, depending on the level of environmental consciousness: the most conscious choice was self-grown or a relative grows the fruits and vegetables; while the less conscious choice was the supermarket. Then, the scores of questions (17) to (20) were summarized to create a new variable: *Pro-environmental behaviour score*.

*** These questions were classified in two groups: environmental knowledge regarding Hungary (L2-4, L7, L8) and willingness of green policy support (L5, L6, L9–13; L16, L18). L1, L17 and L19 measured mindset about climate change, hydroelectric power plant and development of coal and natural gas mining; L14 measured opinion about the reintroduction of large predators (wolves, bears, lynx), but whereas it is a highly controversial topic, it was omitted from further analysis (see *Figure 7*).

Appendix 2

Turkey HSD – Green policy support

Education	Difference	Lower	Upper	p-value
Secondary school, no graduation – Elementary school	1.88	-0.31	4.08	0.123
Secondary school, graduation – Elementary school	*2.49*	*0.60*	*4.36*	*0.004*
University/Collage – Elementary school	*2.60*	*0.73*	*4.48*	*0.002*
Secondary school, graduation – Secondary school, no graduation	0.60	-0.85	2.05	0.708
University/Collage – Secondary school, no graduation	0.72	-0.72	2.17	0.571
University/Collage – Secondary school, graduation	0.12	-0.76	1.00	0.985

Appendix 3

Turkey HSD – Green policy support

Place of filling the Qa	Difference	Lower	Upper	p-value
Farkas-erdő–Dobogókő	0.17	-1.17	1.52	0.997
Királyrét–Dobogókő	*-2.53*	*-3.88*	*-1.19*	*<0.001*
Naplás-tó–Dobogókő	*-1.72*	*-3.06*	*-0.38*	*0.004*
Normafa–Dobogókő	*-2.30*	*-3.65*	*-0.96*	*<0.001*
Királyrét–Farkas-erdő	*-2.71*	*-4.06*	*-1.35*	*<0.001*
Naplás-tó–Farkas-erdő	*-1.89*	*-3.25*	*-0.54*	*0.001*
Normafa–Farkas-erdő	*-2.47*	*-3.83*	*-1.12*	*<0.001*
Naplás-tó–Királyrét	0.81	-0.54	2.17	0.474
Normafa–Királyrét	0.23	-1.13	1.59	0.990
Normafa–Naplás-tó	-0.58	-1.94	0.78	0.769

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A possible strategy for the economic restructuring of a rural region based on wine tourism: Case study of Blue Mountains, Moravia

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Abstract

The article deals with the restructuring of a region focused on intensive agriculture at a time when agriculture ceases to be a source of wealth. It explores the possibilities of using tourism in an area with a high proportion of arable land without neither significant historical heritage nor natural attractions. The study method is a complex geographical analysis that determines the conditions under which the transformation of the microregion takes place. This analysis results in an overview of the microregion's most significant strengths and weaknesses, opportunities and threats. The applied solution is the use of a specific brand, using the significant presence of wine culture. The use of this brand for marketing is presented. The increase in competition ability is based on the introduction of the idea to promote the area under the brand Blue Mountains and the use of other ideas that significantly differentiate the studied region from its neighbours. The key prerequisites are the cooperation of the actors. The main contribution of the article lies in the study of local experiences with tourism promotion and place marketing as one of the possibilities for transformation into a post-productive economy.

Keywords: agricultural region, economic restructuring, wine tourism, brand marketing, Moravia

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Introduction

In connection with the transition to a post-productive economy, labour productivity is increasing in the manufacturing sectors that were crucial for rural employment in Czechia. Workers are moving into services, both within manufacturing sectors and into the service sector in general. One of the proposed options is the development of tourism. As the most economically affected rural areas are peripheral microregions, this is a seemingly appropriate strategy as these regions tend to have a less disturbed natural environment. However, what about rural microregions in fertile areas, which are characterised by a high degree of ploughing, and their landscape is highly transformed and unattractive?

A certain advantage of these microregions is the better transport accessibility of regional centres compared to peripheral mountain microregions, so their inhabitants can conveniently commute to work. However, it is probably not possible to build the economy of entire microregions on commuting alone. The combination of commuting with own activities of villages in at least some settlements is desirable. Therefore, it is necessary to look for local or regional aspects that can create a competitive advantage. In the sphere of tourism, it is then necessary to look for such an advantage in the cultural forms of tourism.

There has been strong discourse aimed at transforming rural places from venues of production into truly diverse socioeconomic landscapes (Almsted, Å. *et al.* 2014). In areas with intensive agricultural production,

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some authors speak about hyper-production (Brouder, P. *et al.* 2015), which means introducing additional economic activities and branches, among other factors. Rural areas and rural landscapes are increasingly becoming areas of consumption. One of the most frequent areas of rural consumption is rural tourism (Eusébio, C. *et al.* 2017). However, Mackay, M. and Perkins, H.S. (2019) point out that these areas are also the residence of their inhabitants.

In general, economic transformation in the countryside means a transfer of workers to services. However, services generally tend to be concentrated in cities or resort villages. In rural areas, tourism services or social services in particular come into consideration in rural areas. Examples of post-socialist countries with developed tourism services is, for example, Slovenia (Gajić, T. *et al.* 2018), and Hungary (Kóródi, M. and Dávid, L.D. 2019). The question is, of course, whether tourism services can compensate, either quantitatively or qualitatively, for job losses in agriculture and industry.

European rural peripheries see the development of tourism as a potential for stabilising and revitalising settlements (Reichert-Schick, A. 2016). On the other hand, in the fertile flat rural areas, which have a high portion of arable land, relatively few forests and pastures and unattractive terrain, the focus remains on cultural tourism. The United Nations World Tourism Organisation defines cultural tourism as a movement of people essentially for cultural motivations, such as study tours, performing arts and cultural tours, travel for festivals and other events, visit to sites and monuments, travel to study nature, folklore or art and pilgrimages. McKercher, B. (2020) identifies four segments of cultural tourism: the purposeful cultural tourist, the sightseeing cultural tourist, the serendipitous cultural tourist, the casual cultural tourist and the incidental cultural tourist. Major research trends include the shift from tangible to intangible heritage, more attention on indigenous and other minority groups and a geographical expansion in the coverage of cultural tourism research (Richards, G. 2018). In our case, we will consider cultural tourism as those forms that significantly include cognitive function (Šťastná, M. *et al.* 2020). This is the interaction between the destination and the traveller depending on whether the tourist is interested and has the potential to explore the destination. It can concern learning about history, architecture and art, nature, the way of life for the locals, customs and gastronomy.

Individual rural microregions can compete in tourism on various factors. This can be price, quality of services, various accompanying attractions, information and marketing, infrastructure, accessibility etc. (Demirović, D. *et al*. 2017). In reality, however, these options are limited, because internal micro-regional resources are usually limited. An important competitive factor is also the institutional support of municipalities (Roman, M. *et al*. 2020). Under these circumstances, the character of one's own place remains as one of the possible effective and real resources. However, this needs to be asserted in competition with other places. A possible form is place marketing through a brand.

Area with intensive agriculture looking for an economic restructuring is represented by South Moravia in our study, namely the microregions located in the Dolnomoravská and Dyjskosvratecká lowlands. It is a non-central part of the Hodonín, Břeclav and Znojmo districts (LAU 1). The comparative advantage of this area is viticulture. However, this advantage applies to the entire region. The question is what specialty to offer visitors to encourage them to visit certain municipalities or a group of municipalities. In our case, another element of competitiveness comes into play – a unifying destination marketing (Hanna, S. *et al.* 2020), idea that allows, on the one hand, cooperation and the interconnection of service providers and residents, and on the other hand, the promotion of a place under one heading and identity (Daszkiewicz, M. and Wołosecka, A. 2019).

The paper tests such a possibility using the example of five municipalities in the district

of Břeclav, which created a voluntary association called Blue Mountains and devised a proposal to create a recessionary republic in their territory focusing on viticulture and wine tourism.

Theoretical background

Although rural transformation was overshadowed by urban changes, its progress was rapid and radical in the second half of the 20th century (Schmied, D. 2005). Although structural changes affect both cities and rural areas, rural areas have certain specificities in this process – environmental, social and cultural (Cloke, P. 2006). The change from a productive to a post-productive countryside specifically means, among other things, the partial replacement (in terms of labour and wealth creation) of productive sectors (in the case of rural areas, especially agriculture) by consumption sectors, which in rural areas can be represented, among other things, by tourism.

The commodification of the countryside through tourism takes a range of forms from purely passive to those that are associated with the activities of tourists (Woods, M. 2011). Tourism is an increasingly important component of rural development, which can act as an economic engine. However, Marcouiller, D. (2013) warns that this sector increases social differentiation, as it produces low-paid and low-skilled employment opportunities and, on the other hand, increasing profits for entrepreneurs who are often not even resident in the region. The issue of target groups is also important. Szörényiné Kukorelli, I. (2011) documents using the example of Hungary that although entrepreneurs would like to expect foreign tourists, rural tourism still depends more or less on domestic visitors. Food and wine tourism is one of the progressive forms of rural tourism. Recently, the offer has expanded towards experiences such as wine trails, folkloric events, direct sales and consumption, and the like (Hall, D. 2005). However, the development of wine tourism can also be associated with certain risks, such as overcrowding, land speculation, and loss of local identity (Costa da Silva, M.A. *et al.* 2024).

However, it should be noted that the countryside is not a homogeneous space. For example, Murdoch, J. *et al*. (2003) identify four types of countryside in Great Britain, each with different characteristics and requiring a different approach. Similarly, in Moravia, different rural areas can be identified (Stonawská, K. and Vaishar, A. 2018), such as suburbanized rural areas, intermediate rural areas (usually intensively used for agriculture), and peripheral rural areas (which can be divided into inner and border peripheral areas).

In Czechia, the share of employees in primary sectors in municipalities with less than 2,000 inhabitants have fallen below 7 percent. In some rural regions, declining job opportunities in manufacturing sectors may be associated with depopulation and/or aging trends (e.g. Labianca, M. and Navarro Valverde, F. 2019). Alternatively, there may be a departure of young and educated people from the countryside and, thus, a deterioration of its social structure compared to cities (Vaishar, A. and Pavlů, A. 2018). In Moravia, this development mainly concerns the most peripheral rural areas (Vaishar, A. *et al.* 2020).

The European Union is spending considerable resources on slowing down the downward trend in jobs in agriculture (Garrone, M. *et al.* 2019). These efforts are, however, directed against natural economic and social development. The rapid reduction in the number of jobs in the manufacturing sectors is inevitable and requires the restructuring of the countryside. Hruška, V. and Píša, J. (2019) identified six models of rural restructuring in post-socialist Czechia: globally integrated, service-oriented, entrepreneurial, industrialised, post-productivist and de-industrialised, including post-mining and energy-producing rural localities.

Vine growing, wine production and related tourism belong to possibilities of the rural tourism development. The scientific litera-

ture concerning this topic has been collected by Gómez, M. *et al.* (2019). However, even in these cases, according to Bruwer, J. and Rueger-Muck, E. (2018), the scenic charm is crucial for the attractiveness of the site. Wine tourism can be considered as part of gastronomic tourism. However, it is often associated with folklore elements, whether living or artificial. It often includes wine trails via walking or cycling (Prokeš, M. 2019). In Czechia, wine tourism is considered an important factor in rural development, especially in southern Moravia (Šíp, J. *et al.* 2018).

However, wine tourism is usually covered by relatively large rural regions; therefore, it is necessary to find a factor that would increase the competitiveness of the site. Place marketing is the tool (Scorrano, P. *et al.* 2019). Destination brand development has been described by Almeyda-Ibáñez, M. and George, B.P. (2017). Recently, more and more participatory approaches have been promoted in this direction (San Eugenio-Vela, J. *et al.* 2020). Some authors speak about community-based tourism (Đurkin, J. *et al.* 2017), which includes the incorporation of different local stakeholders.

The geography of branding is approached by Pike, A. (2009). He presents three basic components of this aspect: geographical origin and socio-spatial history, spatial circulation of values and meanings in uneven development, and territorial-relational spaces and places. Some politicians even consider place branding to be a key part of regional development strategies. On the other hand, Medarič, Z. *et al*. (2021) found, using the example of Lake Balaton, that brand marketing is the worst rated factor in this destination. Geography uses the concept of place to study it (Andersson, I. 2014). Michaelis Aharon, K. and Alfasi, N. (2022) proposed a case study methodology to analyse a brand in a hierarchical structure.

Branding in geography is linked to the theory of sense of place. According to Ashworth, G.J. and Graham, B. (2017), sense of place is inextricably linked to time and heritage. Jepson, D. and Sharpley, R. (2018) studied the relationship between sense of place and deeper emotional experience of tourists in the Lake District in rural England. They concluded, among other things, that being in the landscape, preferably through physical activities, is fundamental to the emotional connection. However, according to Liu, S. and Cheung, L.T.O. (2016), the sense of place also influences the interest of local small and medium-sized entrepreneurs to engage in tourism. The place-based approach contributes to increasing the resilience of small rural communities (Salvia, R. and Quaranta, G. 2017) through three interrelated aspects: the restoration of previously disrupted social relations, the cascading effect of initial activity, and the adoption of a systemic approach that connects sectors. Walker, K. and Moscardo, G. (2018) move the issue from the level of sense of place to the level of care for the place with the aim of preserving values.

The essence of the place-based approach lies in overcoming the sectoral approach in favour of a holistic understanding of place (Vasta, A. *et al.* 2019). From this perspective, it is a highly geographical issue. According to Kastenholz, E. *et al.* (2020), place attachment is very important in rural tourist destinations with a loyal customer base. Jarratt, D. *et al*. (2018) point out that current branding processes may miss the target groups of rural tourists and therefore introduce the concept of a sense of place. In the competition between destinations, the uniqueness of a place and its use play a significant role (Romão, J. 2018).

The local development strategy in the European Union is implemented primarily in the LEADER program, and more recently through community-led local development. Its basic idea is a bottom-up approach. The organizational units are local action groups (LAGs), the creation of which is subject to relatively strict rules. The most important of which, from our perspective, is the participation of the public, private and non-governmental sectors and the prohibition of the majorisation of one of them. The creation of local strategies and their evaluation is also important.

One of the objectives of this activity is to strengthen the sense of belonging to the micro-region, its natural, agricultural, historical and cultural traditions (Menconi, M.E. *et al*. 2018). This can of course work provided that the LAGs are created in accordance with these traditions. However, in many cases the view is promoted that the LEADER programme serves mainly as an additional subsidy source and belonging is not preferred. One of the obstacles is the excessive institutionalization by which individual states or regional activities try to control the activities of LAGs (Chmiełiński, P. *et al*. 2018; Tirado Ballesteros, J.G. and Hernández, M.H. 2018). A covert top-down approach is still being pursued (Konečný, O. *et al*. 2020).

Local action groups also have a role to play in the development of local tourism. Trinajstić, M. *et al*. (2023) state that their contribution lies not so much in direct investment in tourism, as the conditions set would limit the future flexibility of entrepreneurs, but rather in building infrastructure and various supporting activities. The possibilities of using community-led local development in the development of gastronomic tourism were pointed out, for example, by Murmura, F. *et al*. (2024). However, in some countries, especially in Southern and South-eastern Europe, great emphasis is still placed rather on the development of agriculture (Konečný, O. 2019).

Tourism depends on the reputation of destinations (Darwish, A. and Burns, P. 2019), which minimizes possible traveller´s disappointment. A destination brand helps with this, the purpose of which is to simply distinguish the respective destination from its competitors. A destination brand usually includes a name, symbol, logo or other graphic eventually a story that emphasizes the uniqueness of the area for tourism and differentiates it from competitors (Keller, K.L. 2002). Destination marketing combines a geographical unit (region) and a tourism product. According to the author, brand equity is studied from the perspective of three approaches: customer psychology, economics, and a biological-sociological approach. Tasci, A.D.A. (2021) distinguishes between financial and non-financial brand equity as well as brand value from the perspective of the customer, provider, employee and resident. Gulisova, B. (2021) points out that states, large cities and important tourist destinations apply branding similarly to companies, that is, with a centralized approach. Rural areas, which often do not form a strong administrative unit, are looking for differentiated paths. Murray, A. and Kline, C. (2015) identified three main factors of brand loyalty using the example of analogue rural beer tourism in North Carolina: connection to the community, quality product and satisfaction.

In modern times, e-branding is becoming increasingly popular (Kavoura, A. and Bitsani, E. 2013). Its advantage lies in the ease of use, the intimacy of search, interactivity, access to comments of previous visitors. Potential visitors can view the destination through aerial or street views. Visitors' familiarity with the use of IT technologies is a prerequisite. The analysis by Bonarou, C. *et al.* (2019) focused on the analysis of the place marketing of wine tourism through the Internet. Scorrano, P. *et al.* (2019) believe that the level of convergence between online brand identity and online brand image is of increasing importance for the adoption of an effective territory promotion strategy. Online applications (Dimitrovski, D. *et al*. 2019) are increasingly being used for branding purposes.

The question of brand marketing in wine tourism was raised by Gómez, M. *et al.* (2015), who stated that the study of this problem was in its infancy. The role of wine tourism in shaping brand image and brand loyalty was later studied by Joy, A. *et al.* (2021) based on TripAdvisor data. They emphasized the importance of social interactions. Madeira, A. *et al.* (2019) state three dimensions of such interaction: guest, host and place. In some cases, the brand in wine tourism is represented by the certification of protected brands (Molleví, G. *et al.* 2020). Telling oral stories from the cellar door is an important strategy to strengthen heritage and differentiate a winery from its competitors

(Frost, W. *et al.* 2020). Fountain, J. *et al.* (2020) point out certain problems in this regard. This is a contradiction between local culture (preserving authenticity) and the global demands of tourists (increasing professionalism).

The following theoretical assumptions result from the above:

– The structural transformation of rural regions towards a shift from production to consumption is part of the general transformation of society and is inevitable.
– One of the possibilities for consuming the countryside and its landscape is the development of tourism, which uses not only general but also local attractions and peculiarities.
– This activity is connected with the sense of place and destination marketing, eventually using an appropriate brand.
– In this sense, the participation of local citizens, building a sense of place and institutional support of municipalities are extremely important.
– The commercialization of tourism by external entities must be mostly avoided, because the departure of benefits from the place and, conversely, burdening the place with negative accompanying phenomena of tourism threats.

Methodology and area under study

From a methodological point of view, this work is based on a case study. It includes a comprehensive geographical analysis of the selected territory with a special regard to tourism. This analysis was prepared on the basis of public statistical data, the study of secondary sources and repeated field research made in the summer season of 2022. At that time, the impact of COVID-19 antipandemic measures on tourism was also relevant. The knowledge gained made it possible to emphasize the urgency of the solved problem and to name the strengths and weaknesses of the studied region, opportunities and threats to its further development and to discuss possible strategy as parts of the SWOT analysis.

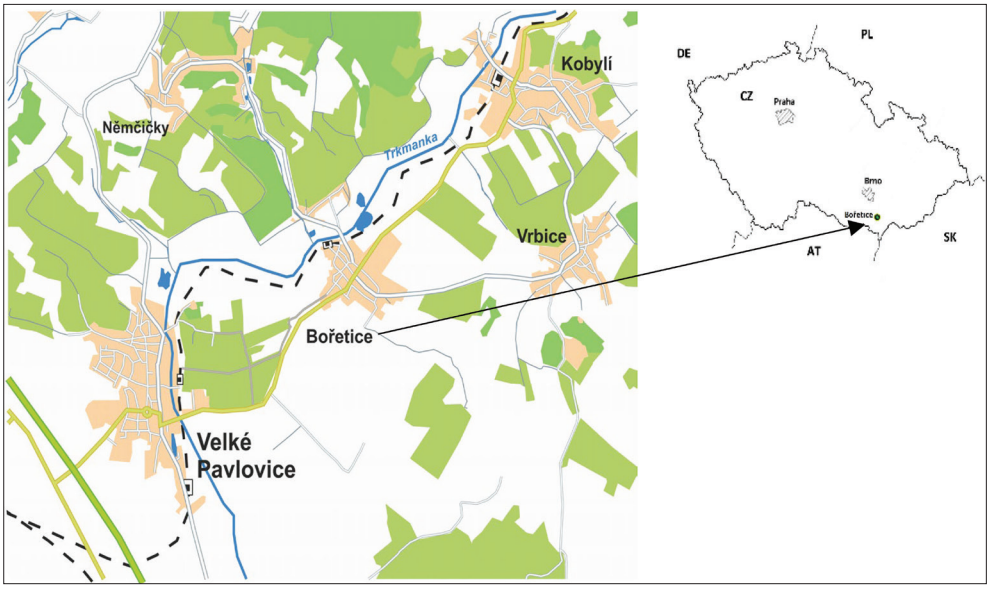

Fig. 1. Map of the study area. *Source*: Authors' own elaboration.

This basic geographical analysis of the studied area is followed by a description of the marketing approach of the association of municipalities of the selected territory, specifically the Blue Mountains microregion and within it the Free Federal Republic of Kraví Hora. Local experience was used in this process. Furthermore, the importance of the implemented marketing approach for the development of the microregion was discussed. This assessment can only be indirect, as there is no comparison of how tourism in the region would develop without this brand.

The area under study is located in the Velké Pavlovice wine region. It consists of five municipalities *(Figure 1)*. All villages have a positive migration balance and a negative natural balance *(Table 1)* which indicates a relatively high average age of the population. The total population growth over the last five years was 2.2 percent. Together 200 new dwellings have been built in the last five years, i.e. 24 dwellings per thousand inhabitants. Further growth can be expected in connection with the immigration of Ukrainians, which statistics have apparently not yet captured.

The ratio of children to seniors is 0.75. The educational structure of the population over 15 is dominated by apprenticeships (39.3%), followed by graduates (25.2%) and people with basic education (23.2%). This corresponds more to a moderately skilled industry. In total, 30 percent of the economically active population, commute to work. The studied municipalities therefore provide a significant majority of job opportunities for their inhabitants in the area.

According to the 2021 census, the area employed a highly above-average 9.8 percent of the population in the primary sector (the national average for rural municipalities was 6.5%). The share of employees in industry and construction was 39.3 percent (the national average for rural municipalities is 37.4%). 15.7 percent of economically active persons were employed in business and transport activities, 11.8 percent of people were employed in education and healthcare. Catering and accommodation services, which can be related to tourism, employed 4.6 percent of economically active persons (nationally 2.8% in rural municipalities). The share of workers in manufacturing has slightly increased since the 2011 census, contradicting the transition to a post-productive economy. Unemployment has fluctuated between 2.5 and 4 percent in the last years with a seasonal increase in winter *(Figure 2)*.

The area geomorphologically belongs mainly to the Ždánický Les highland. The terrain rises towards the east. The lower parts of the area are used for agriculture due to fertile soils, viticulture and arboriculture of thermophilic species, such as apricots, peaches, hawthorns and almonds. There are also forest-steppe and steppe communities. The climate is relatively

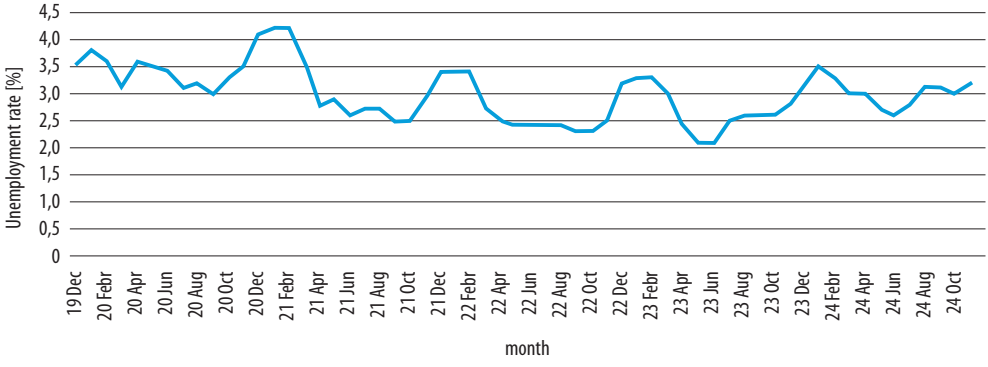

Fig. 2. Unemployment rate in the area under study during the period December 2019 – April 2023. *Source*: Ministry of Labour and Social Affairs of the Czech Republic. Authors' own elaboration.

Table 1. Population of the area

Municipality	Population, 2023	Population balance, 2019–2023		
		Natural	Migration	*Total*
Bořetice	1,379	-2	+115	*+113*
Kobylí	2,001	-35	+1	*-34*
Němčičky	792	-13	+117	*+114*
Velké Pavlovice	3,072	-38	+40	*+2*
Vrbice	1,087	-26	+24	*-2*
Total	*8,331*	*-114*	*+297*	*+183*

Source: Czech Statistical Office Prague and authors' own calculations.

warm and dry. The axis of the area is formed by the small river Trkmanka.

The total area is 7,055 ha, which represents a population density of 114 people per km². The macrostructure of land use is shown in *Figure 3*. More than half of the territory is occupied by arable land. The second most common land use is vineyards, followed by gardens and orchards. Forests and permanent grasslands occupy negligible areas in the highest positions, while water areas are minimal. The studied area, thus, represents an unattractive landscape with a minimum of forests, meadows and water areas.

The area is accessible by the road number 421, which connects to the D2 highway Brno-Bratislava. The second transport axis is the local railway line. The village of Bořetice, located roughly in the middle of the studied area *(Photo 1)*, can be reached from the district town of Břeclav by car in 23 minutes, by public transport in 34 minutes and by bike in 106 minutes. It can be reached from the regional centre of Brno in 40 minutes by car, 43 minutes by public transport and in 200 minutes by bike. From Bratislava, the area can be reached in 63 minutes and from Vienna in 86 minutes by car. Within the integrated transport system of the South Moravian region, the entire area is connected by the bus line 551 and the train line S52. The frequency is 31 pairs of connections on working days and 12 pairs of connections on free days. In the vicinity, there are other small towns: Velké Bílovice (12 minutes by car), Podivín (14 minutes) and Hustopeče (15 mi-

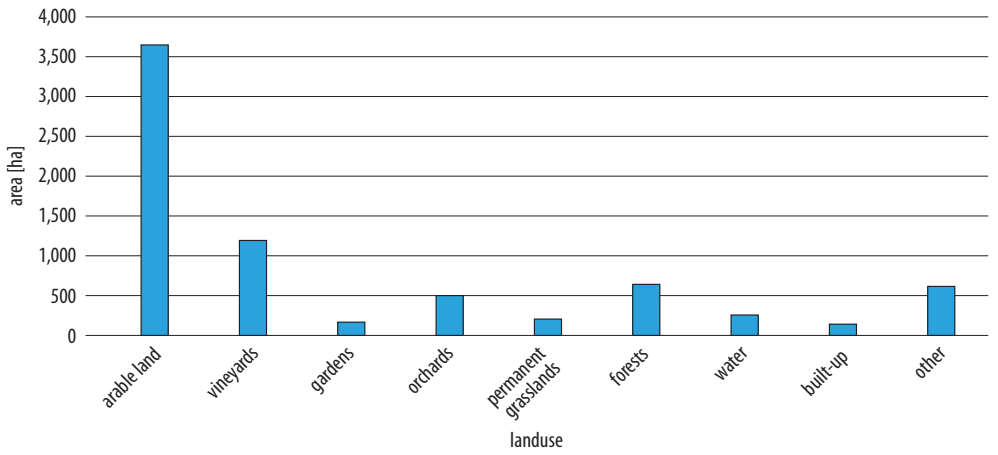

Fig. 3. Land use of the study area, 2024. *Source*: Czech Statistical Office, Prague. Authors' own elaboration.

Photo 1. Hotel Blue Mountains in Bořetice in a rustic style. The flag in the left side is the flag of the Free Federal Republic of Cow hill.

nutes). The last one ensures some administrative functions for the area and has a grammar school and a hospital.

The most important manufacturing companies are Scott Automation Bořetice (custom industrial automation projects), LOMAX Bořetice, (manufacture of metal doors and windows with 80 branches in Czechia and abroad), and PATRIA Kobylí (plastic constructions, building materials). Agriculture is represented by the agricultural cooperatives Velké Pavlovice (plant and animal production), Němčičky (viticulture), and Bořetice (plant production, fattening of broilers). Food processing includes Czech Wineries Velké Pavlovice, and Velké Pavlovice Poultry Plants. There are also about 60 registered wine growers in the area. It can be stated that the microregion is home to companies that process mostly local products but strive for value-added production.

The data show that the studied microregion manages the restructuring of manufacturing industries with problems. Its companies strive for primary production and for the processing of local resources. Individual municipalities have a sufficient population to maintain basic services.

Tourism development

The municipalities have decided to use key ideas to support microregional marketing. In 2008, the municipalities founded a voluntary association called Blue Mountains. The name symbolises the fact that wine production is based mainly on 'blue' varieties (Blaufränkisch, Saint Laurent and Blauer Portugieser). This is an example of terroir tourism (Marlowe, B. and Lee, S. 2018), i.e. a travel destination based on natural conditions for growing grapes in combination with tradition and the art of winemakers.

Although the association's goals are defined as general microregional development, its promotion is strongly focused on the development of tourism. As the microregion does not have significant monuments of historical heritage (perhaps only the baroque church of the Assumption of the Virgin Mary and the Theresian contribution granary in Velké Pavlovice), it based its promotion on viticulture, gastronomy, folklore and on attractions of various types, which have been created at present. These include lookout towers, a sports complex in Němčičky, an ethnographic museum in Kobylí, a salt cave, the Trkmanka eco-centre, the Zahájka biocentre, the Vrbice Peace Cairn and more. *Table 2* summarises the strengths and weaknesses of the microregion in terms of tourism development. Based on the knowledge obtained, we came to the idea of a SO strategy, which consists in using strengths and opportunities to eliminate weaknesses and threats.

Wine culture in South Moravia is often linked to still partially alive folklore.

Table 2. Strengths and weaknesses of the microregion in terms of tourism development

Strengths	Weaknesses
Developed viticulture Satisfactory availability and infrastructure Cooperation	Low natural attractiveness of the landscape Absence of significant architectural monuments
Occasions	Threats
Rising demand for adventure tourism European, national and regional grants	Competition from similar microregions External influences (political, epidemics)

Source: Authors' own elaboration.

Intangible heritage is realised through events (costumed feasts, vintage, open-cellar days, wine and spirit tastings, harvest festivals). The microregion is part of the ethnographic region Hanakian Slovakia, which is represented by typical costumes, wind and dulcimer music and men's dances. Together with other municipalities, the microregion is part of the Hustopeče local action group. The development of wine tourism is one of its priorities.

Physical activities should be part of the tourist offer. The Němčičky sports complex in particular fulfils this role in the Blue Mountains. The curious thing is that it is the lowest Alpine skiing area in Europe, located at an altitude of 180 metres. This activity extended the period of tourism in the Blue Mountains to include the winter season, which is crucial in Czech conditions. However, the area mostly offers opportunities for summer tourism. These are swimming pools, playgrounds and courts for various ball games and a bobsled track with a length of 825 metres. The microregion is interwoven with wine trails, the best-known being the André trail. It is an increasingly popular way of combining physical activity and gastronomic tourism.

The problem with excellent accessibility may be that visitors may prefer one-day visits without an overnight stay. This always means that the financial benefit for local businesses is significantly smaller. This disadvantage is partially offset by the orientation towards wine tourism, where events usually take place until late into the evening, and tourists often prefer to spend the night in the same location. Therefore, the wine cellars also provide the possibility for guests to stay overnight.

In terms of mass tourism facilities, there are 39 collective accommodation facilities in hotels, boarding houses or hostels in the microregion. There were 1,275 beds in 485 rooms in 2023. They accommodated a total of 41,967 guests (5 guests per resident), who spent 79,622 guest nights here. The share of foreigners was 9.3 percent. A large part of the 375 unoccupied flats can also be used to accommodate guests. Therefore, it can be assumed that the total accommodation capacity of the microregion is at least 2,000 beds, and their actual use can be up to twice that of the statistics. These capacities are followed by a number of catering facilities of various types (except the most expensive ones, as the microregion is not aimed at a large clientele). Highly popular are corporate events, such as teambuilding or training, as well as weddings. One of the other impulses may be the reconstruction and creation of a new centre of the largest municipality Velké Pavlovice, which will reflect the Blue Mountains microregion. The construction of the conference centre will support corporate tourism.

A specific urban form is wine cellars, which can occur individually but more often create entire streets or groups. They were originally intended for the production and storage of wine. Today, many of them have acquired commercial and recreational functions, including accommodation. The wine cellars in Bořetice and Vrbice *(Photo 2)*, or the so-called drunk cellars in Velké Pavlovice *(Photo 3)* are famous.

An interesting question is the impact of the coronavirus pandemic on the prosperity of tourism in the area. The first results (Vaishar, A. and Šťastná, M. 2020) suggest that it may not be fatal. Tourism in the microregion is largely

Photo 2. Traditional wine cellars in Vrbice

Photo 3. Wine cellars in Velké Pavlovice. Whereas some cellars reflect the traditional form, others are modern residences with the accommodation function on the second floor. (Photos taken by the authors.)

focused on domestic tourism, which has not been so severely affected. On the contrary, in the summer season 2022, the number of overnight stays increased by 42 percent compared to 2019. In any case, the COVID-19 pandemic can be seen as a challenge to certain changes in the tourism industry (Sigala, M. 2020). Marino, A. and Pariso, P. (2022) assume that wine tourism can help to overcome the COVID-19 pandemic. However, the development of the number of overnight stays over the last three years was 76,992 in 2021, 86,988 in 2022 and 79,622 in 2023. It seems that during the COVID-19 pandemic, interest in domestic accommodation increased, but is now returning to normal.

Within the scope of Destination management of the Lednice-Valtice Area and the Hustopeče Region (Garden of Europe), the Blue Mountains, offering 50 tourist attractions, are one of three recommended destinations. The Blue Mountains Tourist Product (www.modrehory.cz) has been in operation since 2011, and includes a web portal interconnected with an information kiosk in each of the five municipalities with not only a general information but also a range of services and events. This product is in Czech and Polish, which defines the expected range of visitors. Králiková, A. *et al.* (2021) attempted to measure visitor satisfaction, who identified seven key loyalty factors for a sample of the entire Moravian wine region. Namely, the factors include: quality of wine, relaxation, information about wine, natural attractions, friendly acceptance by the locals, wine culture and traditions, as well as vineyard excursion. The Blue Mountains Association focuses on these factors.

When evaluating the success of this activity, we proceed from the fact that the primary goal was not economic profit, but micro-regional development. Therefore, we see success in the stabilization of demographic development, employment and cultural and social life of the micro-region and the improvement of its image. An example is the awarding of the title of Village of the Year 2005 to the municipality of Bořetice. However, it must be admitted that external conditions contributed to the positive development to a certain extent. This is a large increase in immigration from abroad, especially in connection with the war in Ukraine, and measures against the COVID-19 pandemic, which temporarily redirected tourist flows from foreign to domestic tourism.

The fact that this is an initiative of municipalities in cooperation with local entrepreneurs ensures that investments and, thus, profits mostly remain in the region. Direct income of municipalities from accommodation (local fees) is not significant, the benefit is rather overall development.

Free Federal Republic of Kraví hora (Cow hill) as an example

The problem is that the surrounding microregions are in a similar situation. 96 percent of Czech vineyards are concentrated in South Moravia. So the question is how to highlight the studied microregion compared to its neighbours so that it stands up to their competition (Carmichael, B.A. and Senese, D.M. 2012). To promote wine tourism in the microregion the brand marketing approach has been used. The Free Federal Republic of Cow Hill at the cadastre in the village of Bořetice has been established. It is a recessive microstate without permanent residents. Formally, it is a voluntary association.

In November 2000, state officials were elected. At the same time, a Republic was proclaimed. Passports and postage stamps were also issued. On April 2001, the Republic was granted the right to use the emblem and the flag by the Subcommittee on Heraldry and Vexilology of the Chamber of Deputies of the Parliament of the Czech Republic. The Republic has its own constitution and currency, anthem, academy of sciences with the Research Institute for the Fight against Starlings, information service and the like. It is a member of the Moravian Rear Defense Association (MATO) together with other recessive states Wallachian Kingdom and Lacchian Margraviate. The Republic has three consulates

in Czechia and one in Slovakia. (Recessive micro-states do have a head of state, a flag, an anthem, issue money and passports, but they lack the ability to enforce their respect. It is therefore more of a social and cultural phenomenon than a political one. The motivations of the founders vary, it can be a desire to rule something, even a fictitious one, or a joke in a group of friends; but also an ambitious social utopia or a conspiracy on the verge of organized crime. Such communities can be found all over the world and are often tourist attractions. The most known of them, in addition to the three Czech examples mentioned, include the Conch Republic in Florida, the Principality of Hutt River in Australia, Christiania in Copenhagen, Saugeais in eastern France or Liberland on the borders of Serbia and Croatia.)

The Republic consists of three groups of ca. 260 wine cellars (hence it is the federal one). Its mission is to take care of maintaining and improving the quality of local wine and the development of wine tourism. The government of the Republic organizes wine events, excursions to wine regions abroad, recessionary and cultural events. It has its own choir. In order to improve accessibility, an airport for small aircraft and rescue helicopters (code LKANDR) has been set up.

The Free Federal Republic of Kraví hora has existed for more than 20 years. Although, of course, the proclamation of the Republic and its first steps aroused the greatest attention and interest, the Republic still organizes events and has become an integral part of the folklore of South Moravia. The basic factor of success was a good idea and the availability of people who were willing to implement it. The second factor of success is the product, i.e. quality wines, a comprehensive offer, including opportunities for cultural, tourist and sports activities.

The Republic also organizes recessionist events. For example, there was an anti-referendum demanding the stop of the Ferris wheel in Vienna's Prater because it was driving frost into the vineyards of Bořetice, in response to the Austrian referendum on the Czech Temelín nuclear power plant. There was also a referendum on EU accession with a positive result. This type of marketing supports participation, defined as the involvement of local people in activities (McAreavey, R. 2009), which is one of the essential prerequisites for any rural development.

The Free Federal Republic of Kraví hora and the voluntary association of the Blue Mountains municipalities solve one of the biggest problems in the development of Czech tourism, namely the cooperation of municipalities and service providers. Stakeholders have confidence that they will benefit from the joint work.

Discussion

The transformation of the economy in post-socialist states was perceived as a post-socialist or post-communist transformation at the beginning of the 21st century. However, at the same time, structural changes were also taking place, caused by the development of productive forces. Csurgó, B. *et al*. (2018) show, using the example of Hungary, a sharp decline in the importance of agriculture for GDP generation and a simultaneous decline in the number of jobs in this sector. One of the consequences is also a significant differentiation of the countryside and the transformation.

There is not a wide range of possible strategies. Rural microregions close to regional centres and on major transport routes are likely to benefit from their location and cooperate with the centres and with each other, while having to overcome the risk of losing their rural identity. The rural periphery can benefit from a less disturbed environment and attractive landscapes, while having to deal with remoteness, which limits investment and the availability of services. Intermediate regions with intensive agriculture need to restructure their economic base. Developing tourism is one option.

However, the importance of tourism for rural development cannot be overestimated. Hruška and Píša (2019) state that only a few rural locations in the most attractive positions of national parks have experienced

an increase in the number of job opportunities. This is also consistent with our findings, which indicate stabilization of the microregion rather than its growth. However, the question arises whether the goal should be development in quantitative terms. If we were to conclude that quality of life is more important, then stabilization at a certain (perhaps even lower than the current) level could be the right goal. Therefore, the development of tourism brings rather a slowing down of negative developments in a sense of resilience (Heijman, W. *et al*. 2019) and a necessary reorientation of the countryside from a productive to a post-productive economy.

It should not be forgotten that the main goal of tourism development is to improve the quality of life for the local population (Băndoi, A. *et al*. 2020). So what benefits does the development of tourism bring to the local population? It is generally said that these are job opportunities that prevent people from leaving the countryside. However, these job opportunities can create 1–2 percent of the total number of jobs only. Another possible benefit may be tax revenues and fees. Czech municipalities may receive income from recreational fees and income from real estate tax. None of these revenues is (with the exception of very extreme cases) crucial for the municipal budget.

Far more interesting can be the direct profits of business entities, either directly through tourism or through induced activities. However, this assumes that businesses are predominantly local. This seems to be a key issue for the importance of tourism for rural development. The specific financial benefits of these individual local entrepreneurs are, of course, unknown. However, the crucial thing is that these are mostly local entities so the finances stay in the region. However, the activity of municipalities, cooperation (for example within voluntary associations or local action groups) and grant support from the European, national or regional levels are necessary. Another possible benefit is the increase of the general awareness of the region, which may attract other activities or increase the attractiveness of the area for residential preferences.

In the past, the Blue Mountains microregion was part of a fertile region, whose wealth was based on highly fertile soils and a favourable climate. Today, agriculture is no longer a wealth-rich sector competing with other regions, and the local climate is struggling with drought, which is caused by higher evaporation due to rising temperatures.

Nevertheless, our microregion shows quite a successful restructuring. Of course, it can be argued that in our case, wine growing played an important role, which other areas in Czechia do not have. However, we believe that this advantage has been strongly supported by a unifying idea and cooperation. This possibility exists practically everywhere. But it requires ideas and activity. If a specific idea is a leading element of development, it must be systematically developed in the future, otherwise its main meaning will disappear. Maintaining the initial impulses is often a more complex task than their original establishment.

For the sake of completeness, it is necessary to mention the possible negative effects of tourism development. In this case, it is an increased movement of tourists, their means of transport and the associated noise and garbage in sense of overtourism (Butler, R.W. 2020). This may be of particular concern to residents who are not interested in the economic development of the microregion (for example seniors, pensioners). It is a question of the carrying capacity of the territory (Baños-Pino, J.F. *et al*. 2024).

Conclusions

The article tries to use the strengths and opportunities of economic and social transition in the microregion under study to eliminate its weaknesses and possible threats using the place marketing idea in condition of the existing wine culture, relatively easy accessibility (for domestic tourists) and existing cooperation, which is also institutionally anchored. This aim of the study was fulfilled.

From a theoretical point of view, the contribution draws attention to brand marketing in the rural area, which is characterized by a less centralized approach and more horizontal cooperation. Another important aspect – so far little appreciated – is the importance of brand marketing for previously intensively farmed agricultural regions. These regions used to be considered rich and therefore less problematic compared to the peripheries. However, even these regions are going through structural changes and since their attractiveness for tourism is not high, brand marketing is one of the possible solutions.

Although the presented case study discusses the specific use of place branding for rural transformation, we are convinced that the general findings, i.e. the use of a sense of place, original ideas of branding and cooperation between local residents and stakeholders, are applicable in any traditional rural microregion. The condition is the cohesion of rural residents.

The paper attempted to emphasise that the original idea and cooperation of stakeholders in the promotion of the microregion is crucial for the successful development of tourism in a less attractive microregion. The process of restructuring former agricultural or agro-industrial microregions into post-productive regions with a higher share of tourism requires significant endogenous activity. The study can also serve as an example of good practice.

Monitoring this process is an important task for the future. In the near future, an interesting issue will be the resilience of the nascent new economic structure due to the consequences of the COVID-19 pandemic and the anti-pandemic measures. The changing position of the microregion in the process of Europeanisation and globalisation will also be important.

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"Good neighbours are worth their weight in gold" – The role of familiarity on the revisit intention to neighbouring countries

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Abstract

The aim of this study is to narrow down the research gap identified while uncovering the impact mechanism of destination familiarity on the revisit intention to the neighbouring countries. The research, justifies the hypothesis established based on the literature review by placing the analysis in the context of Hungary, located in the heart of East-Central Europe, and its relations with the seven neighbouring countries. In addition to the database of the Hungarian Central Statistical Office on the outbound travels of the Hungarian population, we build on the database of a survey conducted in 2023, with representative sampling, under which 400 Hungarian citizens with outbound travel experience were interviewed. The analysis was executed using simple and multivariate statistical methods. It was concluded that travellers of a non-neighbouring country perceive higher familiarity with the given destination, but it is not affecting more the revisit frequency than it is in a neighbouring country. The results will help to understand the tourist mobility between countries in a particular geopolitical situation due to the storms of history. The study highlights management implication and limitations; moreover, proposes directions for future research.

Keywords: tourism, destination familiarity, revisit intention, neighbourhood, East-Central Europe, Hungary

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Introduction

The establishment and the maintenance of good relations with neighbours is a universal value. Dozens of proverbs, all around the world, highlight that the coexistence with the neighbours affects the quality of life. Social experiences based on visiting neighbours positively influence well-being (Tsai, M.C. 2021). These get-togethers bring significant mental health benefits with relatively little efforts (Breedvelt, J.J. *et al.* 2022). Among the impacts of a change of environment related to tourism, the improvement of the quality of life holds a prominent place (Smith, M.K. and Diekmann, A. 2017). The proximity of the tourist destination and the familiarity associated with it often play a decisive role in travel decisions, and domestic tourism, among other things, is also built on this (Jeuring, J. and Haartsen, T. 2018). National border crossing can strengthen the travellers' awareness of involvement in tourism (Timothy, D.J. 2020). Visiting neighbouring countries often simultaneously provides proximity and familiarity, however, is consciously perceived as international tourism (Verma, T. *et al.* 2019). Just as proximity and familiarity can play a role in maintaining strong relations with the neighbouring residents, these factors may also influence travel to neighbouring countries and the revisit intentions.

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Although distance has played a decisive role in travel decisions since the dawn of tourism, continuous advances in transportation infrastructure have significantly reduced the importance of mere geographical distance in destination choice (McKercher, B. *et al.* 2008). This shift is driven, on the one hand, by technological and technical innovations that have shortened the time required to cover the same physical distance, and on the other hand, by social and economic convergence, which has contributed to a decline in perceived distance (McKercher, B. and Mak, B. 2019). Although proximity in tourism can be interpreted as a rather relative, therefore, a subjective concept, neighbourhood, in the global perspective, covers the countries with common national border that are relatively easy to reach (of course, there are cases where a neighbouring country may be harder to access than a more distant one due to geopolitical and/or infrastructural reasons) (Kozak, M. and Buhalis, D. 2019). The tourism between two neighbouring countries is often characterized by cross-border shopping (Timothy, D.J. 1999), the use of healthcare services (Österle, A. 2009), business-motivated travels (Carvalho, P. *et al.* 2016), gambling (Haucap, J. *et al.* 2023), prostitution (Marttila, A.M. 2008), and visiting friends and relatives (Rogerson, C.M. and Rogerson, J.M. 2019). However, if the countries involved possess attractions that are highly marketable within the international tourism (such as waterfronts, mountains, thermal baths, or World Heritage Sites), proximity can further stimulate mutual tourist flows. Neighbourhood ties, common historical background, cultural (language, religion) similarities can be accompanied by familiarity because of the previous travel experiences gained while visiting each other, which then can catalyse the benefits of proximity and strengthen revisit intention (Brumen, M. *et al.* 2014; Xu, F. *et al.* 2024). At the same time, regional tensions and conflicts, present in many parts of the world, stemming exactly from the poor neighbouring relations, can hinder the development of familiarity and the unfolding of fruitful tourism relations (Țuclea, C.E. *et al.* 2024).

The impact of familiarity on revisit intention to neighbouring countries is a surprisingly under-researched topic in the tourism literature. It is not easy to explain why this important issue has escaped the attention of tourism scholars, especially since the relationship between revisit intention and neighbourhood (Esquivias, M.A. *et al.* 2021; Helal, E.A. *et al*. 2023), as well as between revisit intention and familiarity (Wen, J. and Huang, S. 2019; Shi, H. *et al.* 2022) are examined in relevant studies separately. The topic gains a special context, if it is being examined in a geographical area like East-Central Europe, which, due to the Paris Peace Treaties concluded after World War I and World War II, remains burdened with latent, ethnically rooted tensions up until this day (Tesser, L.M. 2003).

The aim of the present study is to narrow down the research gap, identified while uncovering the impact mechanisms of familiarity on the revisit intention to neighbouring countries sharing a common national border. The study seeks to answer research questions emerging from the literature by placing the analysis in the context of Hungary as the sending country and its neighbouring countries as receiving destinations. In addition to the Hungarian Central Statistical Office's database on the outbound travels of the Hungarian population in 2023, the study is also based on the database of a sampling survey, representative of age, gender, and residence, conducted in late autumn 2023. Within the survey, 400 Hungarian citizens, living in Hungary, having previous international travel experience, and having spent at least one night in a preferred foreign country for tourism purposes during the summer of the given year were interviewed. The primary objective of the research was to answer, how neighbourhood affects familiarity-driven revisit intentions.

Theoretical background

One of the greatest challenges of tourism destination management is to create a tour-

ism product that encourages visitors to return, as beyond the different motivations, personal experience is the main driving force behind revisits (Huang, S. and Hsu, C.H. 2009; Maghrifani, D. *et al.* 2022; Wang, X. *et al.* 2022; Ramos, K. and Cuamea, O. 2023). Consequently, the multifaceted exploration of factors influencing revisit intention carries significant practical value. Satisfaction with the offers of the destination plays a key role not only in the revisits but also in recommending the destination to others (Xu, Y. *et al.* 2010). The revisit intention associated with the satisfaction cannot be considered static, it is dynamically influenced by the travellers' personality traits and sociodemographic characteristics (Agrusa, J. *et al.* 2011; Park, J.Y. and Jang, S. 2014). While Kim, H. *et al.* (2015) highlight that leisure life satisfaction and quality of life can be effective predictors of revisit intention, according to the model of Luna-Cortés, G. *et al.* (2019) perceived social value leads to satisfaction, and satisfaction, in turn, leads to revisit intention and positive word-of-mouth. While destination branding positively and directly affects revisit intention, the mediating role of tourist satisfaction has an indirect effect on returning (Shi, H. *et al.* 2022). In their study on the impact of image on revisit intention, Park, S. and Nicolau, J.L. (2019) found that prior attitudes influence the level of tolerance, thus, also affecting satisfaction and revisit intention. Several studies emphasize that technological innovations (digitalization, smart destinations, etc.) stimulate revisit intention by intensifying visitor experiences (Pai, C.K. *et al.* 2020). Photographs taken and stored on smartphones promote the desire to return to the given destination, through autobiographical memory based on nostalgia (Zhang, X. *et al.* 2021). Studies related to the COVID-19 pandemic have confirmed the importance of risk perception and the pursuit of the security in the traveller's decision to return (Fairuz, R.M. *et al.* 2021; Ahmad, N. *et al.* 2022). Digital nomads represent the transition between the frequent returnees and the second-home buyers (Miocevic, D. 2025).

Familiarity plays a key role in the development of bonding to a destination. Numerous factors contribute to generating familiarity, including influential movies and TV series (The, P.Y. and Goh, H.C. 2016; Kim, S. *et al.* 2009, 2019), social media (Mohd Salim, M.N.H. *et al.* 2024), travel blogs (Tan, W.K. and Chang, Y.G. 2016), the usage of VR technology (Wei, W. *et al.* 2019), behaviours associated with religious practices (Silva, C. *et al.* 2023), storytelling, and tourist narration (Yuan, X. *et al.* 2024). Nevertheless, the factor having the strongest impact is undoubtedly personal experiences (Milman, A. and Pizam, A. 1995; Alam, S.S. 2025). Seo, S. *et al.* (2013) distinguishes the role of experiential and informational familiarity in tourism, with the former being more influential in improving, for example, the image of local food. The connection between bonding and familiarity can also be moderated by factors such as image (Stylidis, D. *et al.* 2020) and authenticity (Scarpi, D. *et al.* 2019). Marinao-Artigas, E. *et al.* (2015) found a link between the mediating role of familiarity in the relationship between cognitive perception, affective evaluation, and destination reputation. Tan, W.K. and Chang, Y.G. (2016) also pointed out that past experience with the destination is necessary for travel blog readers to use their credibility assessment of the article to recommend the destination to others, with place familiarity acting as a moderator. The topic of the link between bonding and familiarity also faces several paradoxes. Phillips, J. *et al.* (2011) showed that even in an unfamiliar environment, older people can develop a sense of place through the aesthetics and usability of the environment as well as through shared memories. Wildish, B. *et al.*'s study (2016) conducted in a youth hostel revealed that even first-time visitors developed a sense of familiarity, likely due to the intense social interactions characteristic of the junior generation (Irimiás, A. 2023).

The study of the role of neighbourhood in tourism has a long history and is approached from multiple perspectives, in which supranational relations receive a prominent role with-

in Europe encompassing through borders, covering a multitude of nations (Grimmeau, J.P. 1980; Leiper, N. 1989; Timothy, D.J. and Saarinen, J. 2013). The exploration of tourism opportunities arising from border connections is also extensive (Stoffelen, A. and Timothy, D.J. 2023). Timothy, D.J. (1995) even interprets the border itself as a tourist attraction. Neighbourhood, especially by using healthcare services and smaller retail offerings (Michalkó, G. *et al.* 2014), stimulates tourism in regions along borders, while VFR tourism, aimed at maintaining social ties based on ethnic connections, also has an impact on it (Provenzano, D. and Baggio, R. 2017).

Tourist flows between neighbouring countries within the European Schengen Area occur without border controls, making cross-border road and rail traffic almost imperceptible (Więckowski, M. and Timothy, D.J. 2021). In the context of inbound tourism to Bulgaria, Korol, O. and Skutar, T. (2019) found that the length of shared borders with neighbouring countries correlates with the number of arrivals from the sending countries. Neighbourhood can also stimulate travel through both geographical (Park, C. *et al.* 2023) and cultural proximity (Irewati, A. and Nufus, H. 2024); moreover, it can be effectively utilized in destination marketing as well (Kozak, M. and Buhalis, 2019). The COVID-19 pandemic highlighted that, as travel restrictions eased, neighbouring countries were prioritized, creating the so-called tourist corridors (Michalkó, G. *et al.* 2022), although, those destinations that were hosts of mass events, were not able to apply this opportunity, even in relation to neighbouring countries (Faris, H. and Griffin, K.A. 2020).

While the relationship between the triad of revisit intention, familiarity, and neighbourhood remains largely unexplored in the tourism literature, there are substantial precedents examining the link between revisit intention and familiarity. Jang, S.S. and Feng, R. (2008) typologized tourists across the novelty–familiarity continuum and developed the concept of Temporal Destination Revisit Behaviour (TDRB), distinguishing three types of tourists: Continuous repeaters, deferred repeaters (tourists whose visits to a destination are occasionally repeated over time), and continuous switchers. Soliman, M. (2021), by extending the model of the Theory of Planned Behaviour (TPB), aimed to predict tourists' revisit intention to Egypt and found that destination familiarity also played a role in returning. Ramesh, V. and Jaunky, V.C. (2021), building on their concept of Intrinsic and Extrinsic Motivation, emphasize that pre-visit behaviour stimulates post-visit behaviour, which influences revisit intention, further moderated by familiarity and satisfaction experienced during the visit. Xu, F. *et al.* (2024), using the Stimulus-Organism-Response and Construal Level theories, distinguish between culturally homologous and non-homologous destinations, finding that travelling to culturally different and immersive experiences is more likely to result in revisits and recommendations. Wen, J. and Huang, S. (2019), studying Chinese cigar tourists travelling to Cuba, found that socialistic nostalgia acts as a pull factor among travel motivations and influences revisit intention, which is also affected by destination familiarity. Kuhzady, S. *et al.* (2020), based on their study among couch surfers travelling to Turkey, concluded that couch surfing improves destination familiarity and revisit intention.

When discussing the triad of revisit intention, familiarity, and neighbourhood, it is essential to evaluate the transformation of distance and its role in tourism. Despite the fact that advances in transport infrastructure have redefined the relationship between travel and distance, the majority of travellers still tend to visit destinations located closer to their residence, while only a smaller share venture to more distant locations (McKercher, B. and Mak, B. 2019). The role of distance in tourism has become highly heterogeneous (Larsen, G.R. 2017), as the traditional physical interpretation has been complemented by institutional (Li, C. *et al.* 2024), psychological (Verma, T. *et al*. 2019), social (Thyne, M. *et al.* 2022), health-related (Dėdelė, A. *et al.* 2020), climatic (Masoudi, M. 2021), and cultural di-

mensions (Yang, Y. *et al*. 2019). The gradual weakening of the classical distance-demand relationship (Crouch, G.I. 1994) has brought renewed attention to the importance of tourist revisit behaviour, as the increasingly accessible and expanding global supply intensifies competition among destinations (Zulfiqar, U. *et al*. 2024). In this context, familiarity grounded in neighbourhood can become a key factor in destination success (González-Rodríguez, M.R. *et al*. 2023).

Hungary provides an extremely appropriate context for investigating the role of familiarity in revisit intention to neighbouring countries, due to its central geographical position and stormy historical background (Liebich, A. 2021; András, E. 2024). For many years, the Hungarian government have been supporting the unique "Without Borders" travel program, aimed for seventh-graders (12–13-year-olds) with nation-building purposes, clearly illustrating the educational and socialization opportunities embedded in cross-border relations, which can serve as catalysts for both familiarity and return (Rátz, T. *et al*. 2020; Molnár, V. 2023). The purchase of real estate in Hungary by foreign citizens living in neighbouring countries may also contribute to strengthening mutual trust based on cross-border connections (Illés, S. and Michalkó, G. 2008). Since trust is partly built on risk reduction, the sense of security plays a key role in encouraging return visits to countries neighbouring Hungary (Kökény, L. *et al*. 2024).

Research methodology

The scientific mission of this paper is to highlight the difference between tourists based on their international travel direction is either a neighbouring country to Hungary or not in case of the relationship between familiarity with a destination and the revisit frequency of the given country. The aim of the research is to measure the positive impact of familiarity on revisit frequency controlling the given country territorial aspect (neighbouring country or not to Hungary). This possible relationship has only been hinted at by a few researchers (Kuhzady, S. *et al*. 2020; Soliman, M. 2021; Irewati, A. and Nufus, H. 2024), but in the context of this study we would like to verify the legitimacy of this approach. With this approach, we hypothesise that those who travel into a neighbouring country to Hungary has higher positive impact of familiarity on revisit frequency than travelling into a non-neighbouring country (H_2). We measured this hypothesized relationship in general for any given country (H_1) without separated it into the two groups (neighbouring and non-neighbouring country). Based on the literature, we also assumed that for those who do not travel from the capital city, familiarity with a destination factor has a greater impact on revisit frequency (H_3). We also assumed a positive correlation in that people who don't live in the capital are more likely to travel to neighbouring countries (H_4). Furthermore, we created a control hypothesis to determine whether it is possible to create a familiarity with a destination factor (H_5). Based on this, the following hypotheses were formulated following the literature review *(Figure 1):*

H_1: There is a positive impact of familiarity with that destination on revisit frequency to the given country.

H_2: Those who travel into a neighbouring country of Hungary has higher positive impact of familiarity on revisit frequency to there than travelling into a non-neighbouring country.

H_3: Those who travel from non-capital city has higher positive impact of familiarity on revisit frequency to there than travelling from the capital city.

H_4: Those who travel from a non-capital city has a positive relationship with who travel into a neighbouring country, thus, a traveller from a non-capital city has higher probability for travelling into a neighbouring country.

H_5: Familiarity with a destination factor can be created.

To test our hypotheses, we conducted a survey using the CATI (Computer-Assisted Telephone Interviewing) method, interviewing a representative sample of 400 individuals in

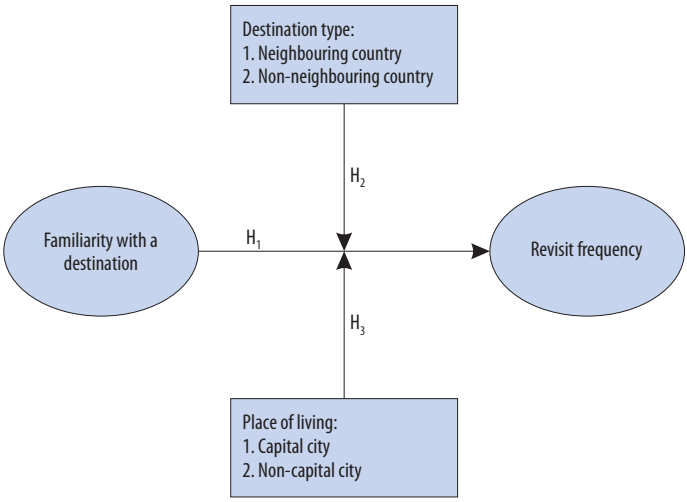

Fig. 1. Hypothesized model used in research methodology. *Source:* Authors' own elaboration.

Hungary. After data cleaning, the final sample consisted of 387 respondents. The survey targeted Hungarian citizens residing in Hungary who had spent at least one night abroad between 2019 and 2023. The key selection criterion was that respondents must have travelled abroad for tourism purpose at least once during the summer of 2023 (between 1 May and 30 September). The survey was conducted in late autumn 2023 and concentrated on this summer travel destination and tourists' behaviour.

For hypothesis testing, we employed quantitative research methods, including Pearson correlation and regression analysis, alongside descriptive statistics. To assess familiarity, we used four validated items from Dayour, F. *et al.* (2019), and mainly Marinao-Artigas, E. *et al.* (2015), which were combined into a single factor through Confirmatory Factor Analysis (CFA) using the Maximum Likelihood method with Promax rotation. Revisit frequency were measured on a continuous scale, and all included variables were standardized for analysis.

We first constructed the Familiarity with a destination factor based on CFA results *(Table 1)*, and we could accept H_5. After standardizing all variables, we performed linear regression analyses to test the hypotheses *(Figure 2)*. The analy-

Table 1. Demographic characteristic of the sample

Variables	Values	Details
Age	Average age, years	46.1 (std. 15.5)
Gender	Female, % Male, %	51.7 48.3
Residence type	Capital city, % County capital city, % City, % Village, %	26.6 19.1 29.7 24.5
Travel frequency between 2019–2023	Average travels quantity	4.6 (std. 1.6)
Revisit frequency between 2019–2023	Average revisits quantity	2.2 (std. 1.3)
Destination type in 2023	Neighbouring country, % Non-neighbouring country, %	35.9 64.1

Source. Compiled by the authors.

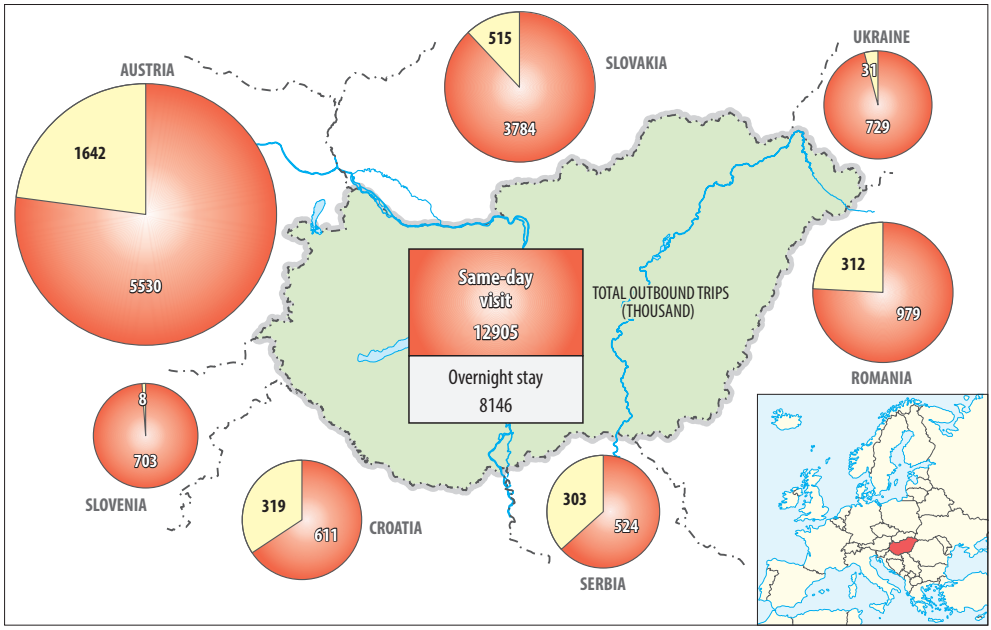

Fig. 2. Features of Hungarian travellers to neighbouring countries, 2023. *Source*: Authors based on the database of Hungarian Central Statistics Office.

sis focused on three key variables: Familiarity with a destination factor, standardized Revisit frequency, and categorical control variables of destination type as it is a neighbouring country of Hungary or not the given country (1 = Yes; 2 = No) and of residence of the respondents, where "1" means the capital city and "2" means a non-capital city.

To obtain a comprehensive understanding of the travel habits of Hungarian society, we utilized data from the Hungarian Central Statistical Office (HCSO). The HCSO conducts a representative quarterly survey on the domestic and international travel patterns of the Hungarian population, providing a reliable dataset for scientific analysis. For the purposes of this study, we focused on international travel undertaken by Hungarian residents in 2023. Specifically, we analysed data on the volume of same-day trips and overnight stays, the main motivations, as well as the distribution of visits to neighbouring versus non-neighbouring countries.

Results

Hungarians' travel to neighbouring countries and beyond

Hungary is among the European states with the highest number of bordering nations. Formerly part of the Austro-Hungarian Monarchy until the Treaty of Trianon in 1920 (a result of the Paris Peace Conference), it now shares frontiers with seven countries in East-Central Europe. Positioned at the crossroads of eastern and western, as well as northern and southern Europe, Hungary maintains good ties with its surrounding states, shaped by significant historical developments in the 20th century. Prior to the redrawing of borders in 1920, its territory encompassed different sizes areas of what are now neighbouring nations (Kovács, Z. 1989; Kocsis, K. and Váradi, M.M. 2016). The collective memory of territorial loss following the post-war agreements remains deeply rooted in na-

tional identity (Ilg, B. 2021). Although often subtle, ethnic tensions continue to influence Hungary's interactions with neighbouring countries which may affects also tourism (Csapó, J. *et al.* 2019; Rátz, T. *et al.* 2020).

According to database of HCSO in 2023, Hungary's population of approximately 10 million undertook a total of 21.05 million international trips, indicating that, on average, each resident crossed the national border twice. Of these journeys, 61.3 percent were completed within a one day, with travellers returning to Hungary within 24 hours. The same-day excursions were directed toward neighbouring states (99.6%). Notably, 80.4 percent of visits to adjacent countries fell into the same-day travel category. Among those who travelled to bordering nations less than 24 hours, 45 percent chose Austria and 27 percent visited Slovakia. These two destinations accounted for 72 percent of all short-term outbound travel (see *Figure 2*). Day trips to neighbouring countries were predominantly motivated by cross-border shopping (35.8%), employment-related purposes (24.5%) and visiting friends and relatives (14.4%). A 24.0 percent of all outbound travels by Hungarians were beyond neighbouring countries, 99.1 percent of which were overnight stay. Surprisingly, 49.9 percent of trips with a stay of more than 24 hours in Austria are employment-related. VFR motivation during trips with an overnight stay is very strong in Serbia (65.3%), Slovakia (46.4%) and Romania (32.1%).

The final representative sample was 387 people. *Table 1* summarizes the details of the final sample.

Factor analysis

Familiarity with a destination factor was measured using the validated scale of Dayour, F. *et al*. (2019) and Marinao-Artigas, E. *et al.* (2015) with four statements on a Likert scale of 1–7 *(Table 2*), where a value of „1" meant strongly disagree and a value of „7" meant strongly agree. The KMO indicator then took the correct value of 0.706 and the Bartlett test for sphericity and significance yielded significant results. The explained coefficient of variance of the four variables was 53.9 percent, Cronbach's alpha was 0.711, while each factor weight exceeded the minimum value of 0.6 as it is required (Hair, J.F. *et al.* 2019).

Hypothesis testing

First, we checked the basic differences between revisit frequency and familiarity with a destination factor values based on control variable (destination type and residence) with ANOVA-test *(Table 3).* Here it can be seen that a neigh-

Table 2. Familiarity with a destination factor

Items by Dayour, F. *et al*. (2019), and Marinao Artigas, E. *et al.* (2015)	Factor weights	Means	Std. dev.	Explained variance, %	KMO value	Cronbach's alpha
This travel destination is very familiar to me.	0.675	6.0	1.1	53.9	0.706	0.711
I know this travel destination very well, because I follow the events there all year round.	0.809	4.5	1.7			
I also follow the events, developments and happenings at the travel destination outside of my stay there.	0.752	4.5	1.7			
My friends and family tell me that this travel location suits me well.	0.693	5.4	1.3			

Source. Compiled by the authors.

Table 3. ANOVA-test results

Country, city	Revisit frequency	Familiar factor
Neighbouring country	2.53 (std. 1.43)	-0.192
Non-neighbouring country	2.07 (std. 1.26)	0.108
p-value	0.001	0.004
Capital city	2.13 (std. 1.43)	0.041
Non-capital city	2.27 (std. 1.30)	-0.015
p-value	0.335	0.626

Source. Compiled by the authors.

bouring travel destination country has significantly higher average of revisit frequency (2.53 vs. 2.07) with moderate eta square explanation value (eta^2 value is 0.167). After it can be stated that the familiarity with a destination is significantly higher in a non-neighbouring country of Hungary with a moderate eta square explanation value (eta^2 value is 0.144). These differences are moderate but significant, which it could be counted for the regression model. Although, the residence does not have any significant difference neither in revisit frequency nor the familiarity factor.

Finally, we created a regression model with four different variables *(Figure 3).* The model has no multi-collinearity (VIF = 1.14), adjusted R-square of the model is 0.51, Durbin-Watson test is well operated with 1.631 value, the model is significant (F-test is significant with 0.001 p-value and 17.482 test value), there is normality based on residuals, and the variance of the errors are constant, which means homoscedasticity.

We can accept first, second and third hypotheses too. In the first hypothesis, there is a significant relationship between familiarity with a destination and revisit frequency, which means that if a traveller feels higher familiarity with a destination it increases the revisit frequency (0.201***). In the second hypothesis, there is a significant difference in the relationships between familiarity with a destination and revisit frequency based on the control variable, destination type (1st group: 0.283***; 2nd group: 0.189***). We could accept the second hypothesis because there is a significantly higher positive relationship between the two measured items in case of neighbouring country. Which means that in case of neighbouring country it could count more the familiarity with the destination to increase the revisit frequency than in a non-neighbouring country.

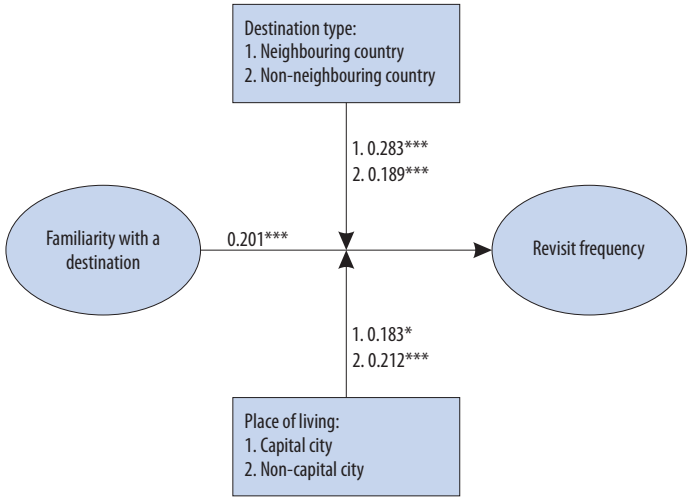

Fig. 3. Hypothesis testing results. *p-value < 0.05; ***p-value < 0.001. *Source:* Authors' own elaboration.

Although this result causes that there is also an increasing effect of familiarity on revisit frequency in case of non-neighbouring country, but lower than in a neighbouring country. Meanwhile, travellers of non-neighbouring countries perceive higher familiarity with the destination. Since, it can be stated that travellers of a non-neighbouring country perceive higher familiarity with the given destination but it is not affecting more the revisit frequency than it is in a neighbouring country. In other words, familiarity is a stronger determinant for a revisit to a neighbouring country than for a non-neighbouring one. In a non-neighbouring country other factors besides familiarity may be even stronger.

In the third hypothesis, there is a significant difference in the relationships between familiarity with a destination and revisit frequency based on the control variable, residence, but in case of the capital city it is slightly significant (1st group: 0.183*; 2nd group: 0.212***). This means that those who travel from a non-capital city familiarity with a destination has a higher positive impact on revisit frequency than in case of a traveller from the capital city. Although it does not mean that those travelling to neighbouring countries are those who do not live in the capital city. Furthermore, it cannot be said that residents outside the capital city revisit the same destination more often, as these results were not significant.

Finally, we cannot accept the fourth hypothesis, because with a chi-square test we cannot find any significant relationship between the two control variables (neighbouring or non-neighbouring country type and capital city or not) (p-value is 0.094, chi-square value is 2.812).

Discussion and conclusions

The present study, by recognizing five hypotheses based on the literature is the first to prove, that neighbourhood plays an influential role in familiarity-related revisit intention. The factors building the relationship between familiarity and revisit intention have already been explored in previous research including the identification of infrastructural and technological (Pai, C.K. *et al.* 2020), linguistic and cultural (Brumen, M. *et al.* 2014; Xu, F. *et al.* 2024), and perceived similarities within the service environment (Timothy, D.J. 1999; Frischhut, M. and Levaggi, R. 2024) – all of which can be moderated by various elements, including social media (Luna-Cortés, G. *et al.* 2019). Earlier studies have also pointed out that, the increasingly differentiated tourism demand, the relationship between familiarity and revisit intention are not linear (Øgaard, T. *et al.* 2019; Mathur, G. *et al.* 2023).

Although being plausible, the role of neighbourhood-related familiarity in shaping international travel decisions – specifically revisit intention – has largely escaped scholarly attention. This is particularly surprising given that the role of neighbourhood, often interpreted by researchers as geographical proximity, has been recognized in domestic tourism. Scarpi, D. *et al.* (2019), for instance, emphasized the mediating role of place attachment by studying the visitors to Rome vicinity. Similarity derived from neighbourhood can influence return visits both positively and negatively, as it may evoke attraction as well as aversion (Bar-Kołelis, D. and Wendt, J.A. 2018; Kazakova, A. and Kim, I. 2021). Along artificially drawn borders, it is common to find communities with shared historical backgrounds, linguistic and cultural roots, and even familial ties. In such cases, that familiarity can foster the trust and sense of security essential for travel – while at the same time it offers little novelty (Stoffelen, A. and Timothy, D.J. 2023). Politics can also alter perceptions of familiarity between neighbouring countries, transforming it into stereotype-based hostility that inhibits travel (Gelbman, A. and Timothy, D.J. 2010; Narbut, N.P. and Trotsuk, I.V. 2017).

The cross-border travel patterns of the Hungarian population confirm that familiarity driven revisit intention, beyond the previously identified control variables, can also be influenced by neighbourhood. Analysing

the source market, it can be stated that the Hungarian capital, Budapest's central location appears to play a less significant role in repeat visits driven by familiarity than the mobility patterns observed among tourists from rural areas of Hungary. Although the role of familiarity is higher in the case of travel to non-neighbouring countries, it has a stronger effect on revisit intention in relation to neighbouring countries. This apparent paradox can be explained, on the one hand, by Hungary's historical past and territorial changes being carried out in the 20th century (all seven neighbouring countries are home to Hungarian-speaking minorities of varying size, which explains VFR tourism), and on the other hand, by European integration process, materialized in the 21st century (Hungary's accession to the EU and the Schengen Area, which facilitates shopping tourism and cross-border commuting for work). Naturally, the influence of the so-called 'post-socialist mindset' cannot be overlooked (Holleran, M. 2015). While it may be most apparent in the travel decisions of the older generation, processes of socialization suggest that its effects may also surface among middle-class and younger cohorts (Irimiás, A. 2023).

Risk perception receives a special attention within the narrow intersection of studies contextualizing tourism and its geopolitical relations (Cohen, S.B. 2020; Seyfi, S. *et al.* 2023). Neighbourhood-related familiarity accordingly could positively influence this safety and security factor (Kazakova, A. and Kim, I. 2021). It is the task of scholars examining tourism from a transdisciplinary perspective to recognize the challenges generated by the symbiosis of space and time (geography and history) affecting travel and to identify best practices in geopolitical model regions like East-Central Europe, which may offer solutions applicable to different regions (Gillen, J. 2024). Should the effect of neighbourhood-induced familiarity on revisit intention gain recognition in international tourism practice, it could contribute to reducing tourism's negative impacts on sustainability (Domínguez, J.A. *et al.* 2015; Dornier, R. and Mauri, C. 2018).

The main theoretical contribution of the present study lies in expanding the existing scientific discourse on the impact mechanisms of familiarity on revisit intention by introducing the neighbourhood factor as a control variable. In addition, it contributes to the broader discussion on the interpretation of distance in tourism by drawing attention to a previously underexplored component of the mechanisms shaping perceived distance (McKercher, B. and Mak, B. 2019). The research findings are highly applicable for national and regional destination management organizations: the former can build on similarities and geographical proximity, while the latter can leverage synergies arising from borderland locations. The validity of the results is supported by the representativeness of the sample emerging from the survey and the reliability of the HCSO database. However, the study also has several limitations, most notably its focus on the relation of Hungary and its neighbouring countries, and the lack of broader international comparison. Future research directions include, first, exploring the expanding functions of travel to neighbouring countries in the context of the changing nature of tourism (e.g. strengthening competitiveness, integrating peaceful coexistence into value propositions); and second, further refining the historical context mentioned in several studies (Kozak, M. and Buhalis, D. 2019; Park, C. *et al.* 2023).

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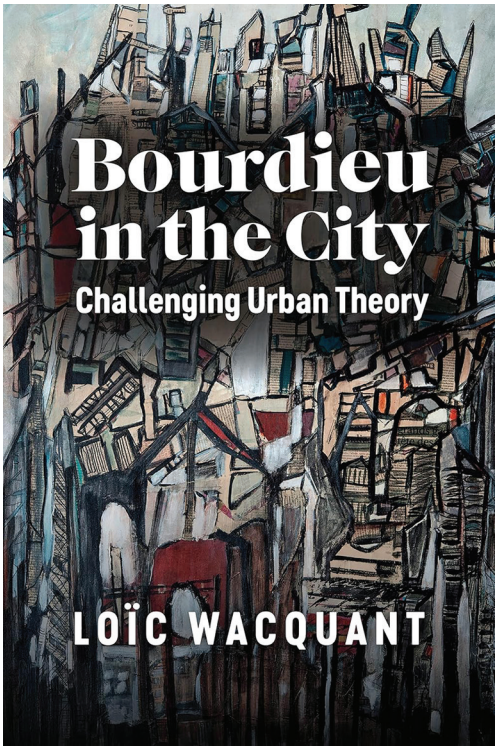
BOOK REVIEW SECTION

Wacquant, L.: Bourdieu in the City: Challenging Urban Theory. Cambridge, Polity Press, 2023. 230 p.

This review pursues a dual purpose. On the one hand, in a rather conventional manner, it introduces the structure and central arguments of Loïc Wacquant's book, as well as its strengths and shortcomings. On the other hand, however, it also ventures somewhat beyond the usual remit of book reviews by illustrating the conceptual apparatus of the volume with examples drawn from a specific urban realm: the world of *urban subcultures*. These examples are intended to assist the reader in grasping Wacquant's concepts and arguments – and, more broadly, the contours of his entire neo-Bourdieusian programme.

To begin with, "*Bourdieu in the City: Challenging Urban Theory*" offers nothing less than a Bourdieu-inspired refoundation of the whole field of urban theory. To that end, the author presents a compelling reinterpretation of Pierre Bourdieu's sociological concepts, positioning them as vital tools for understanding the complexities of urban life. It is argued that although Bourdieu did not *explicitly* focus on urban studies, his theories still offer profound insights into the dynamics of contemporary cities. Wacquant undertakes the ambitious task of pivoting urban theory away from siloed approaches, for instance from "urban science"/big-data universalism or various "culture-only" or "economics-only" lenses. Instead of these, as the core analytic compass for studying cities, he proposes a *trialectic of spaces*. In order to show how cities are made and remade through struggles over classification, capital, and territory, he aims to braid together (1) *symbolic space* (classifications and categories), (2) *social space* (distribution of various capitals), and (3) *physical space* (the built environment). If the reviewer may be permitted a truly personal remark at this point, he is himself an avowed admirer of Henri Lefebvre and Edward Soja – and, thus, found it an intellectually particularly challenging task to come to terms with the fact that the trialectic discussed in this volume is *not the same* as the well-known trialectic elaborated by Lefebvre (and subsequently by Soja). That said, it proved highly valuable for the reviewer to set aside, at least temporarily, *one kind* of trialectical thinking in which he has long found himself almost ensnared (having employed in a number of earlier works [Berki, M. 2012, 2015, 2017]), and – through deliberate intellectual effort – to inhabit *another kind* of trialectical reasoning. It is always stimulating to approach the same problems and research questions from different vantage points and within alternative conceptual frames – as the reviewer sought to do while engaging with Wacquant's book.



Regarding the structure of the volume, the *Prologue* maps the previously mentioned "siloed" (fragmented) state of current urban studies, and argues that Bourdieu's relational, multi-scalar sociology can coherently link macro-structures (state, markets), meso-level institutions (policy, academia, journalism, etc.), and micro-level interactions, practices in the city (embodied dispositions/habitus). Chapter 1 reconstructs "*Bourdieu in the city*", i.e. his engagement with urban questions, showing how his early work (e.g. in Algeria) and later concepts (field, habitus, capital, symbolic power) yield a city-sensitive sociology that treats urban space as a generative arena where power is produced, con-

tested, and reproduced. Here, cities are understood as sites where varied capitals accumulate and collide, and where symbolic power (naming, ranking, stigmatising, etc.) reorganises social and physical space. Chapter 2 then synthesises Wacquant's longstanding programme on territorial stigmatisation, showing how stigma is fabricated, disseminated, and enacted across symbolic, social, and physical space (as illustrated through cases like the reinforcing cycles of poverty in Paris's Red Belt). This chapter also presents a topology of "territorial taint" – demonstrating how the marking of places as "tainted" travels through media, policy, policing, and everyday categorisation to produce material consequences across the city, not just within the targeted neighbourhoods. Following that, Chapter 3 braids class, ethnicity, and penalty into a single analytic triad, arguing that the late-20th–early-21st century metropolis must be read through their intricate interlinkages (e.g. the ghetto/banlieue and the carceral state *together*). Here, Wacquant recasts his own prior work, showing how marginality and neoliberal governance (including the "penal state") crystallise in urban space. Finally, the Epilogue pushes a redefinition of "the urban" itself – according to the author, all urban boundaries are porous and historically contingent, and the city is a strategic stake and a site of struggle where habitus and capital are continuously composed, contested, and converted. Across the entire book, Wacquant advances a methodological ethos, too (often tagged to his "carnal sociology"): a reflexive, comparative, and multi-temporal practice that is able to range along levels of abstraction without losing empirical grip. Ultimately, his programmatic vision is a Bourdieusian, relational topology that is not just an addition to the existing urban canon but a real challenge to it, intended to reorient how we build and test urban theory.

Given the ambition of Loïc Wacquant's book (and his programme in general), it is hardly surprising that several scholars have already recognised "*Bourdieu in the City* (…)" as a significant contribution to urban theory (see d'Assenza-David, H. 2023; Ivanova, A. 2024; Kirmizi, M. 2024; Richardson, A. 2024; Wright, J.T. 2024). While it is mostly praised for its innovative application of Bourdieu's theories to urban contexts and for providing a comprehensive framework that bridges macro-level structures with micro-level interactions, certain reviews also draw attention to some of its shortcomings. The perceived weaknesses are centred around four major nodes: (1) a selective engagement with urban theory, (2) a high barrier to entry for non-Bourdieu specialists, (3) a rather limited empirical case material, and (4) potential redundancy with Wacquant's earlier works. These criticisms may be summarised as follows. (1) While the author makes a compelling case for the urban pertinence of Bourdieu's sociology, he tends to selectively engage with the broader canon of urban theory. The book positions Bourdieu's framework *in opposition* to paradigms like assemblage theory, planetary urbanism, or actor-network theory, and often critiques these in a somewhat strawman fashion, without always giving them their due complexity or acknowledging areas of complementarity. For some readers, this may slightly weaken the book's claim to being a "challenge to the canon" rather than a valuable *addition to it*. (2) Furthermore, the book assumes substantial familiarity with Bourdieu's prior work, potentially posing challenges for newcomers to his theories. Even key Bourdieusian concepts (such as habitus, field, symbolic power, capital forms) are not always explained accessibly for readers completely new to these ideas. According to the reviewer, this makes it less pedagogically effective for a general urban studies audience or especially graduate students approaching Bourdieu for the very first time. (3) Additionally, although Wacquant discusses a range of urban milieux (e.g. the American ghetto, French banlieues, or Latin American urban margins), "*Bourdieu in the City*" remains overwhelmingly a theoretical and epistemological treatise. Some readers might expect richer, more varied empirical vignettes to demonstrate how the trialectic operates in diverse urban settings, which limits the book's immediate applicability for empirical urban researchers looking for methodological guidance. (4) Finally, as another observation, much of the theoretical groundwork and key concepts (territorial stigmatisation, advanced marginality, carceral urbanism, etc.) were already developed in Wacquant's earlier works (including "*Urban Outcasts*", "*Punishing the Poor*", and "*Deadly Symbiosis*"). As such, parts of this volume risk retreading ground already familiar to Wacquant readers.

Nonetheless, if the book is read more like *a synthesis* (rather than as an original advance), then its genuinely synthetic power (i.e. its conceptual clarity, integrative approach, and multi-scalar sensibility) must certainly be acknowledged. The trialectic of symbolic–social–physical space gives researchers a portable but rigorous way to connect multi-scalar processes (from state and markets to everyday practices) without lapsing into either abstract systemism or micro-only accounts. Furthermore, by situating his earlier studies within a single "analytic cartography", Wacquant models the reflexive research posture he advocates and offers readers an actionable research agenda rather than a purely exegetical tour of Bourdieu. Additionally, his reconceptualising of "the urban", i.e. the reframing of the city as a fluid, contested site and stake – rather than a fixed container – has strong heuristic value for empirical projects that must cross administrative or morphological boundaries. Finally, the author's programmatic ambition is coupled with methodological guidance as well: he does not only "add Bourdieu to the canon" but also shows how to use Bourdieu for ur-

ban research (fields, capital, habitus, symbolic power) and why a topological, relational lens matters for case comparison and theory cumulation. Given all these merits, "*Bourdieu in the City: Challenging Urban Theory*" is strongly recommended to scholars across all disciplines engaged in the study of cities – including, of course, *geographers*. Additionally, although the book does not engage with Central and Eastern Europe (or other post-socialist contexts) at all, it nonetheless carries particular relevance for scholars working in/on CEE settings too, including Hungary. In the wake of the post-1989 politico-economic transformations, cities of this region have experienced intensifying uneven development, often accompanied by marginalisation and territorial stigmatisation, making them apt testing grounds for the Bourdieusian trialectic that Wacquant advances. Hence, the volume is highly recommended for *Central and Eastern European* urban scholars as well.

As it was indicated at the outset, in the second part of this review the book's main arguments are considered through the lens of *urban subcultures*, with its key concepts illustrated by examples drawn from these realms – so that a more nuanced understanding of the work of Wacquant (and, more broadly, of Bourdieu) may hopefully be facilitated.

Although these topics are not discussed in the book, "*Bourdieu in the City* (…)" offers an excellent conceptual apparatus for theorising urban subcultures. To start with, Wacquant's *trialectic of spaces* provides a promising framework for analysing how subcultural appropriations of space both reflect and contest broader urban power relations and symbolic hierarchies. (1) Speaking of *symbolic space*, urban subcultures construct alternative cognitive and aesthetic categories (of what is cool, valuable, sacred, or deviant, criminal, etc.) that challenge mainstream symbolic structures. (2) Regarding *social space*, subcultures represent distinctive positions within the broader social space of the city, often emerging from marginalised or intermediary positions in terms of economic, cultural, and social capital. (3) At the same time, in *physical space*, subcultures also appropriate, mark, and contest actual urban loci (such as squats, skate parks, underpasses, clubs, record shops, graffiti walls, or underground venues), often transforming the meaning of marginal or disused spaces. As examples, graffiti crews, hardcore/punk scenes, or underground techno acts not only use space but also re-symbolise it – as a result of which, an abandoned warehouse becomes a venue, a bare wall a canvas, and a street corner a meeting point of cultural capital. An actual location, e.g. a hardcore/punk squat is therefore at once a physical site (a space reclaimed), a social space (organised through networks of trust, DIY capital, and activist links), and a symbolic space (often stigmatised by authorities as deviant, while celebrated by scenesters as authentic).

In addition to the trialectic of spaces, the *question of capitals* is also highly relevant for the study of urban subcultures – let it be the accumulation/contest of different kinds of capitals; the conversion of capitals within subcultures; or the identification of a specifically subcultural capital (Thornton, S. 1995). Building on Bourdieu's concepts, Wacquant repositions the city as a site for the accumulation, diversification, and contestation of capitals. In a subcultural sense, knowing riffs, graffiti styles or the local slang can be understood as *cultural capital*; networks of promoters, zinesters or bandmates as *social capital*; whereas credibility or authenticity as *symbolic capital*. These can also convert into each other, e.g. when symbolic "cred" helps an underground band get shows, resulting in limited economic capital as well, which is in turn invested into social activism by the band members. Furthermore, urban subcultures also constitute prime examples of groups contesting the legitimacy of dominant capitals (economic capital, conventional [institutional] cultural capital), and instead of those, valorising alternative forms (such as street cred, reputation, authenticity – i.e. subcultural capital). In Sarah Thornton's classic "*Club Cultures*" (1995), subcultural capital determines *status* within rave scenes – a form of capital that is unrecognised in mainstream fields but pivotal within subcultural fields. The same can be observed across virtually all urban subcultures, whether it is the knowledge of rare records in hip-hop DJ culture or the pursuit of authenticity in punk.

One of Wacquant's strongest concepts is *territorial stigmatisation*, convincingly demonstrating how entire districts get marked as "dangerous" or even "degenerate". Over time, however, the negative symbolic capital acquired by these deprived neighbourhoods, red-light districts, industrial peripheries, etc. might generate alternative habitus as well, in order to cope with, or even invert, their stigma. And this is why many urban subcultures were born in precisely these kinds of milieux: in South Bronx, the Lower East Side, Kreuzberg, or Belleville, MI, a western suburb of Detroit – creatively reworking these territorial meanings and turning stigmatised spaces into cultural resources. Youth scenes and their places that are labelled by the authorities, the media, etc. as a "druggy punk area" or a "gangsta rap block" might be considered by the members of the respective subcultures as "underground", "real", or "resistant" hoods. According to Wacquant, the city can be understood as a crucible of *habitus proliferation* (see also in Wacquant, L. 2022). He argues that the metropolis is especially distinctive because it fosters both the multiplication of diverse habitus and the collision of incongruent dispositions. For subcultures, this is key: hardcore/punk, rap, graffiti, parkour, etc., can all be read as specific microcosms born from this urban "ferment", where heterogeneous social backgrounds meet and generate

new doxai (local logics, values, etc.). Subcultures truly thrive in this crucible, as they are the products of both disjuncture (youth disaffection, migration, inequality, etc.) *and* creative responses (new practices, aesthetics, solidarities, etc.). Therefore, urban subcultures should also be studied as "distinct doxai" (i.e. pluralised truth regimes, micro-worldviews) that emerge out of urban diversity and inequality, in several instances in deeply stigmatised neighbourhoods. Here, territorial stigmatisation not only constrains possibilities (through policing or public vilification) but also fuels the symbolic capital of "authenticity".

Stakes and struggles over *classification* is another central node of "*Bourdieu in the City* (…)". Wacquant stresses the symbolic power to classify: in our case, who defines what counts as "music", "visual arts", "performative arts", etc.? Urban subcultures are paradigmatic arenas of these classification struggles. Police officers may classify an illegal rave or an open-air rap battle as "public nuisance," while participants frame it as cultural expression – likewise, while authorities initially considered graffiti as mere "vandalism" (and, thus, criminalised it), certain art institutions later re-classified it as "street art," completely shifting its social and economic value. This resonates with the author's insistence that urban research must track how categories themselves reshape the city. Additionally, just to make it even more complex, Wacquant's long-standing interest in classification also involves *sociological classification*. With a decent level of reflexivity and the so-called "double move", he insists that urban sociology must both demarcate (build objective maps of positions) and repatriate (bring back the agents' own categories and perceptions). When applying this to urban subcultures, researchers should not only map the subcultural actors' positions in social space (e.g. marginal youth with low economic capital but high cultural capital) but also take seriously their own categories of self-description (such as DIY, underground, "real", etc.). Keeping both in mind might bridge the gap between structural analysis and phenomenology – exactly what subcultural studies are often struggling with. And finally, the *multi-scalar perspective* propagated in the book is also more than relevant for the study of urban subcultures, since they are never purely local – on the very contrary, via international DIY circuits, record labels, streaming platforms, etc., they connect across geographical scales.

To sum up, it can be argued that Wacquant's neo-Bourdieusian programme can be fruitfully extended to explore the hidden realm of urban subcultures. The reviewer strongly hopes that these subcultural examples have demonstrated the portability of Wacquant's framework – and encourage readers to reflect on their own research topics and questions through the lens of Loïc Wacquant's "urbanised Bourdieusian" agenda.

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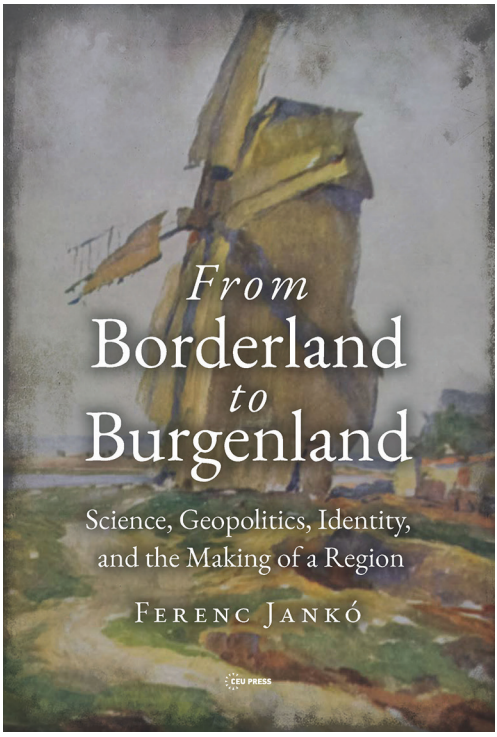
Jankó, F.: From Borderland to Burgenland. Science, Geopolitics, Identity, and the Making of a Region. Budapest, CEU Press, 2024. 381 p.

In recent years, historical research has shown a significant increase in interest in the relationship between spaces and the formation of identity (Guldin, R. 2014; Hanisch, E. 2019; Withers, C. 2001; Etzemüller, T. 2022; Renes, H. 2022). At the same time, approaches and perspectives have changed and multiplied. Spaces, regions and landscapes are no longer regarded as given entities but as constructed ones—shaped through discourses, narratives, and everyday social and cultural practices (Werlen, B. 2009; Ermann, U. *et al* 2022). The shift allows us to trace how boundaries were drawn and specific spatial identities were defined and collectively imagined, leading to the formation of a concept of "our" territory. Linking questions of regional and national identity formation with inquiries into the production, circulation, and sharing of spatial knowledge by communities also opens up new insights into nation-building processes (Miller, N. 2022).

In his book, Ferenc Jankó explores this issue through the example of the Austrian province of Burgenland. This predominantly German-speaking region belonged to the Hungarian half of the Habsburg Monarchy until the end of the First World War. Under the Treaty of Trianon (1920), Hungary was obliged to cede what was then known as *German-West Hungary* to the new Republic of Austria. In 1921, the territorial acquisition was completed, and the new province received its present name by the Federal Constitutional Law of 25 January 1921. After the Second World War, the border with Hungary became part of the Iron Curtain, bringing all contact and cooperation to a halt. Only after 1989 – and especially following the accession of Austria and Hungary to the European Union – did perceptions of Burgenland change once again.



Jankó's book investigates the complex process of Burgenland's creation after the First World War and examines the scientific, political, and social transformations that led to its incorporation into Austria. While the focus lies on the interwar period, the book also considers the era of the Habsburg Monarchy and the post-1945 period as pre- and post-histories. From the outset, the concept of the "borderland" is used as a key metaphor to describe the intricate interactions between different national and cultural identities. Building on this, the author analyses how the image of Burgenland evolved – from a peripheral and supposedly backward border region into an area that came to symbolise unity and modernisation.

The book is divided into eight chapters, each approaching the topic from a different perspective.

Initially, the *first chapter* outlines the author's methodological and theoretical framework, presenting Burgenland as a "geographical project" shaped by experts who, through mapping, classification, and description, contributed to its identity formation. Jankó asks how Burgenland was "discovered" and "made" as a region through scientific and geopolitical discourses. Drawing together recent debates from the histories of geography, science, and culture, he weaves them into a coherent interpretation that situates the making of Burgenland within broader European transformations.

Subsequently, the *second chapter* examines the region's prehistory within the Habsburg Monarchy, which had often been romanticised as a frontier between the Austrian (*Cisleithanian*) and Hungarian (*Transleithanian*) halves of the empire. Here, the author compares the narratives produced on both sides, showing how each used geographical and symbolic descriptions to claim the region within contrasting territorial imaginaries. Both sides relied on historical analogies and idealised images of belonging and national identity to underpin their competing claims.

Thereafter, the *third chapter* explores the relationship between ethnographic documentation and po-

litical-territorial claims. This multifaceted discussion analyses the active construction of the region through scientific practice and symbolic labour. A wide array of actors – geographers, historians, ethnographers, statisticians, teachers, engineers, lawyers, and artists –are drawn into view, all operating from different professional and social positions and with varying motivations. These predominantly Austrian knowledge producers are portrayed as both the "discoverers" and "inventors" of Burgenland. Jankó convincingly demonstrates that geographical knowledge is not a neutral description of space but a social construct – a product of specific actors, their professional roles, and the political discourses of their time. Their research and publications contributed to the perception of Burgenland as a "natural" border region. Special attention is given to the work of geographers and their mapping projects, which spanned from the annexation by Austria to the reconfiguration of the area as a *Greater German* borderland under Nazi rule.

Meanwhile, the *fourth chapter* analyses the interconnections between emerging geographical discourses and German-national geopolitical interests. Burgenland was construed as part of a broader German-speaking "borderland" strategy aligned with National Socialist conceptions of space and nation. Reading these narratives against the grain, Jankó reveals how geographical discourses were constructed, mediated, and disseminated through coordinated texts, images, and maps – turning them into powerful tools of political imagination with tangible effects on local life.

In the following *fifth chapter*, the author turns to tourism and *Heimatkunde* (local heritage studies) as cultural instruments of regional identity formation. In the 1920s, Burgenland was increasingly presented as an idyllic and unspoiled *Heimat* – an idealised homeland that countered the political tensions of the time and fostered a positive sense of belonging. The author shows how popular texts, images, and symbols contributed to consolidating a regional identity that depicted Burgenland as a land of fertility, peace, and harmony.

Subsequently, the *sixth chapter* examines the concept of the "borderland" and its different meanings in German-speaking and Hungarian scholarly and political contexts. Jankó traces how Austrian, German, and Hungarian actors used the term with distinct ideological connotations. During the interwar years and the period of Nazi expansion, Burgenland was conceptualised as a geopolitical buffer zone situated between competing national and cultural spheres. The notion of the borderland, thus, emerged as a central political and cultural construct linking various, often contradictory narratives.

Later, the *seventh chapter* shifts focus to the everyday lives of Burgenland's inhabitants and the social transformations resulting from the region's border status. Beyond political and scholarly discourses, the author examines the lived experiences of rural populations in an unstable frontier environment. Migration, mobility, and infrastructural change profoundly shaped local life. Particularly illuminating is Jankó 's analysis of architecture, housing, and settlement patterns, which were deeply influenced by geopolitical shifts and social upheavals. Questions of migration and encounters between ethnic groups are treated as central, illustrating the practical implications of geographical and political transformations.

Ultimately, in the *final chapter*, the author summarises his findings, concluding that Burgenland was not a natural geographical entity but a historically constructed project, shaped by the interplay of science, politics, and culture. The "discovery" of the region, he argues, was not only a collective imagination but also a tangible enterprise rooted in institutional and material practices.

The book, thus, offers a profound analysis of the emergence of Burgenland and of the geographical, political, and cultural processes underlying its identity formation. It is more than a historical-geographical case study: it transcends disciplinary boundaries to provide a dynamic synthesis of discourse analysis, the history of science, and regional history. The region's changing fortunes serve as a prism through which broader historiographical and methodological questions are refracted. Jankó engages directly with current historiographical debates, skilfully connecting regional historical inquiry with perspectives from discourse, science, and knowledge history. The study thereby contributes to a growing body of research on the historical production of knowledge, using Burgenland as a compelling example.

The book demonstrates not only how geographical knowledge was produced and reproduced but also how it shaped regional identity. Although the emerging identity of the region – like its physical borders – was often fluid and contested, Burgenland ultimately became a powerful collective imagination. Jankó convincingly shows how such projections influenced local socio-political realities, affecting everyday life, administration, infrastructure, architecture, transport, tourism, and migration. By integrating both elite and popular forms of knowledge, the study moves beyond the narrow confines of disciplinary history. The diversity of knowledge examined encompasses not only the perspectives of scientific and political centres, but also the voices within the region itself, adding depth and complexity to the analysis. A further strength of the book lies in its binational perspective: it juxtaposes the Austrian-German and Hungarian viewpoints in a productive dialogue. This comparative framework highlights the transnational lines of conflict and the divergent interpretations that shaped Burgenland's formation.

Some questions inevitably remain open – such as the representativeness and influence of individual

experts – but this does not diminish the value of the study. On the contrary, these gaps invite further research and reflection. It would also have been insightful to shift the scale and explore the reciprocal dynamics between the formation of a regional Burgenland identity and its impact on the construction of a broader Austrian national identity. By elevating the landscapes of Burgenland to idealized places of social cohesion, they may well have become instruments of higher state policy. Thus, the Burgenland region could be understood as a projection surface for broader visions of social and political order, which anticipated and naturalized the imagined community of the new nation-state of the Republic of Austria.[1]

The book *From Borderland to Burgenland* is a fascinating and meticulously researched investigation into the making of Austria's easternmost province. Combining an interdisciplinary framework with rich empirical material and a critical analysis of geographical discourse, Jankó 's work constitutes a major contribution to historical regional studies and the comparative history of geopolitics. It not only fills significant gaps in scholarship but also opens new pathways for research into the construction of similar regions across Europe and beyond. Through his ability to weave together diverse perspectives, Jankó has produced an important work for anyone interested in the making of regions and national identities in the 20th century and thereafter. The book, thus, represents a valuable contribution to the history of Central Europe in the interwar period.

For students and scholars of historical and political geography, as well as for those engaged in the history of science, knowledge, and Central European regionalism, the book is highly recommended. Richly illustrated and supported by detailed source material and case studies, its open-access publication further enhances accessibility, making its coloured maps and figures available to a broader readership.

Norman Henniges[2]

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[1] See the example of the Rhineland for the German nation-state (Etzemüller, T. 2022. 71–86).

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