Latvia University
of Life Sciences
and Technologies

# LANDSCAPE ARCHITECTURE AND ART

SCIENTIFIC JOURNAL
OF LATVIA UNIVERSITY
OF LIFE SCIENCES
AND TECHNOLOGIES

VOLUME 26 / ISSUE 26

# LANDSCAPE ARCHITECTURE AND ART

VOLUME 26
NUMBER 26

JELGAVA, 2025

**ADDRESS OF THE EDITORIAL BOARD**
Institute of Landscape Architecture and Environmental Engineering, Faculty of Forest and Environmental Sciences,
Latvia University of Life Sciences and Technologies, 22 Riga street, Valdeka palace, Jelgava, Latvia, LV–3004
Phone: + 371 29185575
E–mail: laa@lbtu.lv; una.ile@lbtu.lv

**Abstracted and indexed***
SCOPUS (indexed since 2016); Web of Science ™, Clarivate Analytics (indexed since 2016); AGRIS;
CABI PUBLISHING CAB ABSTRACTS; EBSCO Art Source

(*) – Attention! The data bases select the articles from the journal for including them in their data bases after individual qualitative examination. All scientific paper was reviewed by two independent reviewers. Every author is responsible for the quality and the information of his article.

**Scientific journal on-line:**
https://journals.lbtu.lv/laa
https://lbtufb.lbtu.lv/lv/lbtu-e-izdevumi/lbtu-izdotie-krajumi-un-zurnali-tiessaiste
https://scholar.google.lv/scholar?q=%22Landscape+architecture+and+art%22+latvia&btnG=&hl=lv&as_sdt=0%2C5
http://www.theeuropeanlibrary.org/tel4/record/3000059529403?classification-cerif=T000&count=1000&locale=uk&link-level=DIGITAL_OBJECT&collection-id=a0163

Scientific journal cover photo: from Artūrs Mengots private collection / Lielupes palienes pļavas, Latvia

ISSN 2255–8632 print
ISSN 2255–8640 online
DOI: https://doi.org/10.22616/j.landarchart

## INTRODUCTION

The collection of scientific publications in this edition examines two main research areas:

- the provision of green spaces and balanced ecosystems in urban environments (the studies include measurements, comparative data, analysis of problem situations, and prognostic insights);
- the assessment of built-up areas and the architectural language of form, addressing both cultural-historical development and modernist trends.

The articles explore and evaluate a wide range of topics, including:

- issues related to snow accumulation and management, which present new challenges for urban planning and the creation of safe and high-quality public outdoor spaces; also, a study on the concentration of heavy metals in snow within urban areas of Latvia;
- the urgent need for cities to ensure effective ecosystem services, such as the use of bryophytes (mosses), which are capable of absorbing up to ten times their dry weight in water. This property is directly applicable to the design of vertical gardens, green roofs, and innovative ground-cover solutions;
- how proximity to nature and cultural amenities influences real estate value — according to the hedonic pricing method, areas near coastlines and nature trails tend to have higher value;
- the history of Lithuanian architecture, with a focus on its significant development and transformation under German occupation;
- the impact of COVID-19 and the "15-minute city" concept as one of the possible tools for the renovation and revitalization of post-Soviet residential districts;
- the nomination of Kaunas in 2023 to the UNESCO World Heritage List under the title "Modern Kaunas: Architecture of Optimism, 1919–1939", reflecting its transformation into the temporary capital of Lithuania. Approximately 80% of the city's cultural heritage sites possess unique characteristics;
- the heritage of the modern movement, which forms an important part of today's built environment. A large proportion of post-war modernist buildings have already been significantly altered or have completely disappeared. This is not a coincidence but a logical outcome, as the architecture, execution, and urban quality of these structures have not withstood the test of time. They have physically and morally deteriorated much faster than the heritage of previous eras, including the interwar modernist monuments;
- in contemporary Latvian school architecture, the interaction between indoor and outdoor spaces is increasingly emphasized, highlighting its importance in creating a sustainable living environment.

## PRIEKŠVĀRDS

Izdevuma zinātnisko publikāciju apkopojums aplūko divus galvenos pētnieciskos blokus:

- zaļās teritorijas un sabalansētas ekosistēmas nodrošināšana pilsētelpai (pētījumi ietver mērījumus, salīdzinošos datus, situāciju problēmjautājumus un prognostiku);
- apbūves un tās arhitektoniskās formveides valodas novērtējums, aplūkojot gan kultūrvēsturisko apbūvi, gan modernisma tendences.

Rakstos tiek aplūkoti un izvērtēti daudzpusīgi temati:

- sniega uzkrāšanās un tā apsaimniekošanas jautājumi rada jaunus izaicinājumus pilsētas teritoriju plānošanā, drošai un kvalitatīvai publiskai ārtelpai. Arī pētījums par smago metālu koncentrāciju sniegam pilsētelpā Latvijā;
- pilsētām ir akūti nepieciešami efektīvi ekosistēmu pakalpojumi, briofīti jeb sūnas , kas spēj absorbēt ūdeni līdz pat desmit reizēm vairāk par savu sauso svaru. Tas ir tieši piemērojams vertikālo dārzu, zaļo jumtu un inovatīvu zemes segumu risinājumu izstrādē;
- kā dabas tuvums un kultūras objektu tuvums ietekmē nekustamā īpašuma vērtību - Hedoniskās cenas noteikšana, piemēram, piekrastei un dabas takām, ir augstāka vērtība;
- Lietuvas arhitektūras vēsture ar iespaidīgu apbūves attīstību un transformāciju Vācijas okupācijas apstākļos;
- COVID-19 un koncepts par 15 minūšu pilsētas koncepts kā viens no iespējamiem instrumentiem pēcpadomju dzīvojamo rajonu renovācijai un revitalizācijai;
- 2023. gadā Kauņa tika nominēta UNESCO sarakstā ar nosaukumu Modernā Kauņa: optimisma arhitektūra, 1919–1939;
- atspoguļojot tās pārvēršanos par Lietuvas pagaidu galvaspilsētu. 80 % no kultūras mantojuma objektiem piemīt unikālas īpašības;
- modernās kustības mantojums veido nozīmīgu daļu no mūsdienu apbūvētās vides. Lielākā daļa pēckara perioda modernās kustības ēku jau ir būtiski pārbūvētas vai pilnībā zudušas. Tas nav nejaušs gadījums, bet gan likumsakarība, jo konkrēto ēku arhitektūra, izpildījums un pilsētbūvnieciskā kvalitāte nav izturējusi laika pārbaudi. Tās fiziski un morāli novecojušas daudz ātrāk nekā iepriekšējo laikmetu mantojums, tostarp arī starpkaru perioda modernisma pieminekļi;
- mūsdienu Latvijas skolu arhitektūrā novērojama ārtelpas un iekštelpas mijiedarbību, uzsverot tās nozīmi ilgtspējīgas vides veidošanā.

**Aija Ziemeļniece**
Editor of Chief

CONTENT

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.01

# GREENSPACE PLANNING AND ASSESSMENT USING THE NORMALIZED DIFFERENCE VEGETATION INDEX IN NEIGHBOURHOODS NEXT TO RIGA FREEPORT, LATVIA

**Kristīne Āboliņa, Dainis Jakovels, Andis Zīlāns**
*University of Latvia, Latvia*

**Abstract. In urban planning, greenspace in spatial plans is typically understood as specifically defined functional land use zones. However, in relation to the establishment of green corridors and the provision of ecosystem services as well as for the health of residents, greenery located outside of greenspace zones is equally important. In Latvia, the minimum area of greenery located on a land parcel is defined by the free area greenspace indicator. The objective of the research was to identify the changes in greenery cover on land parcels with different functional land use zoning using the normalized difference vegetation index (NDVI) method. The study was undertaken in five neighbourhoods in Riga. The results of the analyses indicate that adherence to the minimum free area greenspace indicators that are specified for different functional zones will result in a significant decrease in the amount of free area greenery in the studied neighbourhoods. The largest reduction in free area greenery is expected in non-residential functional zones. Greenspace zones, such as forest parks and parks, which are to undergo major upgrades in recreational ammenities, will experience a reduction the size of the natural areas by as much as one third. The application of the NDVI method is well-suited for monitoring the amount and distribution of urban vegetation cover and for assessing spatial development at the neighbourhood level. However, due to the structure of existing zoning regulations in Riga, which can differ at the level of individual land parcels, the systematic application of the NDVI method in Riga is not presently possible.**
**Keywords: urban greenspace, spatial planning, normalized difference vegetation index, neighbourhoods, land use**

## Introduction

In urban planning, greenspace in urban spatial plans is typically understood as specifically defined areas within one or more land parcels, where the main function is linked to nature, such as, forests, parks, squares, family gardens, and other greenery. For the monitoring of urban sustainability, the accessibility of greenspace zones and its size per capita is included in the assessment of basic services [1]. The European Common Indicators [2], for example, state that there must be greenspace with at least 5,000 m2 within 300 metres of a residence. This greenspace must be publically available, without charge and allow pedestrians and cyclists to engage in recreation, and furthermore, such areas are free of motorized traffic. Greenspace in the urban environment not only provide a variety of recreational opportunities, but are also an indispensable element in the provision of ecosystem services, including addressing the most pressing urban quality issues today - creating a favorable microclimate, maintaining biodiversity, adapting to and mitigating climate change, and rainwater management [3;4]. From a social standpoint, accessibility to public outdoor space and green outdoor space is not only important for maintaining the physical and mental health of residents, but also for socialization and community-building activities [4]. However, despite their functional role as natural areas, they are subject to development pressures.

The vegetation on each non-greenspace zone land parcel, also makes a significant contribution to the urban environment [5]. Without trees along streets, green courtyards, raised flower beds, greenery along water bodies, and green window sills, walls, balconies and roofs, there is no respite from a high density urban landscape, nor the possibility to connect greenspace into a single network.

Many European cities and regions have experienced declining population numbers, and such shrinking cities have to choose between adaptation or transformation strategies for urban resilience [6]. The range of actions in this case includes both the expansion of greenspace and the reduction of building density to create a higher environmental quality, land use change to adapt to the special needs of the municipality, zoning sites as temporary use, and the further attraction of investments for new building projects in the hope that these objects will attract users [7]. The assessment phase in the cycle of land use planning and implementation is critically important which ensures that the results of adopted policy measures can be identified prior to formulating further development policies. The implementation of desired land use policies and the monitoring of results is the driving force for the selection of most appropriate indicators and monitoring instruments [1]. The development of technologies has resulted in the broader use of remotely sensed research data, whereby the normalized difference vegetation index (NDVI) has demonstrated its applicability for measuring different types and quality of vegetation [8].

Riga, the capital city of Latvia, as many cities in Europe is confronted by variety of development challenges. With an area of 307 km2, in 2025 Riga had a population of 592 thousand, a 35% decrease since the 1990s due to a low birth rate nationally, outmigration and suburbanization processes stimulated by more attractive housing and living conditions in neighbouring municipalities. Riga is a Baltic Sea port city. The Riga Freeport is the fifth largest port in the Baltic Sea transit corridor. Previous Riga Spatial Plans, binding for the periods 1995-2004 and 2005-2018 were developed and adopted in a period of rapid economic growth, in part ignoring the demographic decline [9], and rezoning about 1/3 of the greenspace existing in 1994. However, as a result of both the 2009 financial crisis and the continuing "shrinkage" process, contradictions exist between what is proposed by the Riga Spatial Plan and actual development processes on the ground. Large areas of undeveloped greenfield land have undergone multiple changes in ownership and are still "waiting" for an investor or the right market conditions to be developed.

The non-alignment between planned development scenarios and actual development trends impacts on how greenspace in Riga is perceived and viewed in the context of future development. The general impression of a "green" city still persists, however, when a greenfield is unexpectedly converted to a construction site, public protests by concerned citizens are not uncommon [10]. Residents of the city do not

live their lives in the visions of spatial plans, but rather in the existing urban landscape, and the majority of residents are not aware of the development consequences of spatial plans. Furthermore, the size and complexity of the Riga Spatial Plan does nothing to encourage non-specialists to be interested and to participate in public discussions. In 2021, the draft Riga Spatial Plan 2030 consisted of more than 143 separate files on 1825 pages, including 94 files containing cartographic material. At the same time, a short easy to understand summary of proposed changes in the size of functional zones, including greenspace is not made available to the general public.

Greenspace is regulated in two different ways in the Riga Spatial Plan: firstly, as "nature and greenery" or greenspace zones based of cadastral units and, secondly, as minimum "free area" greenspace indicators. The latter represents the undeveloped portion of a land parcel that must remain with a cover of greenery or vegetation. Discussions with the Riga Planning Department reveal that the recently adopted Riga Spatial Plan 2030 has rezoned 400 ha previously zoned for development as greenspace. On the other hand, the city of Riga does not have a system in place for measuring and monitoring free area greenspace. Consequently, the areal coverage of free area greenery in different neighbourhoods and on different functional zones it is not known, nor how close or far the defined minimum free area greenspace indicators are from the actual situation on land parcels.

The objective of the research was to analyse the planned changes in free area greenspace indicators defined for different land use functional zones in Riga Spatial Plan 2030 and to measure the actual amount of free area greenery in five neighbourhoods and to compare this with the defined minimum free area greenspace indicator values. Measurement of the actual free area greenery was undertaken using the normalized difference vegetation index (NDVI).

The territory selected for the study were the five of 58 neighbourhoods in Riga: Vecmīlgrāvis, Daugavgrīva, Kundziņsala, Mangaļsala and Bolderāja, located on the periphery of Riga about 10-15 km from the city center. These neighbourhoods are in the lower reaches of the Daugava River, but they are separated from the river by the Riga Freeport. The neighbourhoods are similar in that they have a sizeable industrial function both inside and outside the Riga Freeport. Residents in these neighbourhoods are alarmed by the air and noise pollution caused by companies operating in the port area, which in certain locations exceeds permissible health standards [11]. 43% of the residents of the studied neighborhoods have considered the possibility of moving elsewhere mainly due to issues related to poor environmental quality [12]. In turn, the presence of nature in the residential areas, including forests, water bodies and nature parks is the most pleasant aspect of the neighbourhoods, as indicated by 58% of the surveyed respondents in these neighbourhoods [13]. Thus, to some extent, it can be said that presence of nature and greenspace are critical factors for ensuring residents continue to be satisfied with the neighbourhood as a home.

## Methodology

To contextualize the analysis, the regulatory frameworks that define the amount of natural and greenspace in populated areas in Latvia were reviewed. This includes the "Territorial Development Planning Law" of the Republic of Latvia, as well as at the local level - the Riga Spatial Plan [14]. The functional zoning map Riga Spatial Plan was used, which depicts the location of areas zoned greenspace, and the associated Land Use and Building Regulations, which define the minimum amount of "free area" greenspace, such as greenery and lawn area, on each land parcel according to the functional zoning. The analysis did not include an analysis of greenspace in the historical centre of Riga, which is designated a UNESCO world heritage site, as it has its own separate land use and building regulations, but significantly less greenspace and greenery. Thus, this would warrant a separate study.

In order to compare the amount of free area greenspace specified by the Riga planning regulations and to determine the trend and magnitude of possible changes, the NDVI was used. Vegetation cover on clusters of land parcels were assessed using Sentinel-2 satellite optical data analysing NDVI changes in the period 2016-2020. NDVI is calculated from red and near-infrared spectral channels [15] and has been widely used for vegetation status assessment and change monitoring [8; 16]. It has been also widely used for urban greenspace assessment [17; 18; 19]. The main benefit of freely available Sentinel-2 satellite data is a wide coverage with relatively high observation frequency that allows remote NDVI assessment anywhere on the planet with new observations up to every 5 days during cloud-free conditions [20]. Cloudy weather limits the amount of useful data, however, at least one observation per month could be expected even in Northern regions such as Latvia providing a sufficient amount of data for land cover mapping [21]. The spatial resolution of Sentinel-2 data-based NDVI is 10 m/pix which limits its applicability to a minimum area of 1000 m2 to avoid mixed border pixels. NDVI is useful for mapping areas covered by vegetation as well as vegetation intensity and health assessment, however, it does not provide information on vegetation functional type, species composition or use. Nevertheless, NDVI has demonstrated a good correlation with vegetation density [22; 23] and has been widely used for the quantitative assessment of urban greenspace [24; 25]. In this study, all available Sentinel-2 archive data for the period 2016-2020 was used. Maximum NDVI values were calculated for each year and each image pixel representing a 10x10 m area on the land. Since NDVI values change during the year due to phenological changes in vegetation, in the study maximum NDVI values were used representing maximum vegetation density that is reached in a particular image pixel during the year of interest. This approach permitted an assessment of the vegetation status of each image pixel as well as to analyse changes between different years. NDVI values are in the range of 0 to 1 and it is assumed that a value of >0.5 represents an area where vegetation dominates over other land cover types (e.g. buildings, paved surfaces, bare soil). Using the NDVI threshold of >0.5 enabled mapping and calculating vegetation cover percentage on clusters of land parcels.

The clusters of land parcels in the five neighbourhoods included in the NDVI analysis were selected on the basis of the following criteria:

1) Clusters were at least 1000m2 in size to be compatible with recommendations for the calculation of the NDVI;

2) Clusters did not include major roadways, to ensure that NDVI calculations were not negatively biased;

3) Clusters contained only one land use functional zone to enable comparison between the measured NDVI value and the free area greenspace indicator value defined by the Riga Spatial Plan;

4) Clusters did not contain cadastral units zoned greenspace, to avoid introducing a positive bias to the NDVI calculation. If a cluster of land parcels contained land zoned greenspace, the greenspace was excluded from the analysis;

5) Clusters did not include large greenfields zoned development where development had not yet commenced.

Based on these criteria, 14 clusters were selected for analysis. It was not possible to analyse all functional zoning types in each neighbourhood since some neighbourhoods, such as Kundziņsala and Bolderāja, had only two different functional zones that could be analysed.

The proportion of each cluster covered with vegetation was determined using the NDVI methodology. A comparison of NDVI results with the free area greenspace limits set by the Riga Spatial Plan 2030 in each analysed functional zone allowed for the identification of the permitted change in vegetation cover in each functional zone resulting from the implementation of the Riga Spatial Plan 2030.

**Territorial Planning Regulatory Framework**

In Latvia, in accordance with the national territorial planning regulatory framework, the minimum proportion of greenspace in cities is not determined. Instead, each municipality determines the desired goals and policy in this regard. The Riga Spatial Plan 2030 states that the World Health Organization recommends a minimum of 9 m2 per capita of greenspace (parks, forests, grasslands, gardens, cemeteries). As there are currently 114 m2 of greenspace per capita in Riga (year 2017), increasing the amount of greenspace is not considered necessary [14]. Environmental quality and the provision of ecosystem services is not only dependent on the presence of officially designated public greenspace zones, but also on the presence of greenery on individual land parcels. The Riga Spatial Plan 2030 defines different land use functional zones, and a minimum free area greenspace indicator is defined for each functional zone. The minimum free area greenspace indicator (as a percentage of the total parcel area) defines the proportion of vegetation cover that must be maintained on land parcels. The Riga Spatial Plan 2030 has the following zones: three types of detached house zones, three types of low-rise residential zones, two types of multi-storey residential zones, 8 types of mixed-center zones, an industrial building zone, three types of transport infrastructure zones, two types of technical building zones, four kinds of nature and greenery zones and three types of water zones. The free area greenspace indicator is not defined for transport infrastructure zones, technical building zones and water zones.

The free area greenspace B (m2) formula is B = Z – L1 – L2 – L3 + L4xK (m2), where: Z is area of the land unit; L1 is sum of building areas of all buildings; L2 is area occupied by access roads; L3 is area occupied by parking lots; L4 is the territory that can be partially included in the free area greenspace territory by applying the coefficient K; K is the coefficient applicable to the territory, which can be partially included in the free territory. The elements of green infrastructure that can be included in the free area greenspace with an appropriate coefficient are roof gardens; extensive roof gardens; green walls; newly formed meadow, crop or perennial beds, shrubs; underground covering with greenery; natural meadow with at least 10 species of plants; green rainwater management elements - rain gardens, infiltration site with plants or rubble; preservation of an existing tree; new tree. The revised free are greenspace indicator formula makes it easy to understand the actual area of vegetation cover that must be retained, regardless of the number of storeys, while not requiring greenery at ground level. For example, if the building were to have a roof garden and a rainwater infiltration area with water-permeable material in the car parks, the criteria for free space would be met even without any vegetation cover at ground level. Although green walls, roof gardens and other specific forms of greenery have been proposed as solutions to increase greenery in sustainable, climate-neutral and resilient cities, in Riga they are used as substitute of traditional green elements.

In all functional zones the free area greenspace indicator is not specified for land parcels with individual houses. In all functional zones, except in the mixed centre zone JC3, low-rise and high-rise residential land parcels have free area greenspace indicators of 40-60 %. On education institution land parcels the free area indicator is equivalent to the total floor area. Low-rise residential zones with public building land parcels have a free area greenspace indicator of 40-60 %, but in high-rise residential zones and mixed centre zones (except in the Mežaparks neighbourhood) land parcels with non-residential buildings have a free area greenspace indicator of only 10 %. Although the specific regulation zone TIN14 prescribes a minimum of 50 % free area greenspace, only 11 places in Riga are zoned as such – six parks adjacent to existing health care centres, two greenfield development

TABLE 1

Minimum specifications for free area greenspace indicator in different functional zones in Riga Spatial Plan 2030 [created by author's]

| Type of functional zoning | Free area greenspace indicator |
|---|---|
| Individual home zone<br>DZS1; DZS2; DZS3 | No requirement* |
| Low-rise (up to 3 floors) residential building zone<br>DZM1–DZM4 | DZM1 – No requirement for individual residential houses; Other functions** – 40%<br>DZM2 – 60%*<br>DZM3 – 40%*<br>DZM4 – 45%** |
| High-rise residential building<br>DZD1-DZD2 | DZD1 – No requirement for individual residential houses; Other residential buildings – 40%; Other functions* – 10%<br>DZD2 – No requirement for individual residential houses; Other residential buildings – 40%; Educational** and social care institutions – 40%; Other functions – 10% |
| Specific regulation zone | TIN14 – 50% |
| Mixed centre zone<br>JC1-JC8 | JC1, JC2, JC6 – No requirement for individual residential houses<br>Other residential buildings – 40%, (JC6-30%); Other functions** – 10%<br>JC3, JC4 – 10%<br>JC5 – No requirement for individual residential houses; Other functions – 10%<br>JC7 – No requirement for individual residential houses; Other functions** – 45%<br>JC8 – Specific regulations for Riga city historical centre and its protection zone |
| Industrial building zone | 10% |
| Nature and greenery zone | Forest park territories – 70% for forest; Parks – 60% for nature;<br>No specifications for squares |

* Except for educational institutions – equal to the floor area

** Except for preschool educational institutions – equal to the floor area

sites and two other land parcels.

Only in a few places in detached house functional zones is it stipulated that greenery must cover at least 20 % of the land parcel, whereas elsewhere it is 10 % or not even specified. Furthermore, 15 years ago, forest areas were reclassified as forest parks – previously there were 10 forests and one forest park in Riga, but since 2005 none of the forests in the city are defined as such. Presently, there are 11 forest parks. The increased establishment of recreation and entertainment infrastructure in forest parks is aimed at intensifying their recreational function, which in turn reduces ecosystem services. Additionally, fragments of natural forests are preserved in three protected nature territories of national significance, which are zoned separately.

Focussing on the selected five neighbourhoods, four out of the five neighbourhoods are relatively well endowed and located in close proximity to greenspace functional zones. Two of the three Natura 2000 areas in Riga are located here and one of two protected nature territories of national significance. The national and European protection status afforded to these sites appears to guarantee that they will not be subject to future development pressures. The Riga Freeport (1962 ha land territory) in the vicinity of the five neighbourhoods contains industrial functional zones with a minimum free area greenspace indicator of 10 %, but there are also two protected nature territories (75 ha in total or about 4 % of the Riga Freeport area) and five areas zoned greenspace, each about 2 -10 hectares in size.

Analyzing the residential areas of the neighbourhoods according to the Common European Indicator "greenspace zone is located within 300 m from residences", only in two out of the five neighbourhoods (Daugavgrīva, Kundziņsala) with mixed center functional zones is the criterion regarding proximity to greenspace zone satisfied.

The main function of the mixed centre (JC1 and JC2) functional zones is defined as being the neighborhood center, with commercial, cultural, educational, social and health services functions, as well as well-maintained public outdoor space. The mixed centre functional zone is foreseen only in the central part of the residential neighbourhood of Vecmīlgrāvis, whereas in the neighbourhoods of Daugavgrīva and Bolderāja the mixed centre zone is only designated on the very periphery of the residential area, while the neighbourhoods of Kundziņsala and Mangaļsala do not have mixed centre zones. Significantly, the minimum free area greenspace indicator for mixed centre zones JC1 and JC2 is set at only 10%, which means that relatively little area is foreseen for green public outdoor space near public buildings.

Regulation of greenspace by the Riga Spatial Plan 2030 differs markedly from the current situation in the neighborhoods.

## NDVI - The Hidden Value of Greenery on Land Parcels

According to NDVI data between years 2016 and 2020, 25-80 % of the entire area of the five studied neighbourhoods of Riga are green, while 13-56 % of the territory is without vegetation. There is more vegetation in the neighbourhoods with Natura 2000 and national protected nature territories – in Vecdaugava and Mangaļsala (Table 2).

Furthermore, in Vecmīlgrāvis, which have the most developed Riga Freeport infrastructure, the vegetation index data indicates that only 9% of the area is green, which is even less than the 10% free area greenspace minimum specified by planning documents. On the other hand, in the part of Vecmīlgrāvis outside the Riga Freeport area, 54% of the territory is green, which is influenced by the presence of greenspace zones. The lowest permanent vegetation cover is on Kundziņsala, a 555 ha island in the Daugava River. The 35-hectare historic residential area, which is encompassed by the Riga Freeport, since 2021 is mainly zoned as mixed

TABLE 2

Proportion of permanently green and permanently built-up areas in the five neighbourhoods of Riga based on NDVI [created by author's]

| Neighbourhood | Areas | Hectares | Permanent greenery (%) | Permanently without vegetation (%) |
|---|---|---|---|---|
| Daugavgrīva | Total | 752 | 69 | 19 |
| | Without Riga Freeport | 551 | 72 | 16 |
| | Port | 201 | 61 | 25 |
| Bolderāja | Total | 726 | 55 | 26 |
| | Without Riga Freeport | 666 | 55 | 26 |
| | Riga Freeport | 59 | 54 | 26 |
| Mangaļsala | Total | 648 | 80 | 13 |
| | Without Riga Freeport | 546 | 87 | 7 |
| | Riga Freeport | 101 | 46 | 40 |
| Kundziņsala | Total* | 555 | 25 | 56 |
| | Mixed centre area within it | 35 | 90 | 7 |
| Vecmīlgrāvis | Total | 449 | 35 | 48 |
| | Without Riga Freeport | 261 | 54 | 26 |
| | Riga Freeport | 189 | 9 | 78 |
| Rīga | Total | 26058 | 64 | 22 |
| | Without Riga Freeport | 24096 | 65 | 21 |
| | Riga Freeport | 1962 | 50 | 37 |

* all territory of this neighbourhood is within Riga Freeport borders

TABLE 3

Average proportion of vegetation cover in 2016-2020 in selected functional zones in five Riga neighbourhoods [created by author's]

| Neighbourhood | Average proportion [%] of vegetation cover in 2016-2020 | | | | |
|---|---|---|---|---|---|
| | Individual home zone (no minimum free area greenspace required*) | Low-rise (up to 3 floors) residential buildings zone (minimum 40 %*) | High-rise residential buildings (min 40 % for residential buildings, 10 % for others*) | Mixed centre zone (JC1, JC2) (min 10 %*) | Mixed centre zone (JC4, JC5) (min 10 %*) |
| Mangaļsala | 88 | n/a | 81 | n/a | 86 |
| Vecmīlgrāvis | 83 | 71 | 59 | x | x |
| Kundziņsala | n/a | n/a | n/a | n/a | 96 |
| Daugavgrīva | n/a | 85 | 65 | 59 | x |
| Bolderāja | x | 73; 77 | 49 | 25 | x |

* – according to the norms of the Building code

n/a – not appropriate as there is not such functional zoning in the neighbourhood

x – not analyzed for this functional zone in the neighbourhood

centre (JC5). Only a few small greenspace zones are present with a combined area of 2-2.5 ha. Throughout the island, outside areas with a greenspace zoning, the Riga Spatial Plan 2030 standard specifies that parcels of land must have a minimum of 10 % free area greenspace.

The data on the amount of vegetation in different functional zones outside the Riga Freeport (Table 3) show that the highest average proportion of vegetation cover is in detached house functional zones, where the regulations do not define the free area greenspace indicator. In low-rise residential building zones, the average share of the green cover is 71-85 %, while in multi-storey residential areas it is 49-66 %. In Bolderāja, for example, the minimum of 40 % free area greenspace specified by regulations in high-rise residential zone is already being approached. In Mangaļsala, the amount of vegetation cover in multi-storey residential zones (81%) is similar to that in detached house zones.

In turn, the greenest mixed centre zones (JC5) in Mangaļsala and Kundziņsala, characterized by historic dwellings with fourth and fifth generation residents, are subject to the greatest development pressures and, consequently, potential changes. They are formally located in the Riga Freeport, where the level of environmental pollution and noise makes the area unsuitable for residential living, and are considered objects for research on gentrification and environmental justice.

Table 3 shows that in all functional zones outside industrial zoning, the current amount of vegetation is higher than the minimum set by planning regulations. There are four important aspects here. Firstly, there is no reason to believe that the amount of vegetation in the analyzed zones will not decrease - there is a lack of parking lots near multi-storey residential buildings, moreover, there are still undeveloped plots of land in residential areas. In turn, in service and industrial functional zones, developers are not interested in leaving more free area greenspace than required. Secondly, all functional zones in Table 3 allow for both residential and non-residential development, which have differing requirements for the greenspace indicator. Thus, it is not possible to determine whether the free area indicator is observed in the area larger than a land parcel. Thirdly, if it were necessary to determine using NDVI whether the free area indicator was observed in each plot, this would be possible only if there was an additional map layer reflecting the function of the building (e.g. educational institution, residential, commercial). In an interview, a representative of the Riga Development Department indicated that such cartographic information is not available and would be resource-intensive to maintain. And fourthly, most of the vegetation is in the residential areas with detached houses, where the minimum free area greenspace is not regulated. Thus, the contribution of the free area greenspace of detached house land parcels to the total greenspace of neighbourhoods is the biggest unknown.

## Discussion

According to the research of Cardoso et al on the "Cities we need" [26], nature and greenspace appear as necessary elements in several dimensions of human needs - aesthetic, health and leisure. Sue Stuart-Smith [27], in her study, discusses the deeper and more profound importance of the presence of nature and human-nature interaction for a person's wellbeing and mental health from various aspects. The present study highlights the importance of greenspace in meeting basic human needs, which are undermined by adopted development regulations.

Greenery and greenspaces in the city are a classic common resource [28]. It is to everyone's benefit to have as much as possible, and their abundance depends on three main actors. The municipality determines the location and area of green zones, as well as the minimum free area greenspace in functional zones. Landowners / developers and those responsible for the day-to-day maintenance of greenery each have different interests regarding the amount and types of greenspace. For anyone responsible for a small part of the resource, maintaining greenery requires more or less resources. The fourth actor is the general public, who directly use the urban landscape. The capacity of this latter group to influence the quantity and availability of the common resource greenspace is severely limited. The analysis of greenspace in the five port-side neighbourhoods shows that through the application of city regulations, which require a relatively large greenspace around residential buildings, responsibility for the management of this common resource at the level of land parcels is placed on the shoulders and resources of homeowners. Areas zoned industrial use in particular contribute less to good urban quality because of the low value set for the greenspace indicator, whereas a higher greenspace indicator would contribute to improved air quality, noise reductions and could help to lessen the visual impact of technical buildings.

From the point of view of the common resource theory, the policy chosen by the Riga planning administration not to define the minimum greenspace for the detached house zone is questionable. As the data in Table 3 show, if the proportion of greenery in these zoning areas was reduced to only 10 %, then the decrease in actual vegetation cover would be the greatest of any of the functional zones. In some

of the land parcels of analysed areas with detached houses, the amount of free area vegetation is close to zero. Therefore, it would be informative to identify factors motivating owners in this regard – improving real estate tax rates or perhaps the desire to reduce yard work associated with fallen leaves or regular lawn maintenance. Consequently, the territories with the greatest amount of greenery on land parcels are currently the most vulnerable from the perspective of governance, as free area greenery is largely unregulated and, under the right conditions, vulnerable to dramatic change.

With regard to Riga as a shrinking city, there has been no attempt to adapt to the demographic decline as has been done elsewhere by not building on existing greenspace. The recently approved Riga Spatial Plan 2030 was a great opportunity to rezone undeveloped areas as greenspace, thus potentially improving environmental quality and recreational opportunities. This would have been particularly important for the neighbourhoods near the Riga Freeport, located next to intensive and polluting industrial functions. On the contrary, the creation of territorially large parcels of land (up to 40 ha) in the Riga Freeport and in its immediate vicinity, indicates the policy pursued by the Riga Freeport Authority and approved by municipal decision-makers is to transition from shipping and cargo handling to industrial functions on a scale uncharacteristic of Riga.

The planning of massive industrial zones without intervening greenspace zones and with limited free area greenspace is in opposition to the constructive historical experience of urban development. At one time, both the concepts of the "garden city" and "new urbanism" were the antidote advocated by urban planners and progressive cities to poor urban environmental quality and social conditions caused by concentrating polluting industries in one location and the disregard for the health of residents. The direction chosen by Riga in relation to the definition of free area greenspace is also inconsistent with the concept of resilient and climate neutral cities, as 10% of a land parcel is a critically small area for the creation of gray infrastructure for rainwater management, the reduction of the heat island effect and for linking greenspace into an integrated network.

The study demonstrates that the NDVI is a useful tool inventory and monitor greenspace in urban areas. NDVI is more applicable to the analysis of city blocks or neighbourhoods, but in the case of Riga this level of analysis is not feasible due to the definition of different free area greenspace indicators in one functional zone depending on the function of the building. Greenspace planning and research in Riga is hampered by the fact that the Riga Spatial Plan does not provide relevant quantitative data on changes made in the area and location of greenspace zones.

## Conclusions

In addition to the greenspace functional zones defined in the Riga Spatial Plan 2030, a significant proportion of vegetation in the city is found in the yards and courtyards adjacent to buildings. A significant reduction in the area covered with vegetation is permitted through the reduction of the minimum free area greenspace indicator for land parcels. The largest decrease in free area greenspace is allowed in non-residential functional zones - industrial, commercial, services and other similar functional land uses. Furthermore, according to the Riga Spatial Plan 2030, greenspaces, such as forest parks and parks are to be subject to major infrastructure and recreational ammenity upgrades, thus reducing natural areas by as much as by a third. It can be concluded that the ecological, economic and social importance of greenspace is not valued equally with other development priorities.

The application of the NDVI method is well-suited for monitoring the amount and distribution of vegetation cover and for assessing spatial development at the neighbourhood level. However, due to the nature of existing zoning regulations in Riga, which can differ at the level of individual land parcels, the systematic application of the NDVI method in Riga is not presently possible.

## Acknowledgements

This study was undertaken within the multidisciplinary research project "Living Next to the Port: Eco-Narratives, Local Histories and Environmental Activism in the Daugava Delta" (2018-2021), financed by Latvian Council of Science (lzp-2018/1-0446), implemented at the Institute of Literature, Folklore, and Art, University of Latvia.

## References

1. **Merino-Saum, A., Halla, P., Superti, V., Boesch, A., & Binder, C. R.** Indicators for Urban Sustainability: Key Lessons from a Syste matic Analysis of 67 Measurement Initiatives. Ecological Indicators, 2020, No. 119. https://doi.org/10.1016/j.ecolind.2020.106879.
2. European Environmental Agency. European Common Indicators: Towards a Local Sustainability Profile. [online 6.05.2025.].https://www.eea.europa.eu/publications/environmental_issue_report_2002_30/chap10-annex3.pdf/view.
3. **Kabish, N., Bonn, A., Korn, H., et al.** (eds). Nature-based Solutions to Climate Change in Urban Areas - Linkages of science, society and policy. Springer, 2017.
4. **Langemeyer, J.** Urban Ecosystem Services: The Value of Green Spaces in Cities. Ph.D. thesis, Universitat Autonoma de Barcelona, and Stockholm University. 2015. [online 2.05.2024.] https://ddd.uab.cat/pub/tesis/2015/hdl_10803_327016/jl1de1.pdf.
5. **Cooke, B., Landau-Ward, A. & Rickards, L.** Urban Greening, Property and more-than-human Communing. Australian Geographer, 2019. [online 4.02.2024]. https://www.tandfonline.com/doi/full/10.1080/00049182.2019.1655828.
6. **Folke, C., Carpenter, S. R., Walker, B., et al.** Resilience Thinking: Integrating Resilience, Adaptability and Transformability. Ecology and Society, 2010, No. 15(4). [online 31.03.2025]. http://www.ecologyandsociety.org/vol15/iss4/art20/.
7. **Walker, B., Gunderson, L. H., Kinzig, A., et al.** A Handful of Heuristics and some Propositions for Understanding Resilience in Social-Ecological Systems. Ecology and Society, 2006, No. 11(1). [online 31.03.2024]. http://www.ecologyandsociety.org/vol11/iss1/art13/.
8. **Pettorelli, N.** The Normalized Difference Vegetation Index. Oxford University Press, 2013.
9. **Akmentina, L.** Resilience to Urban Shrinkage in Riga. Ph. D. thesis, Technical University of Dresden, 2017. [online 7.07.2024]. https://nbn-resolving.org/urn:nbn:de:bsz:14-qucosa-232632.
10. **Bērtule, A., Feldmanis, K.** Organizatori: Protestā «Marsa» parka aizstāvībai piedalījušies vairāk nekā 400 cilvēku. Latvijas sabiedriskie mediji. 2021. [online 5.05.2025.]. https://www.lsm.lv/raksts/zinas/latvija/organizatori-protesta-marsa-parka-aizstavibai-piedalijusies-vairak-neka-400-cilveku.a361619/.
11. **Abolina, K.** Daugavas lejteces apkaimes: vide un kopīgie resursi. In: Bula, D. (ed.) Dzīve līdzās ostai. Latvijas Universitātes Literatūras, folkloras un mākslas institūts, 2022.
12. **Daugavietis, J., Zile-Veisberga, A.** Iedzīvotāji vērtē savu dzīves vidi līdzās ostai. In: Bula, D. (ed.) Dzīve līdzās ostai. Latvijas Universitātes Literatūras, folkloras un mākslas institūts, 2022.
13. **Bula, D.** (ed.). Dzīve līdzās ostai. Latvijas Universitātes Literatūras, folkloras un mākslas institūts, 2022.
14. Rīgas domes pilsētas attīstības departaments. Rīgas teritorijas plānojums līdz 2030. gadam. [online 8.06.2023.]. https://www.rdpad.lv/rtp/speka-esosais/.
15. **Tucker, C. J.** Red and Photographic Infrared Linear combinations for Monitoring Vegetation. Remote sensing of Environment, 1979, No. 8(2), p.127-150.
16. **Huang, S., Tang, L., Hupy, J. P., et al.** A Commentary Review on the Use of Normalized Difference Vegetation Index (NDVI) in the Era of Popular Remote Sensing. Journal of Forestry Research, 2021, No. 32, p. 1-6. [online 21.01.2023.) https://link.springer.com/article/10.1007/s11676-020-01155-1.
17. **Liu, Y., Guo, J.** The Research of NDVI-based Urban Green Space Landscape Pattern and Thermal Environment. Progress in Geography, 2009, No. 5.

18. **Fung, T., Siu, W. L.** A study of green space and its changes in Hong Kong using NDVI. Geographical and Environmental Modelling, 2001, No. 5(2), p. 111-122. [online 4.04.2022]. https://www.tandfonline.com/doi/abs/10.1080/13615930120086032.
19. **Shahabi, H., Ahmad, B. B., Mokhtari, M. H., et al.** Detection of Urban Irregular Development and Green Space Destruction Using Normalized Difference Vegetation Index (NDVI), Principal Component Analysis (PCA) and Post Classification Methods: A Case Study of Saqqez City. International Journal of Physical Sciences, 2012, No. 7(17), p. 2587-2595.
20. **Drusch, M., Del Bello, U., Carlier, S., et al.** Sentinel-2: ESA's Optical High-Resolution Mission for GMES Operational Services. Remote Sensing of Environment, 2012, No. 120, p. 25-36. [online 5.08.2024]. https://www.sciencedirect.com/science/article/abs/pii/S0034425712000636.
21. **Jakovels, D., Filipovs, J., Brauns, A., et al.** Land Cover Mapping in Latvia Using Hyperspectral Airborne and Simulated Sentinel-2 Data. Conference presentation, Fourth International Conference on Remote Sensing and Geoinformation of the Environment, 2016, Paphos, Cyprus RSCy2016 (9688), 96881Q. International Society for Optics and Photonics, 2016. [online 9.10.2024]. https://doi.org/10.1117/12.2240742.
22. **Purevdorj, T, S., Tateishi, R., Ishiyama, T., et al.** Relationships between Percent Vegetation Cover and Vegetation Indices. International Journal of Remote Sensing, 1998, No. 19(18), p. 3519-3535. [online 21.20.2024.]. https://www.tandfonline.com/doi/abs/10.1080/014311698213795.
23. **Jiang, Z., Huete, A. R., Chen, J., et al.** (2006). Analysis of NDVI and Scaled Difference Vegetation Index Retrievals of Vegetation Fraction. Remote Sensing of Environment, 2006, No. 101(3), p. 366-378. [online 2.02.2025.]. https://www.sciencedirect.com/science/article/abs/pii/S0034425706000290.
24. **Chen, B., Nie, Z., Chen, Z., et al.** Quantitative Estimation of 21st-Century Urban Greenspace Changes in Chinese Populous Cities. Science of the Total Environment, 2017, No. 609, p. 956-965. [online 2.02.2025.]. https://www.sciencedirect.com/science/article/abs/pii/S0048969717319551.
25. **Kondo, M. C., Fluehr, J. M., McKeon, T., et al.** Urban Green Space and its Impact on Human Health. International Journal of Environmental Research and Public Health, 2018, No. 15(3), p. 445. [online 2.02.2025.]. https://www.mdpi.com/1660-4601/15/3/445.
26. **Cardoso, R., Sobhani, A., Meijers, E.** The Cities we Need: Towards an Urbanism Guided by Human Needs Satisfaction. Urban studies, 2021. [online 23.04.2024.]. https://journals.sagepub.com/doi/10.1177/00420980211045571.
27. **Stuart-Smith, S.** The Well Gardened Mind: Rediscovering Nature in the Modern World. William Collins, 2020.
28. **Huron, A.** Working with Strangers in Saturated Space: Reclaiming and Maintaining the Urban Commons. Antipode, 2015, No. 00(0), p. 1–17. [online 22.10.2023.]. https://onlinelibrary.wiley.com/doi/abs/10.1111/anti.12141.

**Authors**
**Kristīne Āboliņa**, Dr. geogr., freelance researcher and promoter of sustainable development. Academic and research experience for almost thirty years. Currently working at the Municipality of Cesis as expert of circular economy.
e-mail: kristine.abolina@cesunovads.lv
ORCID ID: https://orcid.org/0009-0005-3557-4260

**Dainis Jakovels**, Dr. phys., leading researcher and head of the remote sensing group. Research experience in remote sensing and Earth observation for more than ten years, currently working at the Institute for Environmental Solutions.
E-mail: dainis.jakovels@vri.lv
ORCID ID: 0000-0002-2969-5972

**Andis Zīlāns**, Dr. geogr., sustainability researcher and consultant with more than 20 years of experience. Currently working for Stantec sa/nv as an independent expert for the evaluation and revision of proposals submitted for EU LIFE Programme funding.
E-mail: azilans@hotmail.com
ORCID ID: 0000-0002-5415-7471

**Kopsavilkums**
Dabas teritorijas vai zaļās zonas ir termini, ar kuriem latviski vistuvāk var apzīmēt kopējo zaļojošo teritoriju pilsētā. Zaļās zonas ietver gan teritoriju plānojumos īpaši dabai definētas funkcionālās zonas, gan atsevišķus kokus, zālienus, dobes un citus "dabas gabaliņus" starp ēkām. Pēdējie pieminētie ir būtiski iespaidam, cik pilsēta ir zaļa tiešajā nozīmē, un tie ir neaizstājami zaļo koridoru, minidzīvotņu, ekosistēmu pakalpojumu nodrošināšanai, kā arī iedzīvotāju veselībai un mikroklimatam. Pilsētu zaļās zonas platības mērīšana ir metodoģisks izaicinājums.
Pētījuma mērķis bija noteikt starpību starp esošo un plānoto zaļo zonu platību zemes gabalos ar atšķirīgu funkcionālo zonējumu, izmantojot normalizēto diferenciālās veģetācijas indeksa (NDVI) metodi. Pētījums tika veikts piecās Rīgas apkaimēs: Boderājā, Daugavgrīvā, Kundziņsalā, Mangaļsalā un Vecmīlgrāvī. Analīžu rezultāti liecina, ka, ievērojot dažādām funkcionālajām zonām noteikto minimālās brīvās zaļās teritorijas rādītāju, pētītajās apkaimēs var būtiski samazināties zaļās zonas apjoms. Vislielākais apstādījumu samazinājums ir paredzams nedzīvojamās funkcionālajās zonās. Piemēram, meža parkos un parkos, kuros paredzēts veikt ievērojamus atpūtas ērtību uzlabojumus, dabisko platību platība samazināsies pat par vienu trešdaļu. NDVI metodes pielietojums ir labi piemērots pilsētu veģetācijas seguma daudzuma un izplatības uzraudzībai, kā arī telpiskās attīstības novērtēšanai apkaimju līmenī. Tomēr, ņemot vērā esošo zonējuma noteikumu struktūru Rīgā, kas var atšķirties atsevišķu zemes gabalu līmenī, NDVI metodes sistemātiska piemērošana Rīgā pašlaik nebūtu jēgpilna.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.02

# SCENIC WEALTH OF BIOSPHERE RESERVE: VALUING CULTURAL ECOSYSTEM SERVICES USING HEDONIC PRICING

**Anda Mežgaile, Andris Klepers**
*Vidzeme University of Applied Sciences, Latvia*

**Abstract. This research uses the hedonic pricing method to explore the economic valuation of cultural ecosystem services (CES). North Vidzeme Biosphere Reserve, located in Latvia, has been used as a case study site. This vast area, with its diverse ecosystems, is crucial for studying CES due to its unique ecological and cultural significance as well as its interaction with human settlements. CES, including recreation, aesthetic appreciation, and cultural heritage, contribute to human well-being but are underrepresented in economic valuation and can be utilised in decision-making, especially in decisions regarding development alternatives. This study uses real estate transaction data and geographical information systems (GIS) to analyse how proximity to natural and cultural amenities influences property values. The research variables include structural attributes (e.g., property size and age), environmental factors (e.g., distance to waterbodies, coastlines, or nature trails), and neighbourhood landscape characteristics. Hedonic pricing models reveal that properties near natural amenities, such as coastlines and nature trails, exhibit higher valuations, reflecting the premium on access to CES and the potential for higher usage. Key findings include significant positive correlations between property prices and proximity to CES-rich environments, underscoring their role in shaping market perceptions and economic behaviors. However, the study highlights areas of concern, such as data limitations and methodological complexities, in isolating the specific impacts of CES. This interdisciplinary research provides empirical evidence for integrating CES into sustainable land-use planning and policy-making. By quantifying the economic benefits of CES, it advocates for enhanced recognition and preservation of these services, thereby balancing ecological conservation with socio-economic development.**
**Keywords: countryside, cultural ecosystem services, hedonic pricing, economic valuation, water bodies**

## Introduction

As of 2023, approximately 109 million people reside in rural areas of the European Union, constituting about 24,3 % of the total EU population. These rural regions encompass over 80 % of the EU's territory and represent a core of the European way of life [17]. Many cultural traditions contribute significantly to national and regional identities. In Latvia, the rural population accounts for 31,6 % of the country's total population [17;30] Although depopulation makes the countryside emptier and older, counter-urbanisation is evident in various regions, caused by various pull factors [30;13]. Especially as remote work and improved infrastructure make living outside cities more feasible, cities are left in favour of more space and especially a desire for a connection with nature, among many other reasons. The problem is that this may increase demand and pressure on the most scenically outstanding and ecologically sensitive natural areas, among which waterfronts are prominent [50]. This shift raises important questions for rural regions, particularly concerning the sustainability and demand of existing rural properties. Many occurred in historical times, providing another argument for choosing the location – will they be in demand in the future? Buying a property in the countryside to live close to nature offers unique competitive advantages, factors, and considerations that differ from those of urban property purchases. When purchasing a countryside property, the ultimate goal is to strike a balance between your desire for a natural lifestyle and practical considerations, such as accessibility, comfort, and long-term value.

Historically, society has undergone various phases in its relationship with nature – from fear and worship to domination and exploitation, and from provision and utilitarianism to acceptance and sustainability [51;52;10;2]. These late-phase efforts, among others, have led to the introduction of the biosphere reserve concept, with the "Man and the Biosphere Programme" (MAB) highlighting its impact on integrated, holistic, and sustainable development [9], [10]. Even after a few decades, researchers have questioned critically our ability to make real progress in these special status areas [11]. MAB ideals integrate the sciences, economics, and education to enhance human livelihoods and promote the equitable distribution of benefits while safeguarding natural and managed ecosystems. This approach fosters innovative, socially and culturally appropriate, as well as environmentally sustainable, economic development strategies [12]. It's important to note that the North Vidzeme Biosphere Reserve encompasses several value zones, each with different base values.

Until the 1990s, several terms were used to express the benefits that humans derive from nature, including environmental services or natural capital [42;9] and ecosystem services (ES) [15;16;35]. Ecosystem services are "the benefits humans derive from ecosystems" [35], including regulatory, provisioning, cultural, and support services. According to Costanza et al. [8] cultural ecosystem services are defined as "ecological processes, functions, and processes that directly or indirectly contribute to human well-being." In other words, non-material benefits that people gain from interaction with different environmental places. The concept of cultural ecosystem services is useful for capturing the full range of values provided by ecosystems that go beyond their material and regulatory functions, ensuring that cultural, spiritual, recreational, and identity benefits are recognized in science, policy, and everyday life [35]. Several researchers have emphasised the need to expand the scope of research on cultural ecosystem services beyond its predominant focus on more tangible forms of nature, such as tourism and recreation [36;20;34]. For example, a comprehensive review highlighted that while recreation and ecotourism services account for around 60,9 % of empirical CES research, other categories remain under-represented. Furthermore, the literature on ecosystem services has underlined that sociocultural and environmental values are underweighted relative to those in economic decisions, and there are often intangible, implicit, unstated, difficult to express, and poorly represented in public policy processes [27]. The authors recommend that future research delve deeper into these under-researched areas to gain a more comprehensive understanding of CES [53]. This highlights a persistent lack of knowledge in this area, which is further underscored by the research focus in the rural region, particularly within the Biosphere Reserve.

Hedonic pricing has been chiefly used for CES evaluation in urban green space [40;44].

Several studies have shown that natural amenities, including water views, proximity to green spaces, and scenic landscapes, have a positive impact on property values. The hedonic pricing method is a robust tool to quantify these effects, aiding in informed spatial planning and real estate valuation. Hedonic pricing method result as an indicator according [4] can be defined as a verifiable data-based measure that provides information not only about itself. There is a growing demand for assessments to evaluate ecosystem services in terms of specific outcomes [21]. To make this possible, indicators must be "SMART" (specific, measurable, achievable, relevant, and time-bound) [48]. The urban waterfront study employed the hedonic pricing method to measure the impact of proximity to various waterfronts, including bays, rivers, and streams, on residential property values in coastal Alabama. Findings indicated that properties with water views commanded a premium, with water views associated with a 26 % increase in house prices [12]. Aladwan and Ahamad [1] found that property prices are positively influenced by factors such as maintenance, cleanliness, historical value, green space, purchasing power, and accessibility to public transportation and upgrading programs. Loomis et al. [14] proved that house sale prices within 2 km of a special protected area were, on average, 9.8 % higher.

Conversely, land-use patch richness, an aging population, traffic noise, and proximity to freeways negatively impact prices. While structural and locational attributes play key roles, neighbourhood characteristics, traditional views, and customs were found to be insignificant. GIS analysis was used to measure property distances to key amenities, revealing that buyers prioritise structural attributes over other factors.

Hedonic pricing is an economic theory that suggests that the price of a good or service is related to its various characteristics, or "attributes". This approach assumes that the value of a product is derived from its characteristics rather than the product itself. "Hedonic" derives from the Greek word "hedone," meaning pleasure or delight. Hedonic pricing models in real estate valuation have been frequently applied in numerous research studies and projects since their introduction by Rosen in 1974 [1]. It is an economic valuation method used to estimate the economic value of non-market goods and services, including cultural ecosystem services. In the context of hedonic pricing for valuing cultural ecosystem services, the approach involves examining how changes in the quality or quantity of cultural amenities provided by ecosystems affect property values, thereby evaluating the impact of proximity to green infrastructure on real estate markets [32]. This method assumes that individuals are willing to pay a premium for properties with better access to cultural amenities.

Examining how changes in the quality or quantity of cultural amenities provided by ecosystems affect property values to evaluate how proximity to green infrastructure impacts real estate markets [32]. Hedonic pricing assumes that individuals are willing to pay a premium for properties with better access to cultural amenities. The technique assumes that a property is sold (or bought) as a package of inherent attributes. Four broad categories of variables are primarily addressed through the hedonic model. They include following characteristics: structural (such as age of the house, type of construction materials, size and number of bedrooms), locational (such as distance to the central business district), neighborhood (such as income and education levels in a block), and environmental (such as air and landscape quality) [25]. Each characteristic has its implicit price, which the hedonic equation could estimate.

While some researchers believe that various ecosystem services can be valued using hedonic pricing, Czembrowski and Kronenberg [11] are somewhat sceptical about this assumption and highlight that hedonic pricing is not powerful enough to separate the effects of individual ecosystem services, even if the buyer recognises them. Similarly, other researchers argue that the hedonic pricing method has limitations in isolating the effects of individual environmental attributes on property prices [5;41;28]. In Latvia, research has been conducted on the value of cultural ecosystem services for various ecosystems [39;49;43;31;45], however, their impact on real estate prices in highly valued natural areas has not been studied in depth. Another study was conducted in two cities in each country to assess real estate using a GIS approach (based on similar methodologies in Latvia and Brazil), but ecosystem values were not analyzed [33]. Most people involved in the real estate industry agree that among the various criteria for evaluating real estate, one of the most important is the "view from the window," as well as the improvement of the territory and surroundings, proximity to infrastructure, accessibility to nature, and various recreational opportunities—everything that a potential buyer might find important and that determines overall demand [37]. At least five international projects have been implemented using the cultural ecosystem services measurement approach, but not specifically in relation to real estate demand. To address this information gap, a hedonic price methodological approach has been applied to assess the impact of proximity to a biosphere reserve on real estate prices.

This leads to the research question: How does proximity to scenic landscapes and integration with nature influence the market value of rural residential properties in a biosphere reserve? The research objective of this study is to quantify the influence of proximity to scenic landscapes and integration with nature (CES) on the market value of rural residential properties within a biosphere reserve using the hedonic pricing method.

Hypothesis 1: The pricing of housing is affected by coastline, water bodies, and viewpoints. The EUR per kilometre would explain the result quantitatively if there is a causal relationship.

Hypothesis 2: CES positively impacts property listing valuation in NVBR.

## Materials and Methods

### *Case study area*

The study is interdisciplinary, connecting economics, ecology, and sociology. The North Vidzeme Biosphere Reserve has been selected as a study site due to its relevance to the purpose of such an area. It is also a typical rural area with a sufficiently large number of rural property transactions that can be analysed quantitatively. It is a vast area where nationally and internationally important natural and landscape values are preserved by ensuring sustainable social and economic development. NVBR is the only biosphere reserve in Latvia, established in 1997 and recognised as a protected territory of international importance within the framework of the UNESCO MAB program. Together, covering 4,576 km² of land and 167.5 km² of sea, about 6% of Latvia's total area, it is well accessible and home to 2.6% of Latvia's population (49,600 inhabitants as of July 1, 2022).

### *Research design*

The study design involves a mixed research approach. Following a documentary study reviewing key publications and reports to establish a solid theoretical basis combining

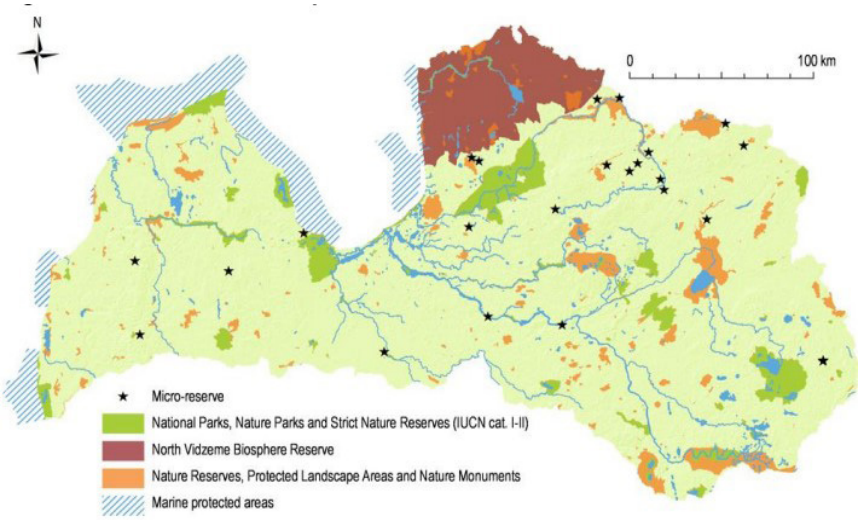



Fig. 1. Map of North Vidzeme Biosphere Reserve in comparison with other major SPNA's in Latvia [37]

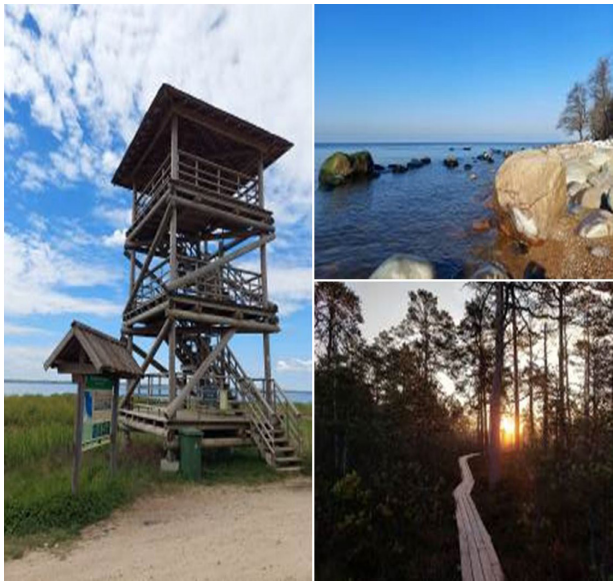


Fig. 2. North Vidzeme nature [foto by L.Kaulina]

the measurement of cultural ecosystem services using the hedonic price approach. Primary data collection is carried out using GIS datasets, supplemented by secondary data, including statistical analysis. This data is synthesized to integrate the findings from the sources used into a unified analysis. Finally, our disseminated results ensured that the knowledge gained effectively contributed to the field. This study uses the Cultural Ecosystem Services (CES) framework, which includes subgroups such as inspiration, aesthetic values, social relationships, sense of belonging, cultural heritage values, and educational values in the context of the real estate market using hedonic price analysis. We chose hedonic pricing as the methodological approach for this study because it can be measured and is considered an appropriate indicator for this type of research.

*Hedonic pricing method and cultural ecosystem services*

The hedonic pricing method conceptualises property value as a function of its inherent attributes, which can be categorised into four key groups. Structural characteristics encompass variables such as the age of the building, construction materials, total area, and number of bedrooms. Locational characteristics refer to spatial factors, including proximity to the central business district and accessibility to essential services and amenities. Neighbourhood characteristics encompass socioeconomic indicators, including distance to the nearest educational institution and distance to the capital city, within a specific area. Environmental characteristics include landscape aesthetics [25]. Each attribute possesses an implicit price that can be quantified using the hedonic pricing approach, enabling the estimation of its contribution to the overall property value. A facility's distance to the nearest hotspot for five CES benefits (ecotourism and recreation, landscape aesthetics, spiritual, heritage, knowledge development, and scientific research) represented environmental attributes. Comparable studies use hotel proximity to scenic spots [54], tourist attractions [22], heritage sites, nearby beaches, and forest areas [29] on-site green infrastructure within the city, views of natural elements, and water bodies [32] as measures of environmental attributes.

*Data colletcion*

Sales data are open-access data for everyone in Latvia. The State Land Service has published Real Estate Market Data on the Latvian Open Data Portal (https://data.gov.lv/dati/lv/dataset/nekustama-ipasuma-tirgus-datu-bazes-atvertie-dati). The data is updated monthly and contains information on real estate transactions registered in the Real Estate Market Information System as of 2012. Within one year, the Real Estate Market Database may record data on transactions from different years, as ownership rights are registered in the State Unified Computerized Land Register several years after the transaction occurs. For example, the transaction occurred in 2012, but the ownership was registered in the State Unified Computerized Land Register in 2020. Real estate transaction data are grouped in specific files according to the registration date. One file contains information on a single object type: land, land and buildings, or groups of rooms (such as condominiums). The data used for the study were groups of rooms and land with buildings. We used the flats and buildings as one-, two-, or three-apartment houses in the NVBR area. As different variables are available in the files, the specific files have also been analysed differently, thus showing the difference between the characteristics of apartment and house purchases. However, we paid the most attention to determining the CES value. 334 records were selected for further processing from room groups (further RG) out of 24281 relevant on a national level and 451 from land and buildings (further LB) out of 9592 relevant on a national level. We restructured the data in the datasets as spatial data for the NVBR using Esri ArcGIS software and the prepared NVBR

$$In\ P = \beta_0 + \beta_1 In\ ARE A_{GROUP} + \beta_2 In\ TOTAL_{AREA} + \beta_3 In\ NUM_{ROOMS} + \beta_4 In\ NUM_{BEDROOMS} + \beta_5 In\ AGE + \beta_6 In\ DEPRECATION + \beta_7 In\ LOW_{FLOOR} + \beta_8 In\ HIGH_{FLOOR} + \beta_9 In\ DIST_{COAST} + \beta_{10} In\ DIST_{WATER} + \beta_{11} In\ DIST_{NATTRAIL} + \beta_{12} In\ DIST_{VIEWP} + \beta_{13} In\ DIST_{CUL} + \beta_{14} In\ DIST_{EDI} + \beta_{15} In\ DIST\_RIGA$$

in which $\beta_0$ Is the stochastic term and $\beta_1 \dots \beta_{15}$

EQUATION 1. HEDONIC PRICE EQUATION [adapted from Jim&Chen; 25]

area layer. We measured distances between the property and spatial variables using the BalticMaps online map viewer measurement tool. Spatial measurements are in meters of driving or walking distance.

*Hedonic Equation*

The research employed the semi-log functional form, featuring a log-dependent variable and a linear combination of independent variables. It has been demonstrated to provide a sound statistical fit [19] and has been widely adopted in empirical studies (see Equation 1).

The listing price (€) was the dependent variable, whereas the structural characteristics were the independent variables including environmental (5) that are representing CES analysed among other 10 variables. We conducted the hedonic regression analysis using Microsoft Excel.

*Selection of model variables*

Table A-1 for RG and Table A-2 for LB (included in the Annex) define the dependent variable (PRICE) and the explanatory variables used in this study. For RG, 15 explanatory variables were employed. Eight variables related to housing structural characteristics were considered: area of group of rooms (AREA_GROUP), total area of apartment (TOTAL_AREA), Number of rooms in group of rooms (NUM_ROOMS), number of bedrooms in apartment (NUM_BEDROOMS), age of home in years (AGE), physical deterioration of the building (DEPRECEATION), lowest floor of the group of rooms (LOW_FLOOR) and highest floor of the group of rooms (HIGH_FLOOR), for LB 13 explanatory variables were used. Six variables related to housing structural characteristics were considered: total area of land sold (TOTAL_AREA_LAND), number of buildings (NUM_BUILD), number of floors above ground (NUM_FL_ABOV), total building area (TOTAL_BUILD_AREA), age of home in years (AGE), physical deterioration of the building (DEPRECEATION). Five explanatory variables described the environmental amenities representing the CES. They include distance to the coast/seaside (DIST_COAST), distance to the nearest waterbody (DIST_WATER); distance to the nearest nature trail (DIST_NAT_TRAIL), distance to the nearest designated viewpoint (DIST_VIEW) and distance to the nearest cultural attraction or object (DIST_CUL). Two explanatory variables described neighbourhood variables: distance to the nearest educational institution (DIST_EDI) and distance to the capital city, Riga (DIST_RIGA). This study does not include variables such as distance to the nearest forest or green area, as all points are within a 10-15 minute walk or less from the nearest green area.

## Results and Discussion

The country as a whole is experiencing a downward trend in the total number of real estate transactions from the second half of 2022 onwards, which is closely linked to the geopolitical situation and the general social and economic situation in the country, where energy and consumer prices have risen and mortgage interest rates continue to increase. During the COVID-19 pandemic, there was a strong interest in properties in rural areas, as people sought to escape crowding and be closer to nature.

*Spatial dispersion*

The number of permanent residents per square kilometre in 2023 (see Fig 2) indicates that most people live in the transition zone. However, compared to other specially protected nature areas elsewhere in the world, there is also a higher population density in the immediate vicinity of the core zones.

A spatial visualisation of the data in Fig. 3 shows that in 2022, most RG transactions were located in or very close to towns, with most LB observations in the coastal area (129 observations). The distribution is relatively even throughout the region, except at the border with Estonia,

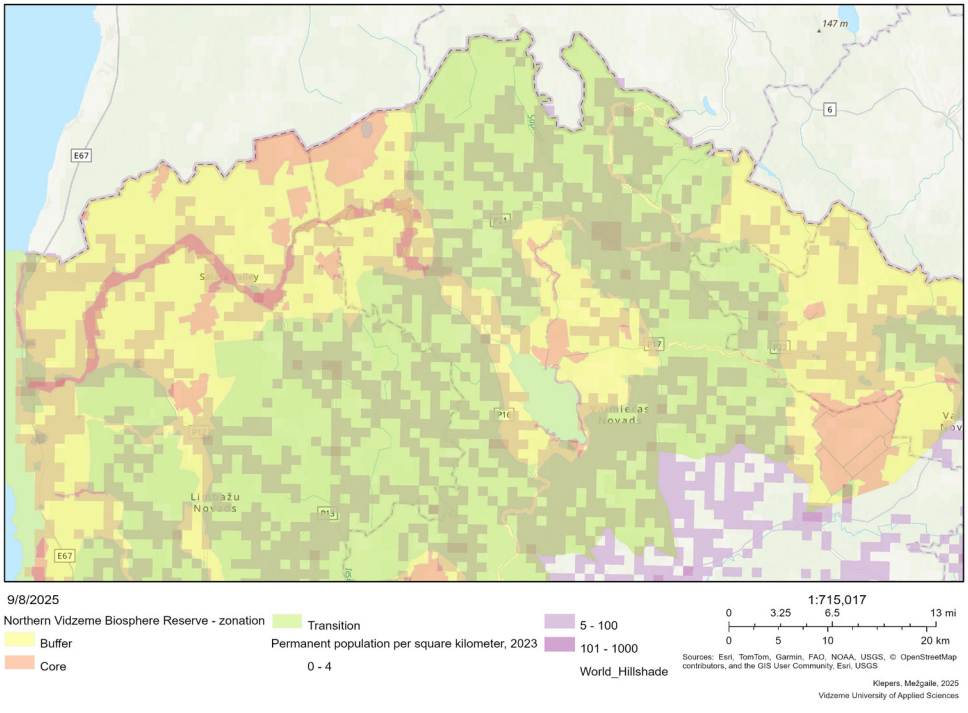



Fig. 3. Permanent population per square kilometre in 2023 and zoning of the North Vidzeme Biosphere Reserve

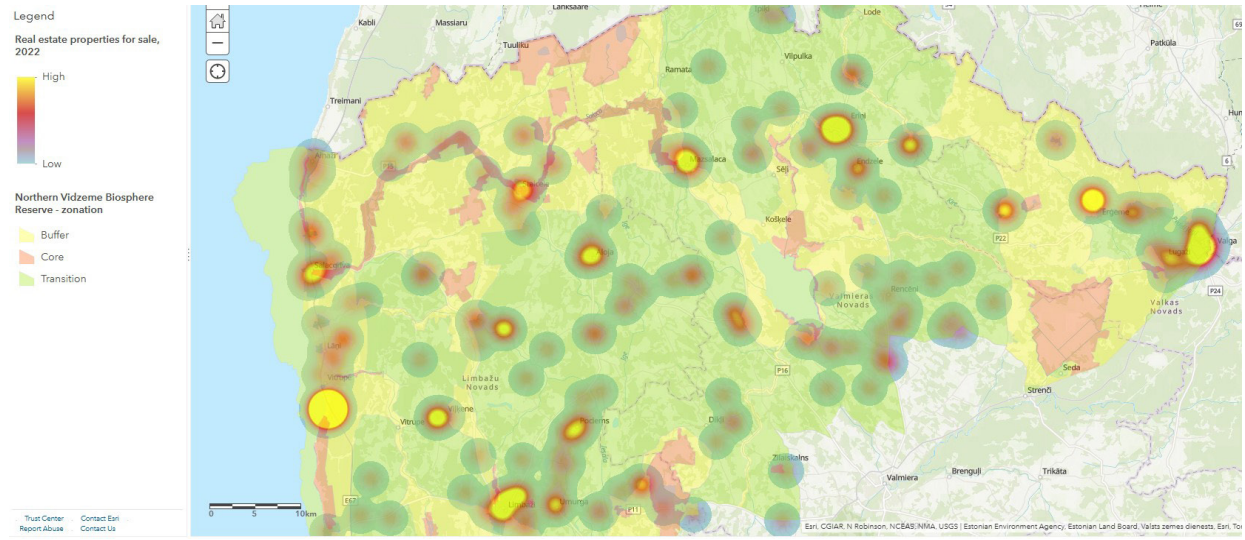



Fig. 4. Heatmap of real estate transactions – room groups and land and buildings 2022 in NVBR [created by author's]

where there are almost no transactions, despite the lower population density in that area.

*Hedonic price analysis*

We carried out a hedonic price analysis separately for RG (see Table 1) and LB (see Table 2). The regression was run with a 95 % confidence level.

The correlation coefficient that range from -1 to 1, and its absolute value indicates the strength of the relationship is calculated in the table above. For the RG, the R square indicated that the price listings explain 42 % of the characteristic's variations. The adjusted R-squared indicated that the price listings explain 39 % of the variation in the values of the structural characteristics. However, for the LB, the R-squared value indicated that the price listings explain 47% of the variation in characteristics. The adjusted R-squared indicated that the price listings explain 45 % of the variation in structural characteristics. This reinforces that the model is a good fit.

The standard error represents the average distance that the observed listing prices (in euros) deviate from the regression line. On average, the observed values fall € 9024,01 from the regression line in RG. There is a 95 % confidence level that the observed sample mean is plus or minus 1.96 standard errors from the population mean.

Positive coefficients indicate that for every increase in the unit of an independent variable, the dependent variable increases. Likewise, negative coefficients indicate that for every unit increase in the independent variable, the dependent variable decreases in value. Therefore, the signs of the coefficients in this research suggest the increase or decrease of the listing price in euros when structural variables are detected. Five of the total 15 variables had positive coefficients, and 10 had negative coefficients for RG. Out of the total 13 variables, six had positive coefficients, and seven had negative coefficients for RG. Both studies demonstrated that the coastline, waterbodies, and viewpoints have a positive impact on housing prices, thereby confirming Hypothesis No. 1.

Seven of the coefficients were statistically significant for RG and six for LB. This is established through P-values that are less than 0.05. This results in the rejection of the null hypothesis for these coefficients. The null hypothesis of the P-values was that the coefficient equals zero, implying that it has no effect. Therefore, the P-values indicate that these coefficients have a statistically significant impact on the listing prices (dependent variable). The results showed that proximity to the coast,

TABLE 1

The complete results of the hedonic pricing for RG [created by author's]

| | CES represented | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|---|
| Intercept | | 22757,23 | 4103,82 | 5,55 | 0,00 |
| AREA_GROUP | | 412,46 | 117,25 | 3,52 | 0,00 |
| TOTAL_AREA | | -313,83 | 123,72 | -2,54 | 0,01 |
| NUM_ROOMS | | -143,36 | 432,66 | -0,33 | 0,74 |
| NUM_BEDROOMS | | 2765,48 | 1187,83 | 2,33 | 0,02 |
| AGE | | -41,24 | 27,47 | -1,50 | 0,13 |
| DEPRECATION | | -65,63 | 41,07 | -1,60 | 0,11 |
| LOW_FLOOR | | 54,91 | 1922,69 | 0,03 | 0,98 |
| HIGH_FLOOR | | 1582,82 | 2003,74 | 0,79 | 0,43 |
| DIST_COAST | + | -0,06 | 0,02 | -4,19 | 0,00 |
| DIST_WATER | + | -0,15 | 0,37 | -0,40 | 0,69 |
| DIST_NAT_TRAIL | + | -0,38 | 0,18 | -2,07 | 0,04 |
| DIST_VIEWP | + | -0,31 | 0,18 | -1,75 | 0,08 |
| DIST_CUL | + | -0,65 | 0,52 | -1,26 | 0,21 |
| DIST_EDI | | 0,00 | 0,10 | 0,04 | 0,97 |
| DIST_RIGA | | -0,17 | 0,03 | -5,00 | 0,00 |

Multiple R 0,65 R Square 0,42 Adjusted R Square 0,39 Standard Error 9024,01

TABLE 2

The complete results of the hedonic pricing for LB [created by author's]

| | *CES represented* | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|---|
| Intercept | | 40596,81 | 11659,45 | 3,48 | 0,00 |
| DIST_COAST | + | -0,16 | 0,08 | -2,06 | 0,04 |
| DIST_WATER | + | -0,54 | 0,70 | -0,78 | 0,44 |
| DIST_NAT_TRAIL | + | 0,27 | 0,46 | 0,59 | 0,55 |
| DIST_VIEWP | + | -0,96 | 0,42 | -2,31 | 0,02 |
| DIST_CUL | + | -0,92 | 0,74 | -1,23 | 0,22 |
| DIST_EDI | | 1,38 | 0,42 | 3,27 | 0,00 |
| DIST_RIGA | | -0,06 | 0,10 | -0,55 | 0,58 |
| TOTAL_AREA_LAND | | 0,28 | 0,02 | 16,14 | 0,00 |
| NUM_BUILD | | 99,86 | 266,22 | 0,38 | 0,71 |
| NUM_FL_ABOV | | 3485,39 | 3637,04 | 0,96 | 0,34 |
| TOTAL_BUILD_AREA | | 13,67 | 9,45 | 1,45 | 0,15 |
| AGE | | 67,55 | 61,31 | 1,10 | 0,27 |
| DEPRECATION | | -427,55 | 99,78 | -4,29 | 0,00 |

Multiple R 0,68 R Square 0,47 Adjusted R Square 0,45 Standard Error 27897,35926

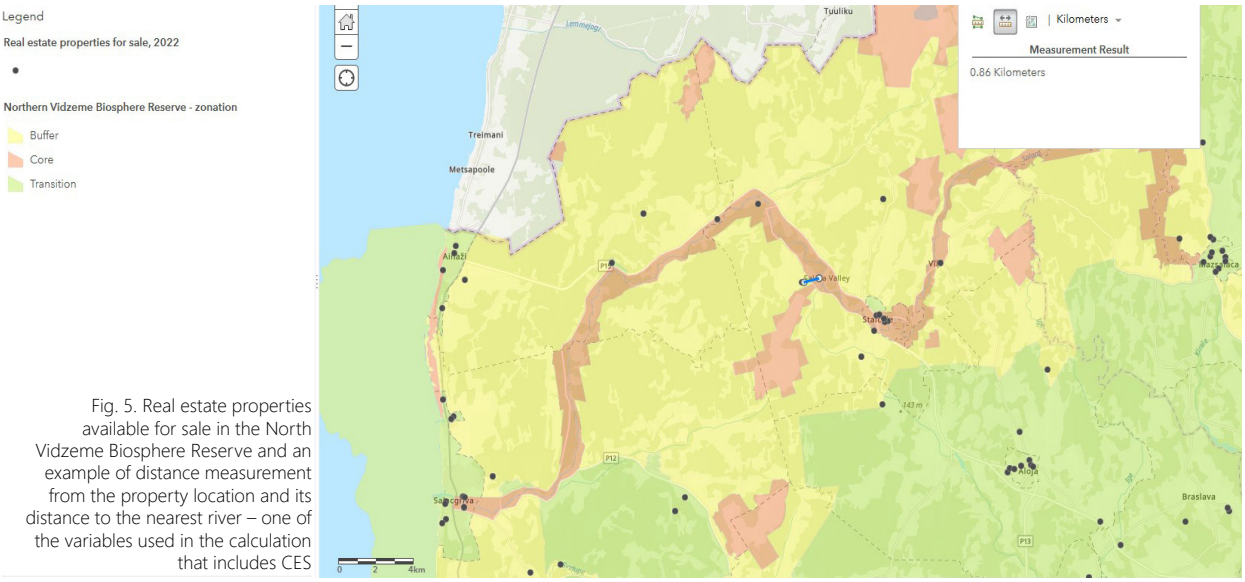



Fig. 5. Real estate properties available for sale in the North Vidzeme Biosphere Reserve and an example of distance measurement from the property location and its distance to the nearest river – one of the variables used in the calculation that includes CES

water bodies (see Fig. 4) and specially designed viewpoints increases the price of real estate.

For example, with every one-metre increase in distance from the coastline for RG, the real estate listing lost €0.06 in value. This equates to a €60 loss of value per km away from the coastline. Moreover, for every one-metre increase in distance from the nature trails, the real estate listing lost €0.38 in value. This equates to a €380 loss of value per km away from the nature trails. For every one meter increase in distance from the capital city of Riga, the real estate listing lost € 0,17 in value. This equates to a €170 loss of value per km away from the capital city, Riga.

Similarly, for LB, with every one-metre increase in distance from the coastline, the real estate listing lost €0.16 in value. This equates to a €160 loss of value per km away from the coastline. Furthermore, for every one-meter increase in distance from the waterbodies, the real estate listing lost € 0,54 in value. This equates to a €540 loss of value per km away from the water bodies. For every one-meter increase in distance from the designated viewpoint, the real estate listing lost € 0,96 in value. This equates to a € 960 loss of value per km away from the designated viewpoint.

The standard errors of the coefficients were also displayed in the output. This is the standard deviation of each coefficient. The standard error value indicates the model's precision for that coefficient. The standard errors in the model are significant across the output compared to the coefficients. This implies that the model does not accurately reflect the overall precision of the results.

The model produced mainly unexpected results. Many of the coefficients were counterintuitive values, not statistically significant, or did not meet the confidence thresholds in various statistical tests conducted using the hedonic price method. This implies that the results and model should be reviewed critically.

Meaning was not derived from any of the coefficients without statistical significance. The coefficients that were not statistically significant are still examined in the comparative literature. This research hypothesised that CES would positively impact property listing valuation in NVBR. Although many of the CES structural variables did not produce statistically significant results, it is worth noting what was not produced. No statistically significant result conflicted with Hypothesis 2 or the literature supporting positive associations between property valuation and CES.

The coexistence of several environmental factors makes attributing price changes to a specific ecosystem service challenging and raises further discussion. Interaction with nature creates a sense of community and belonging, sets specific values [38]. Preferences and socio-economic factors influenced by customer values may affect the perception of different ecosystem services, leading to biased assessments. Similarly, buyers may not be aware of all the environmental benefits when they purchase a property, and some may only become apparent later as they develop a rural lifestyle. Therefore, the sceptical group of researchers can agree on the accuracy of using this method to disaggregate the individual components of the total price. This confirms the conclusions drawn by Boyle [5], Sander and Polasky [41], Klaiber and Phaneuf [28] and Czembrowski and Kronenberg [11].

At the same time, however, it should be recognised that the findings of one region are not so unique and could be transferred to another region, even though there are different market conditions and ecological characteristics. The study in a rural region, which drew lessons from this case, is comparable to similar results obtained by other researchers in a suburban environment, where people's preferences for locations with views and nature are similar [6;40;44]. The addition makes a new contribution to the knowledge of CES quantifications of monetary value outside the dominant tourism and recreation services sector. A comprehensive study of this kind in a biosphere reserve also provided insight into the socio-economic processes occurring in areas of this status, revealing that they are not significantly different from the situation in other regions.

Real estate prices in Latvia are relatively low compared to other European Union countries, but they still significantly impact individual finances. Recent data indicates that home ownership in Latvia has risen from 80.2 % in 2020 to 83.7 % in 2024. During the same period, the housing price index has also increased, showing a 153% rise from 2010 to 2024 [18;46]. Additionally, over the 10-year period from 2015 to 2025, the cadastral value of real estate has doubled [23; 26].

The conclusions and the need for further research also raise a question for discussion. Would biosphere reserves built on larger comprehensive ecosystems, and thus more effectively manage different environmental risks that are less influenced by external factors - would there be more advantages in the long term to living in a nature-friendly, biodiverse environment here than in other regions? Would the price aggregation arguments found in the study provide an advantage for selling real estate in the biosphere reserve in

the future? The best justification is likely to be for properties where the additional factors include good accessibility, a shorter distance to the service centre, and greater privacy of the space. It becomes more challenging to sell an apartment or part of a building in the countryside with outstanding natural views or waterfronts, mainly if it is a small and isolated apartment building, such as those constructed during the Soviet occupation, often located near cattle farms or in small villages, which are now commonly shared properties. The intention is to further test the use of different measured CES values in decision-making processes at various levels within local authorities, among other contexts, in situations where the benefits of natural ecosystems are sometimes countered by the notion of "positive change" in the name of economic development. The special ecological conditions and responsible local management of the Biosphere Reserve could become a long-term catalyst for building more resilient communities in rural areas and attracting new residents, thereby addressing a broader range of regional development challenges.

By quantifying the economic benefits of CES, it advocates for enhanced recognition and preservation of these services, thereby balancing ecological conservation with socio-economic development. The results obtained from the biosphere are typical for a rural region with its population structure. No specific characteristics of the impact of the biosphere region on the importance of ecosystem services were found. This raises questions for the discussion about the effectiveness and capacity of the UNESCO MAB programme to administer these objectives in an integrated manner, which is a complex task given the day-to-day functions carried out by local authorities or national conservation authorities, to which only part of the overall content of the MAB programme is delegated. Further research is needed on how to achieve more sustainable progress in specially designated biosphere reserves, which are subject to the same trends as the rest of the rural periphery.

## Conclusion

Key findings include significant positive correlations between property prices and proximity to CES-rich environments, underscoring their role in shaping market perceptions and economic behaviours.

The study reveals that access to cultural ecosystem services, which offer scenic aesthetic values, social interaction, a sense of belonging, education, and inspiration, significantly influences real estate sales prices. For the LB group, the greatest influence is exerted by scenic viewpoints and proximity to waterfronts, while for the RG group it is nature trails (walking trails) and proximity to cultural sites. Depending on the type and location of the real estate, the availability of cultural ecosystem services can affect real estate prices, for example, distance to coastline from 1-5 %.

Overall trends in real estate transactions indicate a gradual shift in the rural population structure. There is a growing demand for properties in urban areas and the countryside, particularly in areas of outstanding scenic and natural beauty or near the coast. A few farmsteads, many of which were built 100 years ago on utilitarian agrarian landscapes, are no longer in such high demand. Similarly, with apartment blocks in remote small rural villages, some of which remain derelict and are losing their edge. The biosphere reserve has proved no more immune to general demographic and economic trends.

At the local and regional levels, policymakers could utilise the values calculated here, along with additional ecosystem service values calculated using hedonic pricing, to identify the potential economic impacts of land-use policies. There is, thus, considerable potential to utilise economic values for ecosystem services, as calculated using hedonic pricing models, to promote more sustainable development. Land-use plans and policies that disregard impacts on these services not only may affect them but also are likely to negatively impact property values and the quality of life of local residents.

Research limitations include that several indicators did not show strong statistical significance, indicating that future work can be conducted to improve the model. To further enhance our understanding of the intricate interplay between people, environment, and behavior, studies could be expanded to different categories of housing with varied environmental qualities and varying provision of green spaces.

## Acknowledgements

The study was conducted with the support of the Man and the Biosphere (MAB) Programme Young Scientist Research Award.

## Conflicts of interest

The authors declare no conflict of interest.

## References

1. **Aladwan, Z., Ahamad, M. S. S.** Hedonic pricing model for real property valuation via GIS – A review. *Civil and Environmental Engineering Reports*. 2019, vol. 29, no. 3, p. 034–047. DOI 10.2478/ceer-2019-0022.
2. **Amrith, S.** *The Burning Earth: An Environmental History of the Last 500 Years*. London: Allen Lane, 2024.
3. **Batisse, M.** The Biosphere Reserve: A Tool for Environmental Conservation and Management. Environmental Conservation. 1982, vol. 9, no. 2, p. 101–111.
4. Biodiversity Indicators Partnership (BIP). *Guidance for national biodiversity indicator development and use*. Cambridge: UNEP World Conservation Monitoring Centre, 2011.
5. **Boyle, K. J.** Contingent valuation in practice. In: *Handbook of Environmental Economics*. 2003, vol. 2, p. 445–489.
6. **Chen, Y., Liu, G., Yan, N., Yang, Q., Gao, H., Su, L., Santagata, R.** Comprehensive evaluation of urban greenspace ecological values marketability through the spatial relationship between housing price and ecosystem services. *Ecological Modelling*. 2023, vol. 484, p. 110482. DOI 10.1016/j.ecolmodel.2023.110482.
7. **Coetzer, K. L., Witkowski, E. T. F., Erasmus, B. F. N.** Reviewing Biosphere Reserves Globally: Effective Conservation Action or Bureaucratic Label? *Biological Conservation*. 2014, vol. 176, p. 162–171.
8. **Costanza, R., d'Arge, R., de Groot, R., Farber, S., et. al.** The value of the world's ecosystem services and natural capital. *Nature*. 1997, vol. 387, no. 6630, p. 253–260.
9. **Costanza, R., Daly, H. E.** Natural Capital and Sustainable Development. *Conservation Biology*. 1992, vol. 6, p. 37–46. DOI 10.1046/j.1523-1739.1992.610037.
10. **Cronon, W.** *Uncommon Ground: Rethinking the Human Place in Nature*. New York: W.W. Norton & Company, 1996.
11. **Czembrowski, P., Kronenberg, J.** Hedonic pricing and different urban green space types and sizes: Insights into the discussion on valuing ecosystem services. *Landscape and Urban Planning*. 2016, vol. 146. DOI 10.1016/j.landurbplan.2015.10.005.
12. **Dahal, R. P., Grala, R. K., Gordon, J. S., et. al.** A Hedonic Pricing Method to Estimate the Value of Waterfronts in the Gulf of Mexico. *Urban Forestry & Urban Greening*. 2019, vol. 41, p. 185–194. https://doi.org/10.22034/gjesm.2024.02.03
13. **Dorigo, G., Tobler, W.** Push-pull migration laws. *Annals of the Association of American Geographers*. 1983, vol. 73, no. 1, p. 1–17.
14. **Eloomis, J.; Richardson, L.; Dara, P. K.; et. al.** Ecosystem service values provided by National Parks to residential property owners. *Ecological Economics*, 2024, vol. 220, p. 108175. DOI 10.1016/j.ecolecon.2024.108175.
15. **Ehrlich, P. R., Ehrlich, A. H.** *Extinction: The Causes and Consequences of the Disappearance of Species*. New York:

Random House, 1981, p. 72–98.
16. **Ehrlich, P. R., Ehrlich, A. H.** The Value of Biodiversity. *AMBIO*. 1992, vol. 21, p. 219–226.
17. **European Commission.** *A long-term Vision for the EU's Rural Areas — Towards More Substantial, Connected, Resilient and Prosperous Rural Areas by 2040* [online]. 2021 [viewed 2025-09-05]. Available from: https://www.fao.org/family-farming/detail/en/c/1414177/
18. **Eurostat.** *House price index (HPI)* [online]. [viewed 2025-09-05]. Available from: https://ec.europa.eu/eurostat/databrowser/view/prc_hpi_a/default/table?lang=en&category=prc.prc_hpi.prc_hpi_inx
19. **Garrod, G., Willis, K. G.** Valuing Goods' Characteristics: An Application of the Hedonic Price Method to Environmental Attributes. *Journal of Environmental Management*. 1992, vol. 34, p. 59–76. DOI 10.1016/S0301-4797(05)80110-0.
20. **Gould, R. K., Morse, J. W., Adams, A. B.** Cultural ecosystem services and decision-making: How researchers describe the applications of their work. *People and Nature*. 2019, vol. 1, no. 4, p. 457–475. DOI 10.1002/pan3.10044.
21. **Hernández-Morcillo, M., Plieninger, T., Bieling, C.** An empirical review of cultural ecosystem services indicators. *Ecological Indicators*. 2013, vol. 29, p. 434–444. DOI 10.1016/j.ecolind.2013.01.013.
22. **Hong, I., Yoo, C.** Analysing spatial variance of Airbnb pricing determinants using multiscale GWR approach. *Sustainability*. 2020, vol. 12, no. 11, p. 4710. https://doi.org/10.3390/su12114710
23. *Investropa. Latvia Price Forecasts* [online]. [viewed 2025-09-05]. Available from: https://investropa.com/blogs/news/latvia-price-forecasts
24. **Ishwaran, N., Persic, A., Tri, N. H.** Concept and Practice: The Case of UNESCO Biosphere Reserves. *International Journal of Environment and Sustainable Development*. 2008, vol. 7, no. 2, p. 118–131.
25. **Jim, C. Y., Chen, W. Y.** Value of scenic views: Hedonic assessment of private housing in Hong Kong. *Landscape and Urban Planning*. 2009, vol. 91, p. 226–234. https://doi.org/10.1016/j.landurbplan.2009.01.009
26. **Jankava, A., Palabinska, A., Didrihsone, D.** Analysis of the indicators of the cadastral value base for residential building land in Latvia. *Journal of Baltic Surveying*. 2016, vol. 4, p. 41–47
27. **Kaltenborn, B., Linnell, D. C. J., Gomez-Baggethun, E.** Can cultural ecosystem services contribute to satisfying basic human needs? A case study from the Lofoten archipelago, northern Norway. *Applied Geography*. 2020, vol. 120. https://doi.org/10.1016/j.apgeog.2020.102229
28. **Klaiber, H. A., Phaneuf, D. J.** Valuing open space in a residential sorting model of the Twin Cities. *Journal of Environmental Economics and Management*. 2010, vol. 60, no. 2, p. 57–77. https://doi.org/10.1016/j.jeem.2010.05.002
29. **Latinopoulos, D.** Using a spatial hedonic analysis to evaluate the effect of sea view on hotel prices. *Tourism Management*. 2018, vol. 65, p. 87–99. https://doi.org/10.1016/j.tourman.2017.09.019
30. **Lee, E. S.** A Theory of Migration. Demography. 1966, vol. 3, no. 1, p. 47–57.
31. **Lībiete, Z., Jūrmalis, E., Pauliņa, I., Bārdule, A., Gerra-Inohosa, L.** Discussing indicators for some less studied cultural ecosystem services provided by forests: example from Latvia. In: *Rural Development 2023: Bioeconomy for the Green Deal*. Kaunas: Vytautas Magnus University Agriculture Academy, 2025. DOI 10.15544/RD.2023.039.
32. **Lieber, J.** *A Hedonic Pricing Model in Helsinki, Finland: Exploring the Impacts of Green Infrastructure on Apartment Listing Prices*. In: Aarrevaara, E., Maksheeva, A., eds. MurCS Proceedings. 2022 [online]. Available from: https://www.theseus.fi/bitstream/handle/10024/791456/LAB_2023_MUrCS.pdf?sequence=5#page=140
33. **Luminor.** *Nekustamā īpašuma vērtējums: kāpēc nepieciešams un kad to veikt?* [online]. Luminor Bank AS, 17.08.2023 [viewed 2025-09-04]. Available from: https://www.luminor.lv/lv/jaunumi/nekustama-ipasuma-vertejums-kapec-nepieciesams-un-kad-veikt
34. **McElwee, P., He, J., Hsu, M.** Challenges to understanding and managing cultural ecosystem services in the global South. *Ecology & Society*. 2022, vol. 27, no. 3. DOI 10.5751/ES-13427-270323.
35. Millennium Ecosystem Assessment. *Ecosystems and Human Well-being*, Vol. 2: Current States and Trends. Washington DC: Island Press, 2005, p. 917.
36. **Nowak-Olejnik, A., et al.** The benefits and disbenefits associated with cultural ecosystem services of urban green spaces. *Science of The Total Environment* [online]. 2024, 172092 [viewed 2025-09-05]. Available from: https://doi.org/10.1016/j.scitotenv.2024.172092
37. *Organisation for Economic Co-Operation and Development (OECD). OECD Environmental Performance Reviews: Latvia 2019*. Paris: OECD Publishing, 2019 [online]. DOI 10.1787/2cb03cdd-en. Available from: https://www.oecd-ilibrary.org/environment/oecd-environmental-performance-reviews-latvia-2019_2cb03cdd-en [viewed 2025-09-04].
38. **Özkan, D. G., Özkan, S. D.** Evaluating social interaction performance and sense of community in urban green space: the case of Trabzon Ganita coast. *Landscape Architecture and Art*. 2024, vol. 24, no. 24, p. 21–27. https://doi.org/10.22616/j.landarchart.2024.24.03
39. **Ruskule, A., Klepers, A., Veidemane, K.** Mapping and assessment of cultural ecosystem services of Latvian coastal areas. *One Ecosystem*. 2018, vol. 3, e25499. DOI 10.3897/oneeco.3.e25499.
40. **Sander, H. A., Haight, R. G.** Estimating the economic value of cultural ecosystem services in an urbanising area using hedonic pricing. *Journal of Environmental Management*. 2012, vol. 113, no. 1–2, p. 194–205. DOI 10.1016/j.jenvman.2012.08.031.
41. **Sander, H., Polasky, S.** The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota. *Land Economics*. 2009, vol. 85, no. 4, p. 527–544. https://doi.org/10.1016/j.landusepol.2008.10.009
42. **Schumacher, E. F.** *Small is Beautiful: Economics as if People Mattered* [online]. 1973 [viewed 2025-09-05]. Available from: https://web.archive.org/web/20141014171926/http://www.ditext.com/schumacher/small/small.html
43. **Spage, A., Markova, M.** Assessment of cultural ecosystem services in a national park: participatory mapping in Latvia. *Land*. 2025, vol. 14, no. 9, p. 1822. DOI 10.3390/land14091822.
44. **Spanou, E., Kenter, J. O., Graziano, M.** The effects of aquaculture and marine conservation on cultural ecosystem services: An integrated hedonic–eudaemonic approach. *Ecological Economics*. 2020, vol. 176, p. 106757. DOI 10.1016/j.ecolecon.2020.106757.
45. **Surgelas, V., Puķīte, V., Arhipova, I.** Property Valuation in Latvia and Brazil: A Multifaceted Approach Integrating Algorithm, Geographic Information System, Fuzzy Logic, and Civil Engineering Insights. *Real Estate.* 2024, vol. 1, no. 3, p. 229–251. https://doi.org/10.3390/realestate1030012
46. *Trading Economics. Latvia Home Ownership Rate* [online]. [viewed 2025-09-05]. Available from: https://tradingeconomics.com/latvia/home-ownership-rate
47. *UNESCO. Man and the Biosphere Programme (MAB)* [online]. 2025 [viewed 2025-09-05]. Available from: https://www.unesco.org/en/mab
48. United Nations Development Programme. *Handbook on planning, monitoring and evaluating for development results*. New York: United Nations Development Programme, 2009.
49. **Veidemane, K., Reke, A., Ruskule, A., Vinogradovs, I.** Assessment of coastal cultural ecosystem services and well-being for integrating stakeholder values into coastal planning. *Land*. 2024, vol. 13, no. 3, p. 362. DOI 10.3390/land13030362.
50. **Wang, C., Jie, H.** Long-term evolution of ecologically fragile waterside rural areas and strategies for local spatial planning: An empirical study in Baiyangdian, China. *Land*. 2024, vol. 13, no. 10, p. 1675. DOI 10.3390/land13101675.
51. **Worster, D.** *Nature's Economy: A History of Ecological Ideas*. Cambridge: Cambridge University Press, 1977.
52. **Worster, D.** The Wealth of Nature: Environmental History and the Ecological Imagination. Oxford: Oxford University Press, 1993.
53. **Yang, L., Cao, K.** Cultural ecosystem services research progress and future prospects. *Sustainability.* 2022, vol. 14, no. 19, p. 11845. DOI 10.3390/su141911845.
54. **Zhang, Z., Ye, Q., Law, R.** Determinants of hotel room price. *International Journal of Contemporary Hospitality Management*. 2011, vol. 23, no. 7, p. 972–981. DOI 10.1108/09596111111167551.

**Authors**
**Anda Mežgaile**, Mg.oec, PhD candidate, research assistant. Academic and research experience more than six years. Currently working at the Scientific Institution in Vidzeme University of Applied Sciences. E-mail: anda.mezgaile@va.lv
ORCID ID: https://orcid.org/0000-0002-1064-4470

**Andris Klepers**, Dr.geogr., professor, lead researcher. Academic and research experience more than twenty years. Currently working at the Scientific Institution in Vidzeme University of Applied Sciences. E-mail: andris.kleprs@va.lv
ORCID ID: https://orcid.org/0000-0002-7314-7957

**Kopsavilkums**
Lai novērtētu to, kādu pievienoto vērtība sniedz dabas tuvums nekustamā īpašuma iegādē, izmantota hedoniskā cenu noteikšanas metode. Tā izmantota, lai izpētītu kultūras ekosistēmu pakalpojumu ekonomisko vērtību. Kā pētījuma teritorija - Ziemeļvidzemes biosfēras rezervāts. Šī plašā teritorija ar daudzveidīgajām ekosistēmām ir ļoti nozīmīga kultūras ekosistēmu pakalpojumu (KEP) pētīšanai, jo tai ir unikāla ekoloģiskā un kultūras nozīme, kā arī tā mijiedarbojas ar cilvēku apdzīvotajām vietām. KEP, tostarp rekreācija, estētiskā bauda un kultūras mantojums, veicina cilvēku labklājību, bet ir nepietiekami pētīti ekonomiskajā griezumā, un var tikt izmantoti lēmumu pieņemšanā, jo īpaši lēmumos par teritorijas attīstības alternatīvām. Šajā pētījumā izmantoti nekustamā īpašuma darījumu dati un ģeogrāfiskās informācijas sistēmas (GIS), lai analizētu, kā dabas tuvums un kultūras objektu tuvums ietekmē nekustamā īpašuma vērtību. Pētījuma mainīgie ietver strukturālos atribūtus (piemēram, nekustamā īpašuma lielumu un vecumu), vides faktorus (piemēram, attālumu līdz ūdenstilpēm, krasta līnijām vai dabas takām) un apkārtnes ainavas raksturlielumus. Hedoniskās cenu noteikšanas modeļi liecina, ka nekustamajam īpašumam, kas atrodas tuvu dabas objektiem, piemēram, piekrastei un dabas takām, ir augstāka vērtība, atspoguļojot KEP pieejamības priekšrocības un potenciālu to plašākai izmantošanai. Pētījumā izcelti arī problemātiski jautājumi, piemēram, datu pieejamības ierobežojumi un metodoloģiskas grūtības, izdalot KEP konkrēto ietekmi. Šis starpdisciplinārais pētījums sniedz empīriskus pierādījumus KEP integrēšanai ilgtspējīgā teritorijas izmantošanas plānošanā un politikas veidošanā. Kvantificējot KEP ekonomiskos ieguvumus, tas aicina uzlabot šo pakalpojumu atpazīstamību un saglabāšanu, tādējādi līdzsvarojot ekoloģisko saglabāšanu ar sociālekonomisko attīstību.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.03

# BRYOPHYTES AS REGULATORY ECOSYSTEM SERVICES PROVIDERS IN THE URBAN LANDSCAPE

**Juta Kārkliņa[1,3], Edgars Kārkliņš[1,3], Lilita Ābele[1,3], Līga Strazdiņa[2]**
*[1] Centre for Nature and Engineering, RTU Liepaja Academy, Latvia, [2] Institute of Biology, University of Latvia, Latvia*
*[3] Latvia University of Life Sciences and Technologies, Latvia*

**Abstract. Human survival, health and well-being depend directly on ecosystem services or the benefits humans derive from ecosystems. Regulatory ecosystem services are essential to humans, as they represent services that regulate the environment, such as climate regulation, clean air and water availability, and flood control. Different plants provide ecosystem services in cities, but the authors focus on bryophytes (or mosses) in this article. Moss's ability to provide ecosystem services is represented broadly in the literature, but there is no systematized approach to view them. Therefore, the author's objective of the study is to develop systematization and answer the research question "What ecosystem services provided by mosses to the urban landscape should be included in the systematization of regulating ecosystem services?". To answer the question, authors fulfilled such tasks as analyzing theoretical sources on the ecosystem services provided by mosses in urban landscapes; to develop a systematization of the regulating ecosystem services and benefits mosses provide to the urban landscape, using systemic analysis. After the execution of the analysis, regulatory ecosystem services provided by mosses were prepared in a systematization depicting interactions and implications. Identified ecosystem services provided by mosses that fulfil regulatory services include improving air quality, photosynthesis of CO2 into oxygen, rainwater retention, reduction of the heat island effect, promotion of biodiversity, reduction of noise pollution, and mitigation of the long-term impact of climate change. The research rationale is novel in its outcome, as there is a current gap in knowledge of a structured, systematized summary of regulatory ecosystem services provided by mosses. These finding carry both theoretical and practical value, as they can be used both for study purposes and envidening view on ecosystem services and specific plants providing them; at the same time from practical perspective, this research brings a framework for policy makers, urban planners, and landscape architects on regulatory ecosystem services provided by mosses.**
**Keywords: regulatory ecosystem services, moss ecosystem services, moss systematization, mosses in landscape architecture, landscape architecture students**

## Introduction

Most people live in cities and urban environments today-nevertheless, human survival depends directly on nature and ecosystems [3]. Cities depend on ecosystems beyond city borders and benefit from internal urban ecosystems [10]. Ecosystem services refer to the benefits humans derive from ecosystems, which contribute to public health and improve the well-being of urban residents [3]. The EU Nature Restoration Regulation (entered into force on 18 August 2024) promotes the ambitious restoration of natural and environmental values and the improvement of urban green spaces, while adapting to climate change. The Regulation follows the framework of the green economy, the green deal and ecosystem services [34]. Ecosystem services, systematisation and assessment are the starting point for nature's contribution to humans. The concept of ecosystem services was introduced in the 1980s to highlight human dependence on the natural environment [8, 17, 26]. To categorize ecosystem services, authors chose to use the Millennium Ecosystem Assessment [6] as it provides a globally accepted typology of ecosystem services, making it suitable for international view and comparison of ecosystem services. According to it, the classification system can be divided into four main categories:

1. Supporting: services that are essential for soil formation and the circulation of nutrients in nature;
2. Provisioning: directly usable services, such as food, materials, and energy;
3. Regulating: services that regulate the environment, such as climate, access to clean air and water, flood control, etc.
4. Cultural: services that provide recreation, spirituality, and aesthetic aspects [29].

This article focuses on regulating ecosystem services and the role of bryophytes (or more commonly used – mosses) in providing them, as mosses have a unique ability to grow on a variety of substrates [25] that are unsuitable for any other plant and, despite their small size, mosses account for a significant proportion of the world's plant biomass [33]. Unlike all other plants, mosses are found everywhere, on all continents, from deserts to the Arctic, except in seas and oceans [18]. Species that grow in, for example, Europe may also be found elsewhere in the world, such as Asia or America [19]. Many mosses grow in urban environments, providing a range of ecosystem services [9] due to their natural growth in cities and the influence of human activities (for example, using mosses for green infrastructure). Bryophytes are the second-largest group of plants in the world, surpassed only by the angiosperms – flowering plants [24]. Botanically, mosses are nonvascular plants in the land plant division Bryophyta. Mosses are among the first plants on Earth, having survived for over 400 million years [32], enduring all climate changes and developing robust survival mechanisms [19]. There are approximately 12,000 species of mosses, which occupy more than six million square kilometres of land and are ecologically and evolutionarily important [24]. Central Europe, especially the mountainous regions of the Alps and, to some extent, Scandinavia, Scotland, Wales, the Pyrenees, and Eastern Europe, has the highest number of moss species. Species richness gradually decreases towards the south and east of Europe [20]. Mosses provide a range of ecosystem services that are important for both humans and life on Earth in general:

1. Some moss species have adapted to survive in extreme conditions. Studies have shown that the temperature at which mosses freeze is -3 to -8 ºC, depending on the species; the lowest air temperature at which they can photosynthesizes is about -5 ºC, and the highest is about 30 ºC [37]. To survive extreme heat, mosses dry out, as this allows them to tolerate high temperatures better. Studies indicate 120 ºC is the highest temperature that some moss species can tolerate for a short time [38]. After periods of drought, when mosses are fully hydrated, they quickly resume their metabolism upon rewetting [19]. Mosses also affect soil temperature,

protecting the soil from immediate heating in hot weather and acting as a layer between air temperature and soil in cold weather, thereby achieving higher soil temperatures [38]. The regulation of soil temperature and moisture is an essential component of the overall ecosystem's health, as it controls the concentration of nitrogen available to plants [36]. For example, the moss species Homalothecium sericeum, Barbula unguiculata, Pseudoleskea incurvata, Grimmia pulvinata, and Hypnum cupressiforme have been proven to reduce surface temperatures by up to 14 °C in a specific application.

2. Mosses have played a crucial role in ecosystem processes over centuries—permafrost formation and thawing, peat accumulation, and microtopography development. Mosses account for the majority of biodiversity [24]. For example, bogs form ecosystems fundamentally dependent on mosses [20]. Moses also provides habitat for various organisms [36], shelter and food for small invertebrates, and nesting material for birds and mammals.

3. The ability of bryophytes to regenerate and grow from any fragment, a feature called fragmentation, vegetative reproduction, or asexual reproduction, makes them remarkably resilient and is partly a result of totipotency - the ability of any cell in the organism to dedifferentiate and then differentiate into a new plant. All bryophytes are totipotent to some extent: they can regenerate from a fragment or even a single cell, making them excellent survivors [19]. The authors have researched this unique feature of mosses and identified moss species Brachythecium albicans, Brachythecium rutabulum, and Bryum argenteum as the most resilient, mainly when cultivated in combination [15].

4. Reducing plant pathogens and increasing carbon sequestration in the soil, thereby improving overall soil health, is an essential function of mosses. Mosses also protect long-term carbon storage systems such as bogs and permafrost. Moss growth is increasingly being incorporated into models to enhance the accuracy of climate change projections [24]. Mosses act like sponges, using capillaries to hold onto water. They help absorb precipitation, retain moisture in the soil below, and maintain moist conditions around them. This allows other plants to thrive around them, such as in habitats such as swamps and forests [22]. Given the moss's uptake capacity, a moss mat can act as a reservoir that traps large amounts of nutrients in an ecosystem [5]. Studies indicate that mosses can store 8–10 times their weight in water [1,12].

5. Mosses play a critical role in the global carbon cycle as the largest carbon store on the planet [19]. Because mosses are small, they grow close to the soil surface and are exposed to Carbon Dioxide (CO2) released by decomposing soil organic matter. Thus, mosses are likely exposed to significantly higher levels of CO2 than most other plants. Unlike vascular plants, mosses do not use stomata to take up CO2 and may have less access to available CO2. A team of researchers from the Pandey and Allen laboratories at the Donald Danforth Center for Plant Science at Danforth University addressed this issue. It demonstrated that the spongy bladderwort Physcomitrium patens, a moss species, produces three times more biomass under elevated CO2 conditions by adapting its growth, metabolism, and physiology, primarily through changes in sugar-nitrogen interactions. These results suggest that the increase in biomass is due to improved photosynthesis and a balance in the moss life cycle between diffuse and abundant growth, depending on nitrogen and carbon availability [24]. It has been estimated that soil covered with moss globally contains 6.43 Gt more CO2 than bare soil [9].

6. Mosses are also unique plants due to their capacity to achieve high levels of air purification, especially under conditions of stable temperature and humidity [2], as they can withstand high levels of salinity, accumulate metals and such air pollutants as Particulate Matter (PM) [27]. This property is facilitated by mosses having rhizoids instead of roots. This means mosses have evolved to obtain nutrients from the air or surrounding water by taking up particles with their leaves [14]. The authors measured PM absorption efficiency in a laboratory setting, and an efficiency of over 40% was found for moss species such as Dicranum scoparium, Hypnum cupressiforme, and Plagiomnium affine [16].

7. Mosses may mitigate noise pollution. Although the market for sound-absorbing moss walls is quite active in Europe and globally, there is a gap in scientific knowledge regarding the efficiency of moss in absorbing noise pollution. Some studies [27;31] indicate that mosses can be a sound barrier. However, further research must determine the sound-absorbing characteristics of different moss species and placements.

Although there is sufficient literature on mosses and their provision of ecosystem services, the authors have identified a gap in current knowledge of unified systematization that covers summarized information on this topic. Therefore, this Article provides summarized information in a unified form.

## Methods

This Article aims to systematize the regulating ecosystem services provided by mosses and their benefits in the urban environment and to answer the research question, "What ecosystem services provided by mosses to the urban landscape should be included in the systematization of regulating ecosystem services?" by covering the following tasks:

1. Analyze theoretical sources on the ecosystem services provided by mosses in urban landscapes.
2. Using systemic analysis, develop a systematization of the regulating ecosystem services and benefits mosses provide to the urban landscape.

To summarize the information obtained and to establish a correlation between the ecosystem services provided by mosses and the benefits in the urban landscape, the authors developed a systematization. Systematization is organizing qualitative data through categorization and thematic analysis to gain consistent insights into a specific topic [11]. Systematization is essential for aligning research questions, methods, and analysis in a structured manner to ensure the validity and reliability of conclusions [7].

Systematization components include:

1. Identifying the purpose - when starting systematization, it is essential to identify the purpose of the research, which also includes posing research questions or hypotheses [7];
2. Conceptual development - the conceptual framework is the basis for understanding and understanding the research question through various research methods and their analysis, systematically organizing and interpreting data [23];
3. Data acquisition and categorization - a structured approach to data acquisition and processing should be divided into categories for further analysis [11], a predefined scheme for analysis ensures consistency [21];
4. Analysis - the most essential part of research, using various analysis methods that ensure systematic interpretation of data [4];
5. Validation (or approbation) - criteria such as reliability, transferability, and confirmability indicate the approbation [13] or confirmation of the study;
6. Synthesis - drawing conclusions, accompanied by clear visual and textual presentations [7].

The article's authors conclude that systematization is fundamental to a successful research outcome. After analyzing the theoretical framework, they elaborate on the results.

TABLE 1

Systematization of moss-regulating ecosystem services and benefits [created by author's]

| An indicator of regulating ecosystem services provided by mosses in urban environments | Ecosystem service explanation | The impact of moss | Benefit for humans |
|---|---|---|---|
| Improving air quality by reducing pollution | Primary services include plant growth, human respiration, and biogeochemical cycling. Secondary services (depending on the primary) are, for example, clean drinking water and its availability, wood for producing further products, environment for recreation and tourism, etc. | Mosses, plants, and GI barriers in urban environments are essential to the overall ecosystem, as they capture pollutants. The moss species Dicranum scoparium, Plagiomnium affine, and Hypnum cupressiform have an average efficiency of more than 40% in reducing PM pollution under laboratory conditions. | Fresh air is one of the basic elements of the vital functions of all living things, including humans.<br>Air pollution causes 8 million premature deaths worldwide. It affects diseases such as cardiovascular and respiratory diseases. |
| CO2 is photosynthesised into oxygen | Photosynthesis is the process by which plants take CO2 and H2O from the air and soil, converting these compounds into glucose and oxygen. Some of the oxygen is released back into the atmosphere. All plants perform photosynthesis, which is necessary for exchanging gases in the atmosphere, including those involved in human respiration. | Mosses absorb CO2 and H2O on their entire surface throughout the year, depending on air temperature to varying extents. Some studies confirm that some moss species have increased CO2 uptake and oxygen release. | Air containing sufficient oxygen is necessary for humans and animals to maintain their vital functions. |
| Rainwater retention | When rain falls in an urban environment, it is crucial to drain or absorb excess water to prevent flooding, which can harm the city's infrastructure and human life. | Depending on the species, mosses absorb water. Some species absorb up to 10 times their dry weight in water. | Improper rainwater collection can lead to flooding, which in turn can result in various injuries, infectious diseases, and even death. |
| Heat island mitigation | Heat islands are areas within a city that have significantly higher air temperatures than their surrounding areas. Mitigating heat islands is an essential ecosystem service that GI addresses in cities. | Moss species such as curly moss Homalothecium sericeum, blunt-leaf barbel Barbula unguiculata, scaly-footed Pseudoleskea incurvata, pad grimmium Grimmia pulvinata and cypress hypnum Hypnum cupressiforme reduce air temperature in urban environments by up to 14 °C. | The heat island has adverse effects on human health and a secondary impact on humans, as its primary effects include air pollution, degradation of groundwater quality, and loss of biodiversity. |
| Promoting biodiversity | Biodiversity refers to the variety of organisms on Earth, and the loss of biodiversity has significant implications for life processes on Our Planet. Biodiversity is a prerequisite for life on Earth. | Mosses in urban environments influence the attraction of other organisms to this environment, provide valuable shelter for insects, shelter and food for small invertebrates, and nesting materials for birds and small mammals. Additional research on mosses as a habitat for microbes is needed. | The diversity of nature has a profound impact on humans, and without it, life on Earth would be unimaginable. |
| Reducing noise pollution | There are many different types of noise in urban environments, and reducing sound pollution is an essential GI ecosystem service in urban environments. | GI, including moss, when installed appropriately (e.g. in the placement of green walls), can significantly reduce noise. | Noise pollution causes adverse effects on the cardiovascular system and metabolism, reduces children's cognitive performance, and causes severe irritation and sleep disturbances. |
| Long-term impacts of climate change | Urban ecosystem services have a significant impact on climate change in the long term. | Mosses, the first plants on Earth, have developed strong survival mechanisms that have enabled them to endure all climate changes. As an essential part of the ecosystem, they also impact the climate and contribute to climate change. | Well-being, comfort, health and survival to a greater or lesser extent (depending on location). |

## Results

The article's authors identify the ecosystem services that mosses provide (Table 1), their impact, and the benefits they offer to humans.

The authors examined ecosystem services in relation to their impact on humans, creating a schematic drawing (Figure 1) that illustrates the consequences for humans and nature if ecosystem services are not provided, as well as the benefits to humans if they are provided. The authors conclude that mosses, as a provider of ecosystem services, have the most significant impact on human well-being and comfortable living. They also significantly impact human health, primarily physical, but ecosystem services also affect mental health. And if ecosystem services are not provided, the negative impact is most substantial on human health, mainly affecting cardiovascular diseases, death, or the disappearance of life on Earth.

After analyzing the theoretical literature and conducting empirical research on systematization preparation, the authors have achieved the article's goal. They have developed a systematization that will serve as a basis for further research on this topic and can serve as a guide or component of methodological material in urban planning in the public sector, for example, in municipalities.

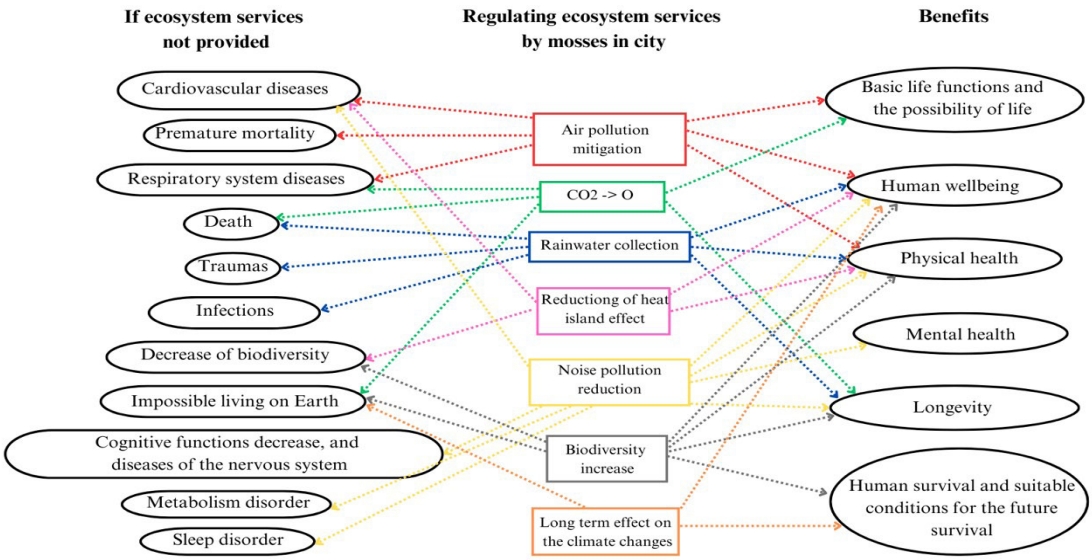



Fig. 1. Scheme of regulating ecosystem services and benefits provided by mosses [created by author's]

## Discussion

This systematization shows a novel approach to viewing mosses in urban environments and valuing their presence that occurs naturally in cities. People also bring a form of green infrastructure to towns, for example. It is essential to provide an overall summary of the regulatory ecosystem services provided by mosses, as this highlights the enumeration of ecosystem services and their interactions and impacts, both positive and negative. Suppose these ecosystem services are not offered in cities by mosses. In that case, there are various implications, ranging from a mild effect on human well-being to natural hazards and even long-term consequences for human survival. On the contrary, if mosses are integrated into the city landscape by landscape architects, urban planners, and policymakers, a long-term positive impact will be evident for humans. For systematization it is essential to align the research question, methods used, and data from analysis. The outcome is presented in a structured manner that ensures validity and reliability.

There is a scaling possibility and practical application of this systematization as well - it can be used globally, as analyzed literature covers global research, and all the chosen moss species are cosmopolitan - they can grow worldwide. At the same time, the practicality of this research result lies in its possibility of instant use by urban planners and landscape architecture students as a broader view on the ecosystem services topic and determination of plants for an urban environment. Although this study did not research other plants, except mosses, an application can be valuable, but it must be considered in the context of the overall objectives of landscape architecture.

## Conclusions

After analyzing the theoretical literature and conducting empirical research, the authors of the article have achieved the objectives of the work: a systematization of the regulatory ecosystem services and benefits provided by mosses in the urban environment has been developed. The authors of the article created a systematization that could serve as a basis for further research on this topic, as well as serve as guidelines or a component of methodological material in urban planning in the public sector, for example, in municipalities. This systematization can also be implemented in educational programs about ecosystem services and various plants that provide them. According to the systematization developed by the authors, the regulatory ecosystem services provided by mosses in the urban environment are air quality improvement, CO2 photosynthesis into oxygen, rainwater retention, heat island effect reduction, biodiversity promotion, noise pollution reduction, and long-term impact of climate change.

## Acknowledgments

This research was part of Juta Karklina's master's thesis and was possible with the support of Riga Technical University, Liepaja Academy's Nature and Engineering Centre. The work was supervised by PhD Lilita Abele (supervisor of the master's thesis) and consulted by Dr. Biol. Liga Strazdina (consultant of the thesis).

## References

1. **Anderson, M., Lambrinos, J., & Schroll, E.** (2010). The potential value of mosses for stormwater management in urban environments. *Urban Ecosystems*, 13(3), 319–332. https://doi.org/10.1007/s11252-010-0121-z
2. **Biloshchytskyi, A., Kuchanskyi, O., Andrashko, Y., Yedilkhan, D., Neftissov, A., Biloshchytska, S., … Vatskel, V.** (2023). Reducing outdoor air pollutants through a moss-based biotechnological purification filter in Kazakhstan. *Urban Science*, 7(4), 104. https://doi.org/10.3390/urbansci7040104
3. **Bolund, P., & Hunhammar, S.** (1999). Ecosystem services in urban areas. *Ecological Economics*, 29(2), 293–301. https://doi.org/10.1016/s0921-8009(99)00013-0
4. **Braun, V., & Clarke, V.** (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
5. **Carleton, T. J., & Read, D. J.** (1991). Ectomycorrhizas and nutrient transfer in conifer–feather moss ecosystems. *Canadian Journal of Botany*, 69(4), 778–785. https://doi.org/10.1139/b91-101
6. **Corvalán, C., Hales, S., McMichael, A. J.** Millennium Ecosystem Assessment, & World Health Organization. (2005). Ecosystems and human well-being: Health synthesis. World Health Organization.
7. **Creswell, J. W., & Creswell, J. D.** (2018). *Research design: Qualitative, quantitative, and mixed methods approach (5th ed.). SAGE Publications*.
8. **Daily, G. C.** (1997). Introduction: What are ecosystem services? In G. C. Daily (Ed.), Nature's services: Societal dependence on natural ecosystems (pp. 1–10). Island Press.
9. **Eldridge, D. J., Guirado, E., Reich, P. B., Ochoa-Hueso, R., Berdugo, M., Sáez-Sandino, T., … Delgado-Baquerizo, M.** (2023). The global contribution of soil mosses to ecosystem services. *Nature Geoscience*, 16(5), 430–438. https://doi.org/10.1038/s41561-023-01170-x
10. **Ervin, D. E., Brown, D., Chang, H., Dujon, V., Granek, E. F., Shandas, V., … Yeakley, A.** (2012). Growing cities depend on their ecosystem services. Solutions, 2, 74–86.
11. **Flick, U.** (2018). An introduction to qualitative research. *American Journal of Industrial and Business Management*.
12. **Gall, C., Nebel, M., Scholten, T., Thielen, S. M., & Seitz, S.** (2024). Water's path from moss to soil vol. 2: How soil–moss combinations affect soil water fluxes and soil loss in a temperate forest. *Biologia*. https://doi.org/10.1007/s11756-024-01666-w
13. **Guba, E. G., & Lincoln, Y. S.** (1989). Fourth generation evaluation. *SAGE Publications*.

14. **Haynes, A., Popek, R., Boles, M., Paton-Walsh, C., & Robinson, S. A.** (2019). Roadside moss turf in South East Australia captures more particulate matter along an urban gradient than a common native tree species. *Atmosphere*, 10(4), 224. https://doi.org/10.3390/atmos10040224
15. **Kārkliņa, J., Kārkliņš, E., Ābele, L., & Strazdiņa, L.** (2024). Bryophytes for the linear barrier as a PM2.5 mitigation technology in the urban landscape. *Landscape Architecture and Art*, 24(24), 45–50. https://doi.org/10.22616/j.landarchart.2024.24.06
16. **Kārkliņa, J., Kārkliņš, E., Ābele, L., Renard, J.-B., & Strazdiņa, L.** (2025). Atmospheric pollution particulate matter absorption efficiency by bryophytes in laboratory conditions. *Atmosphere*, 16(4), 479. https://doi.org/10.3390/atmos16040479
17. **Kronenberg, J.** (2015). Why not to green a city? Institutional barriers to preserving urban ecosystem services. Ecosystem Services, 12, 218–227. https://doi.org/10.1016/j.ecoser.2014.07.002
18. **Lueth, V. M., & Reski, R.** (2023). Mosses. *Current Biology*, 33(22). https://doi.org/10.1016/j.cub.2023.09.042
19. **Norgaard, R. B.** (2010). Ecosystem services: From eye-opening metaphor to complexity blinder. *Ecological Economics*, 69(6), 1219–1227. https://doi.org/10.1016/j.ecolecon.2009.11.009
20. **Martin, A.** (2015). *The magical world of moss gardening*. Timber Press.
21. **Marsaglia, V., Brusa, G., & Paoletti, I.** (2023). Moss as a multifunctional material for technological greenery systems. *The Plan Journal*, 8(1). https://doi.org/10.15274/tpj.2023.08.01.3
22. **Mayring, P.** (2014). Qualitative content analysis: Theoretical foundation, basic procedures and software solution.
23. **McHale, E.** (2020). 7 interesting things about moss. *Royal Botanic Gardens, Kew*. https://www.kew.org/read-and-watch/moss
24. **Miles, M. B., Huberman, A. M., & Saldaña, J.** (2019). Qualitative data analysis: A methods sourcebook (3rd ed.). *SAGE* Publications.
25. **Mohanasundaram, B., Koley, S., Allen, D. K., & Pandey, S.** (2023). Physcomitrium patens response to elevated $CO_2$ is flexible and determined by an interaction between sugar and nitrogen availability. *New Phytologis*t, 241(3), 1222–1235. https://doi.org/10.1111/nph.19348
26. **Nagase, A., Katagiri, T., & Lundholm, J.** (2023). Investigation of moss species selection and substrate for extensive green roofs. *Ecological Engineering*, 189, 106899. https://doi.org/10.1016/j.ecoleng.2023.106899
27. **Perini, K., Castellari, P., Giachetta, A., Turcato, C., & Roccotiello, E.** (2020). Experiencing innovative biomaterial for buildings: Potentialities of mosses. *Building and Environment*, 172, 106708. https://doi.org/10.1016/j.buildenv.2020.106708
28. **Perini, K., Castellari, P., Gisotti, D., Giachetta, A., Turcato, C., & Roccotiello, E.** (2022). MosSkin: A moss-based lightweight building system. *Building and Environment*, 221, 109283. https://doi.org/10.1016/j.buildenv.2022.109283
29. **Reid, W. V., Mooney, H. A., Cropper, A., & Chopra, K.** (2005). Millennium Ecosystem Assessment: Ecosystems and human well-being: Synthesis. Island Press.
30. **Ritchie, H., Samborska, V., & Roser, M.** (2025). *Urbanization. Our World in Data*. https://ourworldindata.org/urbanizationOur World in Data+1Our World in Data+1
31. **Sleinus, D., Sinka, M., Korjakins, A., Obuka, V., Nikolajeva, V., Brencis, R., & Savicka, E.** (2023). Properties of sound absorption composite materials developed using flax fiber, sphagnum moss, vermiculite, and sapropel. *Materials*, 16(3), 1060. https://doi.org/10.3390/ma16031060
32. **Strazdiņa, L., Liepiņa, L., Mežaka, A., & Madžule, L.** (2012). *Moss Guide*. University of Latvia.
33. **Stuiver, B. M., Wardle, D. A., Gundale, M. J., & Nilsson, M. C.** (2014). The impact of moss species and biomass on the growth of Pinus sylvestris tree seedlings at different precipitation frequencies. *Forests*, 5(8), 1931–1951. https://doi.org/10.3390/f5081931
34. **Šneiderienė, A., Viederytė, R., & Ābele, L.** (2020). Green growth assessment discourse on evaluation indices in the European Union. *Entrepreneurship and Sustainability Issues*, 8(2), 360–369. https://doi.org/10.9770/jesi.2020.8.2(21)
35. **Turetsky, M. R., Bond-Lamberty, B., Euskirchen, E. S., Talbot, J., Frolking, S., McGuire, A. D., & Tuittila, E.-S.** (2012). The resilience and functional role of moss in boreal and arctic ecosystems. *New Phytologist*, 196(1), 49–67. https://doi.org/10.1111/j.1469-8137.2012.04254.x
36. **Yin, H., Perera-Castro, A., Randall, K., Turnbull, J. D., Waterman, M. J., Dunn, J. W., & Robinson, S. A.** (2023). Basking in the sun: How mosses photosynthesize and survive in Antarctica. *Photosynthesis Research*. https://doi.org/10.1007/s11120-023-01040-y
37. **Zhuo, L., Liang, Y., Yang, H., Li, X., Zhang, Y., Zhang, Y., ... Zhang, D.** (2020). Thermal tolerance of dried shoots of the moss Bryum argenteum. *Journal of Thermal Biology*, 89, 102469. https://doi.org/10.1016/j.jtherbio.2019.102469

## Authors

**Juta Kārkliņa,** MSc.Env., Scientific Assistant at Riga Technical University with research interests in ecosystem services, circular economy, human well-being, and environment interaction. Currently working on experiments with bryophytes' various ecosystem services for urban environments.
E-mail: juta.karklinalv@gmail.com
ORCID ID: https://orcid.org/0009-0007-8039-8096

**Edgars Kārkliņš**, MSc.Env., Scientific Assistant at Riga Technical University is currently enrolled in air pollution mitigation research. His area of research is circular economy, and lifecycle thinking for environmental technologies and nature-based solutions for air pollution mitigation.
E-mail: edgars.karklinslv@gmail.com
ORCID ID: https://orcid.org/0009-0009-1920-594X

**Lilita Ābele**, PhD, Senior Lecturer and Senior Researcher at the Riga Technical University Liepaja Academy Nature and Engineering Center. Head of Environmental Direction. Sphere of interests: landscape design, circular economy, ecotechnologies, ecosystem services, digitization, smart cities, green innovation.
E-mail: lilita.abele@rtu.lv
ORCID ID: https://orcid.org/0000-0001-8709-236;
SCOPUS ID: 57213156051

**Līga Strazdiņa**, Dr.biol., a researcher at the Institute of Biology of the University of Latvia. Certified bryophyte, lichen, and vascular plant expert with research interests in bryophyte natural habitat management. Together with other authors, currently enrolled in research on the propagation of bryophytes for urban application. E-mail: liga.strazdina@lu.lv

## Kopsavilkums

Strauji pieaugot urbanizācijai, pilsētām ir aktūti nepieciešami efektīvi ekosistēmu pakalpojumi, un briofīti jeb sūnas ir spēcīgs, bet bieži vien nepietiekami novērtēts resurss šo vajadzību apmierināšanai. Pētījuma galvenā problēma ir vienota, sistemātiska ietvara trūkums, kas apkopotu sūnu sniegtos regulējošos pakalpojumus pilsētvidē. Tāpēc šī darba mērķis bija izstrādāt sistematizāciju, kas kalpotu kā praktisks rīks pilsētplānotājiem un ainavu arhitektiem. Pētījumā tika identificēti un sistematizēti septiņi galvenie regulējošie ekosistēmu pakalpojumi, ko sniedz sūnas. Šo pakalpojumu efektivitāti apstiprina konkrēti dati: sūnas spēj absorbēt ūdeni līdz pat desmit reizēm vairāk par savu sauso svaru. Tās var samazināt virsmas temperatūru pat par 14°C. Turklāt laboratorijas apstākļos ir pierādīts, ka atsevišķas sugas spēj no gaisa absorbēt vairāk nekā 40 % cieto daļiņu piesārņojuma. Šis sistematizētais ietvars sniedz ainavu arhitektiem uz pierādījumiem balstītu pamatojumu sūnu integrēšanai zaļās infrastruktūras projektos. Tas ir tieši piemērojams vertikālo dārzu, zaļo jumtu un inovatīvu zemes segumu risinājumu izstrādē. Nobeigumā, šis pētījums kalpo kā fundamentāls ceļvedis, kas ļauj dizaineriem izmantot sūnu unikālo bioloģisko noturību. Tas paver iespēju pārveidot pilsētas virsmas par augstas veiktspējas, pašpietiekamām ekosistēmām, kas uzlabo gan cilvēku labklājību, gan ekoloģisko veselību.
Pētījums arī iezīmē skaidrus virzienus turpmākajai izpētei. Tajā ir skaidri norādīts uz zināšanu trūkumu par sūnu skaņu absorbējošajām īpašībām un nepieciešamību pēc papildu pētījumiem par sūnām kā mikrobu dzīvotnēm. Šie identificētie trūkumi nosaka skaidru kursu nākotnes starpdisciplinārai pētniecībai.
Ainavu arhitekti, akustiskie inženieri un mikrobiologi varētu sadarboties projektos, lai:
1. Kvantificētu dažādu sūnu sugu un montāžas veidu trokšņa samazināšanas koeficientu (NRC), radot uz datiem balstītu katalogu akustiskajam dizainam.
2. Izpētītu unikālās mikrobu kopienas, kas mīt pilsētas sūnās, un to lomu bioģeoķīmiskajos ciklos vai patogēnu nomākšanā.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.04

# UNIVERSAL DESIGN OF URBAN SPACES IN UKRAINE: PROBLEMS AND PROSPECTS

**Natalia Novoselchuk[1], Liudmyla Shevhenko[1], Olena Troshkina[2], Arsenii Troshkin[3]**
*[1] National University "Yuri Kondratyuk Poltava Polytechnic", Poltava, Ukraine,*
*[2] National Academy of Fine Arts and Architecture, Kyiv, Ukraine,*
*[3] State University "Kyiv Aviation Institute, Kyiv, Ukraine*

**Abstract. The issue of the development of the concept of universal design in Ukraine at the present stage is considered in the article. The general state of the solution of this issue is characterized and statistical data is provided. Using the example of Ukrainian cities, in particular the city of Poltava, the main problems and prospects for development that require gradual resolution are outlined. The main task is to ensure the accessibility of the urban environment by creating comfortable conditions for using the housing and communal infrastructure and equipping buildings, taking into account the needs of low-mobility population groups. The object of the study is urban spaces and streets from the point of view of their barrier-free nature and landscape organization. To achieve the set goal, various scientific methods were used in the work. In particular, the empirical method was used for the purpose of observation and comparison. The theoretical method was used to process historical data on the development of the spaces and streets selected for the study. The method of field surveys helped to identify existing problems in the studied areas of the city. And the method of experimental design contributed to the implementation of the main techniques and recommendations in practice. The result of the research is the analysis and development of a number of project proposals taking into account the principles of universal design and modern landscape organization. Currently, for Ukraine, solving the problems of disability and low-mobility population groups is one of the priority areas of the state's social policy. A significant impetus is the ongoing russian-Ukrainian war. Since the number of people with disabilities who received it as a result of the war is growing every day. True accessibility and barrier-freeness covers all spheres of public life. Universal design is not limited to accepted principles, laws or prescribed rules. It includes respect for other people's borders, a human-centric approach, concern for comfort for everyone and the understanding that human needs are noticed. We can talk about full inclusion only when every person has unhindered access to buildings, education, the Internet, has the opportunity to work and freely use transport. Ukraine, which is becoming a veteran-centric state in the realities of war, is obliged to be inclusive.**
**Keywords: universal design, barrier-free, accessibility, low-mobility population groups, disability**

## Introduction

The United Nations Convention on the Rights of Persons with Disabilities [1] was the first international legal instrument to establish the obligation of governments to carefully consider and implement the principles of accessibility and universal design. They aim to enable people with disabilities to "live independently and participate fully in all aspects of life." A study by the Center for Social Change and Behavioral Economics, supported by the United Nations Children's Fund (UNICEF) and the Expert Council on Accessibility Communication, found that 83 percent of respondents consider accessibility to be a new value for society [2].

In their study Una Īle, Lelde Bergmane note that efforts to ensure a safe and accessible outdoor environment for all citizens are only at the planning and research stage. Urban planning decisions, building codes, political attitudes and other ambitions of the previous decade have left a significant mark on the environment. A change of approach cannot happen quickly and on a large scale. Therefore, the existing urban environment requires thoughtful, careful and detailed planning and implementation [3].

So, today accessibility and barrier-freeness are one of the most important indicators of the comfort of urban spaces. This applies to all types of urban environments: streets, public buildings and spaces, landscape and recreational areas, residential areas, etc. That is, areas where people move, work, relax, get healthy, play sports, etc. The main indicator of accessibility is an environment that is free from obstacles and organized on the basis of the principles of universal design.

In 2020, a national survey was conducted in Ukraine by the Kyiv International Institute of Sociology and the public organization "Bezbariernist". According to it, more than 70 percent of Ukrainian citizens have encountered various kinds of barriers. These obstacles can lead to discrimination on various grounds, such as social status, gender or disability [2].

Currently, for Ukraine, solving the problems of disability and low-mobility population groups should become one of the priority areas of the state's social policy. A significant impetus for this is the ongoing russian-Ukrainian war. The hostilities have led to a significant increase in the number of people with disabilities and functional impairments in Ukraine. This necessitates the use of urgent measures to ensure the accessibility of the architectural and urban environment for all categories of the population.

The number of people with disabilities who have suffered from injuries is growing every day. Thus, according to official data, there are already three million people with disabilities in Ukraine as of October 2024. More than 300 thousand of them have received this status since the beginning of the full-scale invasion [4]. And these numbers are constantly growing. The war continues, and the number of people with disabilities is only increasing. Therefore, Ukrainian cities urgently need a barrier-free environment. In Ukraine, as in the whole world, universal design should become the optimal means of humanizing the aggressive architectural and urban environment. Universal design should be aimed at forming an architectural environment for use and adaptation to the needs and capabilities of all categories of users. The design of streets, houses, parks, public spaces, any elements of the subject-spatial environment and individual objects should be convenient for everyone, regardless of physical limitations, age, weight, and perception characteristics and other.

However, the statistics are not very encouraging today. According to the results of 2023, only 22 percent of the 54 thousand studied facilities were barrier-free [2]. Given the growing number of people with disabilities in Ukraine as a result of hostilities, the main importance of universal design lies in the possibility of active involvement of this population group in public life, their full social integration

and adaptation. The importance of universal design also lies in the fact that new buildings and structures designed and constructed according to its principles do not require additional adaptation when used by a wide range of citizens with different functional capabilities and needs. That is, they do not require additional financial costs for their reasonable adaptation. And of course, the issue of ensuring accessibility in historical buildings or buildings of the Soviet period, which were built without taking into account modern standards, is much more difficult.

It should be noted that positive developments in the field of universal design in Ukraine took place back in 2020. This happened thanks to the "Without Barriers" program launched by Olena Zelenska. It is aimed at creating a universal public space that is friendly to low-mobility population groups and families with children. In addition, in 2021, the "National Strategy for Creating a Barrier-Free Space in Ukraine for the Period Until 2030" was approved [5]. Already during the war, in the spring of 2023, the Action Plan for 2023-2024 for the implementation of this Strategy was approved. It covers six areas: physical, informational, digital, social, educational, and economic barrier-free.

## Materials and Methods

Any methods and approaches gradually evolve over time. Today, a comfortable human life is becoming a priority. And this directly affects the requirements for designing a quality environment. A very relevant issue is the reconstruction of urban spaces and the creation of a safe, accessible, sustainable and environmentally healthy environment. Respect for people should be the key strategy for changing the way the urban environment and all its components are designed. At the same time, creating an accessible environment is a task that affects all components of the city – from common urban spaces to a separate courtyard and residential cell. Taken together, this forms a residential cluster that creates a quality life.

The purpose of this work is to analyze the current state of accessibility of urban spaces and streets, identify problematic issues and prospects for their resolution, using the example of Ukrainian cities, in particular the city of Poltava. The object of the study is urban spaces and streets from the point of view of their barrier-free status and landscape organization. To achieve the goal, the following tasks have been outlined:

- To characterize and summarize the main existing problems regarding the accessibility of urban spaces;
- To conduct a field survey and visual analysis of selected routes (street fragments) to identify shortcomings and problematic issues in terms of accessibility and architectural organization of these spaces;
- To outline prospects and ways to solve the issues of accessibility of urban spaces and provide proposals for improving and ensuring accessibility and landscape organization of selected street fragments.

The study used various scientific methods. The empirical method was used for the purpose of observation and comparison. On its basis, various urban spaces in the city of Poltava were studied and analyzed, the main problems were identified and summarized in terms of their accessibility, architectural and design solutions and the overall attractiveness of the urban environment. On the basis of the theoretical research method, data on the historical development of the spaces and streets selected for the study over time were processed. The method of field surveys helped to identify existing problems in the studied areas of the city. The experimental design method was used to implement the main techniques and recommendations in the practice.

To study the issue under study, sections of the largest streets of Poltava were taken – Europeyska and Reshetylivska, as well as fragments of Gogol and Velikotyrnivska streets. The visual analysis conducted based on the method of field surveys made it possible to identify a number of unresolved problematic issues regarding accessibility and landscape organization of spaces. Based on this, design proposals for Reshetylivska and Evropeyska streets were developed. They demonstrate the landscape reconstruction of selected areas and fully take into account the issues of accessibility of these spaces. In addition, an analysis of fragments of Gogol and Velikotyrnivska streets is presented, which shows specific problem areas and provides proposals for their solution.

In previous publications, the authors explore the issues of landscape organization of urban spaces, landscaping and greening of residential courtyards [6, 7, 8, 9, 10, 11, 12] and broadly cover the Ukraine architecture of different periods and its national traditions [13, 14, 15, 16]. All these studies provide an opportunity to deeply study the range of tasks set in this article. In working with the urban environment at the present stage, architects need to be guided by the principles of barrier-free, participatory and human-centricity.

## Results and Discussion

It should be noted that at the present stage, the world is actively moving from the "medical model" to the "social model", from the creation of "smart adaptations" for people with disabilities to universal design. Adherence to the concept of universal design allows citizens with limited mobility to visit various objects in the urban environment almost regardless of their physical condition. The "medical model" views disability as a pathology that requires treatment. It emphasizes that a person needs to overcome their disability through medical intervention, that something is "wrong" with a person, rather than what a person needs. This leads to the fact that people lose independence, choice and control in their own lives. The "social model" views disability as a problem created by society. It considers social discrimination to be the most significant. This model considers disability to be a normal aspect of the life, not a deviation.

In recent years, Ukraine has paid significant attention to the implementation of universal design principles in the process of designing and constructing buildings and structures. Today, the country has the State Building Code V.2.2-40:2018 "Inclusivity of buildings and structures. Basic provisions" (effective from April 1, 2019) [17]. This is the result of significant work by a team of authors who tried to take into account the needs of people with disabilities as much as possible. This standard includes several sections, including requirements for land plots, planning organization of buildings and structures, the living environment of low-mobility population groups, etc.

A huge list of unresolved issues can be divided into 4 groups: these are entrances and courtyards of residential buildings, streets, public spaces and entrance groups of public buildings. An analysis of State Building Codes helped to understand that they contain answers to almost every problem. However, despite a fairly broad regulatory base, this is not enough to create a comfortable city for everyone. Why? Accessibility specialists and leading architects agree that regulatory documents are structured according to the types of objects. Each of them provides accessibility standards. In order to design an urban space, it is necessary to use different regulatory documents. Sometimes the standards provide generalized parameters of solutions, and sometimes they have significant detail. In some cases, designers interpret them independently and do not always create optimal design solutions from the point of view of accessibility. Regulatory documents do not always correlate with each other and have differences in solutions. The vast majority of existing buildings and infrastructure were built according to the standards in force at that time and their owners have no obligation to bring these facilities up to current accessibility standards.

Therefore, the following problems regarding the accessibility of the environment are present in urban spaces and buildings:

- Lack of full-fledged functional zoning of the residential yard: there is no clear division into areas for a specific functional purpose, places for various activities, a sufficient percentage of greenery, parking areas for cars;
- Lack of fences - around green areas, flower beds near houses or on sidewalks to separate them from cars using car tires, posts, hemispheres-limiters. All this creates additional obstacles for pedestrians, especially for people with visual impairments;
- Uneven surface – holes, ledges, cracks;
- Parked sidewalks and roadsides - cars parked in inappropriate places violate traffic rules and do not leave enough space for pedestrians to move;
- Obstacles on the way - columns, semicircles against parking, advertising stands and city lights, barriers, low flower beds and fences around trees are inconvenient for creating obstacles in the way of people's movement, are dangerous for people with

visual impairments;
- Lack of address signs - buildings often lack signs indicating the address and house number, including directions to other buildings. Existing signs are not always accessible for reading due to incorrect location or incorrect size and contrast of the inscriptions;
- Cluttering of pedestrian streets – kiosks, terraces, summer areas of food establishments take up the territory of pedestrian ways on the sidewalks and limit the space for people to move, including in wheelchairs;
- Lack of places to rest – too few or no benches, short-term rest areas along the streets;
- Absence or critically low number of bicycle paths – the movement of people on bicycles or electric scooters on sidewalks creates additional danger for pedestrians, especially for low-mobility groups of the population (people with autism, the blind, children and the elderly). This is prohibited by traffic rules. Sometimes the existing bicycle paths are too narrow, which creates additional danger. For safe movement, bicycle users need an extensive bicycle network, and for ease of use, the presence of bicycle parking lots and bicycle maintenance stations. Narrow spaces where it is impossible to conveniently turn the bicycle, and spaces near buildings where they cannot safely leave the bicycle, are inaccessible to them;
- Lack of shade and greenery – insufficient shade on sidewalks in the summer makes it more difficult for older people and parents with children to move around. The absence or lack of greenery on the streets affects the overall temperature in the area and creates a heat island effect, when the area as a whole becomes hot;
- Low tree canopy and overhead obstacles – tree crown, low-placed signs and markings can interfere with pedestrian movement and lead to injuries, especially for people with visual impairments;
- Unequipped underpasses – underpasses that are not equipped with ramps or elevators are inaccessible to the elderly, people in wheelchairs, and parents with children in strollers. The issue of organizing the correct ramp remains problematic, while the arrangement of underground passages with elevators has isolated cases.

The identified problems require a gradual solution at all levels. The main task is to ensure the accessibility of the urban environment: roads and streets, parks, residential buildings, public spaces, buildings. This is possible by creating comfortable conditions for using the housing and communal infrastructure, including the equipment of public buildings, taking into account the needs of low-mobility groups of the population. The problematic issue is ensuring accessibility to historical buildings and rethinking the Soviet heritage. These buildings were designed according to other State Building Codes, where accessibility issues were not taken into account. Therefore, when reconstructing such objects, problems are solved individually in each specific case. This is especially difficult to solve in historical buildings, where the planning and/or constructive solution imposes significant restrictions. Especially since some of these buildings are monuments of culture.

In Ukraine, the Big City Lab team has developed the "Album of Barrier-Free Solutions". It examines in detail the construction of a barrier-free environment. It is necessary to understand human diversity in order to create an environment based on the principles of universal design. It is necessary to know what everyone needs for unhindered use of space. The structure of the Album is based on the formation of a new philosophy and approach to designing spatial solutions, which is designed to create a world that is as convenient as possible for different people [18].

Therefore, the album is a thorough guide for designers of public spaces, which contains all the necessary standards and recommendations regarding dimensions, materials, and location. Architects can evaluate the space and design an adaptive solution by referring to this album. The album describes the principles of designing territories and buildings based on universal design. While the design algorithm must be decided individually depending on the specific situation. The algorithm requires taking into account the features and factors of each specific urban location and each residential yard: the number of residents, the area of the territory, the development in this place, etc [18].

When developing a physical accessibility strategy, it is advisable to prioritize. It is necessary to analyze at the city level which tasks are of primary importance and require immediate implementation, and which can wait. Urban spaces are a priority task. In addition, buildings that require urgent attention and adaptation in Ukraine are healthcare facilities, retail establishments and administrative institutions, as well as sports facilities and cultural and recreational facilities. A very relevant issue for Ukraine is the development of accessibility for civil defense structures (shelters and bomb shelters). After all, modern realities are such that the vast majority of shelters are old buildings where this issue is not addressed at all. This greatly complicates or makes it impossible for people with disabilities to use shelters. An example and a step forward is the development by the Big City Lab team of accessibility recommendations for shelters in the city of Slavutych. But so far these are only recommendations that require a lot of financial resources and implementation.

When monitoring and analyzing the current state of urban areas and developing accessibility strategies, the use of interactive maps and geoinformation systems (GIS) can be useful. This will allow combining a model image of the territory with tabular information (various statistical data, lists, economic indicators, etc.). The use of GIS will simplify the collection and systematization of information, its analysis and concentration of general data in one common system.

In Ukraine, urban communities face a number of problems in developing physical accessibility. When solving them, it is important to provide answers to the following questions:
- How to systematically work with accessibility in the community?
- Is it advisable to create a council on accessibility and what will its functions be?
- How to conduct research on physical accessibility?
- How to correctly develop a strategy on accessibility?
- How to build the work of the council on accessibility in accordance with the National Accessibility Strategy and the real needs of users?
- How to create projects on accessibility together with Ukrainian and international organizations?
- How to involve community residents in making decisions on accessibility?
- How to teach architects and builders to design and build barrier-free?
- Can all builders and designers create barrier-free solutions according to standards and how should they be tasked?

Studying the experience of successful international practices in the field of universal design and accessibility is a significant reference point for the development of an accessible environment in Ukraine. Analysis of these practices allows us to identify key success factors and will help adapt them to the realities of Ukrainian cities. The experience of the city of Graz (Austria) is useful and interesting. The city signs Mobility Contracts with developers of residential and multifunctional areas. This contract provides for the following main measures:
- Reduction of parking spaces for vehicles. This will help reduce the number of cars along the roads and in parking lots. Instead, it is planned to create centralized multi-storey garages for new areas, which will reduce the number of cars on the streets and maintain pedestrian accessibility in densely built-up areas;
- Support for pedestrian traffic: creation of public pedestrian paths passing through the development area;
- Support for cycling – availability of high-quality bicycle parking spaces directly at the entrances to buildings, provision of an increased volume of parking spaces compared to standard indicators, availability of service and self-service stations;
- Reconstruction of difficult sections of roads (where possible) to comply with the new volume of traffic. It is planned to build collective garages and the absence of a direct connection between the garage and the apartment. This will ensure the same access conditions for cars and public transport in terms of pedestrian accessibility [2].

Applying the experience of the city of Graz to Ukrainian realities will improve mobility and the environmental situation in cities by reducing car dependence and stimulating the development of environmentally friendly transport' modes. Such mobility contracts provide better mobility opportunities for residents of new developments. As a result, the city gets the opportunity to expand projects without overloading the road infrastructure, and residents have convenient

Fig. 1. An experiment conducted in the city of Poltava on the initiative of the National Assembly of People with Disabilities of Ukraine, which demonstrated the unsatisfactory state of physical accessibility [according to 20]

travel conditions.

The "Barrier-Free" pilot project is an example of the implementation of physical accessibility in Ukraine. It was developed for the city of Slavutych (Kyiv region), one of the youngest cities in Ukraine. In 2021, the country's first Memorandum on the development of barrier-free architecture was signed between the authorities of the city of Slavutych, the Office of Olena Zelenska, and the Ministry of Regional Development of Ukraine. The implementation of accessibility began with the lowering of curbs – the most common barriers on the streets of Ukrainian cities. In 2021, an interactive map "Barrier-Free Slavutych" was developed, which is constantly updated today. In addition, the program "Slavutych – a barrier-free city for 2024-2026" was developed. It offers ways to solve problems, the volume and sources of funding, the terms and stages of the program, and the main list of tasks and activities. The city of Slavutych has taken on the responsibility of being the first in this area. The city has become a laboratory for the development and implementation of barrier-free architectural solutions. Today, the city of Slavutych, despite the war, continues the barrier-free program and has "laboratory" research and effective solutions. This experience can be implemented by every community that aims to become barrier-free [19].

Other Ukrainian cities are also gradually addressing this important issue. At the initiative of the National Assembly of People with Disabilities of Ukraine, an experiment was conducted in Poltava. It demonstrated the difficulties that people with disabilities encounter when moving around the city streets. Representatives of local authorities were invited to the event. They had the opportunity to sit in a wheelchair and experience the difficulties of moving around the city (Fig. 1). The development of the Accessibility Strategy of the Poltava Urban Territorial Community for 2025-2030 is currently a noticeable positive development. The Strategy was developed by the Big City Lab team [2]. According to the monitoring conducted, the state of physical accessibility in Poltava is at an unsatisfactory level. This is demonstrated by the inadequate condition of sidewalks, which is a danger for pedestrians and the population with reduced mobility, problems with transport and cycling infrastructure, insufficient number and spontaneity of parking lots, missing or incorrect cycle paths, lack of equipment at public transport stops (no timetable, unequipped roof, seats), etc. The most pressing problem for the community was the inaccessible general public space – the lack of correct ramps, accessible places for rest, pedestrian paths, incorrectly lowered curbs (incorrect slope), etc. One of the biggest problems is the limited number of barrier-free spaces and premises that could be used for various events [2].

Today, the city authorities have developed areas of activity and an action plan. They provide for monitoring and control in the field of accessibility of physical environment objects on a systematic basis, conducting an audit of public spaces and objects that are in the greatest demand or are in critical demand, and conducting analysis and monitoring of problems. It is planned to address such priority issues as: developing a universal design of the pedestrian part of the city's main street, reconstruction of public spaces, universal design of adjacent areas of multi-apartment residential buildings with inclusive workout areas, universal design of public toilets for the urban environment and landscaped areas, creation of barrier-free space of underground passages.

So, today there are a number of unresolved issues in the city of Poltava, especially in its historical districts. Here, in the middle of the pedestrian part of the street, elements may be located that make it difficult and dangerous for people to move, in particular people with disabilities (Fig. 2). The historical buildings themselves, which are located on narrow streets, are also a problem. They have entrance groups that do not meet modern requirements. Sometimes, the level of the first floor is much raised, which dictates the use of a sufficiently long ramp or there are already incorrect ramps, etc. All this significantly complicates the solution to the issue of accessibility. In each such situation, it is important for architects to look for an individual approach. There are no universal schemes.

Another problem in addressing the issue of accessibility of urban spaces is Soviet-era buildings, the areas around them, and entrance groups. This includes, for example, the presence of stylobates with a significant number of steps, the installation of irregular slopes of ramps without railings, the absence or insufficient number of recreation areas, etc (Fig. 3).


Fig. 2. Problem areas on the pedestrian part of the fragment of Gogol Street in Poltava (Ukraine) and proposals for their solution. Author – Natalia Novoselchuk [from N. Novoselchuk scheme]


Fig. 3. Problem areas at the entrance to shops located on the first floor of a residential building built during the Soviet period, Poltava (Ukraine). Author – Natalia Novoselchuk. [from N. Novoselchuk scheme]

It is necessary to note the positive developments in Ukrainian cities in this area. Among them – the installation of elevators to the entrances of buildings with a significant number of stairs, the replacement of ramps with irregular slopes with new ones, a lowering curbs according to standards. A separate problem is the underground passages, which are not equipped with elevators, except in isolated cases.

The design project of the city's intermediate recreational spaces using the example of a fragment of Reshetylivska Street in Poltava is an interesting project of reconstruction of public spaces taking into account the issue of universal design. An important aspect of future development is the preservation of the historical character of Reshetylivska Street. The renovation concept can be used to create a harmonious image that will reflect the rich cultural experience of Poltava. The presented project was developed taking into account the latest urban development trends. The main idea is to create a functional and aesthetically attractive environment for residents and guests of the city. The organization of a recreation area with benches of different heights and a small children's entertainment area demonstrates consideration of the needs of different age groups and the creation of an atmosphere of family comfort. Special attention was paid to the recreation area with canopies, chargers, a generator and parking spaces for bicycles and scooters. This not only creates opportunities for recreation, but also supports the use of environmentally friendly modes of transport and promotes a healthy lifestyle. The open rain channels implemented in the project not only make life more comfortable during wet weather. They serve as a functional element, which at the same time demonstrates the desire to create spaces in interaction with the environment. The landscaping in this project has not only a decorative effect, but also practical. It acts as a barrier from external noise and dust, which is important for creating a pleasant urban environment. The implementation of this project in a modern city will contribute to the creation of a barrier-free, comfortable, safe and functional space for all residents (Fig. 4).

One of the main streets of Poltava is Yevropeiska Street, 5.66 km long. It also needs improvement and modernization, taking into account the principles of universal design and accessibility. When deciding on the design of this street, green areas along it and squares were identified for detailed development. All selected areas have common problems. These are partially damaged paving of paths with holes and cracks, spontaneously created paths without hard surface, which require paving, a small number of benches and small architectural forms, which are of the same type and inconvenient, low tree crowns in some areas and partially old trees, an insufficient number of street lamps and outdated landscape design, which does not meet modern trends.

The first section (fragment 1), selected for study, and contains a small square, which is of great importance as a recreational area for local residents. The modernization project provides for the solution of all identified problems and the diversification of the functional and planning structure of the square, the change of small architectural forms to new modern ones (Fig. 5). Another landscaped section

Fig. 4. Design of an intermediate recreational space of a Reshetylivska Street's fragment in Poltava (Ukraine) taking into account the principles of accessibility and universal design. Authors – Liudmyla Shevchenko, Veronika Tyshchenko [from L. Shevchenko scheme]


Fig. 5. Design of an intermediate recreational space of a fragment of Yevropeiska Street in Poltava (Ukraine) taking into account the principles of accessibility and universal design. Authors – Liudmyla Shevchenko, Yaroslava Salvarovska [from L. Shevchenko scheme]

(fragment 2) currently has no improvement, only landscaping is located on it. The project provides for the creation of a square with places for recreation with the introduction of water elements and modern small architectural forms. This should modernize and enrich this area. The next section (fragment 3) currently has the most attractive appearance, but also requires modernization. Therefore, in this area, it is proposed to divide pedestrian flows into the main and additional ones, along which benches for recreation, small architectural forms, flowers and landscaping are placed. The use of colored paving makes it possible to clearly distinguish functional zones in this area. Yevropeiska Street also ends with a small square around which such important objects for the city are located as: the Poltava Art Museum named after Mykola Yaroshenko, the main building of the Poltava National Pedagogical University named after V.G. Korolenko and the office center. The modernization project proposed to change the existing planning solution of the square to another, more modern and appropriate to the importance of this territory (fragment 4). When developing the modernization project of all green areas and squares, the requirements for universal design and accessibility were taken into account.

It is necessary to note another significant problem regarding the introduction of accessibility and universal design in Ukraine. This is an insufficient level of funding. During martial law, other areas are a priority. Therefore, today, in order to begin to address the issue of accessibility, the optimal way may be for local communities to attract funds from international and domestic charitable funds. It is possible to obtain funding through:

1) Earmarked funds that cannot legally be spent on any other area;
2) Funds from European partners, who are not ready to finance the military sector, but have a desire to help Ukraine;
3) Participation in grant programs and receiving grants.

## Conclusions

True accessibility and barrier-freeness covers all spheres of public life. Barrier-freeness is an environment that is comfortable and safe for every person. It is the opportunity to fully participate in the life of society regardless of health status, age, gender, etc. It is human-centricity in every decision. This issue concerns each of us. True accessibility is comprehensive. That is why, according to the National Strategy for Barrier-Freeness in Ukraine until 2030, 6 main areas of ensuring accessibility and adaptability have been identified. These are physical, informational, digital, social and civil, educational and economic barrier-freeness.

Accessibility is not limited to adopted laws or written rules. It includes respect for other people's boundaries, concern for comfort for everyone, and understanding that your needs are noticed. Accessibility must take into account the diversity of human requests and needs. We can talk about full inclusion only when everyone has unhindered access to both buildings and education or the Internet, the opportunity to work and freely use transport.

So, it can be said that Ukraine is making significant steps towards the development and implementation of universal design in all six areas. There is still a lot of work to be done. It is important to find donors who will help resolve the financial issue, without which positive developments are impossible. Much depends on local authorities and self-government bodies. It is necessary to raise the level of awareness of the population, work with communities, train specialists, conduct audits, develop adaptive design solutions, etc. But, despite the difficult realities of the war, Ukraine does not stop working and is trying to gradually resolve these issues. They are extremely important for a country in which the number of people with disabilities, unfortunately, is increasing in progression. The veteran-centric state that Ukraine has become in the realities of the ongoing war is obliged to be inclusive.

## References

1. Convention on the Rights of Persons with Disabilities. *United Nation*, 2007. 31 p.
2. *Barrier-free Strategy of the Poltava Urban Territorial Community for 2025-2030*. Retrieved March 21, 2025, from https://rada-poltava.gov.ua/people/gromad/people/strateg (Стратегія безбарєрності Полтавської міської територіальної громади на 2025-2030 роки)
3. **Ile, U., & Bergmane, L.** (2023). Development Patterns of Universal Design in Residential Courtyards in the Jugla

Neighbourhood. *Landscape Architecture and Art*, 22(22), 109–119. https://doi.org/10.22616/j.landarchart.2023.22.11
4. **Perun, V.** (2024). *Zelenska: There are officially three million people with disabilities in Ukraine*. Retrieved March 21, 2025 from https://lb.ua/health/2024/10/15/639943_zelenska_ukraini_ofitsiyno_ie_tri.html (Перун, В. Зеленська: в Україні офіційно є три мільйони осіб з інвалідністю, 2024)
5. *National Strategy for Creating a Barrier-Free Space in Ukraine*. Retrieved March 19, 2025, from https://mtu.gov.ua/content/nacionalna-strategiya-zi-stvorennya-bezbarernogo-prostoru-v-ukraini.html (Національна стратегія зі створення безбар'єрного простору в Україні)
6. **Shevchenko, L., Novoselchuk, N., Toporkov, V.** (2018). Linear landscape spaces in the planning structure of the city. *International Journal of Engineering and Technology (UAE)*, 7(3), 672-679. doi:10.14419/ijet.v7i3.2.14612.
7. **Novoselchuk, N., Shevchenko, L., Kamal, M.** (2022) Ways of Integration of the Landform Architecture Buildings with Landscape. In: *Onyshchenko V., Mammadova G., Sivitska S., Gasimov A. (eds) Proceedings of the 3rd International Conference on Building Innovations. ICBI 2020*. Lecture Notes in Civil Engineering, vol 181, pp. 525-534.
8. **Shevchenko, L., Novoselchuk, N., Shevchenko, et. al.** (2024). Water as a typical component of historical manor parks of the Poltava Region (Ukraine), *Landscape Architecture and Art*, 24(24), pp. 73-81, DOI: 10.22616/j.landarchart.2024.24.10.
9. **Shevchenko, L., Mykhaylyshyn, O., Novoselchuk, N., et. al.** (2023). Landscaping and Greening of the Residential Buildings Courtyards of the 50s–Early 80s of the XX Century in Ukraine: Current Situations and Renewal Perspectives, *Proceedings of the 4th International Conference on Building Innovation, Lecture Notes in Civil Engineering*, 299, pp. 541-558, DOI:10.1007/978-3-031-17385-1_43.
10. **Shevchenko, L., Novoselchuk, N., Troshkina, O.** (2022). Traditions in the formation of historical manor parks of the Poltava Region (Ukraine), *Landscape Architecture and Art*, 21(21), pp. 105-114, DOI: 10.22616/j.landarchart.2022.21.11.
11. **Troshkina, O., Us, V., Mostovenko, A., Shevchenko, L., et. al.** (2022). Cinematic methods of scenario construction in the design of landscape parks. *Landscape Architecture and Art*, Scientific Journal of Latvia University of Agriculture, vol. 20, No. 20, p. 82-91. DOI: 10.22616/j.landarchart.2022.20.09.
12. **Chebina, O., & Shevchenko, L.** (2015). *The boulevard as a type of urban linear space the historical boulevards of Poltava (Ukraine) and Mons (Belgium)*. [Bulvár ako typ lineárneho urbánneho priestoru historické bulváre Poltavy (Ukrajina) a Monsu (Belgicko)] Architektura a Urbanizmus, 49(3-4), 199-215.
13. **Novoselchuk, N.** (2022). National Traditions in the Architecture of Ukrainian Modernizm of the Early 20th Century, *Docomomo Journal*, 67, pp. 66-71, DOI: 10.52200/docomomo.67.07.
14. **Savchenko, T., & Shevchenko, L.** (2023). National character in Poltava architecture of the beginning of the twentieth century, *Urbani Izziv*, 34(1), pp. 92-106, doi:10.5379/urbani-izziv-2023-34-01-0.
15. **Bozhynskyi, N., Bozhynskyi, B., Shevchenko, L., et. al.** (2023). *Implementation of Folk Housing Traditions in Modern Individual Housing Construction, Proceedings of the 4th International Conference on Building Innovation, Lecture Notes in Civil Engineering*, 299, pp. 421-431, DOI: 10.1007/978-3-031-17385-1_33.
16. **Mykhaylyshyn, O., Shevchenko, L., Mahey A.** (2023). Digital technologies as an innovative tool for the preservation of the palace complexes of Podillya in the late 19th – Early 20th century, 5th International Scientific and Practical Conference "Innovative Technology in Architecture and Design" (ITAD-2021), *AIP Conference Proceedings*, 2490(1), 040015, DOI:10.1063/5.0122741.
17. DBN V.2.2-40:2018 *Inclusiveness of buildings and structures. Basic provisions*. Kyiv. Ministry of Regional Development. 2018, 64 p. (ДБН В.2.2-40:2018 Інклюзивність будівель і споруд. Основні положення. Київ. Мінрегіон. 2018, 64 с.)
18. *Album of barrier-free solutions: Chapter 1* (taking into account wartime): A guide for designers and architects of public space. Retrieved March 19, 2025, from https://mtu.gov.ua/files/big_city_lab_album_war_chapt_1-4-1_compressed%20(1).pdf (Альбом безбарєрних рішень: Розділ 1 (з урахуванням воєнного часу): Посібник для проєктувальників та архітекторів публічного простору)
19. *Slavutych is a barrier-free place*. Retrieved March 20, 2025, from https://surl.li/kafsps (Славутич – безбарєрне місце)
20. **Lysogor, M. (**2016). *Poltava deputies tried themselves as disabled people*. Retrieved March 26, 2025, from https://poltava.to/news/38374/ (Лисогор, М. Полтавські депутати спробували себе у ролі інвалідів, 2016)

## Authors

**Natalia Novoselchuk**, Associate prof. Ph.D, Department of Buildings Architecture and Design National University «Yuri Kondratyuk Poltava Polytechnic». Sphere of interests – landscape and urban design, interior design, heritage architecture. Address: 24 Pershotravneva Avenue, Poltava, Ukraine.
E-mail: Ab.Novoselchuk@nupp.edu.ua
ORCID ID: https://orcid.org/0000-0002-7753-7872

**Liudmyla Shevchenko**, Associate prof. Ph.D, Department of Buildings Architecture and Design National University «Yuri Kondratyuk Poltava Polytechnic». Sphere of interests – heritage architecture and landscape, modern landscape design, urban design. Address: 24 Pershotravneva Avenue, Poltava, Ukraine.
E-mail: Ab.Shevchenko_LS@nupp.edu.ua
ORCID ID: https://orcid.org/0000-0001-6840-8406

**Olena Troshkina**, Associate prof. Ph.D, Department of Architecture of the National Academy of Fine Arts and Architecture. Sphere of interests – landscape architecture, semantics of architecture, architectural space, scenario approaches to architectural space design. Address: 20, st. Voznesens'kyy uzviz, Kyiv, Ukraine.
E-mail: olena.troshkina@naoma.edu.ua
ORCID ID: https://orcid.org/0000-0002-0597-9700

**Arsenii Troshkin**. Senior Lecturer, PhD., Department of Architecture, National University of Water Management and Nature Resources Use. Sphere of interest – urban environment, residential zones, functional-planning structure, urban territory design, public service establishments, food establishments, restaurants, and catering establishments. Address: 49A Chornovola St., Bldg. 6, Rivne, Ukraine.
E-mail: a.a.troshkin@nuwm.edu.ua
ORCID ID: https://orcid.org/0000-0001-7394-0923

## Kopsavilkums

Rakstā aplūkota universālā dizaina koncepcijas attīstība Ukrainā. Rakstā raksturots vispārējais esošās situācijas stāvoklis un sniegti atbilstoši statistikas dati. Izmantojot Ukrainas pilsētu, īpaši Poltavas, piemērus, izcelti galvenie problēmjautājumi un attīstības perspektīvas, kas prasa pakāpenisku un kvalitatīvu risinājumu. Pamatmērķis ir nodrošināt pilsētvides pieejamību, radot ērtus apstākļus dzīvojamās un komunālās infrastruktūras izmantošanai. Pētījuma objekts ir pilsētas telpas un ielas, kuras izvērtētas un aplūkotas no vides pieejamības organizācijas aspektu puses. Lai sasniegtu izvirzītos mērķus, darbā izmantotas dažādas zinātniskās metodes: empīriskā metode tika pielietota novērojumu un salīdzinājumu veikšanai; teorētiskā metode – vēsturisko datu analīzei par izvēlēto pilsētas teritoriju attīstību; lauka pētījumu metode – esošo problēmu identificēšanai izpētītajās teritorijās; savukārt eksperimentālā projektēšana veicināja galveno paņēmienu un ieteikumu praktisku ievieešanu pilsētvidē. Pētījuma rezultātā izstrādāta analīze un virkne projektu priekšlikumu, kas balstīti uz universālā dizaina principiem un ir nozīmīgi ikvienam teritorijas lietotājam.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.05

# MONITORING INTELLIGIBILITY CHANGES OF KAUNAS INTERWAR MODERNISM BUILDINGS

**Kęstutis Zaleckis, Aušra Mlinkauskienė, Marius Ivaškevičius, Ingrida Povilaitienė**

*Faculty of Civil Engineering and Architecture, Kaunas University of Technology, Kaunas, Lithuania*

**Abstract. The research based on the project "Heritage in Depopulated European Areas" (HerInDep), started in April 2023 and examines the transformation of Interwar (the years between the end of the First World War and the beginning of the Second World War) architecture and its influence on the social and urban development of Kaunas, Lithuania. Kaunas, particularly its central region, holds a significant concentration of Interwar modernist architecture, which has endured substantial urban changes during the Soviet era and pressures from business developments post-1990. In 2023, Kaunas' modernist architecture was nominated to the UNESCO World Heritage list under "Modernist Kaunas: Architecture of Optimism, 1919-1939," reflecting its transformation into Lithuania's provisional capital. Approximately 80% of these heritage properties have distinct characteristics meriting legal protection. The idea of the article is to propose and validate a methodology for assessing the legibility of immovable cultural heritage in an urban environment. Such a methodology could be used not only to understand better the importance of cultural heritage in creating urban landscape identity but also to monitor changes in legibility due to various transformations of the urban fabric, even in the absence of destroyed or otherwise physically affected heritage properties. The paper focuses on the presentation of the space syntax or mathematical graph-based intelligibility model which, because of its simulative natures offers predictive possibilities while pointing out further possibilities of its use for monitoring purposes.**
**Keywords: intelligibility, space syntax, interwar modernism buildings, heritage, sociological survey**

## Introduction

The research of the project Heritage in Depopulated European Areas (HerInDep) analyses the transformations of Interwar architecture and their impact on the social and urban development of Kaunas city.

From 1919 to 1939, when Kaunas became Lithuania's provisional capital, many modern architectural buildings were built in Kaunas, the temporary capital of Lithuania. In early 1919, the Council of State, Cabinet of Ministers and other institutions were located here. Diplomatic missions of various countries were also established in Kaunas. Most of them were located on V. Putvinskio Street (USA, Sweden, France, Czechoslovakia, Hungary), others were located on Laisvės (Liberty) Avenue (Austria, Netherlands, Russia), Kęstučio Street (Latvia, Great Britain). Most of the objects that represent it, including the buildings of the Central Post Office (architect F. Vizbaras), the Milk Centre (architect V. Landsbergis-Žemkalnis), the Palace of the Vytautas the Great Museum (architects V. Dubeneckis and K. Reisonas), etc.) were built in Kaunas' New Town [1]. New districts of K. Donelaičio, Kęstučio, V. Putvinskio, Maironio and other streets of the central part of Kaunas, and Žaliakalnis (Green Hill) were formed [2].

The greatest diversity and concentration of Interwar architecture is found in the central part of Kaunas, which suffered a major urban transformation during the Soviet period and has been under pressure from business development since 1990. The population of Kaunas has been fluctuating over the last three decades, with a decrease of 29.8% between 1996 and 2019, and only in recent years has the situation slightly changed. These demographic processes have directly impacted the gradual deterioration of building functions and public spaces. This is particularly the case in areas with a large number of cultural heritage sites and important historical artefacts. Within the scope of the project, the research is carried out in the historically and culturally significant territory of Kaunas city - Naujamiestis (New Town), representing modernist architecture, and Old Town, as an inseparably perceived structural part of the centre of Kaunas. The central part of Kaunas has more than 1500 buildings reflecting Interwar modernism that have survived to the present day. In twenty years (1919-1939), the city's territory expanded sevenfold, and its population increased eightfold, from 18,000 to 154,000 inhabitants [1, 2].

The research area has a protected street network, which was formed in different periods: in the Old Town there is a medieval street network, in the New Town there is a predominantly classical street layout, and in the southern part of New Town, there is a twentieth century street layout. The research area has a natural border made by the Nemunas River and slopes of the river valley with a limited number of entrance axes from the other parts of the city.

In 2023, Kaunas's modernist buildings were nominated to the UNESCO World Heritage list as "Modernist Kaunas: Architecture of Optimism, 1919-1939". This property testifies to the rapid urbanisation that transformed the provincial town of Kaunas into a modern city that became Lithuania's provisional capital between the First and Second World Wars [3]. Most cultural heritage buildings built during the Interwar period are listed in the Lithuanian Register of Cultural Properties of the Republic of Lithuania [1] and have been granted legal protection. Around 80% of these properties have identified individual values, which are defined by the distinctive characteristics of the buildings, such as the volume of the building, including height, roof shape and materiality; the architectural design and decorative elements of the facades; the layout of the floor plans and the location of the load-bearing walls; the artistic and technical elements of the interiors; the construction and the value of the built environment.

The main objective of the article is to present the model for monitoring intelligibility changes in Kaunas Interwar modernism buildings. Such a model would expand traditional monitoring of changes in cultural immovable heritage which, at least in Lithuania, is focussed on the identification of valuable features of the objects themselves, e.g. elements of décor, architectural composition, volume, etc. The proposed model would allow observation and evaluation of how the importance of the heritage objects is decreased, increased or remains unchanged while their urban spatial environment is changing. The concept of intelligibility itself, as it will be clarified in more detail later, is based on the idea of legibility (intelligibility) or imageability by Lynch as "...the apparent clarity ... of the cityscape" and his statement that "legibility is crucial in the city setting" [4], We argue that if applied

to immovable cultural heritage, this concept would allow for monitoring changes of its activeness in a perceived cityscape thus increasing the complexity of cultural heritage monitoring. The tasks of the research were oriented to a description of the study area and heritage sites, legibility and intelligibility research, mathematical graph models for the investigated area, building graph model, validation of the selected heritage objects based on sociological survey and open data.

## Methods

*Observation* was used to investigate and interpret locally significant examples of depopulation. The observations provide data on how cultural heritage signs, events and strategies are implemented, celebrated and appropriated by different actors.

*The assessment of the current state* of heritage objects and areas was carried out by analysing the physical condition, cultural value, and functional use of selected objects, which allows a better understanding of the survival of real cultural heritage objects, as well as how the changing functions of heritage objects affect the recognition and significance of heritage objects.

*Urban legibility studies* were carried out to investigate how changes in heritage assets affect the visual identity of the city. These studies were based on simulation modelling. Simulation modelling allows the prediction of both past and future loss of people in an area and its impact on heritage legibility. This was an integral part of the project. The research analysed statistical and other data such as online images, maps, records, number of visitors to the sites, etc.

*The sociological survey of residents* of the central part of Kaunas City was carried out to validate the results of urban legibility studies.

## Investigated heritage objects

Eighteen Interwar modernist buildings (Table 1) were selected for intelligibility research and sociological survey. The criteria for selecting the buildings are the following: they were built in the Interwar period, they are included in the Register of Cultural Property of the Republic of Lithuania, their valuable properties have been identified, they are located in different quarters of Kaunas New Town and they are built in the inner part of the quarters or along the main streets of the

TABLE 1

List of investigated heritage objects [created by author's]

| No | Title of the object | Address | Year of construction, Architectural style | Author |
|---|---|---|---|---|
| 1. | Building complex house of the artist Antanas Žmuidzinavičius | V. Putvinskio str. 64 | 1928, Modernism | Architect Vytautas Landsbergis-Žemkalnis |
| 2. | Kaunas Central Post House | Laisvės ave. 102 | 1932, Modernism | Architect Feliksas Vizbaras |
| 3. | The Dairy Centre Palace | Laisvės ave. 55 | 1931-1934, Modernism | Architect Vytautas Landsbergis-Žemkalnis |
| 4. | Church of St. Michael the Archangel, Garrison Church | Nepriklausomybės sq. 14 | 1890-1895, Neo-byzantine | Engineer Konstantinas Limarenka |
| 5. | Church of the Resurrection of Christ | Žemaičių str. 31 | 1934-1940, Modernism | Architect Karolis Reisonas |
| 6. | Lithuanian American Joint Stock Company Building (Amlitas) | Kęstučio str. 72 | 1923, Functionalism / Modernism | Architect Vladimiras Dubeneckis |
| 7. | The House of the Engineer Viktoras Rėklaitis | V. Putvinskio str. 33 | 1933, Modernism | Engineer Klaudijus Dušauskas-Duž |
| 8. | Professor Augustinas Janulaitis' House | Kęstučio str. 48B | 1931-1932, Modernism | Architect Arnas Funkas |
| 9. | The Vatican Nunciature (now Artists House) | V. Putvinskio str. 56 | 1930, Modernism | Architect Vytautas Landsbergis-Žemkalnis |
| 10. | The House of the Lawyer Petras Leonas | K. Donelaičio str. 77 | 1924, Modernism | Engineer Edmundas Frykas |
| 11. | The Jewish Gymnasium (now Juozas Naujalis Music Gymnasium) | Kęstučio str. 85 | 1930-1931, Functionalism / Modernism | Architect Boruch Kling |
| 12. | The House of the Lithuanian Diplomat Petras Mačiulis | K. Donelaičio str. 57 | 1935-1936, Modernism | Architect Vytautas Landsbergis-Žemkalnis |
| 13. | The Tercijonai House | V. Putvinskio str. 72 | 1936, Modernism | Architect Bronius Elsbergas |
| 14. | The House of Architect Grigorijus Gumeniukas | Kęstučio str. 19 | 1935, Modernism | Engineer-Architect Grigorijus Gumeniukas |
| 15. | The House of Aleksandra Radzvickienė | Laisvės ave. 2 | 1939, Modernism | Architect Karolis Reisonas |
| 16. | The House of Stefania Montvilaitė-O'Rourke | K. Donelaičio str. 51 | 1937, Modernism | Architect Arnas Funkas |
| 17. | The House of Stasys and Jadvyga Montvilas | K. Donelaičio str. 55 | 1939, Modernism | Architect Arnas Funkas |
| 18. | The House | Laisvės ave. 5 | 1933, Modernism | Not identified |

New Town.

**Kaunas visitor estimation data acquisition**

The site BestTime.app was discovered during the investigation of data sources, although they do not state this in their documentation it is apparent that they use [5] estimation of popular times [6]. As Google itself does not provide an API to gather this data, a demo page of BestTime.app was used to generate the web page with the required data [7]. This way we acquired the required data with one HTML save, instead of scraping it with a browser simulator in a scraping-resistant Google environment.

Data mining of the saved HTML was undertaken by utilising the BeautifulSoup library in Python language. Inconveniently hourly popularity estimates were not stored as values and had to be derived from embedded SVG in the same HTML code. SVG (scalable vector graphics) is an open-source format for vector graphics supported natively by all major web browsers. Values were taken from the path object of the SVG, which was composed of 23 curves. Conveniently y coordinate of 24 endpoints of curves was proportional to the hourly popularity of the place. Only the endpoints of curves were used, because other points did not carry any useful information, they were only for aesthetic reasons.

To be useful as a GIS database, this data was missing GPS coordinates, therefore, to acquire coordinates using the street address, the Nominatim service was used to reverse-geocode database entries. The Nominatim uses an OpenStreetMap database assembled by volunteers.

**Legibility and Intelligibility**

The interrelated terms "legibility" and "intelligibility" are used in research on architecture and urbanism as interrelated terms. Lynch [4] described the legibility defining it as "...the apparent clarity ... of the cityscape" and stating that "legibility is crucial in the city setting, ... (and it) might be called imageability; that quality in a physical object which gives it a high probability of evoking a strong image in any given observer". Thus, relating it to such elements of the image of a city as paths, nodes, districts and landmarks.

Environmental psychology analyses how we perceive the spatial environment, what makes our perception easier and what environment we prefer if such possibility exists – it is summarised on the concept of the preferred environment by Environmental psychology. Kaplan, while describing informational factors essential for the satisfaction of two basic information needs – understanding and exploration, creates a so-called preference matrix of a landscape which contains the following features: legibility, complexity, coherence and mysteriousness. According to him, a combination of the above-mentioned four creates patterns, which affect understanding and preference of an environment. Legibility is defined as "how easy would it be to find your way around the environment depicted, to figure out where you are at any given moment or to find your way back to any given point in the environment" [8]. Coherence shows "how easy is it to organise and structure the scene how well a scene hangs together" [8]. Complexity is "how much the scene contains elements of different kinds" [8]. Mysteriousness shows "how much does a scene promise more if you could walk into it" [8]. The other environmental psychologists [9] stated that higher complexity can "...affect the legibility of the landscape as a consequence of offering too much information". The following indicators of complexity, which could be seen as affecting legibility are mentioned: density, diversity, spatial organisation, variation and contrast, etc. On the other side, if we speak about the perception of the image of a city or its mental map then we can assume that perception of at least complexity and coherence is based on it while legibility should be considered as the basic feature or property of environment which makes possible to create its mental map.

Gordon Cullen [10], while formulating the concept of serial vision on urban spaces, states that townscape could not be perceived directly. Thus, pointing out the importance of the city image as a complex urban map for human-environment interaction and evaluation of the importance of the elements of a cityscape for its perception and significant role of legibility or intelligibility.

John Peponis and Jean Wineman [11] in the chapter "Spatial Structure of Environment and Behavior" in the Handbook of Environmental Psychology use the term "intelligibility" to analyse cognitive aspects of urban and architectural environments. Based on earlier sources „...intelligibility indexes the degree to which the number of immediate connections a line has is a reliable guide to the importance of that line in the system as a whole (namely, it is a correlation between axial connectivity and axial global integration). A strong correlation, or "high intelligibility", implies that the whole can be read from the parts [32]. It is important to point out that this intelligibility is modelled based on the theory and models of Space Syntax as one of the simulative descriptive models of the architectural environment which employs mathematical graph as the main tool to calculate various centralities of the graph nodes, which could be related to certain aspects of human behaviour. Based on the Peponis' definition we will see the intelligibility as an index of legibility as a more complex feature of a landscape.

The presented research aims to propose and validate the methodology for the evaluation of the intelligibility of immovable cultural heritage in urban settings. Such methodology could be used not only for a better understanding of the importance of cultural heritage for the creation of identity of urban landscape but also for monitoring intelligibility changes because of various transformations of urban fabric even without the destruction or other physical impact on heritage objects. The article focuses on the presentation of the model itself while pointing out further possibilities for its usage for monitoring purposes.

**Mathematical graph models**

**for the investigated area**

So, if applied to the objects of immovable cultural heritage, intelligibility can mean that they are seen as visually active, accessible, easy to find, and often seen even without specific intention in an urban fabric or, in terms of Lynch [4], form participate in an image making as significant elements forming nodes, paths, districts, landmarks or edges.

Because of the complexity of human behaviour and cognitive functions, it could be stated that intelligibility or the possibility of understanding any urban structure is related/defined by motivation, attention, prior knowledge, processing speed, emotional state, social and cultural contexts, etc. At least some of the above-presented aspects affecting intelligibility could be modelled based on spatial configurations as the most available type of data:

- Attention could be related directly to spatial structure, the possibility of seeing heritage objects because of better visibility or allocation besides spaces which attract more people. Such probabilities depend on the visibility of urban spaces and the different reachability of city areas.
- Processing speed could be related to movement speed directly, based on the observation that we perceive more details and receive more detailed information about the surrounding environment while walking. The

walkability of urban structures and pedestrian flows could be addressed in simulative modelling as it will be discussed later as well.

- Prior knowledge could be related to the shared collective city image, city map or personal experience. Attention and orientation to pedestrian movement modelling, if related to the elements of the image of a city, could be seen as an important component of such analysis.

Architectural urban configurations, movement and concentration of people could be analysed in many ways including observation in situ or sociological survey. However, in the presented research, it was addressed based on simulative modelling which is used in many research fields for analysis and a better understanding of complex systems. There are in essence three groups of simulative models: cellular automata which, if applied in urban simulation, describes immovable cells (e.g., buildings, land plots, etc.) and a set of rules - how one cell reacts to changes in the other neighbouring cells; agent-based modelling which constructs simulation out of stable environment and moving agents (e.g., people) which interact with both environment and each other ; and mathematical graph-based network analysis which is applied in the presented research. The last one, based on previous experience of the research group and because it requires the least amount of initial information (e.g., no behaviour models of agents or properties of cells) was chosen for intelligibility modelling because of the following reasons:

- Mathematical graph models are based on urban layout, see the city as a network of objects/spaces and are used to simulate human behaviour in a city. Space Syntax is one of such models [12]. Similar models are used for modelling complex systems in many fields.
- Mathematical graph models are tested and validated based on empirical data in many situations. They allow us to model the movement of people, concentration of human activities, accessibility of places, visibility of spaces, etc.
- Simulative models not only allow us to investigate present, past and future situations but enable us to analyse the present situation with very high precision, achievement of which based on in situ investigations, would require an enormous amount of time.

The mathematical graph is made of nodes and links which connect them. Even if such a model looks very simple from the first point of view, it is successfully applied in many fields of science where a system as a network of interacting elements needs to be modelled, e.g.: the human brain, universe, etc. The essence of the mathematical operations is a calculation of the importance or centrality of the nodes for the movement of people, e.g.: each node of the graph which might represent part of visual space, visual axis or segment of street is considered as an origin and destination of calculations of distances and movement. Most often calculations are conducted from every node to the rest of the nodes, and the results make a background for calculations of the centralities of nodes. In more advanced graphs only part of the nodes could be used as destinations or origins, e.g., only nodes representing spaces except for living houses could be used as origins and only nodes representing spaces besides shops could be used as destinations, etc.

Traditional Space Syntax theory uses three types of graphs:

- Axial graph where each node is represented by the longest visual axe of real urban space, e.g., street. The crossroads represent links between the nodes. Such graphs mostly are used inside buildings or while investigating relatively small urban structures where visibility is an important factor for navigation.
- Segment graph nodes are constructed out of straight segments of central lines of streets while turns of intersections of segments at the ends are represented by links. Such graphs could be used for the investigation of urban structures of various sizes – from small to very large.
- Visual graph is constructed out of the cells of tessellated visual space. The possibility to see one cell from another one is considered as a graph link. Such graphs are used when visual relations of architectural space should be investigated with high precision.

Each of the above-mentioned graph types has its own strengths and weaknesses. Each of them could be used for the identification of probable elements of city image and evaluation of the role of heritage objects in it. Yet, the first and essential question is whether the simulative model is working well in the investigated area.

The validation of all three types of graphs is based on the idea of movement economy by Hillier. It states the following: "The theory of the movement economy, built on the notion of natural movement, proposes that evolving space organisation in settlements first generates the distribution pattern of busier and quieter movement pattern flows, which then influence land use choices, and these, in turn, generate multiplier effects on movement with further feedback on land use choices and the local grid as it adapts itself to more intensive development" [12]. Based on this, we can assume that the concentration of the object of interest of city users should correlate with certain calculated centralities of the

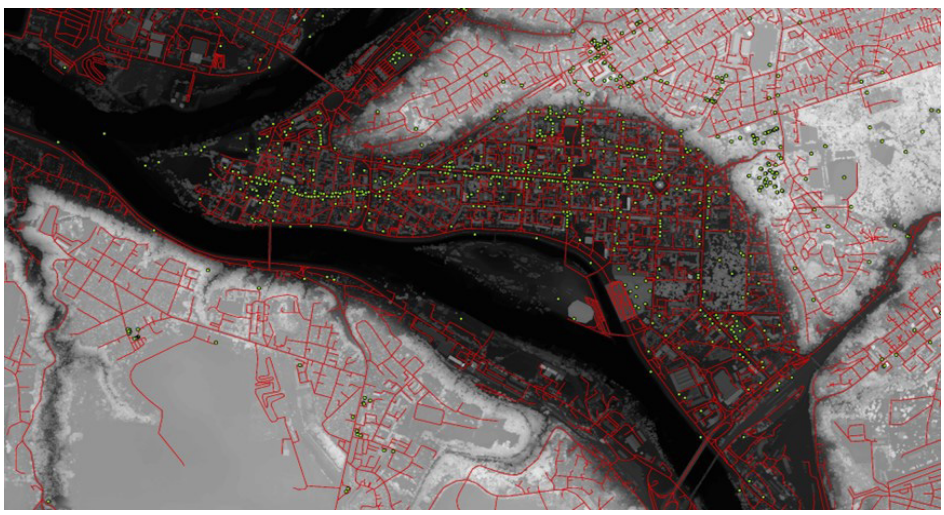


Fig. 1. The streets of the investigated area (marked by red lines) and allocation of (POIS) marked by red dots)

TABLE 2

Pearson correlations between density of POIS within 50 and 30 meters and Space Syntax indexes. Green colour marks strong, yellow colour – moderate correlations. ** mark 0.01 significance level of the correlations

| | Ch3 | Ch5 | Ch7 | Chn | Con | lnRn | lnR3 | lnR5 | lnR7 | NC3 | NC5 | NC7 | TDn | TD3 | TD5 | TD7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pois50 | .625** | .601** | .589** | .634** | .613** | .257** | .355** | .293** | .261** | .420** | .236** | .148** | -.189** | .395** | .198** | .085** |
| pois30 | .657** | .634** | .627** | .682** | .644** | .246** | .353** | .286** | .254** | .410** | .230** | .147** | -.177** | .383** | .193** | .086** |

Space Syntax models. Centralities of all three types of graphs of the Kaunas Downtown area were checked for correlations with the density of so-called POIS (Figure 1) or points of interest based on the Open Street Map (OSM) data.

It is important to point out that the investigated area has a natural border made by the Nemunas River and slopes of the river valley with a limited number of entrance axes from the other parts of the city. That allows us to investigate the area autonomously without considering the rest of the city, especially while speaking about pedestrian movement.

The first tested model was based on an axial graph. The model was used to calculate the following basic centralities:

- Connectivity (Con in Table 2) or number of links each node has – it corresponds to the number of crossroads on each visual axe.
- Choice or betweenness centrality which represents the main probable transit routes within the area with four different radiuses: 3 turns of crossroad passed, 5, 7 and n (Ch3, Ch5, CH7, Chn in Table 2).
- Total depth or sum of the shortest topological distances counted in the number of nodes crossed from each node to the rest of the nodes within specified radiuses (TD3, TD5, TD7, TDn in Table 2). The lower the number, the better reachability the node has within the network.
- Node count of the density of nodes (axes) within specified radiuses (NC in Table 2).
- Integration or normalised Total Depth by comparison of it to statistically probable dispersion of the centrality values to Normal Dispersion (lnRn, lnR3, lnR5, lnR7 in Table 2).

Space Syntax results were intersected with POIS within two radiuses – 30 and 50 meters. Distances for intersection were selected as the most actual for visual perception based on the concept of visual graph based on the visibility of urban spaces.

In essence, the model works quite well, especially while modelling pedestrian flows within the area, which demonstrate strong significant correlations with POIS densities. Despite this, the correlations between POIS and Integration are moderate and weak, showing the limitations of the model in pointing out the most reachable and attractive areas successfully. The resolution of the model, caused by the length of a bigger part of the axes could be indicated as another weakness in the presented research as any building besides a street should be considered of the same importance for the further intelligibility model based on available data. Besides the previously-mentioned weaknesses, the axial graph (Figure 2) uses just topological distances for identifications of radiuses measured in the number of turns – it can possibly help to understand why integration results, which show the most reachable areas in the investigated area, are not working so well.

The segment graph, as it was mentioned earlier, differs from the axial one in two essential ways: a) nodes of the graph are constructed not from the longest possible straight axes but from straight street segments formed by intersections and turns of streets; b) it allows usage of various type of distance measurement, including metric radiuses, which could be more precise if compared to the axial graph.

If Space Syntax indicators of the segment graph are intersected with POIS density within a radius of 400 meters, then both Pearson and Spearman's correlations demonstrate very similar results.

In the case of segment graph analysis, Space Syntax indicators are intersected with POIS within 400 meters. Such radius represents a 5-minute walkable distance as a kind of minimal resolution not on visual connections but on movement lines-based segment graphs (Figure 3).

In both cases, choice or transit flows within the investigated

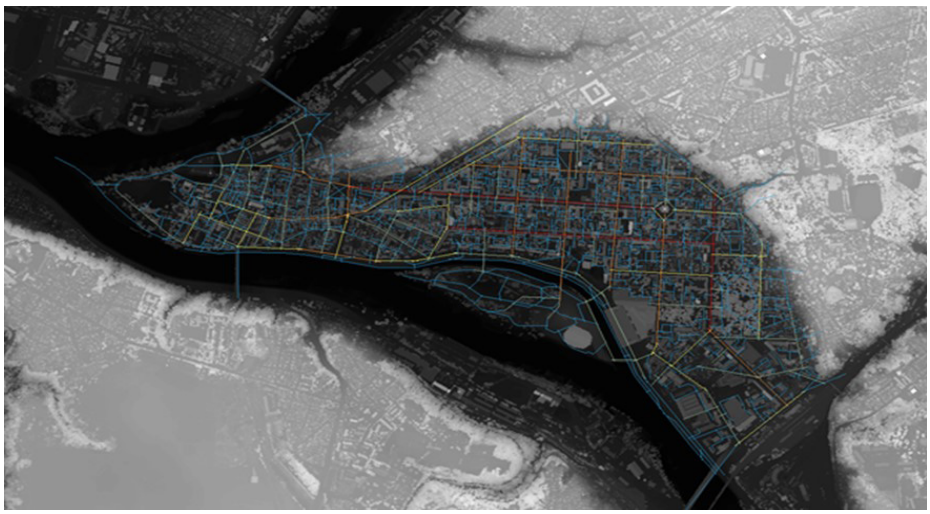


Fig. 2. Axial graph: Choice with radius n. Red colour shows high and blue – low numerical values

Fig. 3. Segment graph: Integration with a radius of 800 meters. Red colour shows high, blue – low numerical values

area (Ch with radius in meters marked in Tables 3 and 4) demonstrate significant but weak correlations. Integration in segment analysis ('In' with radius in meters marked in Tables 3 and 4) considers both the closeness of a segment to the rest of the network and the density of the network around it. It demonstrates significant strong and moderate correlations. The total depth of pure closeness without evaluation of the density of the network shows both positive and negative moderate and strong correlations, especially in the shorter radiuses. In this case, interesting regularity could be observed: TDn or less reachable areas demonstrate a negative correlation with POIS density, and it looks logical. When the radius is decreased (e.g., TD400) correlations are positively strong. It means that the street network around the most reachable areas in a city becomes more complicated and denser, which can reflect the natural phenomena of organic densification in the historical area of the city. So-called Metric reach or Total Metric Length within a radius 800 meters (MR800) shows the densest zones of the street network and confirms the previous insight based on TD400 while demonstrating significant positive strong correlations.

It is hard to say if the segment graph in the case of Kaunas works better than the Axial Graph but each of them works well on specific indicators. If you think about the level of precision needed for the intelligibility modelling of heritage buildings, the resolution of the segment graph is better. Still, there are a lot of different buildings allocated besides many of the street segments.

The third, and the most precise graph suitable for urban analysis and employed by Space Syntax is Visual Graph. During the construction of the graph, all spaces between buildings were tessellated while using a 10-meter step. Cells of the open spaces were connected if they were intervisible between themselves. The intersection of POIS with the visual graph was conducted at a 100-meter radius. Having in mind the social function of urban spaces it is a distance at which a medium size person would be seen as a 1.1 vertical angular degree size object, which could be still perceived as an autonomous single element on a visual field [13].

Statistical analysis of the results revealed significant moderate both positive and negative correlations between POIS density and:

- Connectivity (Conn in Table 5, Figure 4) or simply the sum of visible cells from the cell for which the calculation is conducted so the bigger number means bigger visual space.
- Isovist Occlusivity (IsOcl in Table 5) or length of the invisible perimeter of the visual field from the point of its observation. It is considered that higher occlusivity produces less visually predictable environments.

TABLE 3

Pearson correlations between POIS density and Space Syntax indicators of the segment graph

| | Ch1200 | Ch2400 | Ch400 | Ch800 | Cnn | In1200 | In2400 | In400 | In800 | Inn | MR800 | TD1200 | TD2400 | TD400 | TD800 | TDn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POIS | .159** | .132** | .270** | .204** | .126** | .476** | .463** | .432** | .527** | .327** | .663** | .502** | .147** | .741** | .669** | -.327** |

TABLE 4

Spearman's rho between POIS density and Space Syntax indicators of the segment graph.
Green colour marks strong, yellow colour – moderate correlations. ** mark 0.01 significance level of the correlations

| | Ch1200 | Ch2400 | Ch400 | Ch800 | Cnn | In1200 | In2400 | In400 | In800 | Inn | MR800 | TD1200 | TD2400 | TD400 | TD800 | TDn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POIS | .069** | 0.023 | .195** | .115** | -0.01 | .488** | .454** | .445** | .541** | .324** | .646** | .468** | .116** | .752** | .677** | -.324** |

TABLE 5

Spearman's rho between POIS density and Space Syntax indicators of the visual graph.
Yellow colour marks moderate correlations. ** mark 0.01 significance level of the correlations

| | Conn | IsOcl | IsPerim | PFM | PSM | ThrVis | VMD | ViEntr | VisInt |
|---|---|---|---|---|---|---|---|---|---|
| POIS | -.267** | -.223** | -.224** | -.269** | -.269** | -.215** | -.241** | -.300** | .241** |

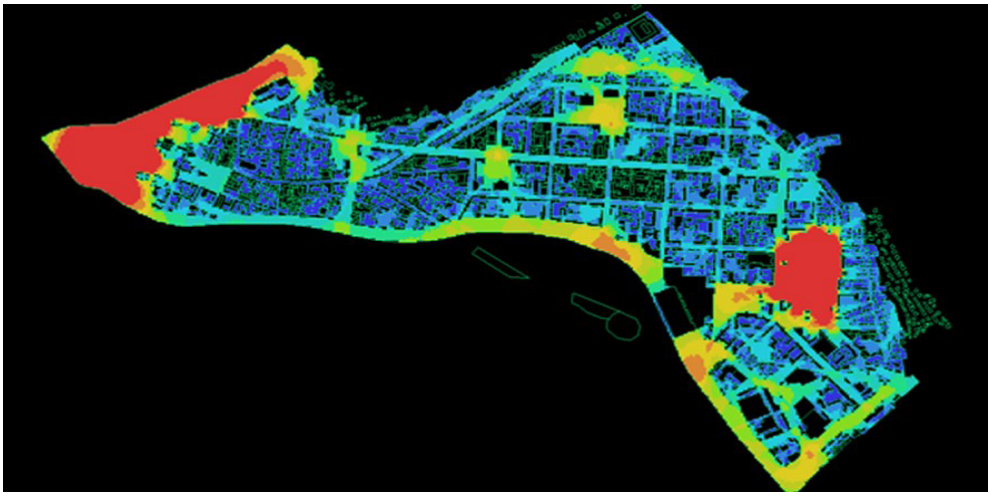


Fig. 4. Visual graph: Connectivity within radius 200. Red colour shows high, blue – low numerical values

- Isovist Perimeter (IsPerim in Table 5). The longer perimeter of the visually perceived spaces offers more visual information for an observer.
- Point First Moment (PFM in Table 5) or elongation/ skewness of a visual space. Higher mathematical value means that visual space is perceived as a kind of urban corridor.
- Point Second Moment (PSM in Table 5) or diversity of radiuses of the visual field – a bigger number means that space offers a higher variety of short, medium and long perspectives and could be considered more interesting for an observer.
- Through Vision (ThrVis in Table 5) or the sum of times when the calculated cell appears on the visual connection between pairs of other cells. A higher value means that space is more exhibited and visible from all sides.
- Mean Depth (VMD in Table 5) is simply a sum of distances counted in the number of turns/changes in direction while moving from the calculated cell to all the other cells in the investigated area. Smaller value shows more reachable space.
- Visual Entropy (ViEntr in Table 5) – an indicator which shows the probability that the calculated point of space could be discovered by accident or unintentionally while moving in a city. A bigger value means that part of the space is more hidden.
- Visual Integration (Vi Int in Table 5) or normalized value of Mean Depth where a bigger number means better reachability of a space spot.

The model demonstrated just medium significance despite the higher precision of the graph if compared with the segment and axial ones. Possible better results could be achieved if graph creation rules were more complex, e.g.: a) two cells could be connected not only when intervisible, but when there is a possibility to move from one to another; b) when different types of border are considered as solid and intervisible; c) high transport intensity streets are removed from the graph as not accessible for pedestrians; d) big open spaces in parks removed as they offer completely different environment for perception in comparison to urban fabric; etc. Because of the lower values of the correlations, there is no possibility to model the movement of people directly and a little problematic. No clear optimal rules for the creation of links between the nodes of the graph, which would require a separate investigation, the visual graph at the moment was found as not the ideal background for the intelligibility of cultural heritage buildings modelling. At the same time, weaker correlations do not mean that the visual graph model is less suitable for the modelling of urban processes. In this case, simply the different data if used for validation can give better results as the visual graph in essence models visual perception of spaces but allocation of POIS is more suitable for modelling the movement and reachability in a city.

## Building graph

All three types of city graphs simulate city functioning quite well as was demonstrated in the previous chapter and, in essence, could be used for modelling the intelligibility of urban structure. The problem arises when the exact task to conduct modelling at the level of single buildings is formulated: axial and segment graphs demonstrate too high resolution, visual graphs calculated with Depthmap [14], do not allow to simulate the movement of people and its resolution is too precise. An ideal solution in this situation would be a graph with buildings as nodes, which would allow us to simulate both the movement and concentration of people. Such a model, based on the same mathematical graph approach, was offered by Sevtsuk and Mekonnen [15]. It uses buildings as graph nodes, allows the addition of various weights to each building thus reflecting its unique properties as volume, perimeter, 3D perimeter, etc., and still incorporates street networks as the backbone of the model. Each building as a node is connected to the closest street segment thus reflecting entrance to a building. An example

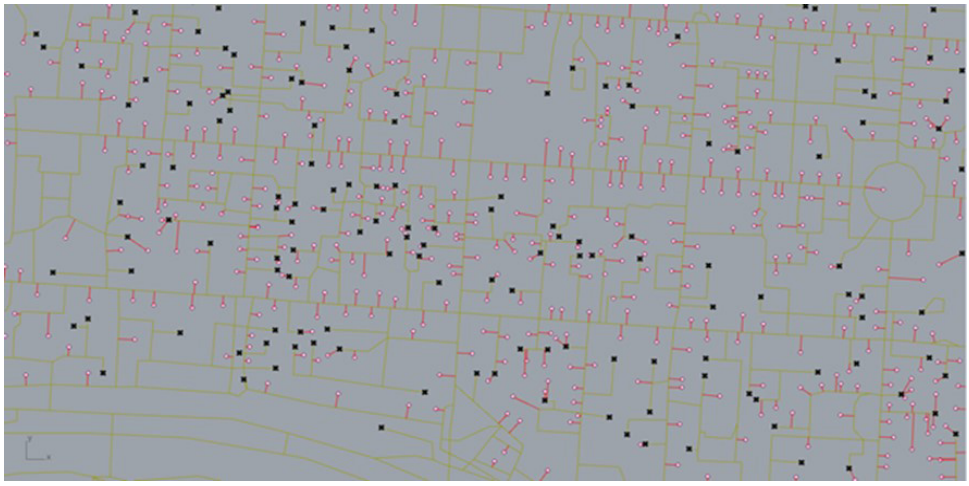


Fig. 5. Part of the building graph of the investigated area in Kaunas created while using the Urban Network Analysis Toolbox (UNAT) [16]. Yellow lines represent segments of streets, white round dots - buildings as graph nodes, red lines - connections between buildings and streets, and black crosses - dead ends of street segments

of such a graph is presented in Figure 5. Creation of one entrance per one building could be seen as a limitation in dense historical urban fabric, but each model represents a simplified view of the real situation, and the most important question is as follows: if it is effective enough?

**UNAT offers the possibility of calculating five graph centralities**

The first one is Reach Centrality, and it is calculated for each node of the graph as a sum of the weights of the nodes reachable from it within a specified radius [17].

The second is Gravity Centrality, which is counted for each node as a sum weight of each node reachable within a specified radius divided by the exponential function of distance to that node [17]. A higher gravity value means that more buildings with bigger weights (e.g.: 3D perimeter or volume) are located closer to a specific point. It demonstrates the most reachable and densely built-up zones of a city thus pointing out potential centres with higher diversity and concentration of functions. If compared to the Reach Centrality, Gravity is more sensible to distances of movement between buildings. In essence, the indicator is similar to the earlier mentioned integration of segment graph in Depthmap which considers both distances and density of reachable nodes.

The third type of centrality is Betweenness which is called Choice in Space Syntax and Depthmap. It is calculated based on a node as a sum of the shortest journeys between all pairs of potential origins and destinations as the starting and ending buildings for a journey within a specified radius, which cross the counted node, divided by the total number of potential node-pairs/journeys and multiplied by a weight of a destination [17]. As a result, betweenness demonstrates the potential transit flows simply normalised by the total number of journeys within the radius. The usage of the weights means that buildings with high value generate bigger flows towards themself in the simulative model.

The fourth indicator is Closeness, and it is calculated for each node by dividing one by the sum of distances from it to all the other nodes multiplied by the weights of those nodes [18]. It could be stated that bigger closeness means that the total sum of distances to the other buildings within the radius from the calculated building is bigger and the building is located in a more distant position on the network. In Space Syntax, it is called Total Depth.

The fifth centrality is called Straightness, which is calculated as a sum of ratios between the real shortest distance from the calculated node to the other node within a specified radius and a straight line of so-called "crow fly" distance multiplied by the weight of the node to which distance is measured [17]. In the presented research it is proposed to multiply the Straightness and Height of a building to evaluate its visual legibility as even the 3D perimeter of the building does not necessarily reflect its height, e.g.: lower but with a bigger area building can have the same 3D perimeter as higher but with smaller area one.

The sixth centrality calculated is called Redundancy. It is based on the idea that people tend to choose alternative routes for movement within certain limits of route elongation acceptable for them. "Redundancy Index computes the ratio of the sum of the lengths of redundant segments to the sum of the lengths of shortest path segments per each ... pair (of street segments within specified radius). If there are multiple

TABLE 6

Spearman's rho between POIS density and centralities of the building graph. Yellow colour marks moderate correlations. ** mark 0.01 significance level of the correlations. Nv means not weighted graph, 3dw means buildings-nodes weighted by 3D perimeter

| | POIS | Reach nv | Closeness nv | Gravity nv | Betweennes nv | Straightnes nv | Norm_Gravity nw | Norm_Betwennes nw | Norm_Reach nw | Norm_Closeness nw | Norm_Straightnesnw | Reach_3dw | Closeness 3dw | Gravity_3dw | Betweennes 3dw | Straightnes 3dw | Norm_Straightnes 3dw | Norm_Gravity 3dw | Norm_Betweennes 3dw | Norm_Reach 3dw | Norm_Closeness 3dw | Reduncdancy index | Redundancy index norm | Legibility nw | Legibility 3dw |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| POIS | 1.000 | .660** | -.607** | .633** | .228** | .625** | .130** | 0.038 | .660** | .203** | .190** | .741** | -.666** | .782** | .274** | .715** | .246** | .440** | .070** | .663** | .494** | .502** | -.499** | .537** | .585** |

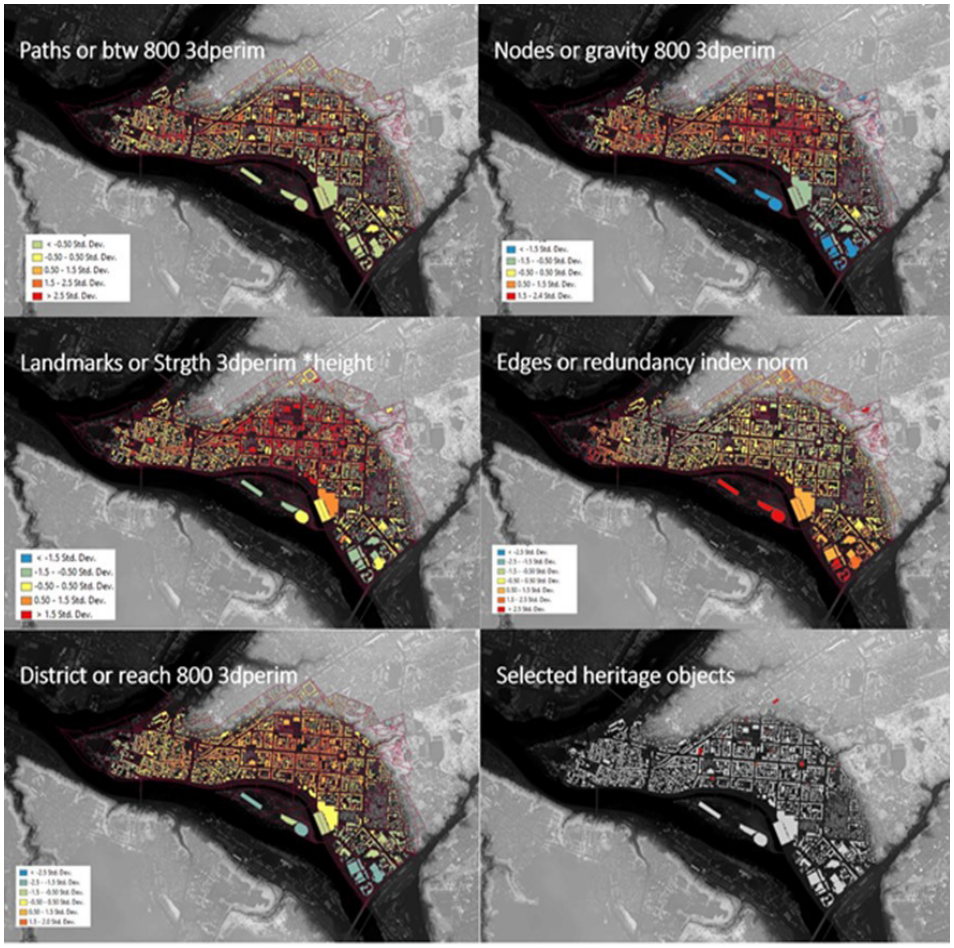



Fig. 6. Results of intelligibility modelling based on graph centrality calculations and structure of the mental city image by Lynch [4] and location of heritage objects

destinations for the same origin, we average these multiple values. Many urbanists have argued that having more path options to Destinations is a positive quality of the built environment enabling travellers more choices" [17].
The first five centrality indexes are normalised in the following way: Reach by dividing it by a sum of the weights of the nodes; Gravity by dividing it by the Reach; Betweenness by dividing it by the Reach; Straightness by dividing it by the Reach [18]. In the presented research it was proposed to normalise Redundancy by dividing it by Reach. In this way, we eliminate street network density parameters and identify and make the result dependent clearly on the morphology of the street network.
Even if the previously presented Space Syntax graph were simulating aspects of the city functioning quite well and we can expect the same from the building graph, its validation should be conducted. For this purpose, the results of calculations of centralities were intersected with a density of POIS within the same radius as in the segment graph – 200 meters. The obtained correlations are presented in Table 6. Straightness multiplied by the height of a building is marked as legibility there. In essence, it could be pointed out that now normalised values with buildings weighted by 3D perimeter demonstrate stronger correlations between POIS and legibility, redundancy index, straightness, closeness, and reach. Weighted betweenness demonstrates the strongest close to moderate correlation if compared to the non-weighted and normalised versions. Based on the presented validation results and suitable resolution of the model for building-focused analysis, it was decided to use the building graph for further intelligibility modelling.

**Intelligibility modelling**

According to Lynch [4], the mental image of a city is constructed in our memory from the following elements:

- Paths as the main connecting elements experienced and formed while moving through a city. Lynch mentions that paths should be identifiable and continuous in addition to their directional quality because of their functional necessity. It is logical to predict that streets with the higher betweenness centrality of choice values in the graph model have a bigger chance to function as paths of the image.
- Edges create a boundary between areas or districts with different characters. Quite often natural elements in a city such as rivers or slopes can function as edges too. In terms of graph centralities, depending on available calculated indicators, zones with the least transit flows (low betweenness centrality), the most peripheric or hard reachable (high closeness centrality) and similar indicators could be associated with edges. Large roads with intensive car traffic can form edges for pedestrians as well.
- Districts are a group of urban spaces that have common characteristic features which could be experienced by an observer. According to Lynch [4], it could be texture, space configurations, form details, building types, activities, etc. Not all of those properties could be modelled in graphs, some of them could be addressed in visual graphs while others in segment or axial graphs. In our case, while looking at the possibilities offered by UNAT, reach centrality could be associated with a district as, if local radius is used, it identifies urban zones with different densities and configurations of street network.

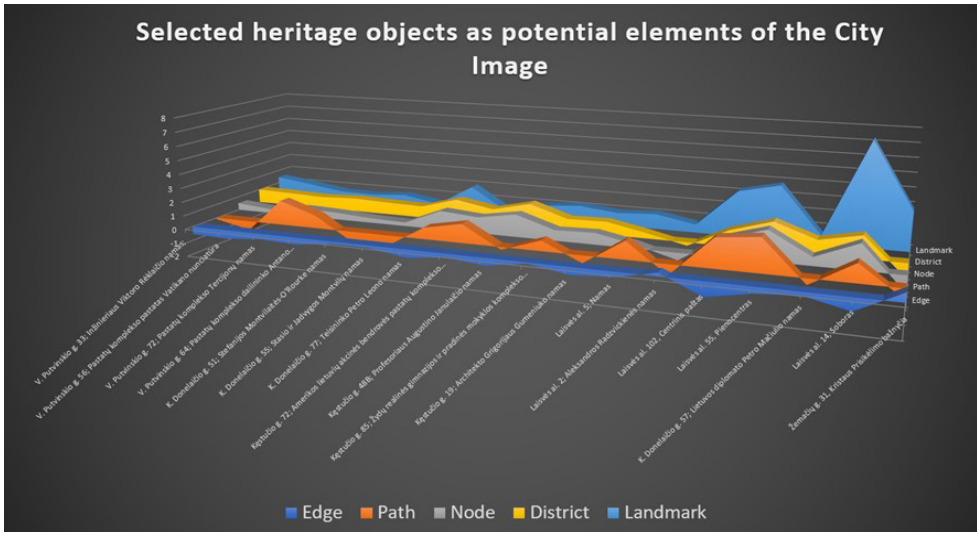



Fig. 7. The scatter plot of normalised graph centralities represents the potential of the selected heritage objects to become elements of the city image

- Nodes are the points or concentrated areas where the observer can enter. According to Lynch [4], nodes can be related to intersections or junctions between paths, but they may be larger than that. A node could be seen as the centre of a district so exhibiting gravity centrality, which identifies the most attractive, well reachable, attracting potentially the biggest number of users, could be seen as graph centrality useful for node identification.
- Landmarks are references like nodes but in comparison to them the observer doesn't enter within landmarks. According to Lynch [4], these elements are unique and memorable in a city context because of the figure-background contrast. Straightness centrality, as it was explained earlier, helps to identify buildings-nodes that appear more often on the straight axes of movement. If weighted by the height of a building, they can help to identify at least part of the potential landmarks as visual dominants of a cityscape.

Based on the presented argumentation for possible connections between the elements of the city image and the graph centralities and while looking at the strongest correlations, the following exact indicators were chosen for modelling:

- Paths – betweenness centrality within a radius of 800 meters weighted by the 3D perimeter of a building (Btw 800 3dperim in Figure 6).
- Nodes – gravity centrality within a radius of 800 meters weighted by the 3D perimeter of a building (Gravity 800 3dperim in Figure 6).
- Landmarks – straightness within a radius of 800 meters weighted by the 3D perimeter and multiplied by the height of buildings (Strgth 3dperim *height in Figure 6).
- Edges –Redundancy normalised within a radius of 800 meters (redundancy index norm in Figure 6).
- Districts – Reach normalised within a radius of 800 meters (Reach 800 3dperim normalised in Figure 6).

The numerical scales of the results of calculations were normalised by dividing them by standard deviation. In this way, bigger standard deviations (both positive and negative) easily identify the most exceptional and unique values of centrality, e.g.: if the value is between 1 and 2 then it represents 13.6 percent of the most unique values if it is above 2-2.1 percent, etc. The higher standard deviation could be related to a higher probability of a building performing a role or being a part of the modelled element of a city image because of its differentiation from a background of urban fabric. While looking at the maps it could be concluded that they demonstrate quite clear, visually recognisable pattern: paths as the main pedestrian streets with nodes concentrated around them at certain points; edges as the zones with offered more opportunities for alternative routes together with reach differentiation, identify three historically different zones and potential districts: the Old Town with its medieval street network; the part of New Town with the most clearly expressed and preserved classicistic street layout; the southern part of New Town with more organic and in the twentieth century deformed layout. The least clear picture is presented by the modelling of the Landmarks as it presents quite a large number of the buildings. Two ways to improve the results could be chosen in the future: increase the value of the standard deviation or search for additional indicators and possibly employ both quantitative and qualitative techniques. But even in the present situation the landmark modelling decreases the number of potential candidates and works quite well in the Old Town where it identifies the main churches and Town Hall. Figure 6 represents the results of all five indicators.

Numerical values are normalised while dividing by standard deviation. Bigger normalised values (red) show a higher probability of the building becoming an element of the city image. In the heritage map, green colour shows Interwar Modernism buildings, and red colour – other heritage objects. The results presented in Figure 6 could be interpreted in the form of a scheme of a city image but for the investigation of the intelligibility and validation of the model, the other path was chosen: different heritage objects, which, according to the expertise of the authors of this research, might perform a different role in the city image of the central part of Kaunas were selected (Figure 6) and the values of centralities, normalised by standard deviation were compared between themself in the first stage of validation (Figure 7). The bigger absolute value of the centrality after normalisation demonstrated the bigger potential possibility for the building marked by it to play a role of the corresponding element of the city image. The clear differentiation of the selected objects could be observed:

- Functionally, symbolically and visually dominating objects such as Soboras, Central Post office or Church of Resurrection could be named as potential landmarks.
- Bigger buildings located both beside the main pedestrian street and in zones of higher multifunctionality could be seen as potential elements of the nodes.
- Soboras and Central Post office, besides their important role as landmarks, could be seen as an element of the edges which mark the transition from the Old Town to

TABLE 7

Spearman's rho between graph centralities and both POIS density and visitors count density in Google maps. Yellow colour marks moderate correlations. ** mark 0.01 significance level of the correlations. Nv means not weighted graph, 3dw means buildings-nodes weighted bey 3d perimeter

| | Reach_3dw | Closeness 3dw | Gravity_3dw | Betweenness 3dw | Straightnes 3dw | Redundancy index norm | Legibility 3dw |
|---|---|---|---|---|---|---|---|
| POIS | 0.741** | -0.666** | 0.782** | 0.274** | 0.715** | -0.499** | 0.585** |
| VISITORS | 0.791** | -0.777** | 0.762** | 0.098** | 0.720** | -0.437** | 0.573** |

the New Town central and southern parts.

- The rest of the buildings could be seen as the formants of the districts with possible differentiated roles within blocks and local streetscapes.

In conclusion to this part of the research, it could be stated that the results of the modelling meet experts' opinion, so the most important final part of validation will be presented by the sociological survey. Before the final validation, one more question should be asked: which group of users the constructed model of the potential elements of the mental city of Kaunas central area represents? Local inhabitants, tourists or both? Maybe different indicators, different weights, or different destinations of journeys should be used if different groups of city users are considered. In the created model all buildings-nodes were seen as both origins and destinations for the calculations. Is such a model correct regarding both tourists and locals? While answering these questions, various hypotheses could be made, e.g.: a tourist might move merely between certain objects and from certain locations like hotels, parking lots or public transport stops; local inhabitants might move from their dwelling to certain, objects such as shops, schools, public transport stops, etc., which are more important for them. Creation and testing of those assumptions would be worth separate research publications. However, before surveying local inhabitants it would be wise to get at least some clarity and get insights if those groups can have a very different mental city image of the investigated area. To receive the answer, information about the most often visited places by tourists in Kaunas centre was obtained based on the methodology described earlier. Correlations between the used centralities and the density of the visits were calculated and compared with the earlier tested correlations with POIS. The results of the comparison are presented in Table 7. The most significant difference could be seen in correlations with betweenness centrality (Betweenness 3dw in Table 7): if compared with the initial model it decreases from nearly moderate to very weak. It might be explained by the assumption that tourists are not restrained by everyday routine and discover cities not following the most rational and short paths of movement in opposition to local inhabitants. At the same time, the relatively weak correlations between POIS and Betweenness could be better understood because POIS includes objects important for both tourists and local inhabitants. The other correlations have quite similar numerical values, and it might show two things:

- The investigated area is quite compact and homogeneous thus not leaving a lot of space for different interpretations of the mental maps by the different types of users.
- The initial model addresses both groups of users and presents some kind of "mean" city image or intelligibility.

More clarity will be obtained after sociological survey-based validations of the model are presented, but, in any case, the presented research should be seen as a pilot attempt to create a methodology for intelligibility analysis.

## Validation of the selected 18 heritage objects as the elements of the city image based on a sociological survey

To test the recognisability and legibility of the elements of the image of the city, selected heritage objects (Figure 8) were used (see the list of the objects in Table 1), the importance of which was determined through sociological surveys and open databases.

### The residents' survey

The survey was focused on the target group - residents of the central part of Kaunas City (Kaunas Center Eldership), and it was conducted online using the Google Forms tool, which complies with the General Data Protection Regulation - GDPR. The random sampling was performed. 59 respondents submitted their answers.

The first block of questions was related to various aspects of the socioeconomic data that not only describe the profile of the survey's respondents but also, in the literature, are considered to be the predictors of the sense of the place. The respondent's gender – some studies claim that gender does not affect the sense of the place significantly [19, 20]. Other researchers claim that women tend to establish closer social relationships and thus, they also feel stronger place attachment [21, 22]. The majority of this survey respondents were women (74, 6%). The respondent's age influences both the sense of the place and the scale of the most important places. For example, children feel most strongly attached to the smallest scale nearest territories, when they grow up, it starts to vary depending on the individual's mobility [22]. While ageing, people's mobility decreases again, and the nearest territories regain their importance [23]. This survey was carried out only for the adults (18+ years). 36 % of all the respondents were between 46 and 65 years old, 34 % were between 31 and 45, 22% were between 18 and 30, 3 % were older than 65 and 5% did not reveal their age. Respondent's education and occupation – some researchers [20] claim that more educated people are geographically more mobile, thus, they feel less attached to a certain place. Other researchers [22] conversely believe that more educated people are more proud and attached to their dwelling places. Regarding education, 88 % of the survey respondents claimed that they have a higher-university education. The rest said to have secondary education (3 %), upper school education (3 %), vocational education (3 %) and higher non-university

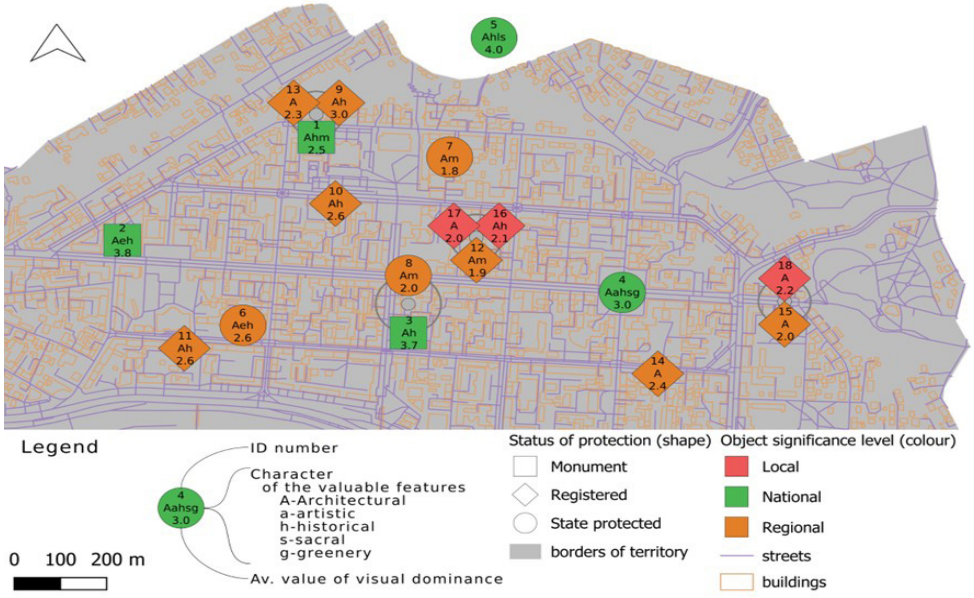



Fig. 8. Location and status of investigated heritage objects (for identification of ID number look at Table 1)

TABLE 8

The scale of Sense of the Place (SoP) based on Axford and Hockings [30]; Shamai [31]; and the percentage of the respondents' choice regarding their feelings towards the entire Kaunas city and its central part

| Scale | Item | Explanation | SoP for entire Kaunas | SoP for Central Part of Kaunas |
|---|---|---|---|---|
| 7 | I am ready to give up even a part of my personal privileges if this is necessary for the welfare of the place | sacrifice and commitment | 3% | 2% |
| 6 | I could dedicate my strength and resources for the benefit of the place | involvement and active participation | 19% | 25% |
| 5 | I identify with the goals lifestyle and values of the local community | loyalty and dedication | 10% | 7% |
| 4 | I am emotionally attached to this place | emotional attachment special place | 41% | 32% |
| 3 | I always feel that I belong to this place | sense of community, belonging | 15% | 7% |
| 2 | I do not feel I am local | knowledge of place, situation, no attachment | 5% | 14% |
| 1 | I feel nothing for this place | neutral state, no feelings | 2% | 7% |
| 0 | I don't want to live here | negative feelings | 0% | 2% |
| Not able to evaluate | | | 5% | 4% |

education (2 %). The respondents' occupations were the following: 81 % were employed, 8% worked while studying, 5 % retired, 3 % were on maternity leave and the remaining 2% were high school students. Place of birth – literature [24, 25, 26] indicates that people born in a particular place possess stronger positive feelings about it, they comprehend the place more fully and deeply. More than half of the survey respondents (64,4%) were born in Kaunas, but just 15% were born in the area of research interest, i.e. in the central part of Kaunas. Time of residence – is one of the best predictors of the positive sense of the place [19, 24, 27, 28, 29], because the longer people live in a certain place, the more attached to it they feel. The average time of the respondents' residence in Kaunas was 34,5 years (the value ranged from 2 years to 65 years). Meanwhile, the average time of residence in Kaunas city centre was 20,5 years (the value ranged from 1 to 63 years).

In the next section, the sense of the place (SoP) was evaluated for the entire Kaunas city and the central part of the city (New Town and Old Town). Based on the existing sense of the place scales [30; 29], eight statements were submitted in the survey (see Table 8). They varied from the highest level of sense of the place (7 points) down to the lowest level (0 points). The respondents had to choose one of the most suitable statements for the entire Kaunas city and one for the central part of the city (New Town and Old Town).

While talking about the sense of place, most respondents chose that they feel emotionally attached to Kaunas city (41%) and the majority also have this feeling for the central part of Kaunas (32%). Even though, on average, the sense of the place score was slightly higher (4,27 points) for Kaunas than for the central part of it (3,98), residents feel that they belong to these places and are attached.

Results of both the first and the second sections confirmed that respondents of the survey are not only familiar with the place but know it pretty well and also have a strong attachment to it. Thus, they are suitable for the evaluation of the different heritage objects existing in the territory.

In the previous sections intelligibility modelling was used to evaluate the potential of the selected heritage

Fig. 9. Church of the Resurrection of Christ [photo 1: kvr.kpd.lt, photo 2: I. Povilaitienė]

Fig. 10. Jewish Gymnasium [photo 1: kvr.kpd.lt, photo 2: I. Povilaitienė]

Fig. 11. House of Engineer Viktoras Rėklaitis [photo 1: kvr.kpd.lt, photo 2: I. Povilaitienė]

objects to become elements of the city image (Figure 9). The sociological survey was one of the ways to validate the results of intelligibility modelling. Therefore, the respondents of the survey were asked to evaluate the same 18 selected heritage objects (Figure 8) in terms of their relationship to the surrounding environment. They rated objects on a scale from 1 to 4, where the numerical values mean: 1 - the object does not stand out in the environment; 2 - the object is a local accent (slightly, but stands out); 3- the object is a landmark (stands out in the quarter, it is possible to orientate on the spot); 4 - the object is a clear landmark of the city (main, predominant, dominant). The respondents could also indicate that they are not able to evaluate. The average values of the evaluation are provided in Table 8, column "Av. value of visual dominance".

While comparing the results, it is noticeable, that the heritage objects, that were predicted to become landmarks in the intelligibility modelling, were also rated highest as the most prominent landmarks of the entire city by the residents of Kaunas.

It also confirms the insight from the intelligibility modelling that bigger buildings located both beside the main pedestrian street and in zones of higher multifunctionality could be seen as potential elements of the nodes, as in the sociological survey they were rated (Figure 10) as standing out of the surroundings and helping to orient within the block (i.e. Lithuanian American Joint Stock Company Building Complex Studio, Jewish Gymnasium (now Juozas Naujalis Music Gymnasium) or Lawyer Petras Leonas' house).

Finally, the survey also confirms that the rest of the buildings could be seen as the formants of the districts with possible differentiated roles within blocks and local streetscapes as in the sociological survey the rest of the heritage objects were rated as local accents (e.g., House of Engineer Viktoras Rėklaitis (see Figure 11), House of Lithuanian Diplomat Petras Mačiulis or House of Professor Augustinas Janulaitis).

## Conclusions

1. The territory of the research - the central part of Kaunas city (Old Town and New Town) - was chosen with the case study identified in the HerInDep project application, which is characterised by the transformations of Interwar Lithuanian architecture and their impact on the social and urban development of the city. The largest variety and concentration of Interwar architecture is found in the central part of Kaunas (New Town), which underwent a major urban transformation during the Soviet period and has been under pressure from business

development since 1990.

2. The modern internet has its own Genius Loci, which in part is producing and sharing open data. Wide acceptance of this idea allowed this research to acquire useful datasets from public and open sources that represented human behaviour. Although data is shared voluntarily it is made public in a way that is not suitable for data analysis in some cases; nevertheless, this obstacle can sometimes be overcome by using data scraping and mining techniques.
3. It could be concluded, based on the investigation of Kaunas' case, that the proposed intelligibility model, which is constructed on the simulation of the behaviour of people in the mathematical graph of buildings, performs quite well and allows analysis and comparison of intelligibility of individual buildings quite well.
4. The presented model reflects the potential of buildings to perform a specific role in the Mental City Image in the present situation but because of its simulative nature, it could be used for the prediction of changes in the intelligibility if urban configuration is changed or new development happens. Therefore, the model could be used as a monitoring tool which, in contrast with the existing heritage monitoring practices focused on physical and functional changes, allows monitoring of changes in the role of heritage objects in perceived cityscape.
5. The possibility to apply a simulative model to the past situation opens the possibility of comparing the present and future intelligibility of the actual buildings with its previous situation, which, if needed, could be used as a benchmark for evaluating the ongoing changes.
6. The limitations of the proposed model should be pointed out:

- It is validated only in the situation of Kaunas so before application to other situations its validations would be necessary.
- The building graph has certain limitations such as one entrance per building, connections of the buildings-nodes to the nearest street segment-nodes based on the shortest distance, but not real connections, etc. In Kaunas' case the last problem was addressed and solved by correcting the graph manually, but, if the investigated area would be bigger – the other solutions should be found. The influence of the potential possibility to model more than one entrance per building on the modelling results should be investigated in the future.
- It still remains unclear if intelligibility from the perspectives of different users could and should be addressed in the model. Some insights were given in the text, but it requires further research.

7. It remains unclear if the proposed building-graph-made model is the best or the only solution for intelligibility modelling. In the case of Kaunas, it worked quite well and offered resolutions suitable for the task. In the other situations with different sizes of territories, while addressing possible different detail levels of intelligibility and if past situations with limited available data would be used, it would be useful to test the other types of graphs.
8. The sociological survey conducted to assess the visual dominance of selected heritage objects in the surrounding environment corresponds to the findings of the intelligibility modelling, indicating a positive relationship between the predicted potential of heritage objects and perceived visual significance by residents, thereby validating the usage of the intelligibility modelling for the revealing the differentiate roles of heritage objects in the entire urban fabric.

## Acknowledgment

This work was supported by the Joint Programming Initiative on Cultural Heritage and Global Change under the project Heritage in Depopulated European Areas (HerInDep), project no.: S-JPIKP-23-1. The ethical assessment of the sociological survey "Sense of place of Kaunas city central part inhabitants in relation to the immovable cultural heritage" has been carried out by the Research Ethics Committee of the KTU and has been approved at the meeting, protocol number M4-2023-14, in case of any questions please contact: tyrimu.etika@ktu.lt.

## References

1. Heritage Department. '*Register of Cultural Properties of the Republic of Lithuania*'. 2024. https://kvr.kpd.lt/#/static-heritage-search.
2. Kaunas County Archives. Kauno Miesto Planai XIX a. – XX a. *Pirmoji Pusė*. 2007.
3. UNESCO. 2023. 'Modernist Kaunas: Architecture of Optimism, 1919-1939'. Nomination 1661. UNESCO Heritage List. UNESCO World Heritage Convention. https://whc.unesco.org/en/list/1661/documents/.
4. **Lynch, K.** T*he Image of the City.* Cambridge, Massachusetts and London, England: The MIT Press. 1960.
5. Google. 2024. 'Popular Times, Wait Times, and Visit Duration'. *Google Business Profile Help*. 2024. https://support.google.com/business/answer/6263531?hl=en.
6. BestTime.app. 'Features - BestTime.App'. *BestTime.App*. 2024. https://besttime.app/#features.
7. IssueTracker. 'Popular Times'. *IssueTracker*. 2024. https://issuetracker.google.com/issues/35827350.
8. **Kaplan, R., Kaplan, S., Brown, T.** 'Environmental Preference: A Comparison of Four Domains of Predictors'. *Environment and Behavior*, 21 (5): 509–30. https://doi.org/10.1177/0013916589215001.1989.
9. **Ode, Å., Tveit, M.S., Fry, G.** 'Capturing Landscape Visual Character Using Indicators: Touching Base with Landscape Aesthetic Theory'. *Landscape Research 33* (1): 89–117. https://doi.org/10.1080/01426390701773854. 2008.
10. **Cullen, G.** *The Concise Townscape*. Oxford ; Boston: Butterworth-Heinemann. 2006.
11. **Peponis, J., Wineman, J.** 'Spatial Structure of Environment and Behavior'. *Handbook of Environmental Psychology*, edited by Robert B. Bechtel and Arzah Ts'erts'man, 271–91. New York: J. Wiley & Sons. 2002.
12. **Hillier, B.** *Space Is the Machine: A Configurational Theory of Architecture*. London: Space Syntax (UCL). 2007.
13. **Kaiser, P.** 'Calculation of Visual Angle'. Web Book. *The Joy of Visual Perception*. 2005. https://www.yorku.ca/eye/toc-sub.htm.
14. *DepthmapX Development Team*. 2017. 'DepthmapX/SpaceGroupUCL'. C++. Space Syntax Lab - UCL. https://github.com/SpaceGroupUCL/depthmapX.
15. **Sevtsuk, A., Mekonnen, M.** 'Urban Network Analysis. A New Toolbox for ArcGIS'. *Revue Internationale de Géomatique*, 22 (2): 287–305. 2012. https://doi.org/10.3166/rig.22.287-305.
16. **Sevtsuk, A.** 'Estimating Pedestrian Flows on Street Networks: Revisiting the Betweenness Index'. *Journal of the American Planning Association*, 87 (4): 512–26. 2021.https://doi.org/10.1080/01944363.2020.1864758.
17. **Sevtsuk, A.** Urban Network Analysis for Rhinoceros 3D. Tools for Modeling Pedestrian and Bicycle Trips in Cities. *City Form Lab*. 2018.
18. **Sevtsuk, A., Mekonnen M., Kalvo, R.** Urban Network Analysis Toolbox for ArcGIS 10 / 10.1 / 10.2 HELP Version 1.01. *City Form Lab*. 2016.
19. **Brown, B., Perkins, D.D., Brown, G.** 'Place Attachment in a Revitalizing Neighborhood: Individual and Block Levels of Analysis'. *Journal of Environmental Psychology*, 23 (3): 259–71. 2003. https://doi.org/10.1016/S0272-4944(02)00117-2.
20. **Lewicka, M.** 'Ways to Make People Active: The Role of Place Attachment, Cultural Capital, and Neighborhood Ties'. *Journal of Environmental Psychology*, 25 (4): 381–95. 2005. https://doi.org/10.1016/j.jenvp.2005.10.004.

21. **Hidalgo, M.C., Hernández, B.** 'Place Attachment: Conceptual and Empirical Questions'. *Journal of Environmental Psychology*, 21 (3): 273–81. 2001. https://doi.org/10.1006/jevp.2001.0221.
22. **Mesch, G. S., Manor, O.** 'Social Ties, Environmental Perception, and Local Attachment'. *Environment and Behavior*, 30 (4): 504–19. 1998. https://doi.org/10.1177/001391659803000405.
23. **Schwirian, K. P., Schwirian, P. M.** 'Neighboring, Residential Satisfaction, and Psychological Well-being in Urban Elders'. *Journal of Community Psychology*, 21 (4): 285–99. 1993. http://dx.doi.org/10.1002/1520-6629(199310)21:4<285::AID-JCOP2290210405>3.0.CO;2-Y.
24. **Hay, R.** 'Sense of Place in Developmental Context'. *Journal of Environmental Psychology*, 18 (1): 5–29. 1998. https://doi.org/10.1006/jevp.1997.0060.
25. **Relph, E. C.** *Place and Placelessness. Research in Planning and Design 1*. London: Pion. 1980.
26. **Tuan, Y. F.** *Space and Place: The Perspective of Experience*. London: Arnold. 1977.
27. **Lalli, M.** 'Urban-Related Identity: Theory, Measurement, and Empirical Findings'. *Journal of Environmental Psychology*, 12 (4): 285–303. 1992. https://doi.org/10.1016/S0272-4944(05)80078-7.
28. **Lewicka, M.** 'What Makes Neighborhood Different from Home and City? Effects of Place Scale on Place Attachment'. *Journal of Environmental Psychology*, 30 (1): 35–51. 2010. https://doi.org/10.1016/j.jenvp.2009.05.004.
29. **Shamai, Sh., Ilatov, Z.** 'Measuring Sense of Place: Methodological Aspects'. *Tijdschrift Voor Economische En Sociale Geografie*, 96 (5): 467–76. 2005. https://doi.org/10.1111/j.1467-9663.2005.00479.x.
30. **Axford, J., Hockings, M. T.** 'Sense of Place: A Tool to Assist the Meaningful Engagement of Communities in Protected Area Management'. *Proceedings of International Conference on Engaging Communities, edited by Dave Gardiner and Katie Scott*, 1–17. Brisbane, QLD, Australia: Queensland Department of Main Roads. 2005.
31. **Shamai, Sh.** 'Sense of Place: An Empirical Measurement'. *Geoforum*, 22 (3): 347–58. 1991. https://doi.org/10.1016/0016-7185(91)90017-K.
32. **Hillier, B., Burdett, R., Peponis, J., Penn, A.** 'Creating Life: Or, Does Architecture Determine Anything?' *Architecture et Comportment / Architecture and Behavior* 3 (3): 233–50. 1987.

## Authors

**Kęstutis Zaleckis**, Dr. arch., Professor at the Faculty of Civil Engineering and Architecture of Kaunas University of Technology and at Vilnius Academy of Arts, Faculty of Vilnius, Department of Architecture. His current and previous research interests include the simulation of evolution and mutations of urban spatial genotypes and urban history.
E-mail: kestutis.zaleckis@ktu.lt
ORCID ID: https://orcid.org/0000-0001-9223-9956

**Aušra Mlinkauskienė**, Dr. arch., Associate Professor at the Faculty of Civil Engineering and Architecture, Kaunas University of Technology. Her current and previous research focuses on the protection of immovable cultural heritage, urban spatial planning and management, and the assessment of valuable properties of heritage sites.
E-mail: ausra.mlinkauskiene@ktu.lt
ORCID ID: https://orcid.org/0000-0003-3553-6123

**Marius Ivaškevičius**, Dr. arch., Assistant Professor at the Faculty of Civil Engineering and Architecture of Kaunas University of Technology. His current and previous research interests include parametric architecture, parametric urbanism, GIS analysis, machine learning, deep neural networks, agent-based modelling, and cellular automata.
E-mail: marius.ivaskevicius@ktu.lt
ORCID ID: https://orcid.org/0000-0002-8578-6940

**Ingrida Povilaitienė**, Dr. arch., Assistant Professor at the Faculty of Civil Engineering and Architecture, Kaunas University of Technology. Her current and previous research interests lie not only in analysing the physical urban environment but also in environmental psychology, cultural studies and innovative and creative pedagogical methods.
E-mail: ingrida.povilaitiene@ktu.lt
ORCID ID: https://orcid.org/0000-0003-3481-1197

## Kopsavilkums

Pētījums balstīts uz projektu "*Heritage in Depopulated European Areas*", kas tika uzsākts 2023. gada aprīlī. Tas aplūko starpkaru perioda (laikposma starp Pirmā un Otrā pasaules kara beigām un sākumu) arhitektūras pārmaiņas un tās ietekmi uz Kauņas (Lietuva) sociālo un pilsētbūvniecisko attīstību.
Kauņā, īpaši tās centrālajā daļā, atrodas ievērojama starpkaru modernisma arhitektūras koncentrācija, kas ir piedzīvojusi būtiskas pilsētas pārmaiņas Padomju Savienības laikā, kā arī spiedienu no komercdarbības attīstības pēc 1990. gada. 2023. gadā Kauņas modernisma arhitektūra tika nominēta iekļaušanai UNESCO Pasaules mantojuma sarakstā ar nosaukumu "Modernistiskā Kauņa: optimisma arhitektūra, 1919–1939", atspoguļojot tās pārvēršanos par Lietuvas pagaidu galvaspilsētu. Aptuveni 80 % no šiem kultūras mantojuma objektiem piemīt unikālas īpašības, kas ir juridiskās aizsardzības vērtas.
Raksta mērķis ir piedāvāt un pamatot metodoloģiju nekustamā kultūras mantojuma salasāmības (*legibility*) novērtēšanai pilsētvidē. Konkrēto pētījuma metodoloģiju varētu izmantot ne tikai, lai labāk izprastu kultūras mantojuma nozīmi pilsētas ainavas identitātes veidošanā, bet arī, lai uzraudzītu salasāmības izmaiņas dažādu pilsētvides transformāciju rezultātā, pat gadījumos, kad mantojuma objekti nav fiziski bojāti vai iznīcināti.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.06

# THE MODERN MOVEMENT IN ARCHITECTURE: ROOTS AND EXPRESSIONS OF FORMAL LANGUAGE

**Jānis Krastiņš**

*Riga Technical University, Latvia*

**Abstract. Studies its roots and reveals hitherto lesser-known examples of the style, analyses the development of the style in different countries and in Latvia, and compares the quality of different implementations of its formal language in different stages of history. Special attention is paid to different early examples that paved the way for the later development of the style. The historical place of the Modern Movement in the cultural heritage has been assessed. All images in the text are photographs by the author if not indicated otherwise.**
**Keywords: modern movement, functionalism, 20th century architecture**

## Introduction

The Modern Movement is the most characteristic style in the contemporary system of architectural styles. At the beginning of the 20th century, contemporary system replaced the previous system of styles of the new era, which was based on interpretations of classical vocabulary. The basic principle of the contemporary system of styles – "form follows function" – was precisely formulated by the American architect Louis Sullivan as early as 1896 [1]. Beginning of this system was Art Nouveau or Jugendstil. The essence of its artistic method was aptly described by the prominent Latvian art critic and publicist Jānis Asars: "a building should not be constructed from the outside inwards, as was done in the past, when only an imposing facade was taken care, the interior layout comes out as it comes out, but it should be constructed from the inside out, the interior spaces should be arranged in a completely useful and beautiful way, and the external shape of the house should follow to their order" [2]. In the 1920s, Art Nouveau was replaced by the Modern Movement. It continued to develop after World War II and is perhaps still the dominant style in architecture today. It is often simply called Modernism, but "modern" in a broader sense generally means something that relates to the present or recent time as opposed to the past. In several languages, Modernism means Art Nouveau, for example, in Spanish, Catalan and Russian. In Latvian, Art Nouveau is called Jūgendstils, but once also "Secessionist Modernism" [3]. The Modern Movement (or MoMo in abbreviation) at certain stages of history has also been called Functionalism, New Objectivity (German Neue Sachlichkeit, English New Objectivity), International Style or Avant-garde. Other names are also known, for example, Constructivism (mainly in Russia).

The Modern Movement was the art of "pure" planes and volumes. Buildings in this style are distinguished by a strongly articulated, cubic massing, flat roofs, ribbon fenestration and extensive glazing. In the 1930s, the Modern Movement often merged with the expression of Neo-eclecticism rooted in the language of classical architecture. In this form, the style continued after World War II, but in the 1950s, the "glass and steel building" – a framework-structure building with more or less completely glazed facades – became the symbol of the Modern Movement in the world. Such architecture, as a brand of the era, has also retained a significant place in the formal diversity of architecture in the first decades of the 21st century.

## The origins of the Modern Movement

The earliest examples of the Modern Movement are generally considered to be the T. Schröder's House in Utrecht, the Netherlands, built in 1924 to a design by Gerrit Rietveld (Fig. 1), and the Bauhaus art school building by Walter Gropius in Dessau, Germany, built the following year. It is one of the most well-known icons of the style (Fig. 2). Origins of the style, however, can be found much earlier. The possibilities for implementing the formal expression of the style were facilitated by the technical innovations of the 19th century – reinforced concrete, rolled glass and rolled profile steel products, while the elevator, along with the introduction of electricity, paved the way for the construction of high-rise buildings. True, architectural styles in history and today have never been determined by the use of materials, structures or technology. They are only means for implementing in architecture the social needs and artistic ideas dictated by each era.

In treatises on modern architecture, the Crystal Palace in London, Hyde Park, is traditionally cited as the first germ towards modernism. It was a more than half a kilometre-long hall, where the 1851 World Exhibition was held. The building was assembled from pre-fabricated metal rods. The outer walls were completely glazed. After the exhibition, the building was dismantled and moved to the London suburb of Bromley, but it burned down in 1936. As early as 1850, New Yorker, watchmaker and architect James Bogardus patented a method of constructing buildings in cast iron structures. His buildings in New York, at 85 and 87/89 Leonard Street (1862, Fig. 3) are mentioned in many, many architectural history

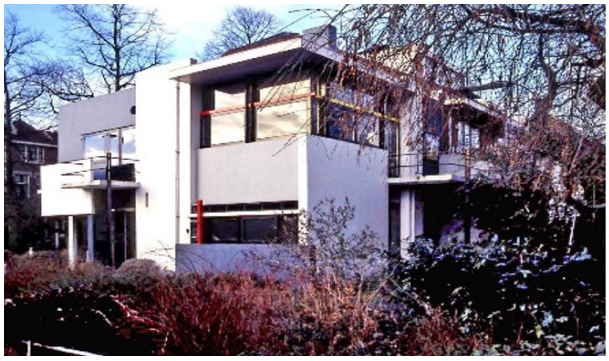


Fig. 1. Utrecht, the Netherlands. T. Schröder's House at Prins Hendriklaan 50. 1924. Gerrrit Rietveld


Fig. 2. Dessau, Germany. „Bauhaus" building at Gropiusallee 38. 1925. Walter Gropius

books as one of the earliest examples of modern glass and metal architecture.

Paradoxically, the department stores in Glasgow, Scotland, built around the same time in similar structural system, have not received much attention in the history of world architecture. The earliest of these is the Gardner's Warehouse at 36 Jamaica Street (Fig. 4). It was built in 1856 to a design by architect John Baird I and civil engineer Robert McConnell, who developed and patented a metal frame structural system in which cast iron elements of any span could be connected with wrought iron elements. Such a structure was less prone to sudden failures in the case of overload or metal casting defects [4].

Another building of similar structure and visual appearance, built around this time in the British Isles was the Oriel Chambers offices at 14 Water Street in Liverpool, England (1864–1865, architect Peter Ellis, Fig. 5). It was noticed as having been significantly ahead of its time already durig the interwar period of the 20th century. The building is argued to be the first "skyscraper" in the UK, although the building measures just five storeys high. This building is often declared "the first in history to feature a metal-framed, glass curtain wall" [5].

Glasgow's innovative contribution to the development of architecture is usually celebrated in connection with Art Nouveau, which Glasgowers themselves proudly call "Glasgow style". The most widely known is the Glasgow School of Art building (1897–1909) by the famous architect Charles Rennie Mackintosh, however, in the context of the genesis of the Modern Movement's language, the Daily Record newspaper publishing house, built in 1900–1901 according to the design of the same Mackintosh (Fig. 6), is more characteristic. The upper floors in the western part of the building were built in 1903–1904 [6]. To the uninitiated, the building may seem to have been built at least thirty years later than it actually was. The architectural language is based on a tectonically very clear massing, as well as the use of finishing materials of different textures and tonalities.

Metal-framed buildings with rhythmically arranged large apertures in their facades are particularly characteristic of the so-called Chicago School. It began with the city's reconstruction after the catastrophic fire of 1871. Chicago was the birthplace of modern skyscraper architecture [7]. Most of the new buildings in the city centre were commercial buildings, which housed large offices or retail premises. These functions also had the greatest impact on the semantic image of new buildings [8]. The Chicago School, although its decorative language was strongly eclectic, is rightly considered as one of the forerunners of the Modern Movement.

The central figure in Chicago architecture is often called Sullivan [9], but one of the pioneers of this school was William Le Baron Jenney. Many of his works have not survived, but the Second Leiter Building (1891) still graces the corner of the block at the intersection of South State Street and East Ida B. Wells Drive (Fig. 7).

In late 19th and early 20th century, buildings with extensive or even completely glazed facades appeared in many European cities. Most of them were department stores or office buildings. One of such striking architectural innovations is the commercial building "Magasin Manrique" in Strasbourg, France, at 33-37, rue des Grandes Arcades (Fig. 8). It was built in 1897 to the design by architects Julius Berninger and Gustav Krafft. In 1899, it was expanded with right-hand wing having one window-axe.

The "Old England" department store in Brussels, at 2, rue Montagne de la Cour (Fig. 9), built in 1899 to a design by architect Paul Sentenoy, pays attention already from afar with its large windows filling the spaces between the metal frame elements clearly exposed in the facades of the building. Another masterpiece of glass and metal construction in Brussels was the People's House (La Maison du Peuple), designed by the Art Nouveau architect Victor Horta, but in 1965, it fell victim to "Brusselization": the building was demolished and replaced by ordinary "modern" office tower.

Glazed facades became more widely used in Art Nouveau architecture only around the middle of the 1910's. During this time, a particularly large number of office and commercial buildings with large windows were built in Hamburg, a city that had not yet been widely noticed in the context of Art Nouveau. Among these buildings, one of the earliest is the residential, office and commercial building "Heine-Haus" at Jungfernstieg 34 (1903, architect Ricardo Bahre).

Fig. 3. New York, USA. 85 & 87/89 Leonard Street. 1862. James Bogardus
Fig. 4. Glasgow, Scotland. Gardner's Warehouse at 36 Jamaica Street. 1855–1856. John Baird I, Robert McConnell
Fig. 5. Liverpool, England. Office building Oriel Chambers at 14 Water Street. 1864–1865. Peter Ellis [10][1]
Fig. 6. Glasgow, Scotland. Daily Record publishing house at 20-26 Renfield Lane. 1900–1901, 1903–1904. Charles Rennie Mackintosh
Fig. 7. Chicago, USA. Second Leiter Building. 1891 William Le Baron Jenney

[1]Liverpool Architecture and Cityscapes [online]. The Victoriam Web : Literature, Histoey, & culture in the Age of Victoria [cited 01.06.2025]. https://victorianweb.org/art/architecture/liverpool/34.html

Fig. 8. Strasbourg, France. Commercial building "Magasin Manrique" at 33-37, rue des Grandes Arcades. 1897–1899. Julius Berninger, Gustave Krafft
Fig. 9. Brussels, Belgium. Department store "Old England" at 2, rue Montagne de la Cour. 1899. Paul Saintenoy
Fig. 10. Hamburg, Germany. Residential, office and commercial building "Heine-Haus" at Jungfernstieg 34. 1903. Ricardo Bahre
Fig. 11. Paris, France. Offices at 124, rue Réaumur. 1905. Georges Chedanne (?) [11]

Its dynamically articulated facade with a bay window in the middle is almost continuously glazed (Fig. 10). Similar commercial buildings were built in quite an impressive number around this time in many other German cities – Munich, Leipzig and, of course, Berlin, where most of them were unfortunately irretrievably destroyed during the World War II. One of the most impressive completely glazed facades had the Tietz department store (Warenhaus Tietz) at Leipziger Strasse 46/49 (1899–1900, architect Bernhard Sehring).

A large collection of glazed facades is concentrated on rue Réaumur in Paris. True, the architectural and decorative finish of most of these facades, which were built around the turn of the 19th and 20th centuries, is saturated with details taken from the vocabularies of historical styles in the spirit of typical eclecticism. However, the office building at 124, rue Réaumur, built in 1905, supposably to the design of the architect Georges Chedanne, visually strongly resembles the "modern building of glass and metal" (Fig. 11). The "La Samaritaine" department store buildings, especially at 75, rue de Rivoli (1912, architect Frantz Jourdain), which has lost many filigree metal details from its facades, are also of an equally modern architectural character.

An impressive example of glazed facades is the Turkish Bank at Szervita tér 3 in Budapest, Hungary (Fig. 12). It was built in 1906 to a design by architects Armin Hegedüs and Henrik Böhm. The facade of the building, with its continuously glazed bay windows and huge shop windows on the lower floors, strongly resembles office buildings or department stores of today. The upper part of the facade is covered with a mosaic by the outstanding mosaic and stained-glass master Miksa Róth, above which a cornice designed in the spirit of the architectural language of Budapest Art Nouveau luminary Ödön Lechner undulates. From the perspective of the methodological principles of the Modern Movement, this technique is not an architectural contradiction, but a convincing example of the synthesis of the arts. It is a quality that the architecture of the Modern Movement also strived for in the second half of the 20th century, but which was then rarely achieved.

One of the cradles of the Modern Movement was the Netherlands, but its contribution to the Art Nouveau period is still less well known. However, in The Hague alone, there are not only individual dazzling decorative Art Nouveau buildings, but also a whole collection of department stores with completely glazed facades. The earliest of them – the Department Store at Dennweg 56 (architect Jan Willem Bosboom) – was built as early as 1898. The facade of the small building, crowned with filigree metal lace, looks like one large mirror. The tectonics of the facades of the rest of these buildings clearly reflects the structural system of the buildings: they all have a metal framework. Such, for example, are the fashion store De Duif at Venestraat 17 (1905, architect Willem Molenbroek), the department store "Magazijn Hollandia" at Prinsegracht 42 (1908, architect A. W. Meyneken), and the Schroder department store, located in the very heart of the city's historic centre, at Dagelijkse Groenmarkt 25 (Fig. 13). It was built in 1906 to a design by architect Lodewijk Antonius Hermanus de Wolf. The architect studied in Vienna, and his works are attributed to the "Viennese Secession style" [12]. It is true that the most famous buildings in Vienna, created by Josef Hoffmann, Adolf Loos and other architects, whose architecture can be considered direct precursors of the Modern Movement, were built no earlier than this building in The Hague.

Denmark is also not particularly notable in the context of architectural innovations of the first half of the 20th century, but in 1906, the commercial and apartment building "Løvenborg" was built at Vesterbrogade 34 in Copenhagen, based on a design by the most famous Danish Art Nouveau architect Anton Rosen (Fig. 14). This building is also an accurate reflection of the framework structure in its extensively glazed but finely detailed facade architecture.

Among the examples of glazed facades with strong massing, the "Wuorio" office building in Helsinki, Finland, at Unioninkatu 30 (Figure 15), built in 1908–1909 according to the design of the architect Herman Gesellius, stands out. Certain architectural details in the facade finish are precursors of the Art Deco language. Even prominent art historians, evaluating this building, have stated that it "was free from both Jugendstil and National Romanticism" [13]. This statement apparently reflects the long-held prejudiced neglection of Art Nouveau, recognizing the architecture of the "Wuorio" building not as a product of its time, but as ahead of its time. Strikingly similar to the "Wuorio" building is the "Buttericks" office building in Stockholm, at Drottninggatan 57 (1908–1910, architects Victor Dorph & Anders Höög) built at the same time.

In Barcelona, which is widely known for the works of Antoni Gaudí and other Art Nouveau masters, the department store (now C&A) located almost in the heart of the city, at Carrer de Pelai, 54 (Fig. 16), is rarely mentioned. It was built in 1913–1915. Construction work began according to the project of the master builder Agustí Mas i Sauris, but it was later modified by the architects Eduard Ferrés i Puig and Lluis Homs i Moncusi. It is one of the first buildings in Barcelona with a cast-in-situ reinforced concrete framework structure. This allowed the facade to be designed freely, with slightly curved continuous glazing arranged in several columns.




Fig. 12. Budapest, Hungary. Turkish Bank at Szervita tér 3. 1906. Armin Hegedüs, Henrik Böhm
Fig. 13. The Hague, the Netherlands. Schroder department store at Dagelijkse Groenmarkt 25. 1906. Lodewijk Antonius Hermanus de Wolf. Photograph by D. Valentijn [12]
Fig. 14. Copenhagen, Denmark. Commercial and apartment building "Løvenborg" at Vesterbrogade 34. 1906. Anton Rosen
Fig. 15. Helsinki, Finland. "Wuorio" office building at Unioninkatu 30. 1908–1909. Herman Geselliuss. Upper floors: 1913–1914. Armas Lindgren


Fig. 16. Barselona, Catalonia. Department store at Carrer de Pelai, 54. 1913–1915. Eduard Ferrés i Puig, Lluis Homs i Moncusi, Ignacio Mas i Morell
Fig. 17. Ljubljana, Slovenia. Drofenig department store at Mestni trg 23. 1914. Karl Brünnler

The idea of the synthesis of arts is also organically implemented in this modern architecture: the fifth floor above the cornice decorated with sgraffito ornaments is designed as an attic, which is decorated with two allegorical sculptures.

An outstanding achievement in the field of Art Nouveau architectural innovations is the Franc Drofenig department store in Ljubljana, Slovenia, at Mestni trg 23 (Fig. 17). It was built in 1914 to a design by architect Karl Brünnler. The building has a cast-in-situ reinforced concrete framework, but the facade, in accordance with the client's ideas about a modern department store, is made almost entirely of glass and metal. During construction, the city's Building Commission tried to impose a proposal for a traditional facade [14], but the original design was implemented, and Ljubljana gained a unique architectural monument.

The Art Nouveau period also saw the emergence of the corner window, which is considered one of the iconic elements of the Modern Movement architecture. The Schröder's House in Utrecht (Fig. 1) also has such one, but it seems to have first appeared in the Fagus shoe factory in Alfeld (Leine), Germany, built in 1911 to a design by Walter Gropius and Adolf Meyer (Fig. 18). Since 2011, the building has been a UNESCO World Heritage Site.

An even more characteristic brand of the Modern Movement's vocabulary is the ribbon fenestration, whose tectonics derives directly from the external wall attached to the framework structure. However, this form is already known in various formal and structural versions in Art Nouveau.

Several works by architect Béla Lajta in Budapest, Hungary stand out with its wide glazing on the lower floors and emphasized horizontal window strips on the upper floors. Such are both the large apartment building with shops and a bank at Dohány utca 15 / Rákóczy út 18 (1911–1913), and the retail and apartment house at Szervita ter 5 (1912). Both buildings speak the formal language of the Modern Movement of the 1920s.

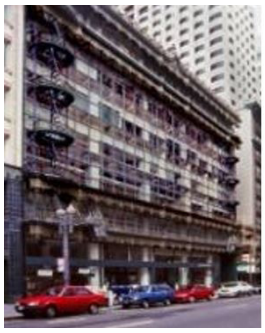
For the uninitiated, several actually Art Nouveau buildings in Vienna, Austria is also difficult to visually distinguish from the icons of the Modern Movement. In this respect, the works of Josef Hoffmann and Adolf Loos are well-known, but that is not all. A perfectly accurate example of ribbon fenestration is the sanatorium of the dermatologist Friedrich Luitlen at Auerspergstraße 9, constructed in 1907–1908 to the design by architect Robert Oerley (Fig. 19). Its façade has retained authentic appearance up to the main cornice, but in 1964, when it was rebuilt into a student hotel, the two prismatic volumes of the operation halls surmounting the building were demolished, replacing them with a continuous attic with simple window apertures. The facade of the apartment house named "Schokoladenhaus" at Wattmanngasse 29 (1914) also has a similar architectural composition, only here the architect Ernst Lichtblau filled the gaps between the windows with ceramic reliefs, so emphasizing the horizontality of the composition (Fig. 20). The reliefs were created by the sculptor Willy Russ.

Curtain wall facades attached to the structural framework of a building, were one of the architectural principles of the Modern Movement. The earliest "true" example of a curtain wall facade is usually considered to be the Hallidie Building, an office building in San Francisco, California (USA), at 130 Sutter Street (Fig. 21). It was built in 1917–1918 to a design by architect Willis Polk. The facade surface of the building is effectively a completely transparent screen, behind which the load bearing structure of the building is also visible.

The anticipations of the Modern Movement in the architecture of the early 20th century were also marked by the vigorous massing, mostly of cubic shape. This language is most widely found in the architecture of small or single-family residential buildings. It was certainly influenced by the "prairie buildings" style created by the American architect Frank Lloyd Wright, which was characterized by a spatially open layout, flat roofs with large overhangs and a distinctly horizontal artistic composition. Apparently, under the influence of Wright's architecture [17, 18], one of the direct preludes of the Modern Movement in Europe was also created – the Henny House (Fig. 22) in Huis Ter Heide, near Utrecht, in the Netherlands.



Fig. 18. Alfeld (Leine), Germany. Fagus factory at Hannoversche Straße 58. 1911. Walter Gropius, Adolf Meyer [15]
Fig. 19. Vienna, Austria. Sanatorium Luithlen at Auerspergstraße 9. 1907–1908. Robert Oerley. Photograph by Thomas Ledl [16]
Fig. 20. Vienna, Austria. Apartment house at Wattmanngasse 29. 1914. Ernst Lichtblau. Photograph by Māris Krastiņš



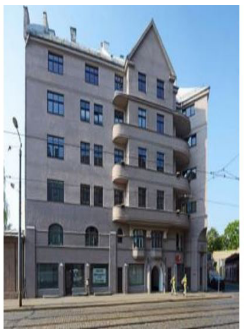




Fig. 21. San Francisco, California, USA. Hallidie Building at 130 Sutter Street. 1917–1918. Willis Jeferson Polk
Fig. 22. Huis Ter Heide, the Netherlands. Henny house. 1915–1919. Robert van't Hoff
Fig. 23. Rīga, Latvia. Apartment house with shops at Ģertrūdes iela 23. 1909. Eižens Laube
Fig. 24. Rīga, Latvia. Apartment house with shops at Miera iela 5. 1912. Alexander Schmaeling, Edgar Hartmann and Viktor Unverhau
Fig. 25. Budapest, Hungary. Apartment house with shops at Népszínház utca 19. 1911–1912. Béla Lajta

It was built in 1915–1919 to the design by the architect Robert van't Hoff.

Several buildings with a strongly articulated cubic massing can also be found in the architectural heritage of early 20th century in Rīga, Latvia, for example, apartment houses with shops at Lāčplēša iela 70, 70a and 70b, and at Ģertrūdes iela 23 (all 1909, architect Eižens Laube, Fig. 23). A unique architectural monument is the apartment house with shops at Miera iela 5 (1912, architects Alexander Schmaeling, Edgar Hartmann and Viktor Unverhau, Fig. 22). The stylistics of the building with its emphasized horizontal, rounded-end balconies and the motif of ribbon-fenestration seems far ahead of its time. It hardly differs from the characteristic examples of the Modern Movement of the 1920's and 1930's. A very similar architectural language has the apartment building with shops at Népszínház utca 19 in Budapest, Hungary (Fig. 25), built at the same time to the design by the architect Béla Lajta.

## Theoretical background

Although the first buildings of the Modern Movement appeared in the mid-1920s, comprehensive flourishing of the style was noticeable only around the turn of the 1920s and 1930s. Various theoretical manifests, developed and popularized by individual masters, as well as various art movements or professional associations, played an important role both locally and internationally. The most famous were the German Association of Craftsmen "Werkbund" (Deutscher Werkbund), the Dutch "De Stijl", the Italian "Gruppo 7" and the Barcelona "GATEPAC" group, the so-called constructivists in Soviet Russia, etc. Architects Walter Gropius and Le Corbusier regularly published their theoretical works. In order to spread and popularize the principles of the Modern Movement, an international group of the most prominent architects of the time founded the International Congresses of Modern Architecture (CIAM from French: Congrès internationaux d'architecture moderne) in 1928. Almost all the theoretical manifests of the Modern Movement in radical way explicitly denied tradition and everything historical. This factor later became a stumbling block for the style.

Articles devoted to theoretical issues of architecture can also be found in various periodicals in Latvia during the interwar period. Most of them were attempts to understand the architectural scene in Latvia, comparing it with the current trends in the world at that time. Architect Heinrihs Pīrangs stated in 1932: "Our slogan is "new practicality"" [19]. Architect Georgs Dauge also tried to explain the basic principles of this architecture: "Modern architecture strives to be functional, i.e., it wants that each building component and the entire building corresponds to its function – meaning and its special requirements", adding that modern architecture is a "style of practical basic forms" [20].

Like every innovative phenomenon, the Modern Movement had its opponents, and G. Dauge soon joined them, labelling the Modern Movement as "a characterless, abstractly theoretically invented internationalism" [21]. The term "International architecture" was introduced into international circulation by W. Gropius in 1925, when he published a collection of articles on the current architectural trends of the time [22]. However, W. Gropius later recognized this term as a "misleading label", since there is "no such thing as an "International style" unless you want to speak of certain universal technical achievements in our period which belong to the intellectual equipment of every civilised nation, or unless you want to speak of those pale examples (..), which you can find among the public buildings from Moscow to Madrid to Washington" [23].

G. Dauge warned that there was nothing more dangerous in architecture than such internationalism, noting that the "teachings of international Marxism", which had initially established its power in Latvia in 1919, "had really brought our lives almost to a catastrophe" [21]. The experience of Latvian

political history naturally had an impact when assessing everything that was happening in Russia at that time. The Modern Movement, which flourished there in the form of so-called Constructivism, was called the "international cube", a phenomenon that was foreign to the understanding of art or destructive to the development of Latvian architecture, a phenomenon which "also suck international forms prepared according to an oriental recipe" [24].

In the wide criticism of the Modern Movement, particularly vivid epithets can be found in several statements by the architect Eižens Laube. He called the Modern Movement "extraterritorial, applicable generally and to all kinds of tasks, lifeless, monotonous" [25], with an "anational" orientation and "cold, abstract forms", which were "smooth, naked, technical, often poor, without profiles, without ornaments, monotonous, sometimes even repulsive" [26]. Architect Aleksandrs Birzenieks, analysing E. Laube's own creative work, pointed out that in his perception the Modern Movement was "a manifestation of spiritual poverty", which "yields to anyone who knows how to handle a triangle and a rail" [27].

Most of the assumptions, opinions and positions on the architecture of that time, including E. Laube's public statements, were devoted to the problems of the national style or specifically Latvian architecture. However, the Modern Movement, although often taking something from Art Deco and folk ornament motifs or the range of neo-eclectic details rooted in the language of classical architectural art, remained the dominant architectural style.

**The Modern Movement in the interwar period**

An important contribution to the early development of the Modern Movement was architecture of the Netherlands. The works of De Stijl members Jacobus Johannes Pieter Oud and Theo van Doesburg have become canonical architectural monuments of the 1920's (Fig. 26 and 27). They reflect the ideas of "neoplasticism" promoted by De Stijl and the use of primary colours of the spectrum, which in fact also fit into the Art Deco aesthetics of the time. However, it is often strictly separated from the Modern Movement, which is perhaps why the Industrial School in Groningen, the Netherlands (1922–1923, architect Leendert van der Vlugt and engineer Jan Gerko Wiebenga, Fig. 28) has so far received insufficient attention in the context of the history of the world Modern Movement. The building has a cubic massing, flat roof, ribbon windows, wide glazing and everything else that corresponds to the canons of modernist language, but the entrance is designed as a wide, stepped portal coated in dark green and brown ceramic tiles. Such an element was quite common in Art Deco architecture.

One of the earliest, most striking and most widely known icons of the Modern Movement is the Van Nelle tobacco, coffee and tea factory in Rotterdam, at Van Nelleweg 1 (1925–1931, Fig. 29). In 2014, the building was inscribed on the UNESCO World Heritage List with the following statement: "It represents an exemplary contribution by the Netherlands to the Modernism of the inter-war years, and has since its construction become an emblematic example and an influential reference throughout the world" [28]. Several other Dutch outstanding contributions to the history of the Modern Movement were made by Jan Duiker, an architect who devoted his talent to improving social welfare, creating innovative projects and publishing articles about a better world [29]. His best-known buildings include the Nirvana Apartments in The Hague, at Benoordenhoutseweg 227 (1926–1929, together with J. H. Wiebenga), and the Open-Air School (Openluchtschool) in Amsterdam (1927–1930, together with Bernard Bijvoet, Fig. 30).

The prominent architectural historian Sigfried Giedion has named the tuberculosis sanatorium in Paimio, Finland (Fig. 31), designed by the Finnish architect Alvar Aalto, as one of the three major works that contributed to the progress of modern architecture, along with the Bauhaus building in Dessau and Le Corbusier's not executed project of the League of Nations Palace in Geneva, Switzerland [30]. It has even been called one of the wonders of the modern world.

Significant place in the overall development of the Modern Movement had construction of small or single-family homes. Housing exhibitions organised by Deutscher Verkbund in Stuttgart in 1927, in Wrocław in 1929 and in Vienna in 1932 were well-known. Different types of small-scale residential buildings were constructed there to the designs of well-known architects, and various methods and possibilities of the use of different materials were tested during their construction. In France, as early as 1924–1925, i. e., simultaneously with Schröder's House in Utrecht, the villa for the fashion designer Paul Poiret in Mézy-sur-Seine, at 32 Rue de la Côté d'Apremont was constructed to the project by the architect Robert Mallet-Stevens (Fig. 32). The building displays impressive dynamic cubic massing, large glassing, balconies and terraces.

Several single-family houses designed by Le Corbusier are also classics of the early heyday of the Modern Movement. The most famous of these is "Villa Savoye" in Poissy, 82 Rue de Villiers, built between 1928 and 1930 (Fig. 33). It is an almost perfectly accurate illustration of Le Corbusier's well-known "five points of a new architecture" published in 1923 [31]. Those included replacement of load-bearing walls with a reinforced concrete framework, open layout, free design of the facade, ribbon fenestration, and flat roof with a garden on it.

Fig. 26. Rotterdam, The Netherlands. Replica of the Cafe "De Unie" at Mauritsweg 34/35. 1924. *Jacobus Johannes Pieter Oud*
Fig. 27. Strasbourg, France. Cinema-Dance Hall in Café Aubette at *Place Kleber*. 1926–1928. *Theo van Doesburg*
Fig. 28. Groningen, The Netherlands. Industrial School at *Petrus Driessenstraat* 3. 1922–1923. *Leendert van der Vlugt & Jan Gerko Wiebenga*



Fig. 29. Rotterdam, The Netherlands. Van Nelle fabrika Van Nelleweg 1. 1925–1931. Leendert Van der Vlugt
Fig. 30. Amsterdam, The Netherlands. Open Air School (Openluchtschool) at Cliostraat 40. 1927–1930. Jan Duiker, Bernard Bijvoet
Fig. 31. Paimio, Finland. Tuberculosis sanatorium. 1929–1933. Alvar Aalto


Fig. 32. Mézy-sur-Seine, France. Poiret's villa at 32 Rue de la Côté d'Apremont. 1924–1925. Robert Mallet-Stevens
Fig. 33. Poissy, France. "Villa Savoye", 82 Rue de Villiers. 1928–1930. Le Corbusier

In Latvia, the Modern Movement or Functionalism in architecture emerged almost simultaneously with architectural innovations in Europe. One of the pioneers and most prolific masters of the new style was the civil engineer Teodors Hermanovskis. Already in the eyes of his contemporaries, he was active in "construction, bringing a new direction to us" [32]. One of his earliest works in architecture is an apartment building with shops at Marijas iela 8 (1926), next to which arises another house he designed at Marijas iela 6 (1928, Fig. 34). The strongly articulated facades of both buildings are designed in the spirit of "pure white" flat surfices, but at Marijas iela 8 formal expression of Art Deco is also quite noticeable. T. Hermanovskis's range of works includes a whole series of buildings with a more or less emphasized cubic massing and ribbon fenestration often contrasting with the vertical continuous glazing of the staircases, which have been quite aptly called thermometers. Such buildings, for example, are the apartment house with the cinema "Teika" in Riga, at Zemitāna laukums 2 (1933, Fig. 35), the apartment house at Stabu iela 4 (1932, Fig. 36), etc. Unfortunately, the balconies of the last building in 2024 were dismantled and the facade architecture was distorted. Typical symbols of the Modern Movement's vocabulary are clearly visible in one of the most outstanding and also the earliest monuments of the style in Rīga – the office and apartment house with shops at Elizabetes iela 51 (1928, Fig. 37). The author of the building's design, architect Paul Mandelstamm, along with T. Hermanovskis, was one of the most active promoters of the Modern Movement in Latvia.

A brilliant example of the Modern Movement or Functionalist language is the former building of the Latvian Joint Stock Bank (now the Rīdzene branch of SEB bank) in Rīga, at Kaļķu iela 13 (1931, Fig. 38), designed by the architects Alfred Karr and Kurt Baetge. Several other canonical architectural monuments of the Modern Movement also were built to the designs of the same architects – the building of the Latvian Booksellers' Association in Rīga, at Lāčplēša iela 43/45 (1930), the office and apartment house with a cinema at Vaļņu iela 9 (1935), etc.

One of the most vocal defenders of the Modern Movement architecture in Latvia was Aleksandrs Klinklāvs. Among the buildings built to his designs, the Tērvete Sanatorium (1930–1934, together with architect Ansis Kalniņš) stands out – a large and unusually modern building for its time, unique in the Latvian rural landscape (Fig. 39).

The characteristic cubistic massing, characteristic of the Modern Movement, is effectively applied in the architecture of many school buildings. In Riga, this shape is present in several schools built according to the designs of the architect Alfrēds Grīnbergs. The most characteristic is Rīga City Primary School No. 10 (now Rīga Čiekurkalns Primary School) in Rīga, at Čiekurkalna 1. garā līnija 53 (1933–1935). Regarding another similar work by A. Grīnbergs – the project of the Rīga City Primary School (now Rīga 34th Secondary School) at Kandavas iela 4/6 (1934–1937) – the Commission for the Review of Monumental Buildings of the Ministry of the Interior, which included some other architects along with E. Laube, pointed out in October 1934 that the "formal architectural solution of the school building is not sufficiently coherent, felt and balanced" [33], and moreover, the content and character of the school were not sufficiently expressed in the architecture. However, the project was implemented




Fig. 34. Rīga, Latvia. Apartment houses with shops at Marijas iela 8 (1926) un 6 (1928). Teodors Hermanovskis
Fig. 35. Rīga, Latvia. Apartment house with shops and the cinema at Zemitāna laukums 2. 1933. Teodors Hermanovskis
Fig. 36. Rīga, Latvia. Apartment house with shops at Stabu iela 4. 1932. Teodors Hermanovskis
Fig. 37. Rīga, Latvia. Office and apartment house with shops at Elizabetes iela 51. 1928. Paul Mandelstamm



Fig. 38. Rīga, Latvia. the Latvian Joint Stock Bank at Kaļķu iela 13. 1931. Alfred Karr and Kurt Baetge
Fig. 39. Tērvete, Latvia. Sanatorium. 1930–1934. Aleksandrs Klinklāvs un Ansis Kalniņš
Fig. 40. Alūksne, Latvia. City Primary School at Lielā Ezera iela 26. 1938. Elza Meldere-Ziemele

without any special changes. A similar principle of spatial composition is also used for the Ernests Gliks Primary School (now Alūksne City Primary School) at Lielā Ezera iela 26 in Alūksne, designed by architect Elza Meldere-Ziemele (1938, Fig. 40). These examples, although quite characteristic, are only a small part of the rich and diverse heritage of Latvian interwar Modern Movement architecture.

## The Modern Movement after World War II: Currents and Echoes

The post-World War II Modern Movement worldwide was a continuation of the pre-war Modern Movement, or Functionalism. The symbolic beginning of the post-war Modern Movement was the United Nations (UN) complex in New York, USA, at 760 United Nations Plaza (1947–1950). It was built to a design developed by an international team of architects. One of the architects of the UN complex, Oscar Niemeyer, became an outstanding master of the principle of contrast. One of the most characteristic examples of his rather simple, but clear, precisely balanced and expressive architectural compositions is the Brazilian Parliament or Congress Palace in the Brazilian capital, Brasília (1959–1960, Fig. 41).

The idea of universal architecture, nurtured by the great architect of the 20th century, Ludwig Mies van der Rohe, was embodied in box-shaped glass and steel buildings. They became the general symbol of the Modern Movement. The earliest example of this stereotype executed by Mies van der Rohe himself is the residential buildings at 860–880 Lake Shore Drive in Chicago, USA, built in 1948–1951 (Fig. 42). One of the icons of this architecture is the office building Lever House, designed by architect Gordon Bunshaft at 375 Park Avenue in New York (1952, Fig. 43). It is a high box-shaped building rising above a wider two-story platform.

The architecture of the glazed box-shaped buildings, however, led to an artistic dead-end. The well-known architectural critic Lewis Mumford, analysing the work of Mies van der Rohe noted in 1962: "His own chaste taste has these hollow glass shells a crystalline purity of form: but they existed alone in the Platonic world of his imagination and had no relation to site, climate, insolation, function or internal activity [..]. This was the apotheosis of the compulsive, bureaucratic spirit. Its emptiness and hollowness were more expressive than van der Rohe's admirers realized" [34]. Mies van der Rohe's works have been recognized by many authorities as poorly articulated, poor in form and full of destructive technical and functional errors, architecture that does not fit in the environment. Theorist of Postmodernism Charles Jencks has devoted extensive research to this issue [35]. Postmodernism flourished starting in the 1970s as a conceptual counterpoint to the Modern Movement.

One of the methods of overcoming the artistic poverty of the Modern Movement was the New Brutalism – the deliberate use of finishing materials and building technical installations or structural elements to achieve architectural and artistic effects. Such a technique has been well known already since the times of Art Nouveau. E. Laube, for example, in 1908 emphasized the need to use only real, natural building materials, stating: "plaster has been used until now as an imitation of stone. [..] naturally, it must be treated like a surfice" [36]. The New Brutalism mostly focused on rough surfaces of cast-in-situ concrete (in French, béton brut), which are given expressiveness by the untreated imprint of the wood texture of the formwork. The name of the movement was introduced into wider circulation after the publication of Peter Banham's book "The New Brutalism" [37].

The New Brutalism was strongly influenced by the post-war work of Le Corbusier. It is often even called the Le Corbusier style [38]. Almost all of the master's works, starting with the famous "residential unit" (Unité d'habitation) in Marseille, France (1946–1951, Fig. 44), are distinguished by the strong massing and articulation of architectural elements, achieved by using the artistic and technical possibilities of cast-in-situ concrete. One of the masterpieces of such architecture is the Dominican monastery of Sainte-Marie-de-la-Tourette near Lyon, in Éveaux-sur-L'Abresle, built in 1951–1963 (Fig. 45).

The New Brutalism was also an integral part of the creative methods in the work of the architect Marcel Breuer. M. Breuer was a bright star in the constellation of Masters of 20th-century architecture. His well-known work is the UNESCO headquarters in Paris (1954–1958), designed together with Bernard Louis Zehrfuss and Pier Luigi Nervi (Fig. 46 and 47). It is an emblematic building of the Modern Movement. The building plan is a trefoil with gently concave "armpits". M. Breuer used the spatial composition scheme of the UNESCO building in the US Department of Housing and Urban



Fig. 41. Brasilia, Brazil. Congress Palace. 1959–1960. Oscar Niemeyer
Fig. 42. Chicago, USA. Residential buildings at 860–880 Lake Shore Drive. 1948–1951. Ludwig Mies van der Rohe
Fig. 43. New York, USA. Lever House at 390 Park Avenue. 1952. Gordon Bunshaft


Fig. 44. Marseille, France. Residential unit (Unité d'habitation). 1946–1951. Le Corbusier, André Wogenscky
Fig. 45. Éveaux-sur-L'Abresle, France. Tourette monastry (Couvent Sainte-Marie-de-la-Tourette). 1951–1963. Le Corbusier, André Wogenscky and others



Fig. 46 and 47. Paris, France. UNESCO headquarters at 7, *place de Fontenoy*. 1954–1958. Bernard Louis Zehrfuss, Marcel Breuer, Pier Luigi Nervi
Fig. 48. Rīga. Building of the Central Committee of the Communist Party of the Latvian SSR at Elizabetes iela 2. 1970–1974. Jānis Vilciņš, Alfons Ūdris, Gunārs Asaris

Development building in Washington, 451 7th St SW (1968), creating the building plan from two trefoils put together. Here and there, more direct reproductions of the UNESCO building plan configuration also appeared. For example, in the 1970s, the current European Parliament building was built at 8 Square de Meeûs in Brussels, designed by architect Michel Barbier. Its three wings have different lengths, but the facades, unlike the New Brutalism characteristic of the eventual Parisian prototype, are clad in fine bronze-colored mirrored glass.

A much more direct imitation of the UNESCO building is the former building of the Central Committee of the Communist Party of the Latvian SSR in Rīga, at Elizabetes iela 2 (Fig. 48), built in one of the historical parks of the Riga city centre (Kronvalda Park) in 1971–1974 to the design by architects Jānis Vilciņš, Alfons Ūdris and Gunārs Asaris. It lags behind the prototype not only in size, but also in terms of the culture and quality of execution of architectural details. The spatially and functionally different trefoil armpits on the park side, as well as the arrangement of vertical communications, absolutely do not correspond to the emphasized monumental symmetry of the main entrance facade. The scale of the building that does not correspond to the specific location and the conceptual denial of values of historical built-up environment meet the principles of the Modern Movement that were still widely recognized at that time: this building "implanted into the network of parks and greenery on Elizabetes iela 2, is clear testimony to the irreverence of the architecture of the time concerning the context of environment and the conclusive role of political powers in making professional decisions" [39]. Of course, at that time "no one was allowed even beep against the communists' plans to erect their headquarters within the park in the city centre" [40]. In 1970, when the design of this building began, disagreements arose between the city architect of Riga, Edgars Pučiņš, who was consistent in his professional activities, and the city's top management. E. Pučiņš was fired and replaced in the position by G. Asaris.

The so-called laboratory building with a library of the Riga Technical University (then the A. Pelše Riga Polytechnic Institute) at Kaļķu (then Ļeņina) iela 1a (1964–1967, architect Ilmārs Paegle) was also strange and inappropriate in the environment. It stretched for almost 140 m from the main building of the Riga Technical University at Kaļķu iela 1 across both Mazā Jauniela and Tirgoņu iela to Mazā Monētu iela. The building was demolished in 2000, when the reconstruction of the Town Hall torn down in 1954 began. In the 1960s, the issue of environmental context was not an actuality. On the contrary, in order to "eliminate the unpleasant legacy", it was recommended to replace the existing buildings with buildings designed in "in modern structures with equal structural spans and architectural solutions" so that they could be "used for any task similarly to universal spaces in the industrial architecture" [41].

## Conclusion

The legacy of the Modern Movement forms an important part of the contemporary built-up environment. The Modern Movement had broad and deep roots. In different periods, it has acquired different artistic expressions and ambiguous evaluations.

Most of the post-war Modern Movement buildings have already been heavily modified or disappeared. This is not a coincidence, but rather a regularity: their architecture, execution and urban quality have not stood the test of time. They have become both physically and morally obsolete much faster than the heritage of previous periods, including the monuments of the Modern Movement of the interwar period. They are much more thoroughly constructed and mostly perfectly inscribed in the environment.

## References

1. **Sulliwan, L.** The tall Office Building Artistically considered. *Lippincott's Monthly Magazine*. 1896, March, p. 408. Pieejams arī: https://archive.org/stream/talloffícebuildi00sull#page/n5/mode/2up
2. **Asars, J.** Mākslas amatniecība. Asars, J. *Kopoti raksti.* 1. sēj., 3. burtn. Rīga, 1910, 26. lpp. (Raksts pirmoreiz publicēts žurnālā *Mājas Viesa Mēnešraksts*, 1904, Nr. 9.)
3. **Rutmanis, J.** Latviešu arhitektūra 19. un 20. gs. *Mākslas vēsture*: I: Arhitektūra un tēlniecība (V. Purviša visp. red.). Rīga: Grāmatu draugs, 1934. 255. lpp.
4. Basic Biographical Details : Robert McConnell [online]. *Dictionary of Scottish Architects* [cited 29.07.2020.]. http://www.scottisharchitects.org.uk/architect_full.php?id=206780
5. History of Oriel Chambers [online]. *Oriel Chambers : Water Street* [cited 01.06.2025]. https://orielchambersliv.co.uk/
6. Daily Record Building [online]. *Charles Rennie Mackintosh Society* [cited 29.07.2020.]. https://www.crmsociety.

com/?venue=daily-record-building
7. **Condit, C. W.** *The Rise of the Skyscraper : The Genius of Chicago Architecture from the Great Fire to Louis Sullivan*. Chicago: University of Chicago Press. 1952. 255 p.
8. **Condit, C. W.** *The Chicago School of Architecture : A History of Commercial and Public Building in the Chicago Area 1875–1925*. Chicago: University of Chicago Press, 1964. 452 p.
9. **Frazier, N.** *Louis Sullivan and the Chicago School*. London: Bison Group, 1991, p. 6.
10. Liverpool Architecture and Cityscapes [online]. *The Victoriam Web : Literature, History, & Culture in the Age of Victoria* [cited 01.06.2025]. https://victorianweb.org/art/architecture/liverpool/34.html
11. New Steel/Identifiant PSS #32554 [en ligne]. *PSS - ARCHI.EU* [cité 30.05.2025]. https://www.pss-archi.eu/photo-32554.html (photograph by Laurent D. Ruamps)
12. Dagelijkse Groenmarkt 25 en 26 [online]. *Den Haag* [geciteerd 31.05.2025.]. https://www.monumentenzorgdenhaag.nl/monumenten/dagelijkse-groenmarkt-25-en-26
13. **Curl, J. S.** *A Dictionary of Architecture*. Oxford: Oxford University Press, 1999, p. 271.
14. **Pirkovič, J., Mihelič, B.** *Art Nouveau Architecture in Slovenia*. Ljubljana: Ministerstvo za Kulturu, Slovenian National Commission for UNESCO, 1998, p. 82, 83.
15. UNESCO World Heritage – Fagus Factory [online]. *Tripadvisor* [cited 04.06.2025.] https://www.tripadvisor.com/Attraction_Review-g1373838-d2546365-Reviews-UNESCO_World_Heritage_Fagus_Factory-Alfeld_Leine_Lower_Saxony.html
16. Auerspergstraße 9 Sanatorium Luithlen [online]. *Wikimedia Commons* [cited 18.01.2025.]. https://commons.wikimedia.org/wiki/File:Auerspergstra%C3%9Fe_9_Sanatorium_Luithlen.jpg.
17. Villa Henny, Geometric Style Icon in The Netherlands [online]. *Iconichouses.org* [cited 03.08.2020.]. https://www.iconichouses.org/icons-for-sale/villa-henny;
18. Private House Henny (Huis ter Heide) [online]. *Architectureguide NL* [cited 03.08.2020.].http://www.architectureguide.nl/project/list_projects_of_tag/tag_id/15/prj_id/602
19. **Pīrangs, H.** Arhitektoniskās stila formas Rīgas pilsētas ainavā. *Rīga kā Latvijas galvas pilsēta*. Rīga: *Rīgas pilsētas valdes izdevums*,1932. 120. lpp.
20. **Dauge, G.** Jaunais stils arhitektūrā. Burtnieks, 1933, Nr. 3, 209. un 211. lpp.
21. **Dauge, G.** Par nacionālu arhitektūru. Burtnieks, 1935, Nr. 10, 773. un 774. lpp.
22. *Internationale Architektur* (Walter Gropius, Herausgeber). München: Albert Lange, 1925. (Bauhausbücher 1). 106 S.
23. **Gropius, W.** *Scope of Total Architecture*. New York, Evanston: Harper & Row, 1955. (World Perspectives, Vol. 3; Copyright 1943, 1949, 1952, 1954). P. XXI.
24. **Kundziņš, P.** Piezīmes par latvju arhitektūru. Students, 1935, 1. februārī.
25. Latvian State Historical Archives (LSHA), case 6343, description 19, file 41, page 23. (E. Laube's review of the Riga City Primary School No. 46 project).
26. **Laube, E.** Arhitektūras gars atjaunotā Latvijā. *Latvijas Arhitektūra*, 1939, Nr. 4/5, 111. lpp.
27. **Birzenieks, A.** Dr. arch. h. c. E. Laubes celtnieciskā darbība patstāvīgā Latvijā. *Latvijas Arhitektūra*, 1940, Nr. 4, 122. lpp.
28. Van Nellefabriek [online]. *United Nations Educational, Scientific and Cultural Organization* / World Heritage Centre [cited 23.08.2020]. https://whc.unesco.org/en/list/1441/
29. **Molema, J.** *Jan Duiker.* Barcelona: G. Gili, 1989. 205 p. (Obras y Proyectos / Works and Projects).
30. **Giedion, S.** *Space Time and Architecture : The Growth of A New Tradition*. Cambridge: Harvard University Press, 1967 (5th ed.). P. 630.
31. **Le Corbusier.** *Vers une architecture*. Paris: Éditions Crès, 1923. XI + 244 p. (Collection de "L'Esprit Nouveau").
32. *Latvijas darbinieku galerija* : 1918–1928 (P. Krodera red.). Rīga: Grāmatu draugs, 1929. 50. lpp.
33. LSHA, case 6343, description 20, file 69, page 7.
34. **Mumford, L.** *The Highway and the City*. London: Secker & Warburg, 1964., p. 156.
35. **Jencks, Ch.** The Problem of Mies. *Modern Movements in Architecture*. Harmondsworth, Middlesex: Penguin Books, 1973. P. 94–108.
36. **Laube, E.** Par būvniecības stilu. *Zalktis*, 1908, No 4, 147. lpp.
37. **Banham, P.** *The New Brutalism : Ethic or Aesthetic?* London: Architectural Press. 1966, 196 p.
38. **Curl, J. S.** *Dictionary of Architecture*. Hoo, Near Rochester: Grange Books, 2005, p. 104.
39. **Dambis, J.** *Modernism. Un–written: Exhibition of Latvia at the 14th International Architecture Exhibition – la Biennale di Venezia. Catalogue* (Curator: architecture office NRJA; architects Uldis Lukševics, Linda Letāne-Šmīdberga, Zigmārs Jauja et al.). Riga: NRJA, 2014. p. 227.
40. **Ozoliņš, A.** Kur Rīgā cels akustisko koncertzāli? *Ir,* 2020, 17. dec. (#50/51), 72. lpp.
41. **Melbergs, G.** Ļeņina iela nākotnē. *Zinātne un Tehnika,* 1964, Nr. 2, 4.–6. lpp.

## Author

**Jānis Krastiņš** was an architect, Dr. habil. arch. (1991), Professor at Faculty of Architecture, Riga Technical University (RTU, 1992); Full member of Latvian Academy of Sciences (1994). The current research fields: theory of architecture, history of architecture, Art Nouveau, Modern Movement.

## Kopsavilkums

Pētījumā tiek aplūkoti un izvērtēti līdz šim mazāk zināmi piemēri, analizēta attīstība dažādās valstīs un Latvijā, kā arī salīdzināta tā formālā valodas izpausmju kvalitāte dažādos vēsturiskajos posmos. Pētījumā ir izvērtēta Modernās kustības vēsturiskā nozīme kultūras mantojuma kontekstā. Īpaša uzmanība pievērsta agrīniem piemēriem, kas iezīmēja pamatu stila turpmākajai attīstībai. Modernās kustības mantojums veido nozīmīgu daļu no mūsdienu apbūvētās vides. Modernajai kustībai bija plašas un dziļas saknes, dažādos laikposmos tā ieguvusi atšķirīgas mākslinieciskas izpausmes un pretrunīgus vērtējumus. Lielākā daļa pēckara perioda modernās kustības ēku jau ir būtiski pārbūvētas vai pilnībā zudušas. Tas nav nejaušs gadījums, bet gan likumsakarība, jo konkrēto ēku arhitektūra, izpildījums un pilsētbūvnieciskā kvalitāte nav izturējusi laika pārbaudi. Tās fiziski un morāli novecojušas daudz ātrāk nekā iepriekšējo laikmetu mantojums, tostarp arī starpkaru perioda modernisma pieminekļi. Pēdējie ir daudz rūpīgāk būvēti un lielākoties harmoniski iekļaujas apkārtējā vidē.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.07

# RENOVATION OF THE POST-SOVIET HOUSING ESTATES IN THE CONTEXT OF PANDEMIC CHALLENGES ON THE EXAMPLE OF NOVI BUDYNKY IN KHARKIV

**Nadiia Antonenko[1], Kateryna Didenko[2]**

[1] *Kyiv National University of Construction and Architecture, Ukraine; RPTU Kaiserslautern, Germany*

[2] *Vilnius Gediminas Technical University, Lithuania*

**Abstract. This study raises the question of revising the usual ideas about the renovation of post-Soviet housing. The new urban movements that have become popular in the context of the COVID-19 pandemic, namely, the concept of the "15-minute city" are taking into account. The purpose of this publication is to identify possible methodological and theoretical shifts in research approaches in dealing with the transformation of post-Soviet residential areas in connection with the active introduction of new concepts of chrono-urbanism, such as the "15-minute city". In order to achieve the goal, a systematic logical and analytical approaches were used to identify the concept of a 15-minute city that is relevant today as one of those that can be used for the renovation and revitalisation of post-Soviet residential areas. The study uses a comparative method, includes a study of literary and documentary sources. The method of information systematisation was also used to summarise the research results. As a site for field research, the Novi Budynky housing estate in Kharkiv was chosen, on the example of which a historical study was carried out. It was analyzed how this housing estate corresponded to contemporary ideas about normal socio-cultural and living conditions, its new functional content, and also analyzed the possible whether (from the point of view of the formed morphology and the established service system) to introduce the concept of "15-minute city". The first steps that can be taken to get closer to the implementation of this concept were formulated, and practical and methodological problems of its implementation into the reality of post-Soviet cities, in the form in which it was theoretically developed, were identified.**
**Keywords: Kharkiv, large-scale housing estate, 15-minute cites, chrono-urbanism, COVID-19**

## Introduction

The COVID-19 pandemic, which has unfolded since the end of 2019, has become a challenge not only for public health and the global health system, but also led to transformations in the way people live. Life in cities began to change. Safety, health, environmental quality, accessibility, the possibility of dispersal in public space have become some of the basic needs of citizens around the world. These issues have become even more pressing in the context of Russia's war against Ukraine, which has affected the viability of residential areas in hundreds of Ukrainian cities due to shelling, street fighting, deliberate homicide, destruction of critical infrastructure, occupation, and depopulation of territories caused by displacement. In such crises, the question of the survival of individual urban structural units, capable of temporary or prolonged self-sufficiency or limited provision, has become even more acute. The question of how to work with the urban environment under extraordinary conditions - whether a pandemic or a war - has begun to be actively discussed in the scientific community.

So, for many researchers, the question of the "death" of cities in the form in which they exist now has become relevant – what the settlements of the future will be, and whether large cities will exist or they will be divided into many small ones [1]. The discussion, which began in the early 2000s with the widespread use of the Internet was updated. Then the disintegration of cities was assumed among the main transformations; significantly reduced need for mobility; replacement of physical networks with virtual ones; spatial homogenization – fragmentation of cities [2]. In this context, great interest has been generated by the possibilities and role of public urban spaces in the cities of the future, which are fundamental elements of the preservation of urban lifestyles [3]. C. Cellucci presented its recommendations for creating healthy, safe and sustainable public spaces, the characteristics of which were formulated in the following key points: contributing to mitigation of current and future pandemics and promoting public health and well-being [4]. N. Antonenko and T. Rumilets [5] considered the possibility of adapting public library spaces, raising the issue of the need to create transformed forms – both architectural objects themselves and internal and external library public spaces. Researchers identify several directions in the development of cities of the future [6] – the creation of multifunctional, transformable spaces; operational data management in urban planning; an inclusive city; changing the scale of urban networks and political power.

One of the most popular urbanistic concepts, which to some extent included these areas, was the concept of the "15-minute city" (in a short time, several developments similar in content appeared), which began to seem to be an effective response to the climate crisis and a way out of the crisis cities that was launched by the pandemic. The "15-minute city" concept calls for dividing the city into a series of so-called 15-minute or pedestrian neighborhoods so that all city residents are able to meet most of their needs within walking or cycling (e-bike) from their homes [7]. At the same time, the concept was operationalized differently in various contexts: in Paris, through quartier-scale reorganization of everyday services [8]; in Melbourne, as part of its long-term metropolitan strategy with the "20-minute neighbourhoods" programme [9]; and in Shanghai, via the creation of "15-minute community life circles" in the 2016 Master Plan [10]. By 2024, more than 70 initiatives aimed at transforming urban areas according to the key principles of the 15-minute city had been recorded [11]. Initiatives related to the 15-minute city are predominantly concentrated in Western Europe, North America, and Oceania.

In recent years, the problems of renovating post-Soviet housing estates, as well as the broader issues of transforming post-Soviet and post-industrial cities, have been actively discussed [12;13;14]. In this context, the question has arisen whether the concept of the "15-minute city" can be adapted to such territories, which are characterized by a complex set of challenges: peripheral location within the urban structure, physical and morphological fragmentation, pronounced social and economic inequality, transport challenges, problems of social organization and the formation of resilient local communities, as well as institutional and governance

barriers.

A review of the existing literature indicates that the 15-minute city concept is increasingly entering scholarly debates on post-socialist urban contexts. Mocák [15] initiated discussions on its potential application in Slovak cities, while Michalska-Żyła [16] highlights its role in fostering social revitalization of urban environments. Hess, Kocaj, and Gorcica [17] advance a conceptual framework for transforming Soviet-era housing estates into sustainable eco-villages by enhancing local services, pedestrian and cycling accessibility. Špirić and Đukić [18] underscore the significance of community-based initiatives in reshaping public open spaces and cultivating local communities – an essential precondition for adapting large housing estates to the principles of the 15-minute city. Complementing these perspectives, Pásztor [19] offers a critical assessment of the opportunities and challenges of chrono-urbanism in post-socialist settings, stressing the importance of socio-economic and cultural particularities. Taken together, these contributions outline a multidimensional research agenda for adapting the 15-minute city framework to the realities of Central and Eastern Europe [20].

However, the limited research on this topic and the lack of sufficient practical transformations have so far prevented the formulation of fundamental principles for the regeneration of residential areas, which could enable prefab housing districts to evolve within the framework of fully-fledged 15-minute cities.

The purpose of this publication is to identify potential methodological and theoretical shifts in the study of transformations of post-Soviet housing estates in connection with the active implementation of new chrono-urbanism approaches, particularly the "15-minute city." Although the article does not aim to provide a systematic comparison with international cases, the juxtaposition with a specific post-socialist housing district helps to mitigate the gap between an ideal-type model and a historically layered urban environment.

The hypothesis advanced in this article is that modernist housing projects, despite their idealism and detachment from residents' everyday lives, were originally designed to improve living conditions and ensure access to essential services and goods. This embedded urban planning principle can serve as a foundation for rethinking and redesigning post-Soviet estates within the framework of contemporary chrono-urbanism.

Such an approach makes it possible to transform existing socio-functional structures into more effective ones that correspond both to the current needs of urban residents and to their perceptions of a high-quality living environment.

The following tasks were set: to formulate the principles and mechanisms of the system of access to household and socio-cultural services and consumer goods within the framework of the "15-minute city" concept; to conduct a comparative analysis of this system and the Soviet staged public service model; to determine the potential and reference points for the renovation of the Novi Budynky housing estate in Kharkiv in accordance with the principles of the "15-minute city"; to identify methodological and practical challenges in adapting and implementing this concept in the post-socialist context.

The selected case for this study, the Novi Budynky housing estate in Kharkiv, represents a post-Soviet urban territory that has been developing since the 1960s. Widespread industrial and residential construction in Kharkiv, which began in the 1930s [21; 22], eventually brought the lands of the Selection Station into the urban fabric. The relatively close location of this site to major industrial enterprises, combined with favorable sanitary, hygienic, and natural conditions, predetermined its use for residential development [23]. The housing estate possesses a number of characteristics that ensure its relative stability. These include compactness, proximity to the city center, a convenient transport interchange, a comparatively well-developed system of public service enterprises (relative to other housing estates of the Soviet period), and a high degree of landscaping. From the perspective of analyzing the applicability of the "15-minute city" concept, Novi Budynky is of particular interest due to its historical territorial isolation. The estate is almost entirely surrounded by large closed industrial areas and other housing estates (Figures 1, 2). At the same time, it benefits from a convenient transport system, including metro, trolleybus, tram, and bus routes.

The study is based on a comparative method, which made it possible:

- to identify similarities and differences in the formal spatial and functional characteristics of the 15-minute city and the Soviet residential area of Novi Budynky;
- to identify ongoing and potential transformations through, site visits, interviews with local residents and document analysis.

To achieve this goal, systematic, logical, and analytical approaches were employed to determine which aspects of the 15-minute city concept are relevant today and can be applied for the renovation and revitalization of post-Soviet residential areas.

The work includes a study of literary and documentary sources, including archive documents (Archive of "Kharkivproekt" Limited Liability Company). Additionally, the method of information systematisation was also used to summarise the research results.

## The 15-Minute City Concept as a Response to Global Public Health Challenges

The cars invention only at first did not have any impact on cities. The city was becoming uncomfortable for people. A growing number of cars took up more and more space in urban areas. Narrow sidewalks were allocated to pedestrians, while the maximum number of lanes was created for cars, which is only possible on old streets.

Beyond the immediate pandemic impetus, proximity-based urbanism has a longer lineage. The 15-minute city concept builds upon established urbanist approaches that emphasize compact form and everyday accessibility, including New Urbanism's neighbourhood unit, the walkability canon, smart-city instrumentation, and small-scale ("tactical"/"acupuncture") interventions that re-programme streets and squares. Situating the concept within this continuum clarifies that it re-articulates established aspirations rather than proposing an entirely new paradigm.

In this regard, in the 1960s an opposition movement emerged as an alternative to modernism, began to form, which opposed itself to the active dissemination and implementation of large-scale renovations of centers, and the construction of huge housing estates in cities. By the end of the twentieth century New Urbanism, one of the most influential urban planning concepts, was formulated. It was a movement for reforms in planning and urban design, which involved the revival of small compact cities (or districts), as opposed to automobile suburbs.The pedestrian issue has been updated and its quality has been revised since 2019, in view of the emergence of a global threat – the COVID-19 pandemic. It turned out that the measures that were previously taken to ensure urban accessibility are insufficient even in developed cities. There has been an increased focus on standardizing urban life, not only in terms of convenience, but, above all, to what extent

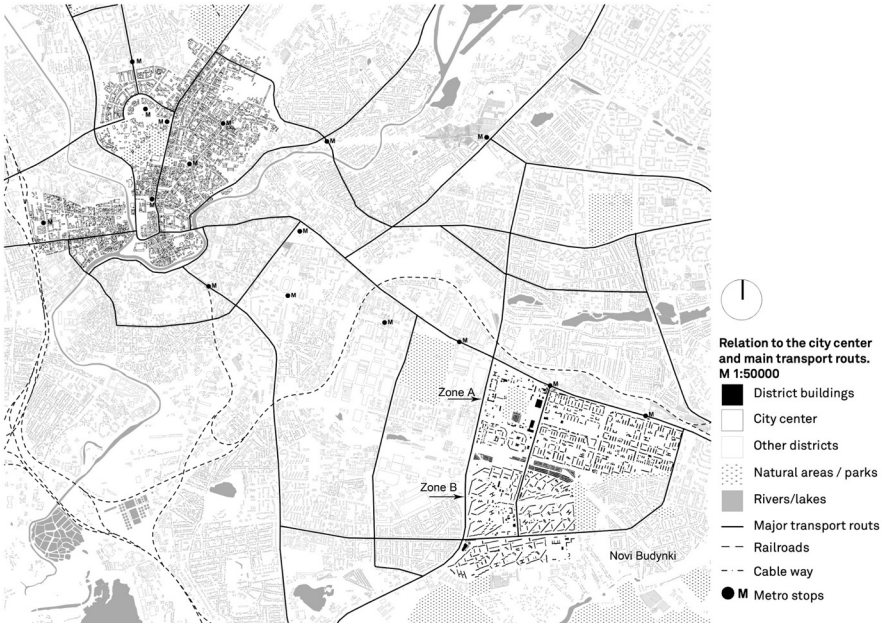



Fig. 1. Novi Budynky. Connection of the housing estate Novi Budynki with the city center [created by authors]

the urban environment contributes to the preservation of the health of citizens [24]. Today, the focus extends beyond the mere presence of roads or long cycling and walking routes to their functional quality: the diversity of services along these routes, the accessibility of essential household and socio-cultural services, and the extent to which these factors support both physical and mental health.

In 2020, K. Moreno introduced the concept of the "15-minute city" as a way to ensure that residents of cities equally remote from the center can perform six main functions – life, work, trade, health care, education and entertainment – in within a 15-minute walk or bike ride from your home. The rhythm of city life should follow a person, not cars. The 15-minute city structure of this model has four components: density, proximity, diversity, and digitalization. According to the authors, dense development will stimulate the emergence of more services offered to the population; proximity – will ensure their payback; diversity – will improve the urban experience and increase the participation of local communities in urban processes; digitalization is a key aspect of modern cities, built on the basis of smart city technology.

Similar ideas were also developed by Weng, who proposed creating 15-minute neighborhoods in Shanghai based on creating a healthy environment, they noted that one of the most important factors that maintains health is walking and minimizing the use of any means of transportation. other than a bicycle [10]. Da Silva using Tempe as an example, Arizona proposed to consider the concept of a 20-minute city, focusing on the accessibility of the urban environment [25]. In April 2020, Barcelona published the Manifesto for the Reorganization of the City after COVID-19, signed by 160 academics and 300 architects, which was based on four key elements: reorganizing mobility, renaturalizing the city, decommodifying housing and halting sprawl [26]. And in July 2020, the C40 Cities Climate Leadership Group published a framework for adapting cities to new conditions, developed based on the concept of the "15-minute city", which emphasized the importance of involving communities in transforming the urban environment using tools that will strengthen local communities: joint budgeting, joint adjustment of city plans and infrastructure development.

In recent years, the concept of the 15-minute city has remained at the center of intensive academic debate, particularly with regard to its adaptation across diverse socio-economic contexts, technological instruments, and potential risks. While practical initiatives—primarily in Western Europe and North America—have demonstrated positive outcomes such as reduced transport demand, strengthened local infrastructure, and improved quality of life, the most radical critiques have largely receded. Nevertheless, substantial scholarly and professional discussions persist, focusing on the risks of gentrification, socio-spatial segregation, and the challenges of applying the model in low-density cities or those with post-socialist morphologies. Current research highlights the necessity of contextual adaptation, requiring planning tools and strategies that are sensitive to specific socio-economic and cultural conditions, particularly in resource-constrained environments [27]. Other studies examine the operational dimensions of the concept, emphasizing the role of smart technologies in supporting decentralized development and reshaping local lifestyles [28]. Further work seeks to establish universal frameworks for inclusive 15-minute cities, exploring how digital instruments such as IoT, 6G, and digital twins can be leveraged to evaluate accessibility and urban resilience [11].

Moreover, the preservation and promotion of public health remain central to the evolution of the 15-minute city model. While much of the recent scholarship emphasizes accessibility, sustainability, and the role of technology, it is essential to underscore that a healthy urban environment is not merely a desirable outcome – but a foundational requirement.

Studies have demonstrated that 15-minute cities, by facilitating walkability and proximity to services, actively contribute to physical activity, reduced air pollution, improved mental health, and overall well-being. For instance, integrating services such as clinics, pharmacies, and parks within walking distance promotes preventive healthcare and enhances mental resilience by fostering regular social interactions and access to green spaces . A critical framework specifically targeting public health and equity within chrono-urbanism is now emerging, arguing for urban designs that explicitly integrate health considerations – from universal accessibility to inclusive engagement – to avoid unintended consequences such as gentrification or inequitable infrastructure distribution [29; 30].

## Features of the spatial development of the Novi Budynky residential district in Kharkiv

The Novi Budynky housing estate is located in the southeastern part of the city of Kharkiv on the former lands of the Research Institute of Genetics and Breeding (former selection station) on an area of 445.9 hectares (Figure 1). Design work on the construction of housing began in 1958. From the north, the building site was bounded by a corridor of high-voltage lines and the then projected East-West road, from the west – by an individual development area (Gertsen village) and reconstructed for the estimated period. Communal, from the south – the area of the city airport, from the east – individual residential buildings of the Novozapadny settlement.

The territory of the future housing estate was divided into zones A and B, between which a high-voltage line was laid. Since section A was adjacent to the main transport artery of the city – Heroes of Kharkiv Avenue, they began to build it up in the first place (according to the project of Ukrgorstroyproekt, architects A. D. Matorin, N. Kireeva, Yu. Koltsov, A. I. Nesterenko and others). Zone "B" of this estate was designed a little later by Kharkivproekt (architects G.B. Kesler, Yu. A. Plaksiev, P.I .Areshkin, etc.) [31; 32].

Initially, it was planned to build only a few microrayons here, but as the pace of construction increased in the 1960s. it was decided to create a large housing estate, consisting of 10 micro-districts, and to resettle more than 150 thousand people. The area of streets and driveways per person was significantly lower than the normative ones, which was associated with the need to save money.

Transport connection of the housing estate with the central part of the city and places of employment were carried out as follows: along Byron Street, which is a city-wide highway of regulated traffic, bus and trolleybus routes were provided towards Gagarin Avenue (to the city center), as well as towards the Kosiora Street (settlement of the Kharkiv Tractor Plant); along Kommunalnaya Street, which is a city-wide highway of unregulated traffic, there are bus and trolleybus routes in the direction of Heroes of Kharkiv Avenue (industrial enterprises, city center), as well as in the direction of the civil airport; the express road along the northern border of the district provides express communication with the central and other remote parts of the city.

The main elements of the greening system of the Novi Budynky housing estate were courtyards-gardens with groups of houses, neighborhood gardens and a garden of a housing estate, greening of a public center and a stadium, boulevards [33]. In addition to the aforementioned green spaces of general use, there were also green spaces for special purposes: the protection zone from the expressway (in the north of the housing estate) and the gap from the civil airport (in the south). The layout of the garden of the housing estate and the site of sports facilities (stadium) was adopted landscape with the wide use of group plantings of trees and shrubs and sustainable grass lawns (Figure 2) [34].

## Practical and methodological problems of applying the concept of a 15-minute city to post-Soviet

The structural system of the housing estate was based on the principle of stepwise division and service with the organization of: the first stage – residential group based on primary service (2500-3000 people); the second stage – a residential neighborhood consisting of several residential groups; the third stage – a housing estate, consisting of several microrayons. The number of necessary household and socio-cultural institutions of the service system was determined according to the technical and economic calculations of the general plan of Kharkiv city. The types of cultural and domestic facilities were adopted in accordance with the nomenclature of a complex series of public buildings. The main elements of this system were:

- primary service institutions, within a coverage radius of 150-200 meters, serving a residential group with a population of 2-3 thousand people and consisting of kindergarten-nursery buildings and primary service blocks;
- institutions of daily service, within a coverage radius of 400-500 meters, serving the population of the microrayon and consisting of buildings of secondary schools and public centers of the microrayon; the community center of the microrayon includes the premises required for centralized services to the population (a canteen, a grocery store, a consumer services plant, a housing maintenance office with public premises, a universal hall and a library);
- institutions of periodic services, within a coverage radius of 1200 meters, serving the population of a housing estate of 78-100 thousand people), consisting of buildings of shopping and cultural and educational


Fig. 2. Landscaping scheme for Zone B of the Novi Budynky housing estate [archive of "Kharkivproekt" Limited Liability Company]

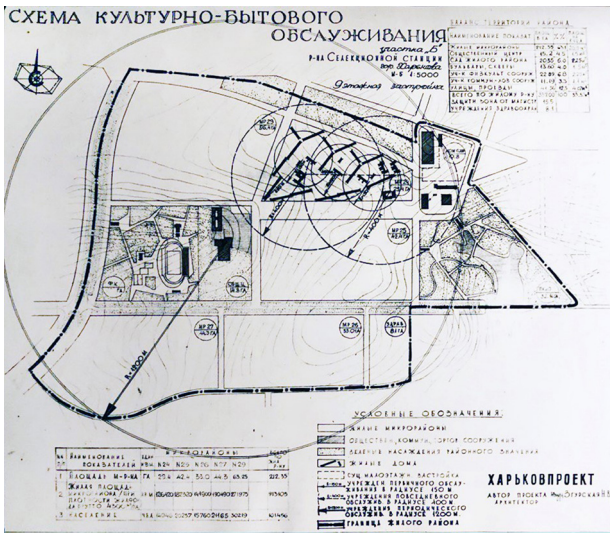



Fig. 3. Scheme of cultural and public services in Zone B of the Novi Budynky housing estate [archive of "Kharkivproekt" Limited Liability Company]

centers, as well as sports facilities (the clinic is part of the hospital complex serving the districts A and B);
- institutions of occasional (rare) use were located in a public center of urban importance, which was common for 6 and 7 industrial and housing estates (Figure 3).

The public and trade center of the housing estate was conveniently connected with housing groups – the farthest distance from the dwelling did not exceed 1.5 km. It housed trade, food and service buildings, a cinema, a restaurant and a Palace of Culture. The center was connected by a 100-meter-wide boulevard street with a park that housed a stadium and an artificial reservoir. In the opinion of the designers, such a concentration of cultural and household buildings in one place created great convenience for serving the population. According to the testimony of the interviewed local residents, it was really rare to go to the center – everything needed was within walking distance. Schools and kindergartens were isolated from the noise and dust of the streets and formed isolated green areas.

The main elements of the system of cultural and consumer services for the population of individual microrayons of a housing estate were (Figure 4):
- primary care institutions, consisting of kindergarten buildings and primary care units, which served the population of housing groups and were located within a radius of 150-200 meters.
- institutions of daily service, consisting of buildings of general education schools and community centers in housing groups. These institutions served the population of the entire microrayon and were located within a radius of 400-500 meters (Table 1).

During the Soviet era, public health was organized through the centralized Semashko system — a state-funded healthcare model that emphasized specialized medical services over primary care [35].

Due to budgetary constraints, measures that were intended to have a direct impact on population health and were included in initial plans for expanding community medical facilities or blue-green infrastructure were often left unimplemented or executed only superficially and on a reduced scale.

With the collapse of the Soviet Union, the Novi Budynky housing estate, as well as many others, began to undergo changes associated primarily with the breakup of the Soviet centralized system of public services and the emergence of other forms of services for the local population. Began to appear en masse: commercial outlets, which in the busiest places were united into markets; garage cooperatives; the housing stock of the first floors of the main highways was transferred to non-residential stock – small grocery stores, beauty salons, bank branches, cafes, private children's centers, and offices appeared. Their location was predetermined by living market mechanisms, therefore, microrayons close to metro stations and ground transport interchange stations, over time, turned out to be more functionally filled than remote peripheral areas of the housing estate.

The functional content of the buildings of the former Soviet infrastructure of the housing estate has been changed. So, for example, since the 1990s the Palace of Sports, in parallel with the sports function, began to play a permanent role as a commercial exhibition center and concert venue. Markets have sprung up on empty areas close to transport. In the late 1990s, some of the kindergartens were transferred for another purpose, which was associated with a demographic failure: courtyards with playgrounds and green spaces began to decline, and the territories of kindergartens and schools were often used for walks with children. A large area between two zones A and B, previously an empty space of the security zone of high voltage power grids, was occupied by temporary garages and paid parking lots. Green areas, gardens, school grounds, local areas gradually fell into decay – funding for housing and communal services fell sharply.

In the 2000s – 2010s the western part of Petra Grigorenko Avenue began to be actively built up with new multi-storey residential buildings and retail outlets. The design of this territory was not carried out within the framework of the general concept and construction and was point-to-point. Central Yuryev Boulevard has turned from a recreational area into an active trade and recreation area. Jasmine Boulevard, which for a long time served as a transit, after reconstruction has become an attractive public place where local residents of different age groups began to spend their time. Park "Zustrich", which in the 1990s it was also a large vacant lot, later

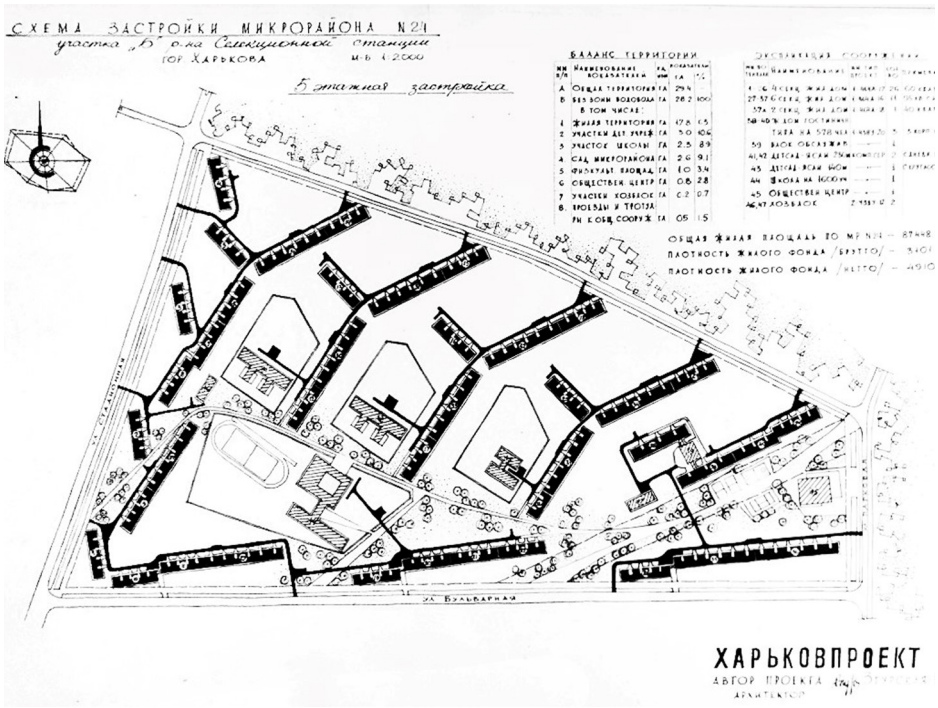



Fig. 5. Scheme of development of microrayon No. 24 [archive of "Kharkivproekt" Limited Liability Company]

TABLE 1

List of public buildings intended to serve the population of microrayon no. 24 with different number of storeys of buildings*

| No. | The name of the structure and the adopted standard design | Number | |
|---|---|---|---|
| | | 5-storey building | 9-storey building |
| 1 | Community center of the microrayon (for 8-10 thousand inhabitants), type 2 | 1 | - |
| 2 | Community center of the microrayon (for 11-13 thousand inhabitants), type 1 | - | 1 |
| 3 | School for 1600 students, type 1 | 1 | - |
| 4 | School for 2,200 students, type 1 | - | 1 |
| 5 | Kindergarten-nursery for 280 places (with day groups), type 1 | 2 | 3 |
| 5 | Kindergarten Nursery for 140 places (with 24-hour groups), type 4 | 1 | 1 |
| 6 | Primary service unit type. project 2-438У-12 | 2 | 2 |
| 7 | Primary service unit type. project 2-438У-13 | 0 | 1 |

* The community center in this microrayon was located in its eastern part, since the center of the housing estate adjoins the microrayon from the west

it was put in order and began to be used by local residents as an additional place for recreation – walks, picnics. At the same time, most of the kindergartens were returned to their original function. The renovated cinema "Kyiv" continued to be the socio-cultural anchor of the community center of the housing estate. Supermarkets and shopping centers have sprung up in the buildings of supermarkets and department stores. In the same years, new standard complexes of children's playgrounds and sports complexes for workout began to be installed in the courtyards of microrayons.

In general, the housing estate is characterized as a comfortable, quiet area of Kharkiv for living with a fairly convenient existing infrastructure of consumer services. According to real estate companies, the housing estate is in the top 10 of the best areas for living in the city, since it has good transport connection, developed infrastructure, sufficient filling with recreation and sports areas, has a reputation as a relatively safe and environmentally friendly area.

Since 2022, the situation has changed dramatically: the city, located near the border, has been subjected to intense shelling by Russian forces. In this context, the Novi Budynky housing estate has proven to be one of the most livable districts, sustaining minimal damage to both residential buildings and essential infrastructure. Many residents have remained in their homes, determined to maintain their connection to the neighborhood and gradually restore their daily lives.

Following the collapse of the Soviet Union, Ukraine's healthcare system underwent significant transformations between 1990 and 2021. The centralized Semashko system gradually gave way to a more decentralized model, with hospitals and local medical institutions gaining greater autonomy in management and financing. Over time, new forms of governance emerged, including the transfer of hospital ownership to local authorities, corporatization of hospitals, and an increasing role for private healthcare providers. These changes redistributed decision-making powers and financial responsibilities between state and non-state actors, affecting the efficiency and accessibility of medical services. Although the reforms aimed to improve the quality and responsiveness of healthcare, their implementation was uneven, particularly in residential districts.

Since 2022, with the outbreak of full-scale war, the healthcare system and urban infrastructure have faced unprecedented pressures. The fact that the Novi Budynky district sustained minimal damage to its functional infrastructure has allowed basic medical services and public spaces to continue operating, albeit under extremely difficult conditions. The district's blue-green infrastructure has proven critically important for maintaining residents' physical and mental health amid disrupted urban life.

## Key differences in the system of consumer services and socio-cultural services in Soviet neighborhoods in the 1960s -1980s and the concept of "15-minute city"

To assess whether a post-Soviet residential area can be reorganized according to the 15-minute city concept, it is necessary to compare the key principles and theoretical ideas of the 15-minute city with the planning principles of socialist housing estates, as well as with examples of how these estates have adapted after the 1990s (in our case, the Novi Budynky housing estate in Kharkiv). It is important to note that the data about post-Soviet housing estates should not be generalized: the features of adaptation, although sometimes similar, are highly context-dependent. The example of Novi Budynky illustrates only the trends that should be considered in further analyses and is not a universal model of adaptation. Against this backdrop, it becomes crucial to outline the general ideas underpinning the 15-minute city concept, which remain consistent with its original theoretical framework: (1) the principle of pedestrian accessibility, which prioritizes walkability and inclusivity, particularly for groups previously overlooked in urban planning such as women, children, people with disabilities, and the elderly; (2) the principle of diversity, which highlights the role of social infrastructure—schools, parks, and cultural facilities—in maximizing urban functions for residents; and (3) the principle of health, which underscores the importance of green spaces for environmental sustainability and public well-being [36].

### 1. Principle of Accessibility

The concept of a 15-minute city divides urban areas into nested accessibility zones, structured according to modes of movement and the frequency of daily needs. These include 5-minute walking areas, 15-minute pedestrian districts, and regions accessible by e-bike, corresponding to short, medium, and long urban mobility distances. Within these zones, residents should have access to essential goods, everyday services, educational, cultural, and recreational facilities, as well as residential and commercial spaces, satisfying daily and weekly needs without having to travel long distances. Public squares or central thoroughfares often serve as nodal points, supporting social interaction and mixed-use activity. The 15-minute city concept acknowledges the impossibility of creating a completely homogeneous environment, recognizing that residents in central areas may have access to a greater number and higher quality of services, while peripheral areas rely on smaller, local facilities.

In contrast, Soviet housing estates implemented a graded system of socio-cultural and consumer services within a planned economy. Formally, this system was similar in structure, but it differed fundamentally in flexibility and adaptability.

Soviet planning was based on two main principles: first, consumer demand was divided into three categories — daily, periodic, and episodic — allowing calculation of the minimum number of service facilities required to meet residents' needs; second, the more frequent the demand, the closer the facility was located to residential buildings to ensure convenient access to daily necessities. Level-one facilities served daily needs (kindergartens, schools, grocery stores, pharmacies, workshops) within a radius of approximately 0.6 km; level-two facilities addressed periodic needs (cultural centers, libraries, clubs, polyclinics, district hospitals) within a 1.5 km radius. Episodic or specialized needs were served at the city level, accessible via public transport to administrative offices, theaters, museums, and large hospitals. Recreational services, such as beaches, sports centers, and out-of-town facilities, constituted a fourth level and also required transport access. Although this system provided formal accessibility, it was rigid and did not account for real social behavior, "live" demand, or market changes.

Post-Soviet housing estates, exemplified by the Novi Budynky residential district in Kharkiv, demonstrate both preservation and adaptation of the Soviet accessibility system. First-level services have been maintained: kindergartens, schools, grocery stores, department stores, cafes, pharmacies, and workshops continue to operate. Additionally, new points of sale and services have emerged: law offices, beauty salons, children's clubs, supermarkets, bars, cafes, and bank branches, expanding the local network of available services. Level-two services continue to meet periodic demand, although socio-cultural institutions (clubs, cultural centers, cinemas, libraries) functioned less effectively due to funding shortages; meanwhile, shopping centers were renovated or newly built. Third-level services, covering episodic demand, require the use of public transport, primarily the metro, to reach administrative and economic offices, museums, theaters, large cinemas, circuses, concert halls, educational and scientific centers, and specialized hospitals. This demand is partially met by locally situated cultural palaces, municipal sports centers, commercial, and medical facilities. Unique fourth-level recreational facilities are absent within the district, requiring public transport to access them.

Comparative analysis shows that the 15-minute city concept envisions smaller primary service zones — approximately 1.5 times smaller than those assumed in Soviet planning — allowing more precise accommodation of residents' needs. "Shadow" or border zones between 5-minute blocks become important concentrations of diverse functions required by residents of adjacent microdistricts, though they are not always systematically organized in practice. Unlike the fixed Soviet model, the 15-minute city emphasizes continuous monitoring of actual demand, especially for socio-cultural services, enabling dynamic adaptation to changes in community needs. Modern planning additionally accounts for e-bike accessibility as a separate category, expanding residents' ability to reach unique cultural, educational, and recreational facilities within roughly 8 km, depending on local infrastructure. Smart city technologies allow real-time data collection and analysis, enabling responses to changes in mobility, service usage, and population behavior — a level of adaptability that was previously impossible under the Soviet system.

**2. Principle of Diversity**

The principle of diversity is central to the concept of the "15-minute city," where social composition, service systems, morphology, and temporary spaces are directed toward creating a dynamic and integrated environment. Within such districts, diversity is understood as the coexistence of multiple social groups, including different age categories, income levels, and household types, which fosters social interaction and inclusivity. The spatial structure is complemented by a wide range of everyday and periodic services, cultural, educational, and recreational facilities, as well as diverse housing typologies – from townhouses to multi-story apartment buildings. Temporary and experimental spaces, such as seasonal markets or co-working hubs, enhance adaptability and allow neighborhoods to respond flexibly to emerging needs.

In contrast, Soviet housing estates, although formally combining residential, public, and service buildings, lacked genuine diversity both socially and morphologically. The social composition was determined by the system of state allocation through enterprises and organizations, which did not aim to achieve heterogeneity, even though the population was not entirely homogeneous. Despite the presence in plans of a developed network of socio-cultural and household facilities, budgetary constraints during project implementation led to a significant reduction in functional diversity. The dominance of prefabricated construction, which depended on the capacities of local housing factories, created monotonous environments with limited morphological variability. Temporary or experimental spaces were marginal and mostly limited to episodic cultural events such as open-air cinemas.

The post-Soviet transformation of housing estates revealed a different trajectory, well illustrated by the case of Novi Budynky in Kharkiv. Housing privatization enabled the free circulation of apartments on the market, fostering demographic renewal, although in recent years the neighborhood has experienced population aging due to urban migration caused by the war. The service network significantly expanded through spontaneous business development, particularly along major thoroughfares. Morphological diversity increased with the emergence of new high-rise buildings on vacant plots, though this also intensified the aesthetic fragmentation of the environment. Informal and temporary spaces—market stalls, garages, seasonal entertainment facilities – became widespread, reflecting a new but uncoordinated form of diversity.

**3. Principle of Health**

The principle of health in a 15-minute city emphasizes the importance of physical activity, mental well-being, and environmental quality, integrating walkability, cycling infrastructure, green and recreational spaces, as well as access to services to support a healthy urban lifestyle. Within a 15-minute city, residents should have access to parks, playgrounds, sports fields, and other recreational areas within walking distance, supporting both physical and mental health. Safe and convenient pedestrian and cycling routes enable active mobility without relying on cars. Monitoring air quality and noise levels, along with the use of green barriers and landscaping, contributes to an improved microclimate. Access to healthcare services—hospitals, clinics, and pharmacies – ensures a rapid response to residents' needs, while markets and stores offering healthy products support proper nutrition. Lighting, security monitoring, and a sense of safety in public spaces further enhance well-being and encourage outdoor activity.

In Soviet housing estates, although a system of green spaces was planned as an interconnected network of parks, squares, protective belts, and water bodies for recreation and microclimate improvement, these areas were often limited or poorly maintained. The transport and pedestrian network

was designed to separate pedestrian and vehicle flows and to ensure connectivity between residential buildings and public facilities, but bicycle infrastructure was not provided. Sanitary and microclimatic controls, including green belts and integration of water bodies, were intended to reduce noise and pollution. The state healthcare system provided territorially organized access to district polyclinics, outpatient clinics, and specialized hospitals. Planned retail trade and markets supplied basic food and consumer goods. Public space safety was primarily ensured through state supervision and patrolling, restricted access to certain areas, and spatial design that emphasized visibility and control. However, state oversight could not fully ensure the safety of residents in remote districts, which contributed to the formation of youth gangs in the 1970s–1980s, and lighting was functional rather than aimed at creating a comfortable environment. Overall, the Soviet system provided basic conditions for supporting health but had limited integration with social life, flexibility, and adaptability to residents' needs.

Post-Soviet transformations of housing estates, illustrated by the Novi Budynky residential area in Kharkiv, show mixed trends. Green spaces were long in decline, partly built over, disrupting the connectivity of green corridors. Public green spaces were later restored; however, overall landscaping remains informal and unmanaged, with trees planted independently by residents often in unsatisfactory condition. Internal pedestrian pathways have been preserved, forming a convenient walking network, but the increase in private car ownership has led to informal parking and higher traffic flows, while cycling infrastructure remains insufficiently developed. Air quality monitoring has gradually developed since the mid-2010s, but targeted measures to improve air quality have been lacking, and the war has introduced a new source of pollution through shelling. Accessibility to healthcare services has remained adequate due to a combination of preserved Soviet facilities and private clinics and laboratories. Retail trade has undergone commercialization, transitioning from Soviet planned stores and informal 1990s markets to stable sources of fresh products within the residential area. Public oversight has weakened; the district is not highly criminalized but not completely safe either, and lighting remains inadequate due to budget constraints and the war. Under these conditions, health-related infrastructure functions unevenly, demonstrating both the resilience and limitations of post-Soviet transformations in supporting the physical and mental well-being of residents.

A comparative analysis of three urban development models – the 15-minute city, Soviet housing estates, and post-Soviet transformations exemplified by Novi Budynky – highlights key differences in accessibility, diversity, and health-oriented planning. Unlike the rigid planned model of the Soviet era, the 15-minute city emphasizes continuous monitoring of actual demand, particularly for socio-cultural services, allowing for dynamic adaptation to changing community needs. Considering e-bike accessibility as a separate category further expands residents' ability to reach unique cultural, educational, and recreational facilities within approximately 8 km, complementing traditional pedestrian and cycling networks. Smart city technologies enable real-time data collection and analysis, allowing for prompt responses to changes in mobility, service usage, and population behavior – a level of adaptability that was impossible under the Soviet system.

Although Soviet microdistricts provided a formally organized service network and a hierarchy of accessibility, they did not account for actual resident behavior, "live" demand for services, or the flexibility necessary to support diverse urban practices.

Post-Soviet transformations, including adaptation to the market conditions of the 1990s, demonstrate that the formal spatial structures of the Soviet period can support variable mobility patterns, service provision, and social interaction, but only with continuous monitoring, adaptive planning, and integration of new technologies. Examples of post-Soviet districts, such as Novi Budynky, show that through strategic interventions, inherited spatial structures can be leveraged to approximate the 15-minute city model, enhancing quality of life, mobility, and social cohesion. This underscores the potential for post-Soviet housing districts to be reorganized or upgraded according to the principles of the 15-minute city, taking into account historical constraints and the capacities of the existing urban fabric (Table 2).

In the course of analyzing the housing estate for the possibility of dividing Novi Budynky it into 15-minute cities, it was revealed that the original structure, which was laid by Soviet designers, allows leaving the contours of the territories of zones A and B as the territory of two 15-minute cities practically unchanged. At the same time, each of them can accommodate seven 5-minute districts, the boundaries of which practically coincided with the boundaries of the existing micro-districts. Each potential 5-minute city has a sufficient building density, a convenient location of children's educational institutions, enterprises that provide various goods and services and compete with each other are represented, there are not enough parking spaces within microrayons, but there are stable accessible garage areas that help reduce the number of parked cars in courtyards.

During the analysis of isochrones, it was found that the original structure laid out by Soviet designers allows zones A and B to function as the territories of two potential 15-minute cities. Within each of these zones, seven 5-minute districts can be delineated, with boundaries closely matching the existing microdistrict borders. Each 5-minute district offers sufficient building density, conveniently located educational facilities for children, and a variety of enterprises providing goods and services in competition with each other. Shortages of parking spaces within the microdistricts are mitigated by the presence of stable, accessible garage areas that reduce the number of cars parked in courtyards. The principle of pedestrian accessibility is largely observed (Figure 6).

The Novi Budynky housing estate partially meets the principle of diversity, but it remains overall limited. Social diversity recovered after the war, during which the number of young families and children significantly decreased. Access to services is basically ensured, and the network of goods and services expanded from the 1990s. However, facilities that would promote social interaction and community development are insufficient, forcing residents to go to the city center. Morphological diversity is limited due to serial housing development. Extensions and the conversion of ground floors into non-residential spaces have somewhat increased functional flexibility, but fragmented interventions create visual noise and do not alter the overall uniformity. Temporary spaces (retail outlets, informal markets, children's zones) add dynamism but do not provide full functional diversity.

This is primarily within the framework of developing a network of urban sub-centers (Figure 7), where the community center of the housing estate could acquire its unique functional socio-cultural specialization. The support for creating and the main potential for establishing such a sub-center is provided by the belt of post-industrial enterprises located along one of

TABLE 2

Comparison of the formal spatial and functional characteristics of 15-minute city Soviet city Housing Estate

| 15-minute city | Housing estate of Soviet city | Housing estate of Post-Soviet city (Novi Budynky) |
|---|---|---|
| Key components | Key components | Key components |
| **the principle of pedestrian accessibility** | | |
| 5-minute walking area (0,4 km) | Service Stage One: daily demand (0,6 km) | Adapted Service Stage One: daily demand (0,6 km) |
| 15-minute walking area (or 5-minute cycling) (1,2 -1,6 km) | Service Stage Two: periodic demand (1,5 km) | Adapted Service Stage Two: periodic demand (1,5 km) |
| 15-minute e-bike area (8 km) | Service Level Three: sporadic demand | Adapted Service Level Three: sporadic demand |
| Using infrastructure of the whole city | Service Level Four: sporadic demand (recreation) | Adapted Service Level Four: sporadic demand (recreation) |
| **the principle of diversity** | | |
| Social Composition of Residents | Social Composition of Residents | Social Composition of Residents |
| Services and Goods / Socio-Cultural Facilities | Public service system | Adapted Public service system |
| Morphology and Housing Variety | Serial prefabricated construction | Adapted housing prefabricated series |
| Temporary/Experimental Spaces | Temporary Spaces | Post-Soviet Temporary/Experimental Spaces |
| **the principle of health** | | |
| Green and Recreational Spaces | Green Structure | Adapted Green Structure |
| Walkability and Cycling Infrastructure | Transport and pedestrian network | Adapted transport and pedestrian network |
| Air Quality and Environmental Conditions | Protected Green Structure | Air Quality Monitiring |
| Access to Healthcare Services | State healthcare system | Adapted healthcare system |
| Healthy Food Availability | Planned retail trade | Retail trade commercialization |
| Safety and Security | State control of public order | Loss of public oversight |

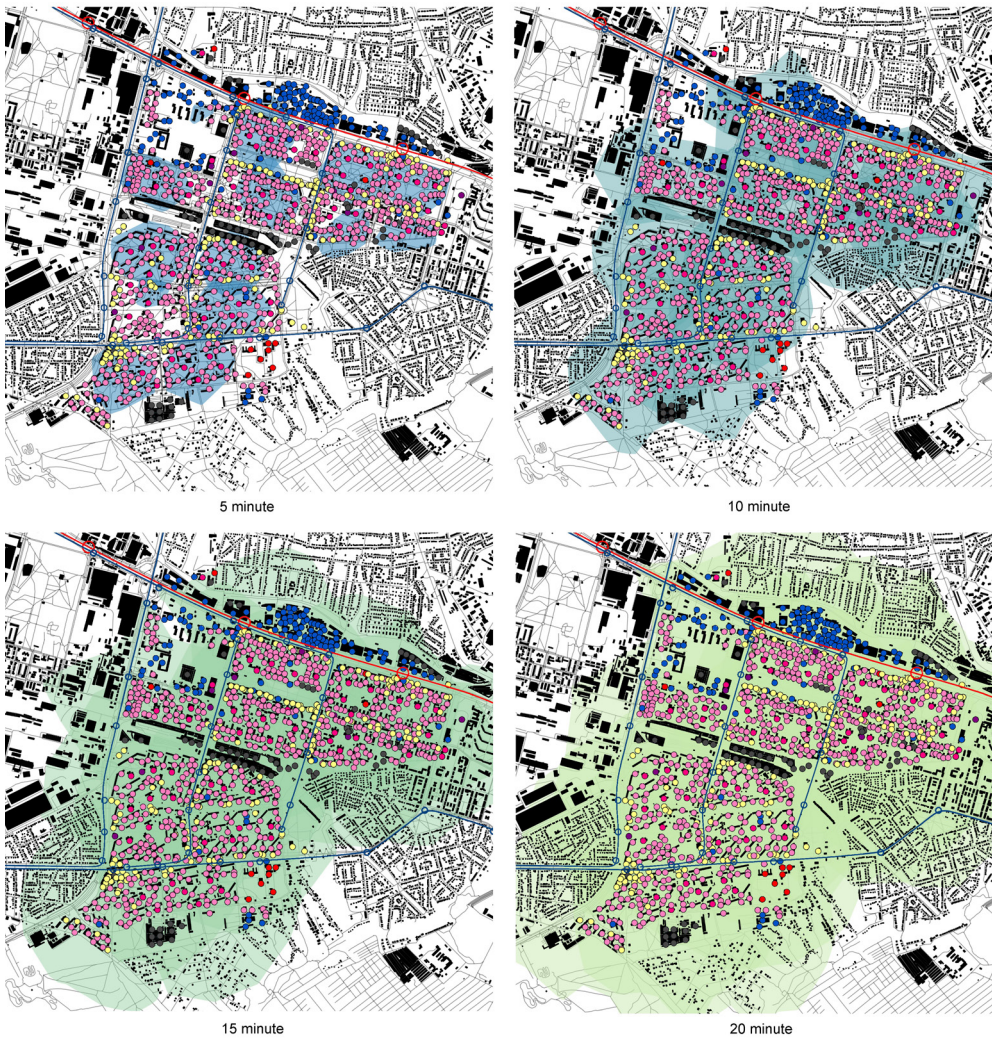



Fig. 6. Analysis of the 10-20-minute accessibility of the socio-cultural infrastructure of Novi Budynki [created by authors]

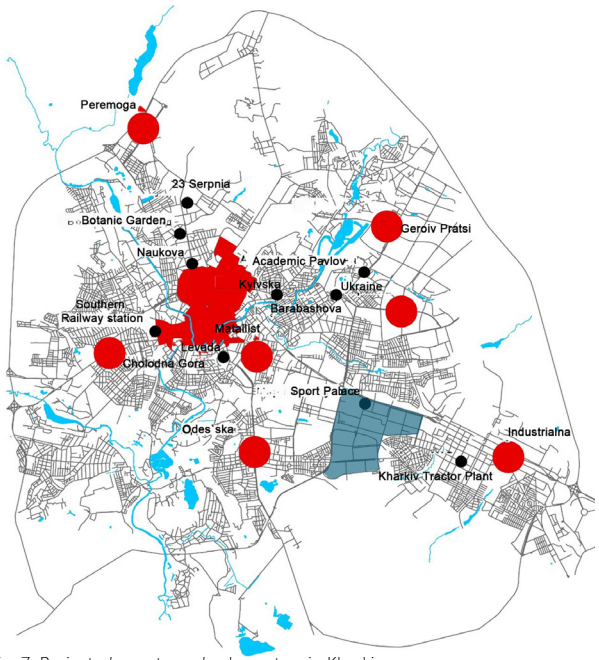



Fig. 7. Project of a system of sub-centers in Kharkiv [provided by prof. O. Buryak]

the city's main thoroughfares - Heroes of Kharkiv Prospect - as well as the area between the turbine plant and the modern public center of the housing estate, which is currently being actively developed.

The Novi Budynky housing estate partially meets the principle of health. Green areas and recreational spaces are largely accessible to residents of all neighborhoods, and the internal network of pedestrian paths is well-developed, promoting physical activity. At the same time, the road network for vehicles fragments the district, and bicycle infrastructure is virtually absent. Air quality improved during the war due to a reduction in traffic flows; however, localized pollution from the use of weapons is observed. Access to medical services is considered adequate, and healthy food is provided by local markets, whereas urban gardening practices are not widespread. Safety in the district has declined during the war; prior to the conflict, it was characterized by adequate street lighting and a positive reputation. Overall, the Novi Budynky housing estate remains relatively environmentally favorable.

## Practical and methodological problems of applying the concept of a 15-minute city to post-Soviet housing estates and case of Novi Budynki

The search for an optimal solution for the system of cultural and consumer services for micro-district populations was carried out until the collapse of the USSR. However, the schemes and calculation methods that were developed and implemented did not ensure the real satisfaction of residents' needs.

Contemporary approaches to the development of residential districts encompass a wide range of urbanistic tools, which enable the creation of flexible, adaptive, and multifunctional spaces tailored to the needs of all population groups. International experience demonstrates that the application of these tools enhances the social resilience of districts, improves residents' quality of life, and promotes public health, including access to green spaces, recreational areas, and sports facilities.

Due to a complex of reasons, primarily related to war and economic constraints, Western models are difficult to implement in post-Soviet cities. For instance, Kharkiv, as a non-capital city, had limited socio-cultural infrastructure during the Soviet period, making it impossible to build a system according to the principles of completeness of public services and reproduction, as proposed by the 15-minute city concept. Under these conditions, the Novi Budynky housing estate received a standard minimal set of institutions to serve the local population.

Reconsideration of the imperfect spatial network of socio-cultural facilities should occur in two ways: bottom-up, reflecting the real needs of residents, and top-down, for example, when forming a network of multifunctional subcenters that strengthen key urban nodes that have historically developed more successfully. Such subcenters should be unique and attractive to people with diverse needs, interests, characteristics, and those with limited mobility [37]. Integration of public health elements, such as medical facilities, rehabilitation centers, sports facilities, and green spaces, will contribute to creating a safe and comfortable environment for residents.

International experience shows that creating a flexible network of subcenters with diverse functions (retail, culture, education, coworking) not only meets local needs but also fosters social interaction and builds resilient communities. Examples include district-level initiatives in Paris, Melbourne's 20-minute neighborhoods, and Shanghai's 15-minute life circles, where subcenters are integrated into the existing urban fabric and take into account the morphological characteristics of the districts.

When considering the potential of the Novi Budynky housing estate for transformation into a 15-minute city, it is important to account for both internal characteristics and the district's place within the broader urban structure. Empty industrial areas near Novi Budynky can be used to create attractive centers of gravity, and rehabilitating such abandoned spaces can facilitate the formation of new subcenters both within the district and within walking distance on the periphery. Growth should focus not only on commercial establishments, which organically generate urban activity, but primarily on facilities that ensure health, social cohesion, safety, and the enhancement of urban nature.

The main problems and potential growth points of the district include:

- The medical network is fragmented and partially commercialized, limiting access to healthcare services for all residents.
- Low socio-cultural content, represented by cinemas, libraries, sports facilities, commercial sports clubs, children's entertainment centers, and religious buildings.
- A large number of abandoned industrial buildings have potential for conversion into creative hubs, coworking spaces, social housing, and offices, providing jobs for local residents. Currently, these sites remain unsafe and largely inaccessible to the general public.
- The urban environment inaccessible to all categories of the population
- The methodological issue of extending functions to "empty" areas and minimizing negative consequences should be considered in the context of the impact of a new subcenter on the existing urban fabric of the Novi Budynky housing estate. This approach would contribute to the capitalization of the area, create an attractive investment climate, and introduce new functional elements that enhance safety and residents' comfort.

Implementing the 15-minute city concept with optimal conditions for comfortable stay and mobility for people with diverse needs requires interdisciplinary research, discussions, project development, and workshops. Detailed sociological

and anthropological studies are needed to determine the district's population composition. Investment is required both in the development of new subcenters with unique socio-cultural functions and in the district's external infrastructure, designed for users of different groups, interests, and characteristics, including people with limited mobility.

It is essential to involve local residents in the pre-project analysis and the development of project proposals. From a methodological perspective, using participatory planning tools - such as participatory budgeting, resident workshops, and pilot urban interventions - is beneficial. These tools allow concepts to be tested on-site, local practices to be considered, and practically applicable recommendations to be formulated within the specific context of the district.

## Conclusion

The conducted analysis confirmed the proposed hypothesis that the spatial structure of post-socialist housing estates can, at least formally, be interpreted as a potential framework for developing 15-minute cities. At the same time, the study revealed a critical vulnerability: the insufficient focus on building a multi-component public health infrastructure. Functional frameworks, blue-green systems, transport and logistics networks, and even the existing urban morphology require reconsideration from the perspective of supporting and strengthening public health.

As a result of the study:

1. It was established that the formal planning and basic functional structure of the Soviet housing estate demonstrate similarities to the concept of the "15-minute city" in terms of the principle of walkability. The radii of the 5-minute pedestrian zone practically coincide with the isochrones of microdistrict accessibility, while the 10- and 15-minute isochrones indicate that each housing district can be considered as a potential "15-minute city." Within the defined 5–15-minute pedestrian territories, residents' basic needs are, in general, met.
2. The Novi Budynky housing estate, examined as a case study, does not correspond to the contemporary principles of the "15-minute city"; in particular, a discrepancy was revealed with regard to the principles of diversity and a healthy environment. This difference should serve as the basis for the development of regeneration plans for residential areas using a "bottom-up" approach, oriented toward creating comfortable and healthy living conditions.
3. It was determined that the integration of the "15-minute city" concept into post-Soviet housing estates is beneficial for improving public health, as it is capable of combining the development of medical infrastructure with supportive ecological infrastructure. This is of particular importance in housing areas affected by military conflict.
4. Key directions for the sustainable development of the housing estate in line with the principles of the "15-minute city" have been formulated. They envisage the development of "top-down" urban projects aimed at creating a network of multifunctional urban sub-centers with the inclusion of participatory practices.

## References

1. **Couclelis, H.** There will be no post-COVID city. *Environment and Planning B: Urban Analytics and City Science*, 2020, vol. 47, no. 7, p. 1121–1123.
2. **Graham, S.** *The cybercities reader.* London: Routledge, 2004. 350 p.
3. **Marino, R. A., Vargas, E., Flores-García, M.** Impacts of COVID-19 lockdown restrictions on housing and public space use and adaptation: Urban proximity, public health, and vulnerability in three Latin American cities. *COVID-19 pandemic, geospatial information, and community resilience: Global applications and lessons.* Routledge, London, 2021, p. 558–580.
4. **Cellucci, C., Di Sivo, M.** Post-pandemic public space: The challenges for the promotion of well-being and public health in the post-COVID city. *Advances in human factors in architecture, sustainable urban planning and infrastructure: Proceedings of the AHFE 2021 virtual conference*. Springer, Cham, 2021, p. 1–15.
5. **Antonenko, N., Rumilets, T.** COVID-19 and library public space transformations. *ACEE — Architecture Civil Engineering Environment*, 2020, vol. 12, no. 4, p. 5–18.
6. **Barcón, A. R.** Post-COVID city: What are we talking about? Windows of opportunity for a more resilient and egalitarian city. *Finisterra*, 2020, vol. 55, no. 115, p. 237–242.
7. **Moreno, C., Allam, Z., Chabaud, D., et. al.** Introducing the "15-minute city": Sustainability, resilience, and place identity in future post-pandemic cities. *Smart Cities*, 2021, vol. 4, no. 1, p. 93–111.
8. **Pisano, C.** Strategies for post-COVID cities: An insight into Paris En Commun and Milano. *Sustainability*, 2020, vol. 12, no. 15, art. 5883.
9. **State Government of Victoria**. *Plan Melbourne 2017–2050: Metropolitan planning strategy* [online 07.09.2025]. https://www.planning.vic.gov.au/__data/assets/pdf_file/0025/654550/Plan_Melbourne_2017-2050_Strategy_.pdf
10. **Weng, M., Ding, N., Li, J., et. al.** The 15-minute walkable neighborhoods: Measurement, social inequalities, and implications for building healthy communities in urban China. *Journal of Transport & Health*, 2019, vol. 13, p. 259–271.
11. **Allam, Z., Bibri, S. E., Jones, D. S., et. al.** Unpacking the '15-minute city' via 6G, IoT, Digital Twins: Towards a new narrative for increasing urban efficiency, resilience, and sustainability. *Sensors*, 2022, vol. 22, no. 4, art. 1369.
12. **Bouryak, O., Vihdorovich, O., Gayevyi, Y., et. al.** Innovative approaches in the period of mass industrial development (on the example of housing estates of Kharkiv). *IOP Conference Series: Materials Science and Engineering*, 2020, vol. 907, 012013.
13. **Bouryak, O., Lavrentiev, I., Antonenko, N.** Leonid Tyulpa – the architect of the period of mass industrial development. *ZARCH: Journal of Interdisciplinary Studies in Architecture and Urbanism*, 2017, vol. 8, p. 154–169.
14. **Antypenko, H., Antonenko, N., Didenko, K.** Urban transformations of Kharkiv's large housing estates: Novi Budynky and Pavlovo Pole after 1991. *Építés — Építészettudomány*, 2022, vol. 50, no. 1–2, p. 45–63.
15. **Mocák, P., Matlovičová, B., Matlovič, R., et. al.** 15-minute city concept as a sustainable urban development alternative: A brief outline of conceptual frameworks and Slovak cities as a case. *Folia Geographica*, 2022, vol. 64, no. 1, p. 69–82.
16. **Michalska-Żyła, A.** Benefits of implementing the 15-minute city concept in stimulating the potential of social urban resurgence. Acta Universitatis Lodziensis. *Folia Sociologica*, 2023, p. 45–58.
17. **Hess, D. B., Kocaj, A., Gorczyca, K.** Envisioning a transformation of socialist-era housing estates into sustainability-infused eco-villages. *Town Planning Review*, 2024, p. 139-154.
18. **Špirić, A., Đukić, A.** Tensions of urban development in post-socialist cities: The case study of community-based initiative for preservation and transformation of open public space in Banja Luka. *Places and Technologies 2023*, 2024, p. 221-229.
19. **Pásztor, G.** The 15-minute city: Utopia or survival strategy? Opportunities and challenges of chrono-urbanism in post-socialist cities. *Erdélyi Társadalom*, 2025, vol. 23, no. 1, p. 183–194.
20. **Rojas-Rueda, D., Norberciak, M., Morales-Zamora, E.** Advancing health equity through 15-min cities and chrono-urbanism. *Journal of Urban Health*, 2024, vol. 101, no. 3, p. 483–496.
21. **Didenko, C., Bouryak, A., Antonenko, N.** Residential housing in Kharkov (Ukraine) 1920–1935. *ZARCH: Journal of Interdisciplinary Studies in Architecture and Urbanism*, 2016, vol. 5, p. 68–85.
22. **Діденко, К.** Соціально-житлові програми в архітектурі столичного Харкова: монографія. Київ: Publishing House «European Scientific Platform», 2023. 320 p.
23. **Matorin, A.** Housing estate Selection Station. *Stroitel'stvo i Arkhitektura*, 1964, no. 3, p. 8–9.
24. **Kent, J. L., Thompson, S.** Healthy cities. *Understanding Urbanism*. Singapore: Springer, 2020, p. 195–210.
25. **Capasso da Silva, D., King, D. A., Lemar, S.** Accessibility in practice: 20-minute city as a sustainability planning goal. *Sustainability*, 2019, vol. 12, no. 1, art. 129.
26. **Paolini, M.** Manifesto for the reorganisation of the city after COVID-19 [online]. *Degrowth.info* [online 07.09.2025]. https://

degrowth.info/blog/manifesto-for-the-reorganisation-of-the-city-after-covid-19
27. **Wang, T., Li, Y., Chuang, I.-T., Qiao, W., et. al.** Evaluating the 15-minute city paradigm across urban districts: A mobility-based approach in Hamilton, New Zealand. *Cities*, 2024, vol. 151, 105147.
28. **Popescu, I. A., Nicolescu, L.** How 'smart' is the 15-minute city? Evaluating the role of technology in advancing accessibility, mobility, and well-being. *Transportation Research Part A: Policy and Practice*, 2025, vol. 196, 104481.
29. **Vervoort, J., Brown, C., Dunning, R., et. al.** Advancing health equity through 15-min cities and chrono-urbanism: A conceptual framework. *Journal of Urban Health*, 2024, No. 5(101), p. 733–748.
30. **Global Development Research Center.** Healthy cities and the concept of a "15-minute city" [online 07.09.2025]. https://www.gdrc.org/sustdev/health/healthy-15-mts.html
31. **Kireeva, N., Koltsov, Y., Matorin, A.** New housing estate of Kharkiv. *Construction and Architecture*, 1962, no. 9, p. 14–15.
32. **Shpara, P.** *Notes of an architect*. Budinelnyk, 1988.
33. **Ignatov, O., Petrenko, V.** Layout of housing estates. *Stroitel'stvo i Arkhitektura*, 1967, no. 6, p. 15–19.
34. **Archive of Kharkivproekt LLC, Kharkiv.** Novi Budynky housing estate project.
35. **Sowa, P. M.** Transformation of hospital governance in post-Semashko health systems. *Governance of Hospitals in Central and Eastern Europe*. European Observatory on Health Systems and Policies, 2016, p. 97–148.
36. **Duany, A., Steuteville, R.** Defining the 15-minute city [online 07.09.2025]. https://www.cnu.org/publicsquare/2021/02/08/defining-15-minute-city
37. **Pozoukidou, G., Chatziyiannaki, Z.** 15-minute city: Decomposing the new urban planning eutopia. *Sustainability*, 2021.

## Authors

**Nadiia Antonenko**, PhD in Architecture, Assosiate Professor, Department of Information Technologies in Architecture, Faculty of Architecture, Kyiv National University of Construction and Architecture, Ukraine; Post-Doc scholar, at RPTU Kaiserslautern, Chair of Urban Planning, Prof. Dr. Detlef Kurth, funded by vhw Berlin, Germany. E-mail: antonenkonadiia@gmail.com
ORCID: https://orcid.org/0000-0001-9047-3669

**Kateryna Didenko**, PhD in Architecture, Senior Researcher, Institute of Architecture, Faculty of Architecture, Vilnius Gediminas Technical University, Lithuania; Assosiate Professor, Department of Architectural Design Fundamentals, O.M. Beketov Kharkiv National University of Urban Economy, Ukraine. E-mail: kateryna.didenko@vilniustech.lt
ORCID: https://orcid.org/0000-0003-2567-686X

## Kopsavilkums

Pētījumā tiek aktualizēts jautājums par ierastajām idejām attiecībā uz pēcpadomju dzīvojamo māju renovāciju. Ņem vērā jaunās urbānās kustības, kas kļuvušas populāras COVID-19 pandēmijas kontekstā, īpaši konceptu par "15 minūšu pilsētu". Publikācijas mērķis ir identificēt iespējamos metodoloģiskos un teorētiskos pavērsienus pētniecības pieejās, risinot pēcpadomju dzīvojamo rajonu transformāciju saistībā ar jauno hrono-urbanisma koncepciju aktīvu ieviešanu, piemēram, "15 minūšu pilsētas" principu. Lai sasniegtu pētījuma mērķi, tika izmantotas sistematiskas, loģiskas un analītiskas pieejas, lai identificētu mūsdienu kontekstam atbilstošo 15 minūšu pilsētas konceptu kā vienu no iespējamiem instrumentiem pēcpadomju dzīvojamo rajonu renovācijai un revitalizācijai.
Pētījumā izmantota salīdzinošā metode, iekļaujot literatūras un dokumentālo avotu izpēti. Tika veikta arī informācijas sistematizācijas metode, lai apkopotu pētījuma rezultātus. Lauka pētījuma vieta: Novi Budynky dzīvojamais kvartāls Harkovā, uz kura piemēra tika veikta vēsturiskā analīze.
Pētījumā kopumā analizēts, kā konkrētais dzīvojamais rajons atbilst mūsdienīgām idejām par normāliem sociāli kultūras un dzīvošanas apstākļiem, tā jaunajam funkcionālajam saturam, kā arī tika izvērtēts, vai, ņemot vērā izveidoto morfoloģiju un pastāvošo pakalpojumu sistēmu, iespējams ieviest "15 minūšu pilsētas" konceptu. Tika formulēti pirmie soļi, kas varētu tuvināt konkrētā koncepta īstenošanu mūsdienās.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.08

# INTERACTION BETWEEN LANDSCAPE SPACE AND INTERIOR SPACE IN THE ARCHITECTURE OF RECENT EDUCATIONAL BUILDINGS IN LATVIA

**Aija Grietēna[1], Aija Ziemeļniece[2]**

[1] *Grietēns Arhitekti, Latvia*

[2] *Latvia University of Life Sciences and Technologies, Latvia*

**Abstract. This study examines the interaction between landscape space and interior architecture in contemporary Latvian school buildings, highlighting its importance in achieving sustainable spatial integration. It builds on a 2019 study and aligns with current European and global sustainability initiatives. Despite demographic decline, Latvia continues to invest in new school construction and renovation, some of which have received national architectural awards. The research identifies both achievements and shortcomings, especially in interdisciplinary collaboration and the integration of timber architecture, offering recommendations to advance sustainable public architecture in Latvia.**
**Keywords: landscape architecture, architecture, interior, harmony, sustainability**

## Introduction

The present study was developed as an extension to the comprehensive study completed in 2019 entitled "Interaction of landscape space and indoors in architecture of education and art buildings in Latvia" [5] .The relevance of the topic is based on the UN Resolution on Environmental Sustainability in Construction Urban Development [10], since 2022, on the European Commission's new project, "New European Bauhaus" [8], since 2021 and Davos Declaration , since 2018 [4; 11]. The primary aim of architecture is to generate a comprehensive and harmoniously balanced environment across all spatial, functional, and aesthetic dimensions. In contemporary practice, this equilibrium is increasingly challenged, necessitating the restoration of environmental integrity through spatial coherence.

One of the defining trends in current architectural discourse and practice is the dissolution of boundaries between interior and exterior environments, facilitated by the extensive use of transparent, glazed facades. This phenomenon accentuates the need to reconceptualize the relationship between landscape and interior space as an integrated whole [9].

In the past five years, several schools have been built or renovated in Latvia that have received high recognition in the field of architecture within the framework of the annual Latvian Architecture Award competition [2]. The Latvian Annual Architecture Award is one of the most significant professional events in the Latvian architectural environment, which not only highlights the most outstanding architectural achievements, but also promotes the sustainable development of the industry and public awareness of the quality of architecture. The award has been presented since 1995 and is organized by the Latvian Union of Architects in cooperation with the Ministry of Culture of the Republic of Latvia. It is recognized as an event of national significance, and the award itself serves as the highest professional assessment in Latvian architecture. The entries are evaluated by an international jury composed of industry experts based on multifaceted evaluation criteria, including: governance, functionality, economy, contextual relevance, diversity, sense of place and aesthetic quality. Every year, the range of works submitted to the competition offers a concentrated view of current developments in the Latvian architectural landscape – it outlines both the prevailing trends and the most significant challenges and quests [1; 6 ].

Aim of the research – to identify the contributing factors for harmonious interaction of landscape and indoor space in the art of environment formation in Latvia in the segment of educationon buildings.

Research tasks:

1. To uncover the economic, political, and other factors influencing school architecture and construction.
2. To evaluate the interaction of landscape space and indoors through large glazed transparent external surfaces in architecture in the context of typology of socially sensitive public education buildings in Latvian architecture created since 2017.
3. To formulate the factors of harmonious interaction of landscape space and indoors in the art of environment formation in Latvia in the segment of education buildings.

The theoretical and practical significance of the present work is to promote the development of harmonious high-quality spatial environments in Latvia through a better cooperation between architects, landscape architects and interior designers and environments sustainability.

## Materials and Methods

A systematic study has been conducted in Latvia, examining the interaction of landscape and interior design in socially sensitive educational buildings, especially those that have received high recognition in the prestigious Latvian Architecture of the Year Award competition since 2019.

In stage 1 the main methods applied are the comparative analysis and graphoanalytical method. In stage 2 the main methods applied are the comparative analysis and the survey method. In stage 3 the qualitative analysis, graphoanalytical and inductive cognitive methods. Each object in nature is evaluated from multiple viewpoints and perspectives from March 2024 to October 2025 in two main directions:

- Viewing from the interior space to the landscape space.
- Viewing from the landscape space to the interior space through architecture.

The information gathered serves as the obtained data. Additionally, the use of materials and the sustainability of the object are evaluated.

*The application of comparative method in summarizing information for the research* [6].

- The criteria for evaluating psycho-emotional interaction of indoor space and landscape:
  - evaluation of spatial composition and proportions of glazed surfaces versus non-glazed parts;
  - evaluation of compositional application of colour, light and shadow impacted by sunlight;
  - evaluation of visual accents created by chiaroscuro;
  - evaluation of visual merging of indoor space and landscape.
- Evaluation of architectural forms in landscape.

## Results and Discussion

The number of students in Latvia has noticeably changed over the past 100 years, depending on political and economic factors in the country. It peaked at around 300,000 students during the period from 1970 to 1990 when populations from

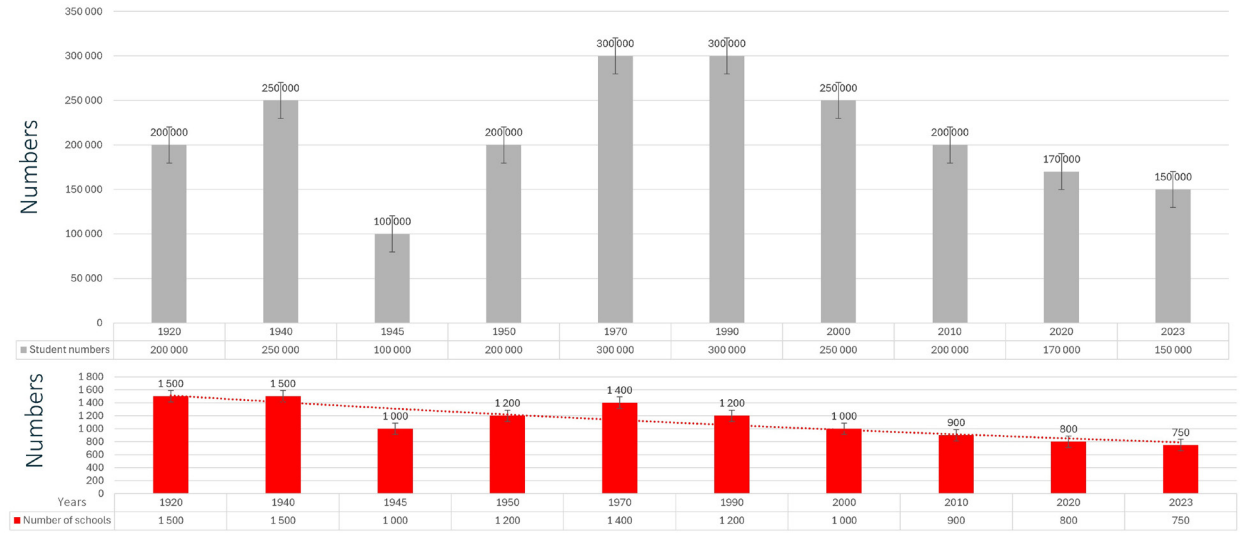



Fig.1. The dynamics of student numbers and number of schools in Latvia over the past 100 years [graphs developed by the author and AI, 2025, based on data from the Central Statistics Database


Fig. 2. Geographical location of examined objects in the map of Latvia [created by the author from electronic resources, 2025]

former Soviet territories were artificially introduced into Latvia, and dropped to 100,000 students during World War II. However, in the past 50 years, the number of students in Latvia has continued to decrease. With a steady student population of 200,000 in 1920, there were 1,500 schools, 1,200 schools in 1950, and only 900 schools by 2010. The number of schools in Latvia continues to decrease significantly, not only due to the decline in birth rates but also because of the education reform School 2030 and to the administrative territorial reform, which focuses on competency-based education and skills, as well as the closure of smaller schools and the concentration of students in larger schools. The number of schools is also clearly influenced by political and economic factors, and despite some fluctuations, the overall trend over the past 100 years has been a steady decline in the number of schools, decreasing by 50% from 1,500 schools in 1920 to 750 schools in 2023 [7] (Fig 1). Despite the declining number of students and schools, Latvia is not only renovating existing schools but also building new ones.

In the past four years, 241 schools have been reformed in Latvia [3]. Among them, several have received high recognition in architecture [2]. The geographical distribution of the studied objects on the map of Latvia shows the concentration of schools that have won the Latvian Architecture Award since 2017 – new buildings and one reconstruction around the capital city and reconstructions in the Kurzeme region (Fig 2). Schools that have been recognized in the last five years within the framework of the Latvian Architecture Award of the Year (Fig 2):

- Reconstruction of Kuldīga Technology and Tourism Technical School – Special Award of the International Jury (2024).
- Reconstruction of Liepāja State Gymnasium No. 1 – Grand Prize of the Year (2018).
- Mārupe Music and Art School – Semi-Finalist (2023).
- New building of Exuperi International Primary School – Finalists (2017).
- New building of Exuperi International Secondary School with Boarding School – Finalists (2024).
- New building of Ogre State Gymnasium – Semi – Finalist (2023).

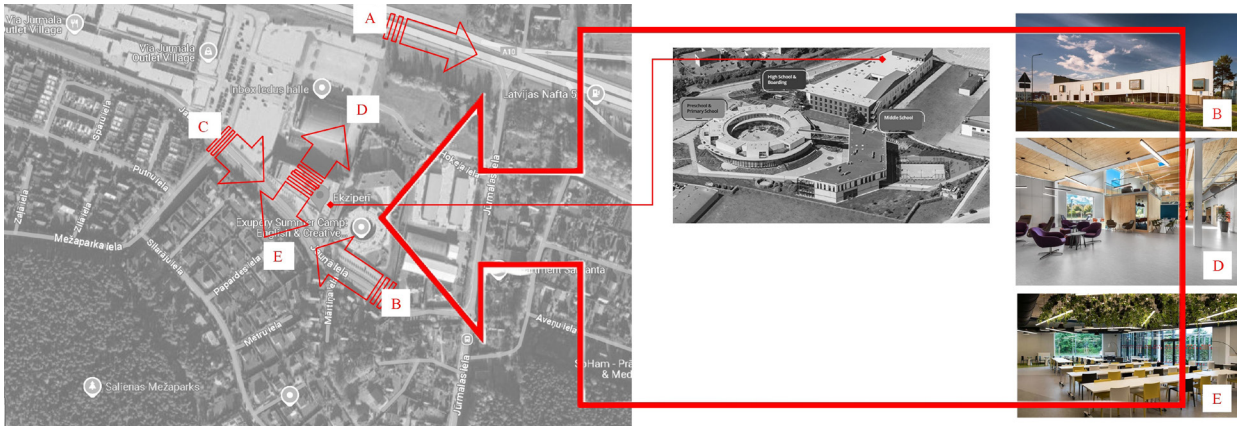



Fig. 3. Evaluation of views lines and points , example- new buidings of the Exupery International high school in Piņķi [created by the author, 2025 (photography – google.lv/ maps, photos created by the I. Stūrmanis, K. Loris]

TABLE 1

Comparative compilation of separate data matrices into a single matrix of percentages of psycho–emotional evaluation of researched buildings and average qualitative assessments by 6 architecture experts (on a scale from 1 to 100 %) [created by the author, 2025]

| Serial No. | TYPOLOGICAL BREAKDOWN OF BUILDINGS | OBJECTS OF THE RESEARCH | CRITERIA: THE CRITERIA FOR EVALUATION OF THE PSYCHO-EMOTIONAL INTERACTIVITY OF INDOORS AND LANDSCAPE SPACE: EVALUATION OF THE SPATIAL COMPOSITION AND PROPORTIONS OF THE GLAZED SURFACES VERSUS THE NON-GLAZED PART | EVALUATION OF THE COMPOSITIONAL APPLICATION OF COLOUR, LIGHT AND SHADOW IMPACTED BY THE SUNLIGHT | EVALUATION OF THE USAGE OF VISUAL ACCENTS CREATED BY THE PLAY OF LIGHT AND SHADOW | EVALUATION OF THE VISUAL MERGE OF INDOORS AND LANDSCAPE SPACE | AVERAGE ASSESSMENT OF THE USE OF GLAZED AREAS IN ARCHITECTURE | EVALUATION OF THE ARCHITECTUEAL SHAPE OF THE BUILDING IN LANDSCAPE SPACE | AVERAGE PSYCHOEMOTIONAL ASSESSMENT OF COMPOSITIONAL STRUCTURE | GOOGLE MAPS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. | RECONSTRUCTIONS | TECHNOLOGY AND TOURISM TECHNICAL SCHOOL | 80 | 100 | 90 | 80 | **88** | 100 | **94** | |
| 2. | | THE LIEPAJA STATE GYMNASIUM | 96 | 100 | 96 | 92 | **96** | 100 | **98** | |
| 3. | | THE MĀRUPE MUSIC AND ART SCHOOL | 98 | 80 | 78 | 80 | **84** | 60 | **72** | |
| 4. | NEW BUILINGS | THE EXUPERY INTERNATIONAL PRESCHOOL AND PRIMERY SCHOOL IN PIŅĶI | 100 | 100 | 98 | 100 | **100** | 100 | **100** | |
| 5. | | THE EXUPERY INTERNATIONAL HIGH SCHOOL AND BOARDING IN PIŅĶI | 100 | 100 | 96 | 100 | **99** | 100 | **100** | |
| 6. | | THE OGRE STATE GYMNASIUM | 96 | 98 | 82 | 100 | **94** | 76 | **85** | |
| | | AVERAGE | **95** | **96** | **90** | **92** | **93** | **89** | **91** | |

TABLE 2

Interaction of landscape and indoor space in visual perception. View points from indoors space towards landscape
[created by the author, 2025]

| Serial No. | TYPOLOGICAL BREAKDOWN OF | THE CRITERIA FOR EVALUATION OF THE PSYCHO-EMOTIONAL INTERACTIVITY OF INDOORS AND LANDSCAPE SPACE | |
|---|---|---|---|
| | | EVALUATION OF THE SPATIAL COMPOSITION AND PROPORTIONS OF THE GLAZED SURFACES VERSUS THE NON-GLAZED PART | EVALUATION OF THE COMPOSITIONAL APPLICATION OF COLOUR, LIGHT AND SHADOW IMPACTED BY THE SUNLIGHT |
| 1. | RECONSTRUCTIONS | The original rhythmic window proportions have been preserved in the historical building - different on each of the three floors. In the new extension, the window arrangement is strictly rhythmic and the window proportions are extended and the same on all floors. | The rhythmic window division creates a rhythmic play of light under the influence of the sun. At a narrow angle of the sun's rays, the rooms acquire warm tones. The widely glazed entrance motif on the 1st floor creates a wide view of sunlight at sunrise. |
| 2. | | The relationship preserves the historical (1912) division, which is psycho-emotionally customary and approved over generations. | The rhythmic division of windows creates rhythmic play of light and shadow in the rooms. The deep window openings and the ornate window moldings have a strong visual impact, softening the play of light and shadow. |
| 3. | | The four-story volume of the building is divided into a wide glazed strip on the first floor and a dynamically rhythmic window line on the upper floors. The division of windows, together with the facade, is designed like music (according to the author's idea). The glazed part, in proportion to the unglazed part, emphasizes the functions of the interior. | The long facades of the building's elongated volume are predominantly oriented in the north and south directions. The play of light and shadow is more expressive in the windows adjacent to the south facade, for example in the hall, where the windows are located on two levels. The rhythmic splay of the widely glazed north facade of the 1st floor creates rhythmic light and shadow. |
| 4. | NEW BUILINGS | In the cylindrical building volume, the glazing part on the 1st floor is maximally wide, on the 2nd floor the glazing is proportionally less than on the facade of the closed part. The air passage between the bodies is completely glazed, leaving only the floors and ceilings unglazed. In the rhomboid body, the glazing against the unglazed part is the smallest part. Large glazed areas from ground level to the roofs are in one corner of the building and in the central part, the rest of the glazing is formed by a rhythmic division of windows at the level of the third floor. | The play of light and shadow is created not only on the facade glazing, but also indoors by the eye-shaped cutouts in the wide overhang of the 2nd floor balcony and the rhythmic striation of the glazing. |
| 5. | | The proportion of glazing to non-glazed parts of the building is slightly smaller. The proportion varies on a balanced way on different facades. | The play of light and shadow created by the sun through the picture windows creates illuminated areas in the open space layout that emphasize specific functions and correspond to the furniture layout. |
| 6. | | The proportion of glazing in the non-glazed part of the facades is smaller. The main facade is decorated with two glazed, dynamic entrance motifs. But the other facades are mainly made up of sash windows, except for the vertical windows facing the courtyard. | The building entrance motifs are created in the original glazing composition. The central, compositional and functional block of the building plan is formed by an atrium with a skylight and an inner courtyard. The skylight creates a play of light and shade in the atrium under the influence of sunlight. The inner courtyard is visually partially connected to the interior through glazed vertical stripes, which create a play of light and shade in the interior. The glazing of the classrooms onto the hallway provides increased natural lighting. |

TABLE 3

Interaction of landscape and indoor space in visual perception. View points from indoors space towards landscape [created by the author, 2025]

| Serial No. | TYPOLOGICAL BREAKDOWN OF | THE CRITERIA FOR EVALUATION OF THE PSYCHO-EMOTIONAL INTERACTIVITY OF INDOORS AND LANDSCAPE SPACE | |
|---|---|---|---|
| | | EVALUATION OF THE VISUAL MERGE OF INDOORS AND LANDSCAPE SPACE | MOST CHARACTERISTIC INDOOR VIEWS |
| 1. | RECONSTRUCTIONS | The interior form a harmonious interaction in the east of the building with the landscape space of the baltic teachers' seminar park. The silhouette of large trees in winter and the foliage in summer create a psycho-emotionally balancing effect. The interior form a western interaction with the east facade of the kuldiga needle factory building, which adjacent to the line of kalpaka street. Due to the set-away of the technical school building from the street line, the row of large trees in front of the facade and the car parks, the density of the |  |
| 2. | | Thanks to the planting of large trees along the outer perimeter of the building, despite the relatively dense construction, a harmonious interaction between the interior and landscape space is created. Even in the winter, the silhouettes of the tree branches soften the spatial fusion, respecting the privacy of all users of the environment in both directions. |   |
| 3. | | A valuable factor of harmonious interaction is the pine forest next to the building, which surrounds it on two sides. Nature merges with the interior through the wide glazed planes, creating a psycho-emotionally calming atmosphere, which is vital for sensitive learning of art and music. Two facades, which open through the glazed planes onto agricultural areas, buildings and some tree plantations, create a less valuable interaction. | |
| 4. | NEW BUILINGS | The interaction between the interior and the landscape space flows harmoniously in both directions, thanks to the appropriately arranged landscape space and greenery, which form a common synthesis with the interior and architecture of the interior. The layout and architecture of the interior are based on the specificity of the educational process, openness and cooperation. The specific example demonstrates the harmonious interaction of the new learning process and the environment. |  |
| 5. | | The wider fusion of the landscape space and the interior through the wide glazed external universes is observed in the most active public transit zones and creates a harmonious spatial interaction. In turn, the individual windows serve as picture frames for works of art, in which the greenery of the landscape space serves as the object of art. |  |
| 6. | | The school has three floors, and its layout is designed to provide a sense of spaciousness and a connection between the landscape space and the interior. The surrounding forest landscape with the interior spaces through wide glazed planes creates a psycho-emotional harmonious way. In the hallway of the second floor, open recreation areas have been arranged in the free areas along the courtyard facade with a view of the central courtyard. The closed courtyard is not intended for greenery. |  |

TABLE 4

Interaction of landscape and indoor space in visual perception. View points from indoors space towards landscape and vice versa [created by the author, 2025]

| Serial No. | TYPOLOGICAL BREAKDOWN OF BUILDINGS | EVALUATION OF THE USAGE OF VISUAL ACCENTS CREATED BY THE PLAY OF LIGHT AND SHADOW | EVALUATION OF THE ARCHITECTURAL SHAPE OF THE BUILDING IN LANDSCAPE SPACE |
|---|---|---|---|
| 1. | RECONSTRUCTIONS | The widely glazed entrance motif on the eastern facade of the building accentuates the building entrance in the light of the morning sun, making the school hall at the entrance light and psycho-emotionally warm. | The historical body of the building with the new extensions fits perfectly into the low-rise buildings of the old town of Kuldīga, creating a harmonious interaction with it. The proportionate proportions of the windows do not create challenges in the interaction of the landscape space and the interior. Wider glazing is used only for the entrance motif of the building's courtyard, which harmoniously visually merges the school courtyard with the entrance hall. |
| 2. | | The principle of symmetry (windows in the great hall), the principle of the central axis (windows, glazed doors at the ends of the corridors) and the principle of rhythm (windows in the classrooms) in the arrangement of windows organize the interior spaces through accents created by light and shadow. | The richly decorated volume of the building, which adjoins Ausekļa Street, stands out from the neighboring Kūrmājas Street. The surrounding 4-5-story historical buildings densely surround the gymnasium building. However, individual trees in the lawn opposite the main facade across Ausekļa Street and around the building deeper into the territory create a balancing background. The building's inner courtyard is strictly marked by the building volumes. Thanks to the historical window division and projections, the interaction of the landscape space and the interior space creates a psycho-emotionally harmonious balance. |
| 3. | | The dynamically rhythmic arrangement of windows in the plastic facade creates unconventional light and shadow accents in the larger rooms. | The four-story building volume (before the reconstruction it was two-story) aggressively rises in a sparsely populated low-rise residential and industrial production areas. The main facade of the building adjoins Mazcenu Alley. Across the street is a pine forest. One end of the facade tends to taper unsuccessfully to the perpendicular street. In front of the main facade is a small curved forecourt with a lawn and low greenery. The first floor of the building is formed by a wide glazed, recessed strip, thanks to which the landscape space and the interior flow into each other. At a certain angle, the adjacent forest is reflected in the glazed facade panels. |
| 4. | NEW BUILINGS | Sunlight, thanks to the wide glazed external planes and open internal layouts, smoothly accentuates one zone after another throughout the day, creating a psycho-emotionally warm environment for younger children. The internal glazed atrium is ensured by the presence of sunlight throughout the sunny days. | The two-story cylindrical building volume of the school is inscribed in a low-rise mixed-use building, which is relatively sparse. The specific large glazed building volume is connected by a glazed tunnel on the 2nd floor level with the second building volume, which is formed by a two-diamond block. The interior spaces of the glazed building volumes create active communication with the public street space through thoughtful greenery and a landscaping strip. Similarly, a strong spatial synthesis is formed in the round courtyard, thanks to a specially manicured garden. Thanks to the close collaboration of architects, interior designers and landscape architects, a unified, harmoniously high-quality environment has been created, which flows from the landscape space to the interior spaces and vice versa. |
| 5. | | Solar accents highlight functional furniture groups in the rooms. For example, discussion and relaxation areas. | The linear building volume of the university is the 2nd phase of the Exupery school. It is more restrained in glazing than the adjacent glazed cylindrical building volume from the 1st phase. Only the entrance area of the 1st floor is extensively glazed. The rest of the facade is playfully played with square window volumes, placed at different depths in relation to the street facade like paintings. The courtyard facades are decorated mainly with emphasized functional, rhythmic window areas. The facades that open onto the inner courtyard are extensively glazed. The landscaping of the inner courtyard garden is also kept in a restrained minimalist style. Psycho-emotionally, the interior spaces and the landscape space create a balanced interaction, thanks to the spacious territory and thoughtful greenery. |
| 6. | | Accents of lighting created by the sun can be read under the skylight in the hall, in rooms adjacent to the atrium, and in individual classrooms. | The expressive architecture of the school building volume contrasts strongly with the surrounding forest landscape and low-rise mixed-use development that surrounds the building. The main facade, which adjoins G.Asara Street, is visually separated from the building across the street by a row of trees, supplemented with new plantings. The wide glazed motifs of the two entrances on the southern facade of the building emphasize the spatial interaction in a dynamic way. |

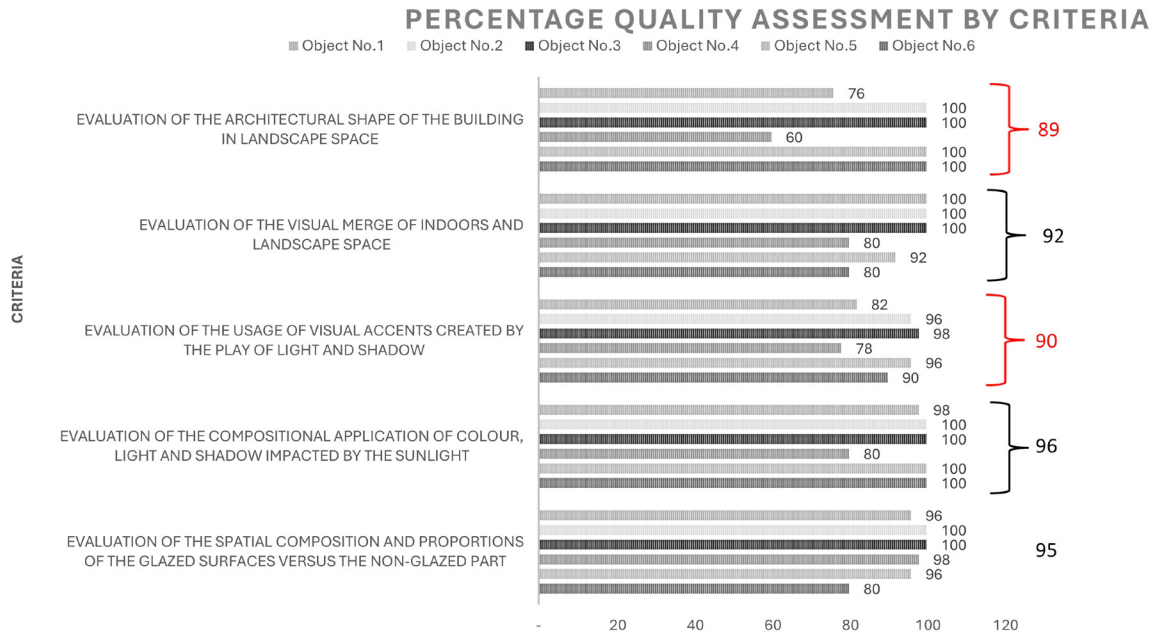



Fig. 4. Graphical representation of the data matrix – percentage quality assessment by criteria [created by the author, 2025]

Among the highly praised schools is the sustainably designed wooden school by Latvian architects Lauder Architects, which was not built in Latvia, but in Estonia – the Sillamae school – a finalist (2024) [2]. This particular school is unique because it is entirely built with wooden load-bearing structures. To date, no such sustainable school buildings have yet been constructed in Latvia.

Each object in nature is evaluated from multiple viewpoints and perspectives in two main directions: viewing from the interior space to the landscape space and viewing from the landscape space to the interior space through architecture (Fig. 3).

The information gathered serves as the obtained data (TABLE 1; 2; 3; 4). Additionally, the use of materials and the sustainability of the object are evaluated.

The percentage evaluation was conducted by summarizing the assessments of 6 architecture experts, and shows lower scores in two criteria (Fig. 4):

1. Evaluation of the usage of visual accents created by the play of light and shadow.
2. Evaluation of the architctural shape of the building in l anscape space.

The only school with full wooden load-bearing structures designed by Latvian architects was built in Estonia. At the beginning of 2025, P. Grietēns and M. I. Valainis conducted a survey of Latvian experts as part of their research to find out what are the discouraging factors for the construction of wood in Latvia and how the situation could be improved in the future. Use of timber in Latvia is hindered by regulations and market conditions. Expert recommendations:

- Revise current fire safety regulations.
- Train highly qualified professionals.
- Promote local timber construction industry.
- Develop successful and expressive public pilot projects.
- Provide state support (tax relief, subsidies) to lower construction costs and enhance competitiveness of timber.

## Conclusions

The findings of the research allow drawing several key conclusions regarding the interaction between architecture, landscape, and the learning environment in Latvia.

1. The development of the Latvian educational system is supported by an increasing orientation toward sustainable architectural stylistics, ensuring that the evolution of school architecture resonates with the principles of Bauhaus.
2. The architectural language of school buildings and their interaction with the surrounding landscape play a significant psycho-emotional role in the development of children and young people. The presence of green areas around schools fosters experiential learning about nature—not only through the planting of lindens, oaks, birches, and ornamental shrubs, but also by establishing apple orchards, berry gardens, and strawberry beds. Such practices encourage exploration of the environment beyond the interior school space.
3. The study highlights the artistic mastery of Latvian architects in the design of individual school buildings; however, the pursuit of coherence with principles of "green thinking" is often underrepresented. The spatial and compositional language of built volumes tends to be detached from adjacent green areas.
4. The findings suggest that a stronger spatial interaction between architectural form and the green environment directly contributes to a higher overall quality of landscape space.
5. Given Latvia's northern geographic location and its long winter period extending from November until early May, light emerges as a critical factor in school architecture. Beyond fulfilling normative requirements for insolation, the integration of outdoor and indoor spaces through large glazed surfaces enhances both visual and spatial continuity.
6. The research demonstrates that spatial synthesis between landscape, architectural form, and interior space creates visual and psycho-emotional interactions that respect and reflect the mentality of northern societies.
7. School buildings located in cultural and historical structures also inherit the cultural landscape of their context (parks, gardens, ceremonial courtyards, alleys), thereby strengthening the perception of cultural identuty.

## References

1. *Arhitektūra un kultūrpolitika Latvijā* [tiešsaiste]. Latvijas arhitektūras politika 2020 [skatīts 7.02.2020]. https://www.latarh.lv/f/Latvijas%20arhitekturas%20politika%202020_pa%20lapam.pdf
2. *Arhīvs. Latvijas Arhitektūras gada balva* [skatīts 11.10.2024]. https: https://www.latarh.lv/konkursi/arhivs
3. **Auzāns, A.** *Četros gados reformēta 241 skola.* Vai skolu tīkls beidzot ir savests kārtībā? Delfi Plus [skatīts 20.11.2024]. https://www.delfi.lv/video/56419816/projekts-43/120068374/cetros-gados-reformeta-241-skola-vai-skolu-tikls-beidzot-ir-savests-kartiba
4. *Baukultur un Davosas deklarācija* [tiešsaiste]. Latvijas arhitektūras politika 2020 [skatīts 7.02.2020]. https://www.latarh.lv/f/Latvijas%20arhitekturas%20politika%202020_pa%20lapam.pdf
5. **Grietēna, A.; Ziemeļniece, A.; Īle, U.** The interactivity of the landscape space and interiors in the architecture of the Latvian education and art buildings of the 20th/21st century. *Landscape Architecture and Art.* 2017, V 11, p. 15-22.
6. *Latvijas Arhitetūras gada balva. Par konkursu* [tiešsaiste]. Latvijas Arhitektu savienība [skatīts 11.10.2024]. https://www.latarh.lv/gada-balva/par-konkursu
7. *Latvijas oficiālā statistika* [tiešsaiste]. Oficiālais statistikas portāls [skatīts 10.11.2024]. https://stat.gov.lv/lv
8. *New European Bauhaus* [tiešsaiste]. European Union. [skatīts 09.0902024] https://new-european-bauhaus.europa.eu/about/about-initiative_en
9. **Skinner, P.** *Reflections on Inside-Outside Space* [cited 11.09.2020.]. https://espace.library.uq.edu.au/data/UQ_3545/insideoutsidetext.pdf?Expires=1548959072&Signature=ZEAsLcwvV389BveVI5DV5RxFiSqTzRu4-FTzJjLr4ErwSSV1T0jcJgbrsQA~M8OpmPpvUyKaQVEgTIdVYEhFyKwTcBHvO~1ogSyYf05Sl1NjIW09If6EtCrtpYXHM7hDXr1PXhMRUXPZCPmqKK0YN739mQYS-0VDqM84oQfP5YnA3xpbirvNetBWF273ISZ5qWev~vXEmgGtRS1LodavRbNiPTjjFLG4s0mnxcJcpxvOCDI4rYcCbKoUuGs-6pWaEGbFkjtHDW70WuZi7~fOchhJYCB02Ma1KBiEBq3rVgDk-ZI7j3gPLwDPEC7bWXUtBq2PmYK0x7ws66waIHWuvA__&Key-Pair-Id=APKAJKNBJ4MJBJNC6NLQ.
10. *UNEP -UN Environment Assembly 5 (UNEA 5.2) Resolutions*. UN environment programme [skatīts 01.09.2024]. https://documents.un.org/doc/undoc/gen/n24/419/22/pdf/n2441922.pdf
11. *UNESCO World Heritage Centre* [skatīts 12.-10.2024] https://whc.unesco.org/en/news/1773

## Authors

**Aija Grietēna**, Dr. arch., member of the executive board company, certified architect and scientific researcher at Grietēns Arhitekti. Field of research: interaction of landscape space and indoors in architecture. E-mail: aijagrietena@gmail.com

**Aija Ziemeļniece**, Dr. arch., is an editor of the internationally cited journal Landscape Architecture and Art (https://journals.llu.lv/laa). She is a Professor at the Department of Landscape Architecture and Planning of Latvia University of Life Sciences and Technologies. E-mail: aija@k-projekts.lv
ORCID ID: https://orcid.org/0000-0001-7096-5850

## Kopsavilkums

Pētījums aplūko mūsdienu Latvijas skolu arhitektūrā novērojamo ainavas un iekštelpas mijiedarbību, uzsverot tās nozīmi ilgtspējīgas vides veidošanā. Tas balstīts 2019. gada pētījuma turpinājumā un saistīts ar globālām iniciatīvām, piemēram, Jauno Eiropas Bauhausu. Mūsdienu arhitektūrā novērojama tendence nojaukt robežas starp iekštelpu un ārtelpu, izmantojot plašus stiklojumus un caurredzamas fasādes. Latvijā, neskatoties uz skolēnu skaita samazināšanos, pēdējos gados uzbūvētas vai renovētas vairākas arhitektūras balvas saņēmušas skolas. Tās atrodas gan Rīgas apkārtnē, gan Kurzemes reģionā, kur ticis respektēts kultūrvēsturiskais mantojums. Jaunajos projektos novērojama telpiska integrācija un funkcionāli pielāgoti risinājumi, taču eksperti norāda uz nepieciešamību stiprināt gaismas un ēnu akcentu izmantojumu, kā arī uzlabot arhitektūras formu integrāciju ainavu telpā. Igaunijā uzbūvēta viena no ilgtspējīgākajām skolām ar koka nesošo konstrukciju, kuru projektējuši Latvijas arhitekti – šādi objekti Latvijā vēl nav uzbūvēti. Kā galvenie ierobežojošie faktori minēti normatīvie akti, kvalificēta darbaspēka trūkums un atkarība no importa. Tādēļ eksperti iesaka pārskatīt regulējumus, attīstīt vietējo ražošanu, veidot paraugprojektus un nodrošināt valsts atbalstu. Pētījums uzsver starpdisciplināras sadarbības nozīmi nākotnes arhitektūrā un nepieciešamību integrēt dabas klātbūtni pilsētvidē.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.09

# ARCHITECTURE UNDER OCCUPATION: THE DEVELOPMENT OF PUBLIC AND RESIDENTIAL STRUCTURES IN GERMAN–OCCUPIED LITHUANIA (1941–1944)

**Evaldas Vilkončius**

*Kaunas University of Technology, Lithuania*

**Abstract. The German occupation of Lithuania, which lasted from 1941 to 1944, was a period that affected all areas of life, including architecture and construction. Thus, the aim of this paper is to present a short, yet dramatic and difficult period in the history of Lithuanian architecture – the development and transformation of public and residential structures amidst the German occupation. The research is based on the study of archival material, literature, and periodicals of that period, as well as recent works on this topic, while the text is supplemented with the design projects of public and residential structures. The article demonstrates that even under the conditions of the German occupation, there was still a strong emphasis on developing public and residential architecture in Lithuania, and the processes regarding the matter were quite actively taking place. As most of the planned structures were not realized at that time, the article assumes that architectural activity during that time can be identified only with the compilation of plans for the needed construction, the development of civil building projects, and theoretical discussions regarding the stylistic properties of Lithuanian architecture.**
**Keywords: Lithuanian architecture; public architecture; residential architecture; wartime architecture; wartime construction**

## Introduction

The beginning of the 1940s was a difficult period for Lithuania. After more than twenty years of independence, the young country was occupied by the Soviet Union in June 1940. A year later, the occupation ended when the war between Nazi Germany and the Soviet Union began. To take advantage of the situation and try to restore independence, the June Uprising began in Lithuania. Also, the Provisional Government of Lithuania was formed, which made efforts to restore the country's structure prior to the Soviet occupation. However, Nazi Germany, which occupied Lithuania, did not support Lithuania's aspirations for independence. Therefore, in the summer of 1941, "the country, called Generalbezirk Litauen ("General District Lithuania"), became one of the four parts of the Reichskommissariat Ostland" [8]. Consequently, as the Germans began to create their own government bodies, the Provisional Government of Lithuania resigned in August 1941. It was replaced by the Administrations of General Advisers, which were subordinate to the Germans who occupied most of the country until the summer of 1944.

Despite the failed aspirations to restore independence, there was a great need to normalize the war–disrupted fields of architecture and construction, and efforts were made to develop it to the greatest extent possible. This was also decided by the need to rebuild the cities and towns, which were damaged during battles between the armies of Nazi Germany and the Soviet Union in the summer of 1941. Thus, it was stressed by the local Lithuanian authorities that "the war almost completely burned or destroyed about thirty cities and several dozen villages, and numerous individual buildings. To rebuild the country <...> the technical forces, resources and labor of the entire country must be mobilized at once. <...> The work is difficult, as it must be done very quickly. However, haste cannot overshadow the purposefulness and efficiency of the work" [43].

However, the architectural processes of the German occupation period in Lithuania are not a widely researched topic, but there are a number of historical sources and data to present this topic. For example, an important information for this topic is provided in the memoirs of architects and engineers who worked in Lithuania at that time [4], [21]. As well as in historical outlines covering, for example, the education of architects and engineers in the country at that time [26]. Moreover, a number of primary sources are preserved in the Lithuanian archives, covering the processes of architectural development during the German occupation period, construction plans at that time and documentation of planned buildings. Information on this topic can also be found in the local periodicals of that time. Therefore, based on these sources, the article aims to present the still little known, yet dramatic period of Lithuanian architecture.

The article consists of the three main parts, which can provide a better understanding on how the public and residential structures were developed in German-occupied Lithuania in 1941–1944. First, the article delves into how the construction and design matters were reorganized, coordinated, and administered in Lithuania through the course of this period. Secondly, the research outlines the principal building types of public and residential architecture, which were designed and proposed to be constructed amidst the occupation and identifies the chief institutions that initiated it. Lastly, the article analyses the stylistic diversity and characteristics of the planned constructions, as well as the theoretical debates regarding the matter that arose during that period.

## Reorganization of the design and construction matters

The processes that led to the reorganization of the design and building construction matters in Lithuania began at the beginning of the war between Nazi Germany and the Soviet Union. A part of them were initiated by the Ministry of Public Utilities, which was part of the Provisional Government of Lithuania. The short–lived Ministry began operating in July 1941 in place of the liquidated People's Commissariat of Public Utilities of Lithuanian SSR, which had been established during the Soviet occupation [43]. The primary task that the Ministry sought to implement at that time, was the aspiration to establish the principal central body that could administrate the architectural and construction matters in Lithuania. It was similarly done during the years of Lithuanian independence, when the central institution, Construction and Roads Inspection, which administered the country's civil architecture and construction matters, had operated under the Ministry of Internal Affairs. Thus, it was planned that by establishing one "strong technical organization," the reconstruction of Lithuanian cities and the management of architecture and construction would proceed more effectively during the German occupation [43].

After the Ministry of Public Utilities was abolished at the end of the summer of 1941, the establishment of the local central architecture and construction institution in Lithuania was taken over by the Administration of the General Adviser for Internal Affairs, which was subordinate to the German–founded higher–level institution, the Chief Construction

Administration in Lithuania [21]. In the autumn of the same year, after the liquidation of the construction and design office for communal objects "Komprojektas" established during the Soviet era, the Chief Construction Board of Lithuania was established in Kaunas. The Board, which operated until the end of the German Occupation, consisted of the Urban Planning, Building Construction and Civil Engineering Directorates. Thus, according to the approved statute, the institution was entrusted with the handling of "construction, urban planning, architectural matters, urban land use, urban planning, housing management, the creation of housing colonies, construction rationalization and standardization, statistics, inventory and formation of the construction policy" in occupied Lithuania [44]. The institution was also engaged in building design and issued permits for professional work to architectural and construction specialists. Therefore, the Chief Construction Board of Lithuania had a wide competence in the field, which was valid "as long as it did not belong to German institutions" [37]. However, the Chief Construction Board itself was subordinate to the Administration of the General Adviser of Internal Affairs, later to the institution of the General Adviser of Engineering and Communications.

Additionally, the institutions of architecture and construction, which operated in independent Lithuania, also began to be restored. For example, in place of the liquidated People's Commissariat of Local Industry of Lithuanian SSR, its Industrial Construction Trust and design office "Pramprojektas", the construction and design company "Statyba", which operated in Lithuania in 1935–1940, was restored [22]. The restored company which operated in Kaunas, and had branches in Vilnius, Šiauliai and Panevėžys, designed and constructed various industrial structures and large public buildings [3]. Furthermore, to reorganize the construction and design matters in Lithuanian villages and rural regions, the design office "Agricultural Construction" of the People's Commissariat of Agriculture of Lithuanian SSR was liquidated [22]. In place of it, the Construction Department of the Chamber of Agriculture, which operated in the years of Lithuania's independence, was restored. It was later renamed into the Agricultural Construction Direction and was assigned to the Administration for Agriculture, subordinate to the General Adviser of Agriculture [25].

The administration and management of architectural and construction fields in German–occupied Lithuania were also conducted by the county and city municipalities that operated during the years of independence, which began to be restored in the summer of 1941 [21]. As before, the local Construction Departments began to operate within the restored municipalities, which carried out design work for municipal and private buildings, issued building permits in counties and cities, and supervised the local civil construction [37]. In some instances, the departments were headed by the same local architects and engineers who had held these positions in the late 1930s.

Thus, at the end of 1941, the principal institutions responsible for the administration and implementation of civil construction matters were established in occupied Lithuania. Although they operated under individual statutes, their activities were supervised by the German institutions, such as the General Commissioners' Administration and the Chief Construction Administration in Lithuania. Therefore, the Lithuanian architectural and construction institutions had to coordinate their activities with the orders and decrees compiled by the German institutions, the early ones of which related to these matters were issued during the first months of the occupation [34].

However, throughout the German occupation, these institutions operated with a great shortage of qualified specialists. This was due to both the deportations of Lithuanians initiated by the Soviet Union in June 1941, and the anti–Semitic policies imposed by Nazi Germany later that year. For example, in September 1940, almost eight hundred architects, civil engineers and construction technicians were registered in Lithuania. However, in June 1941, almost 250 of them were deported by the Soviets and a few dozen fled from the occupied country. Additionally, after the Holocaust conducted by the Nazis, Lithuania had lost more than 160 specialists of Jewish origin as well [40]. Thus, in 1942 there were only around 380 architects, civil engineers and technicians registered in Lithuania who were allowed to engage in professional architectural practice. Around one fifth of them were employed by the Chief Construction Board, while the rest worked in other institutions of architecture and construction. During the occupation, their numbers were slightly increased by a few dozen architects and civil engineers, who graduated from Vytautas Magnus University in Kaunas [26]. Additionally, from 1942, dozens of graduates of Kaunas Higher Technical School, civil technicians, with at least two years of professional work experience, began to receive qualifications in architecture and civil engineering [7].

## New construction initiatives and difficulties of their implementation

One of the principal tasks, which was aimed at implementing at the beginning of the German occupation of Lithuania, was the preparation of new reconstruction plans for war–damaged cities and towns (Fig. 1). Already at the end of 1941, the Chief Construction Board, in cooperation with local German and

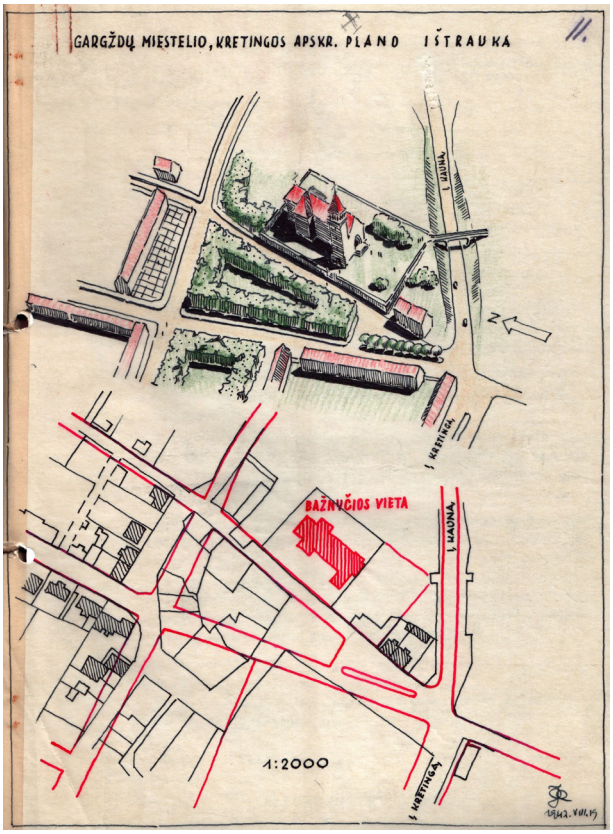



Fig. 1. An excerpt from Gargždai town plan displaying the proposed redevelopment of the central part (civ. eng. Algirdas Dauginas, 1942). [Lithuanian Central State Archives, f. 1342, ap. 1, b. 11, l. 11]

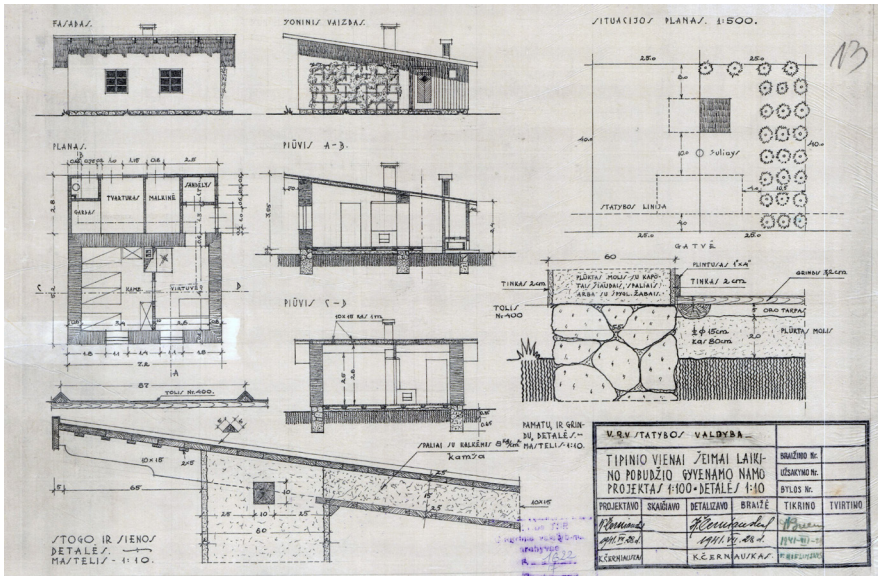



Fig. 2. Project of a standardized temporary one–story shack (civ. tech. Kostas Černiauskas, 1941) [Lithuanian Central State Archives, f. 1622, ap. 7, b. 131, l. 13]

Lithuanian authorities, began to work on this matter. This also became a pretext for changing the urban environment of Lithuania's cities and towns: "The new city redevelopments must be conducted in accordance with the latest urban planning requirements. For this purpose, the streets need to be straightened and widened, the main squares and recreation areas should be created, and suitable conditions for further urban expansion should be prepared. And since there are also streets and buildings in the burned cities that were not completely destroyed by fire, this complicates the task" [49]. Additionally, it was also planned to reorganize the urban environment of the larger Lithuanian cities that had suffered less from the war. For example, in Kaunas, the temporary capital of Lithuania of the interwar period, it was planned to demolish a larger part of its old town, leaving only the several most significant "historical buildings" [27]. Similar urban reconstructions were planned in smaller cities as well, in the main squares of which it was proposed to construct the new city halls and to demolish "all unhygienic, unsuitable buildings" [31]. The proposed reconstructions were to be conducted following the example of Nazi Germany's cities, where large–scale urban transformation had begun in the 1930s [19]. It was planned that while new general plans were being prepared, only temporary buildings, such as single–story clay shacks, would be allowed to be built in Lithuanian cities and towns (Fig. 2). However, at the end of 1942, due to the lack of resources and labor, the implementation of the plans for the reconstruction of Lithuanian cities was postponed until the post–war period, with exceptions made only in rare cases [10]. Therefore, most of the planned radical urban reconstructions were not realized in practice.

Additionally, in late 1941, the plans for wartime and post–war civil construction began to be compiled by the Lithuanian institutions, such as the Administrations of Healthcare and Education, as well as municipalities. The German institutions did not directly intervene in the compilation of such plans. However, the Germans recommended that the plans should meet the principles of economic wartime construction imposed by them, as rapid construction and low costs were to be the essential priorities of that time [35].

Thus, in the case of public buildings, the Lithuanian institutions planned to start constructing only the most needed educational, healthcare, and cultural structures [15]. For example, in 1942–1943, around thirty new primary school buildings and several gymnasiums were planned to be constructed in Lithuania. Also, in the towns of Biržai, Kretinga, Ukmergė and Vilkaviškis it was proposed to build new county hospitals with several hundred beds, while a new 400–bed Red Cross hospital building was planned to be constructed in Kaunas [30]. Some of the hospitals, like the one in Biržai, were designed aesthetically and functionally progressive, following "the best examples of modern hospitals of the time, such as German, French, Swedish" [23]. It was also planned to complete the construction of several school and hospital buildings that had begun prior to the occupation. [23]. In smaller towns, the plans were made to build a dozen public baths, dispensaries, laundries, and infectious disease barracks. There were also proposals to construct cultural structures, such as new opera houses in Kaunas and Vilnius, and theater buildings in smaller towns [46]. These construction plans were not entirely new, as they were more an attempt to continue the aspirations that arose during the period of independence to provide Lithuanian cities with new public buildings for various purposes, the need of which became particularly acute during the wartime period. There was also a surge to build religious buildings as well. Since the Germans proclaimed themselves as the liberators from the Soviet Union, using this aspect new churches and chapels were often started to be built with a symbolic meaning, favorable to the Germans as monuments to commemorate the Lithuanians deported and executed by the Soviets and the end of the Soviet occupation [36].

As in the period of independence, a part of the planned structures, such as primary schools, and public baths, were to be built based on the standard designs, which were developed at the Chief Construction Board [13]. While the larger public structures, such as hospitals, gymnasiums and theaters were to be built based on the individual design projects, which began to be developed by the architects and engineers of the Chief Construction Board, the company "Statyba" and municipal construction departments. In 1942, the construction plans of public buildings were supplemented by an order from the Chief Construction Administration in Lithuania to municipalities to start the construction of about one hundred disinfection stations in cities and towns [45]. This was intended to combat the spread of diseases, such as spotted fever. Most of the stations, on the instructions of German and local authorities, were to be placed in the former Jewish bathhouses, schools and synagogues, the conversion projects of which were

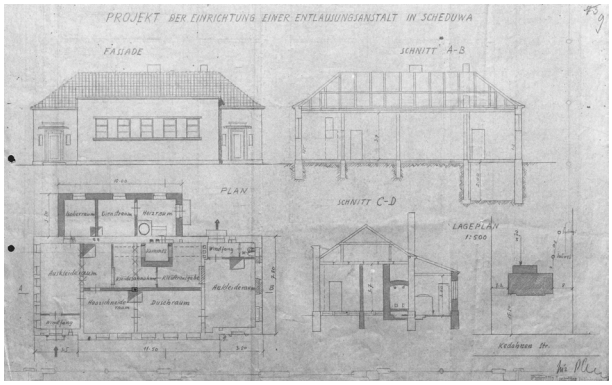



Fig. 3. Conversion project of the former Jewish bathhouse into disinfection station in Šeduva (civ. eng. Petras Lelis, 1942) [Kaunas Regional State Archive, f. R–961, ap. 1, b. 97, l. 9]

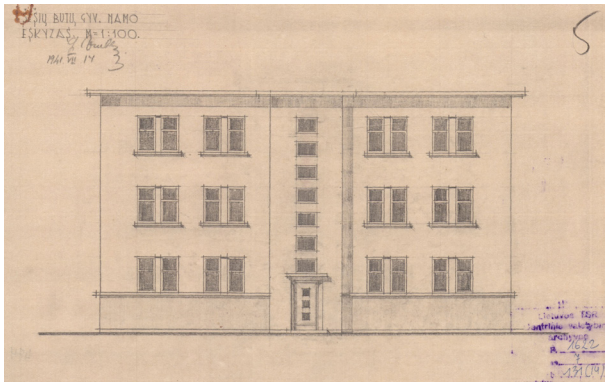


Fig. 4. Sketch project of a six–apartment residential block (civ. eng. Feliksas Bielinskis, 1941) [Lithuanian Central State Archives, f. 1622, ap. 7, b. 131, l. 5]

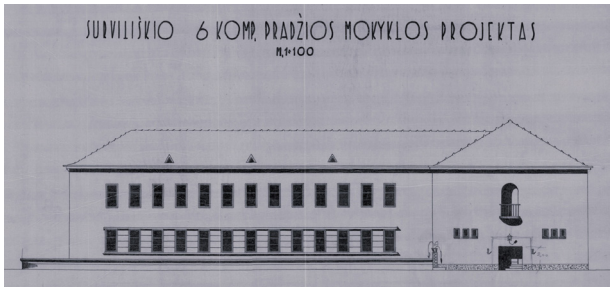



Fig. 5. Project of a 6-class primary school in Surviliškis (civ. eng. Jonas Jankūnas, 1941–1942) [Lithuanian Central State Archives, f. 1622, ap. 7, b. 33, l. 4]

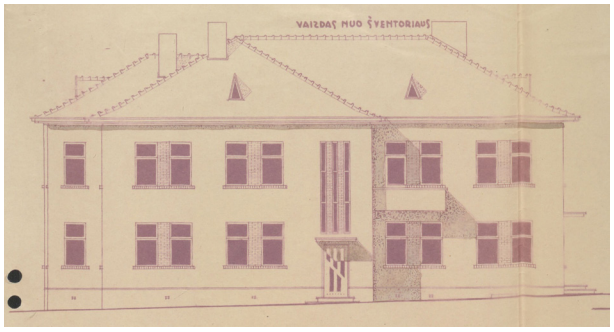



Fig. 6. Project of a parish house in Eržvilkas (civ. eng. Algirdas Kuprys, 1942) [Klaipėda Regional State Archive Tauragė Branch, f. 697, ap. 1, b. 23, l. 2]

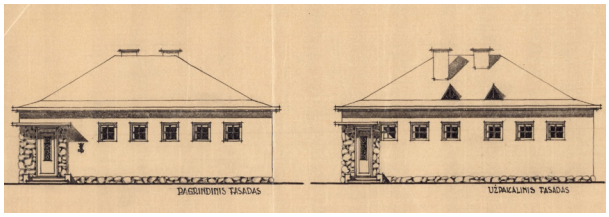



Fig. 7. Project of a standard bathhouse (arch. Boguslavas Liugaila, 1942) [Lithuanian Central State Archives, f. 1622, ap. 7, b. 133, l. 1]

drawn up by the municipal Construction Departments (Fig. 3). Although by late 1942 most such projects were developed, many were not realized due to lack of materials, labor, and low initiative of the municipalities. As Petras Lelis, who was a civil engineer in the Construction Department of the Panevėžys County Municipality during the that time claimed, "we turned a blind eye to these constructions, as it was an unrealistic task <...> We did not start building new buildings anywhere, but instead chose abandoned masonry buildings, in which we installed the necessary disinfection equipment. But we did not finish them" [21]. Due to the anti–Semitic policies imposed by the Germans, more Jewish buildings (schools, synagogues, etc.) were planned to be adapted for other uses as well, for example, to be converted into labor camps, industrial facilities or even sports halls [5]. Plans were also made for the construction of residential buildings in the areas where it was not forbidden to build temporary buildings. Therefore, following the experience of Nazi Germany and other countries, the construction of numerous residential blocks was considered, as it was estimated that to meet the housing demand in post–war Lithuania, "about 25,000 apartments would be necessary to build annually in the countryside and in the cities" [42]. Preparations for this were planned to start during wartime and design projects for standard residential blocks were developed (Fig. 4). However, due to the lack of resources, these ambitions were not further developed and only the construction of the few residential blocks, which began during the years of independence and the Soviet occupation, sought to be continued [40]. It was also planned to develop the construction of residential structures on a private initiative, a process which was almost non–existent during the Soviet occupation due to the mass nationalization of private property. Thus, from the end of 1941, the local design institutions began to develop the standardized and individual projects of private houses for construction in the cities and in the country. It was also planned to develop the industry of construction material production in Lithuania, by establishing new enterprises, such as brick, plaster, and cement factories. Thus, for example, in 1942, the construction and design company "Statyba" had designed several of such factories, which, however, were not built by the end of the German occupation [9]. The planning and implementation of construction work in occupied Lithuania was complicated by the "Order on construction bans," effective as of April 17, 1943, which was issued by German institutions [32]. The ban lasted until the end of occupation. Similar orders had been established in other countries occupied by Nazi Germany as well, where "building activities were to be stopped until Germany's 'final victory'" [12]. Thus, most of the construction plans compiled by Lithuanian institutions had to be postponed. The ban, however, had exceptions. For example, it was allowed to continue the construction of disinfection stations, which were considered priority objects by the German authorities [21]. It was also allowed to conduct small construction and repair work, costing up to five thousand Reichsmarks, as well as to construct temporary buildings. Exceptions were also made for construction crucial to the war effort, such as industrial enterprises. To start other types of construction and receive the necessary materials, special permission had to be obtained from the Chief Construction Administration in Lithuania [47]. Construction conducted without a permit was considered illegal and was therefore treated as a criminal act by the German authorities. The impact of the ban was not uniform in Lithuania. For example, in some of the more seriously war-damaged

provincial towns, due to the "lack of building materials, capital and labor," the building activity had practically come to a standstill even before the ban and only "temporary shelters" were constructed there [2]. However, there were also places where the ban was occasionally ignored and understood as a formality. For example, in several cities and rural regions, "despite the strict construction ban, residential structures, farm buildings, churches, rectory houses, etc., were nevertheless continued to be built, although the builders did not have any building permits." The local institutions were obliged to "take all possible measures to prevent this prohibited action" [47]. However, they themselves often ignored the ban, and sought to use the existing limited building materials for the necessary Lithuanian constructions, and not for the ones ordered by the German authorities, like the disinfection stations. Thus, according to the memoirs of architect Edmundas Arbačiauskas, who at that time worked in the Vilnius branch of the company "Statyba", despite the construction ban, "we [the company] secretly built a Red Cross hospital in Vilnius, a printing house "Švyturys", renovated a theater destroyed by fire in Vilnius. We also gave the Karaites in Trakai materials for the repair of their church. We decorated the church of Lentvaris in the sgraffito technique, <...> We constructed a nail factory in Lentvaris" [4]. The municipalities often ignored the ban as well, and "used the materials obtained through the Construction Board for the construction of new schools, even though this action was prohibited" [21]. Thus, the construction of the necessary civil structures while ignoring the ban, was understood by local architecture and construction specialists as "proof of the Lithuanians' desire for freedom" and dissatisfaction with the German occupation [21]. Consequently, the so–called illegal constructions continued until the end of the occupation.

**The stylistic diversity and national identity in the architecture of the planned constructions**

When the plans for the new constructions began to be compiled, local architectural specialists began to look for paths to follow when designing new buildings. At that time, Nazi Germany had an established hierarchy of architectural styles, which ranged from the simplified neoclassicism to vernacular and modernist designs, the application of which in practice varied from the functional requirements of buildings to the preferences of builders and users [28]. It is known that local Lithuanian specialists were sought to be introduced with German construction, as the trips to cities of Nazy Germany were organized for them [38]. Additionally, they attended the lectures regarding the principles of German wartime construction [41]. However, the German institutions did not take any concrete steps to directly influence the Lithuanian architectural style. Therefore, it can be suggested that this matter was left to the aesthetic aims and preferences of the local Lithuanian specialists. This resulted in a stylistic diversity in the building designs, which in this respect did not differ much from that prevailed in Lithuania in the 1930s.

One of the main stylistic trends, which was sought to be continued during that time, was the local variant of modernism that prevailed in Lithuanian architecture in the 1930s. Therefore, local architects and engineers, drawing from their previous aesthetic experience, aspired to maintain progressivity in architecture, giving a priority to the function and utility, which were the key aspects when designing the needed structures, such as primary schools, bathhouses, and parish houses (Figs. 5–6). A number of these types of buildings were designed with asymmetrically balanced, undecorated, and simple–looking volumes rhythmically divided by ribbon fenestration. The local character of these

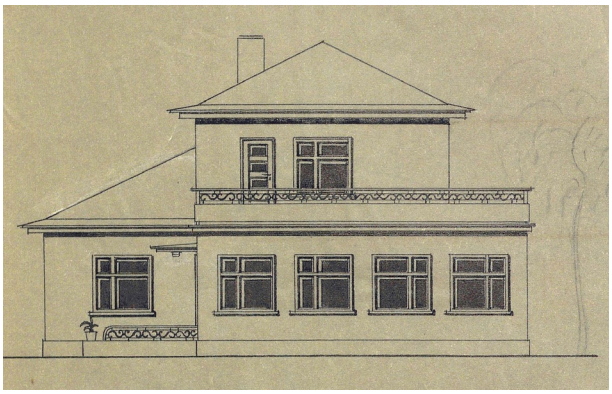


Fig. 8. Project of a single–family house in Petrašiūnai (civ. tech. Mečys Cichanavičius, 1943) [Kaunas Regional State Archive, f. 17, ap. 1, b. 106, l. 22]

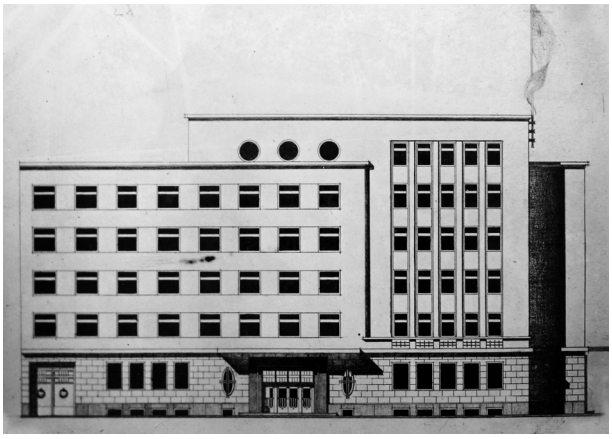


Fig. 9. Diploma project "Hotel–restaurant in Kaunas" by Algirdas Gaigalis of the Vytautas Magnus University's Construction Faculty, 1943 [Lithuanian Central State Archives, f. 631, ap. 19, b. 64, p. 6]

structures was to be emphasized by the high–pitched tile roofs and local building materials. There were also examples of public structures designed, the simple–looking exteriors of which were complemented by the inclusions of fieldstone and clinker tiles (Fig. 7). For dwellings, which were planned to be constructed in cities and towns, as well as industrial structures, modernism also continued to be preferred architectural language (Fig. 8). Moreover, the asceticism of these structures corresponded well to the general requirements regarding the wartime construction, issued by the German authorities, which stated that the buildings, for reasons of economy, should be designed as simple looking as possible, without unnecessary "architectural embellishments" [10]. Additionally, the influence of interwar modernism was also evident in the diploma projects of graduates from the Faculty of Construction at Vytautas Magnus University in Kaunas during that period (Fig. 9).

There were also buildings designed with exteriors, which reflected the influence of past styles to give them a more monumental looking appearance. For example, in the projects of several healthcare and religious buildings, the modern–looking exteriors were designed accentuated with the popular motifs of classicism and historicism, such as arcades, pilasters, and the imitation of rustication (Figs. 10–11). In other cases, while the buildings were designed with radically reduced, and almost unornamented exteriors, their monumentality was to be given by the massing, such as the classical division of the front into three regular parts, articulated with central Avant-corps or symmetrically placed entrances (Figs. 12–13).

There was also an aspiration to develop a national style in Lithuanian architecture, which was not new, as it was aimed at developing it in the 1920s and 1930s [33].

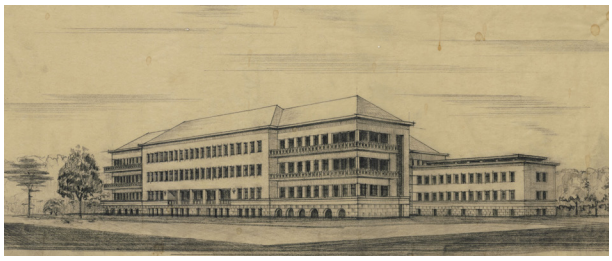


Fig. 10. Design proposal for a county hospital in Biržai (civ. eng. Feliksas Bielinskis, 1943) [Lithuanian Cultural Heritage Centre Heritage Preservation Library, f. 6, ap. 1, no. 14237]

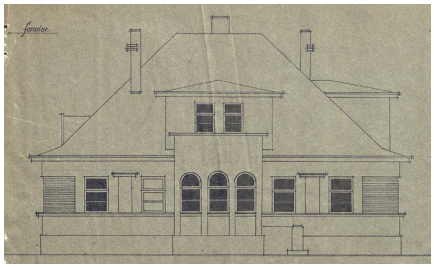


Fig. 11. Project of a rectory in Kalviai (civ. eng. Vladas Ambrazevičius, 1942) [Kaunas Regional State Archive, f. R–381, ap. 1, b. 12, l. 25]

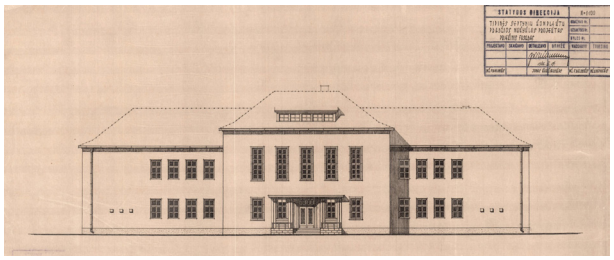


Fig. 12. Project of a standard 7–class primary school building (civ. eng. Feliksas Bielinskis, 1942) [Lithuanian Central State Archives, f. 1622, ap. 7, b. 13, l. 11]

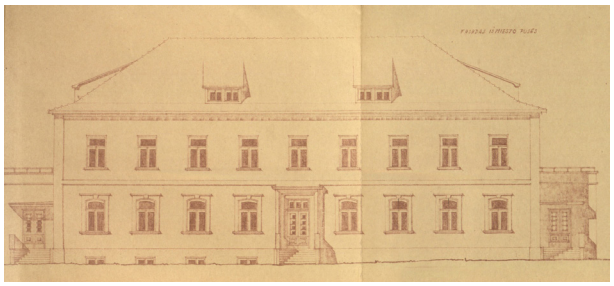


Fig. 13. Project of a county hospital in Vilkaviškis (arch. Kazys Mieldažys, 1942) [Kaunas Regional State Archive, f. R–961, ap. 1, b. 46, l. 23]

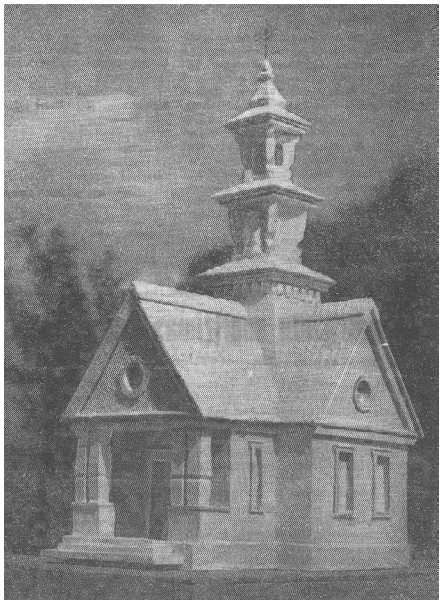


Fig. 14. Model of Rainiai chapel (arch. Jonas Virakas, 1942) [Panevėžio apygardos balsas, 1942 October 10, p. 5]

The idea was revived by the national design competition of a chapel for construction in Samogitian village of Rainiai, which was held in 1942. The chapel was to be dedicated to commemorating several dozen political prisoners killed by the Soviets in 1941, thus the competition guidelines strictly required that the building's "architectonic motifs should be Lithuanian–Samogitian, symbolizing the struggle of the enslaved Lithuanian–Samogitian for freedom" [14]. Out of only nineteen submitted proposals, the design project by Jonas Virakas was awarded the first prize. In this proposal the chapel was designed with the forms and motifs of the old traditional architecture of Lithuania: the bell tower was in the form of a highly ornamented pillar–chapel, the façade was accentuated with columns of folk forms, and the volume was covered with a sharply pitched roof of wooden shingles (Fig. 14). The competition and the possibility of developing a national architectural style in Lithuania provoked theoretical discussions among its cultural representatives, the texts of which were published in the official periodicals of that time.

There were opinions which supported the competition and positively evaluated a proposed revival of a national style, based solely on the old Lithuanian village architecture, as it was thought to be closest to Lithuanian identity. Thus, it was advocated that all Lithuanian architecture should recourse to a traditional style: "Only in our wooden architecture, which in Lithuania has created a truly unique style; both homesteads, our wooden churches, and pillar–chapels are completely original Lithuanian folk art. <...> Therefore, our wooden architecture is the only source of inspiration for our architects" [39]. Such an approach was also perceived to preserve Lithuanian identity and legacy of its cultural traditions [6].

The aspiration to develop a national vernacular style was also perceived by the idea's supporters to eliminate foreign influences in Lithuanian architecture, such as modernism. Critically assessing its internationality and aesthetic monotony, it was proposed to value national individuality more in architecture, insisting that "our architects need to be inspired by the spirit of our nation, and not by the models of architectural journals" [24]. Thus, it was reasoned that in the future architectural modernity would gradually give way to "beauty and nationality" [24]. In this way, a national style was also perceived as an antithesis of modernism, which embodied a national identity and tradition, which the latter, as was thought, did not have.

Such aspirations in Lithuanian architecture were also supported by the Germans. In articles published in their periodicals on the topic of Lithuanian architecture, it was declared that only a vernacular architectural style was suitable for Lithuania, as, in German opinion, a solely agrarian region [29]. It was critically assessed that such a style was not fully developed during the independence when, as a result, Lithuanian architecture was more influenced by international trends, such as modernism: "The truth is that there was not enough creativity in a nation of three million farmers to develop an architectural style based solely on the character of its nationality and landscape. It was necessary to urgently look for examples abroad, and they were sought not only in the relevant European cultural areas, but also among the Yankees" [1]. Such an attitude corresponded well to the Germans' own anti–modernist rhetoric and aspirations to create a national style, based on their own architectural traditions, since in Nazi Germany "traditional, vernacular designs were generally preferred" for the buildings constructed, for instance, in rural regions [11].

However, there were also skeptics of the proposed recourse to vernacular architecture in Lithuania, which questioned the concept for its artificiality and appropriateness, arguing

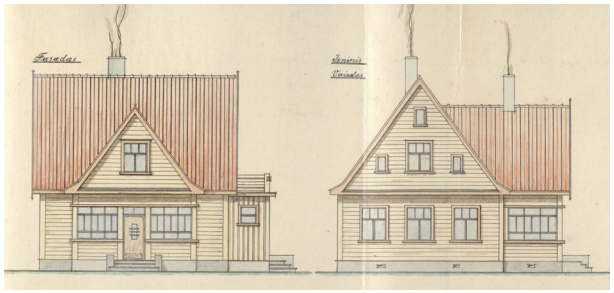


Fig. 15. Project of a rectory in Inkūnai (civ. eng. Jonas Rasinskas, 1942) [Lithuanian State Historical Archives, f. 1650, ap. 1, b. 1, l. 52]

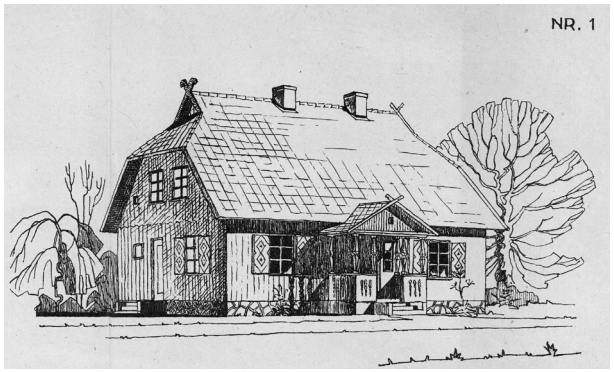



Fig. 16. Project of a standard homestead house, variant for wooden construction (civ. eng. Viačeslavas Daugėla, 1942) [Vilnius Regional State Archive, f. 1171, ap. 4, b. 626, l. 1]

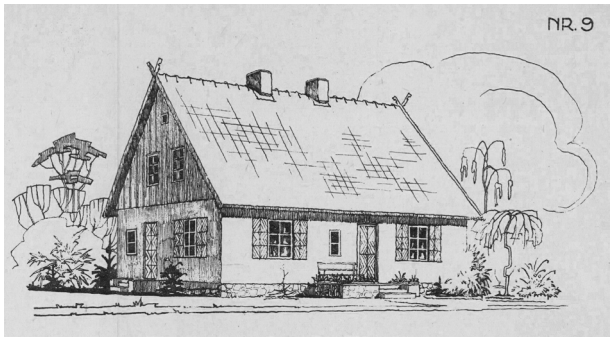



Fig. 17. Project of a standard homestead house, variant for masonry construction (civ. eng. Juozas Markauskas, 1942) [VRVA, f. 1171, ap. 4, b. 626, l. 3]

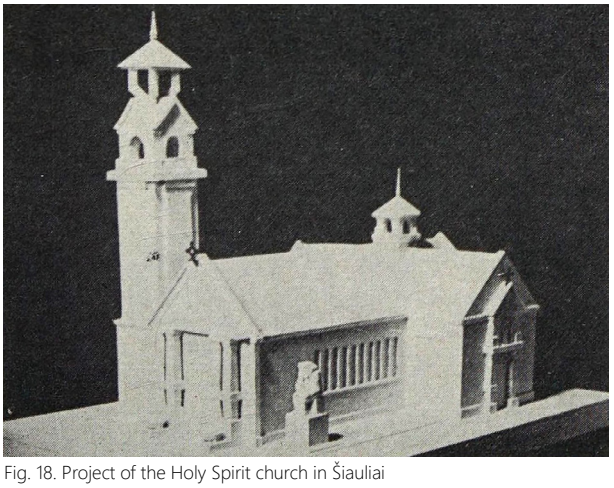


Fig. 18. Project of the Holy Spirit church in Šiauliai (arch. Jonas Ladyga, 1942) [16]

that "the use of motifs of Lithuanian wooden traditional architecture and sculpture, their details and ornaments is of dubious value and, most importantly, they will not instill a true Lithuanian spirit in the building" [18]. There were also opinions, which insisted that the national style should not be developed from the traditional village architecture: "Lithuania is rich not only in wooden crosses and chapels, but also in monumental, world–famous architectural works. So why should such a one–sided recommendation be suggested to the creators of our national style? We must not forget that not every chapel and cross found in Lithuania can be judged from the point of view of creativity and national originality" [20]. There were also pragmatic opinions of the matter, which declared that "the architectural progress must arise and develop freely, unfettered by outdated traditions and personal whims" and that there was no need to follow any style at all [17].

Even though there was no unanimous opinion on the concept of a national style, experiments were still made to embody this vision in various building designs. For example, there were buildings designed with the exteriors which had no ornamentation but displayed highly simplified and synthesized forms of vernacular architecture (Fig. 15). Furthermore, the concept of national style was particularly embodied in the several standardized projects for the single–story homestead houses, developed by architects and civil engineers of the Agricultural Construction Direction. The buildings were designed to be traditional and decorative: the exteriors were accentuated with an abundance of small decorative elements in shutters, doors, porches, and rooftops (Figs. 16–17). The concept also influenced the design of religious buildings as well [16] (Fig. 18). Since most of these buildings were designed to be built using traditional materials: timber walling, wooden ceilings and roofs covered with tiles or wooden shingles, such elements could have contributed to the traditionalism of their appearance as well. The idea of a national style was planned to be developed further in practice, when in early 1944, a few months before the end of the German occupation, it was decided to announce a national design competition for the new standard designs of homestead houses, the proposals of which were required to be based on "Lithuanian homestead planning traditions" [48]. Yet these examples demonstrate the main contradiction of the idea, that it was more suited to the buildings planned to be constructed in rural regions, where traditional building methods still prevailed and where such buildings could suit the overall locality. In Lithuanian cities, this idea, except for isolated cases, did not spread, and buildings with a simplified modern appearance were continued to be designed until the end of the occupation.

## Conclusions

At the beginning of the German occupation of Lithuania, the aim was to normalize architectural and construction matters, to begin the reconstruction of cities and towns destroyed by the war, and to develop these fields in general. Therefore, new design and construction institutions were set up, and those that had operated during the years of Lithuanian independence were restored. Since at first the German authorities did not make direct efforts to forbid the development of civil architecture and construction in the occupied country, the shaping of this matter remained predominantly a Lithuanian field. Consequently, it was managed and supervised by the local design and municipal construction institutions. The most important of these was the newly established Chief Construction Board, a central body that administered and coordinated the principal matters of civil architecture in occupied Lithuania. The architecture and construction fields were also managed by institutions and departments operating within the Administrations of General Advisers and Municipalities, whose decisions were partially influenced by the orders and directives of the German authorities regarding the construction requirements of the wartime period.

Since the Germans did not have a specific civil building

program developed for Lithuania, this matter was managed by the local Lithuanian institutions. They had ambitions even during the wartime to start building the most needed civil structures in Lithuania. Most of them were to be cultural, educational, healthcare buildings, as well as religious and residential structures. Thus, in 1941–1944, numerous designs of such buildings were developed by the local architects and civil engineers. However, in practice the implementation of the planned constructions made little progress. It was due to the shortage of building material, labor and the building restrictions imposed by the German authorities during the last years of the occupation. Consequently, only a small part of the planned structures was built by the end of the German occupation. In addition, the architectural activity in Lithuania during that time was enlivened by several national design competitions which were held at that time, as well as theoretical discussions among the community of local architects and art historians about the most appropriate architectural style in Lithuania.

During the years of the German occupation of Lithuania, the architectural character of the planned constructions was to be diverse, as there was no single stylistic trend to be followed. Thus, there were buildings designed with exteriors influenced by the interwar modernism, as well as by the interpretation of forms and motifs of both the historical styles and vernacular architecture. Such a stylistic diversity, even if it was mostly manifested in the unimplemented designs of the planned structures, did not display a radical deviation from the development of styles during the years of Lithuanian independence. However, there was a strong emphasis on continuing the idea of developing a national style based on the romanticized tradition of old Lithuanian vernacular architecture, that had its origins in the 1920s, which was believed to best suit the Lithuanian locality than the other styles. During that time, this emphasis had a strong nationalist character and was influenced both by the nationalist sentiments stimulated by the German occupation and its policies, and by the aspiration to preserve an architectural tradition in Lithuania.

## References


1. "Warschauer Zeitung" apie Kauną. (1943, October 22). *Ateitis*, 4.
2. **A. G.** (1942, July 31). Ūkio trobesių atstatymas Šiaulių apskrityje. *Tėviškės žiburiai*, 3.
3. AB "Statybos" Vilniaus skyrius – pagrindinė statybos įstaiga Rytų Lietuvoje. (1942, November 11). *Naujoji Lietuva*, 4.
4. **Arbačiauskas, E.** (1990). *Architekto E. Arbo–Arbačiausko biografiniai škicai*. Vilnius Regional State Archive (f. 1171, ap. 1, b. 682, l. 20), Vilnius, Lithuania.
5. Atliktų remonto darbų buv. žydų sinagogoj patikrinimo aktai. (1942). Lithuanian Central State Archives (f. 1264, ap. 1, b. 829, l. 20), Vilnius, Lithuania.
6. **B. B.** (1943, May 30). Lietuvio sodyboje – lietuviška dailė. Naujoji sodyba, 103.
7. Baigusiems Aukštesn. Technikos Mokyklą Kaune išduodami inžinieriaus pažymėjimai. (1942, March 25). *Į laisvę*, 6.
8. **Buttar, P.** (2014). *Tarp milžinų. Mūšis dėl Baltijos šalių 1939-1945*. Vox Altera, 116.
9. **Drėmaitė, M.** (2022). *Arno FUNKcionalizmas. Architekto Arno Funko (1898–1957) gyvenimas ir kūryba*. Nacionalinis M. K. Čiurlionio dailės muziejus, 213.
10. Generalinio tarėjo vidaus reikalams aplinkraščiai, nurodymai ir kt. statybų, statybinių medžiagų ir kt. klausimais. (1942). Lithuanian Central State Archives (f. 1361, ap. 1, b. 487, l. 40-50), Vilnius, Lithuania.
11. **Hagen, J., & Ostergren, R. C.** (2020). *Building Nazi Germany: Place, Space, Architecture, and Ideology*. Rowman & Littlefield, 42.
12. **Hořejš, M.** (2021). Relics of Nazi Architecture in the Czech Republic. Current Research, New Evidence, and Its Planned Integration into a Geographic Information System (GIS). *Journal for Culture and History of the Germans in Eastern Europe*, 2, 113. https://doi.org/10.1515/9783110759891-005
13. Iš Statybos Valdybos veiklos. (1942, January 19). *Į laisvę*, 3.
14. Iš visos Lietuvos. (1942, January 23). *Į laisvę*, 5.
15. vairių įstaigų statybos ir išlaidų sąmatos. *Kauno regioninis valstybės archyvas* (KRVA). f. R–961, ap. 1, b. 64, l. 48–51.
16. **Jonynas, V. K.** Lietuviškoji architektūra. *Aidai*, 1954, No. 8, p. 349–351.
17. **Jurėnas, P.** Architektūros konkursai. (1944, June 14). *Ateitis*, 4.
18. **Kairiūkštytė-Jacinienė, H.** (1942, May 15). Žemaičių kankiniams atminti koplyčios projektų paroda. *Į laisvę*, 4.
19. Kas daroma miestų atstatymo reikalu. (1943, January 13). *Ateitis*, 3.
20. **Landsbergis-Žemkalnis, V.** (1942, July 25). Tautinės architektūros pradmenų beieškant. *Į laisvę*, 3.
21. **Lelis, P.** (1973). Lietuvos keliu. 1910–1973 metai. *Litho–Art*, 218-220.
22. Lietuvos Laikinosios Vyriausybės įstatymų, nutarimų ir potvarkių nuorašai. (1941). Lithuanian Central State Archives (f. 1075, ap. 2, b. 5, l. 17-31), Vilnius, Lithuania.
23. Ligoninių statybos klausimais. (1941–1943). Lithuanian Central State Archives (f. R–627, ap. 1, b. 114, l. 17; 54-56), Vilnius, Lithuania.
24. **Maceinienė, J.** (1942, August 8). Kai naujus miestus statysime. *Į laisvę*, 3.
25. Mačio Vlado asmens byla. LCVA. f. 392, ap. 3, b. 822, l. 38.
26. **Matukonis, A.** Vytauto Didžiojo universiteto techniškųjų fakultetų veikla vokiečių okupacijos metais. *Nuo Aukštųjų kursų Kaune iki Kauno technologijos universiteto*, 1920–1997. Kaunas: Kauno technologijos universitetas, 1997, p. 100–108.
27. Miesto Komisaras Cramer apie Kauno perplanavimą. *Į laisvę*, 1942, No. 4 (165), p. 6.
28. **Miller Lane, B.** (1986). *Architecture and Politics in Germany 1918-1945* (New ed.). Harvard University Press, 215.
29. Naujas "Ostlando" numeris apie lietuvių statybos namus. (1943, January 22). *Ateitis*, 3.
30. Naujos Kauno chirurginės ligoninės projektavimo byla. (1940–1943). Lithuanian Central State Archives (f. R–978, ap. 2, b. 85, l. 17), Vilnius, Lithuania.
31. Panevėžio miesto tvarkymo darbai. (1942 January 10). *Panevėžio apygardos balsas*, 6.
32. Parėdymas dėl draudimų statyti. (1943, June 1). *Amtsblatt des Generalkommissars in Kauen*, 129.
33. **Petrulis, V.** (2015). Tautinio stiliaus paieškose. In V. Petrulis (Ed.), *Lietuvos tarpukario architektūros palikimas: materialumo ir nematerialumo dermė* (pp. 77–87). Technologija.
34. Potvarkis dėl darbo jėgų užtikrinimo valstybiniu ir ūkiniu atžvilgiu svarbioms statyboms. (1941, December 24). *Amtsblatt des Generalkommissars in Kauen*, 249.
35. Pranešimai dėl statybos uždraudimo ar apribojimo, pažymėjimai, išduoti piliečiams norintiems pirkti miško medžiagą, pareiškimai ir leidimai statyboms. *LCVA*. f. 805, ap. 1, b. 464, l. 10.
36. Rudenėjančiame Panevėžyje. (1943, September 1). *Naujoji Lietuva*, 4.
37. Savivalda statybos srity. (1942, April 8). *Į laisvę*, 8.
38. Statyba karo metu. (1943, June 13). *Ateitis*, 4.
39. **Stulginskis, S.** (1942, July 3). Lietuvių tautinės architektūros reikalu. Į laisvę, 3.
40. Susirašinėjimas su Finansų Vadyba, Žemės ūkio vadyba, Pavenčių cukraus fabriku, apskričių valdybomis ir kt. statybos klausimais. *LCVA*. f. R–617, ap. 1, b. 39, l. 18; 202.
41. Susirašinėjimas su Vyr. Statybos Valdyba ir kt. statybos draudimo, aprūpinimo ir kt. klausimais. *LCVA*. f. 1361, ap. 1, b. 552, l. 52.
42. **Tarulis, A.** (1942, January 18). Laikas ruoštis plataus masto pokarinei statybai. *Į laisvę*, 3.
43. V. Landsbergio-Žemkalnio – LLV Komunalinio ūkio ministro – veiklos dokumentai. *Lietuvos literatūros ir meno archyvas*. f. 81, ap. 1, b. 1248, l. 121–159.
44. Vidaus Reikalų ministro aplinkraščiai ir statybinės taisyklės. *KRVA*. f. R–961, ap. 1, b. 1, l. 76.
45. Vyr. Statybos Valdybos cirkuliarai apie dez. punktų statybos kontingentinių medžiagų paskirstymą ir susirašinėjimas su savivaldybių departamentu apie išutėlinimo įstaigų išlaikymą.

*KRVA*. f. R–961, ap. 1, b. 4, l. 12.
46. Vyr. Statybos Valdybos posėdžių protokolai ir susirašinėjimas su įvairiomis įstaigomis administraciniais klausimais. *KRVA*. f. R–961, ap. 1, b. 6, l. 44.
47. Vyresnybės aplinkraščiai, parėdymai, kiti raštai žinoti, vadovautis ir pildyti. *LCVA*. f. 1567, ap. 1, b. 507, l. 147.
48. Žemės Ūkio sodybų projektams paruošti konkurso sąlygos. Naujoji sodyba, 1944, No. 52, p. 52.
49. Žemėtvarkos darbai miestuose ir kaimuose. *Į laisvę*, 1941, No. 158, p. 2.

## Author

**Evaldas Vilkončius.** Doctor of Humanities (History and Theory of Arts, 2022), Researcher at the Institute of Architecture and Construction of Kaunas University of Technology; Tunelio st. 60, LT–44405 Kaunas, Lithuania. E-mail: evaldas.vilkoncius@ktu.lt
ORCID ID: https://orcid.org/0009-0007-9492-5328

## Kopsavilkums

Vācijas okupācija Lietuvā, kas ilga no 1941. līdz 1944. gadam, bija periods, kas ietekmēja visas dzīves jomas, tostarp arhitektūru un būvniecību. Līdz ar to raksta mērķis ir atspoguļot īsu, taču dramatisku un sarežģītu posmu Lietuvas arhitektūras vēsturē – sabiedrisko un dzīvojamo ēku attīstību un transformāciju Vācijas okupācijas apstākļos. Pētījums balstīts uz arhīvu materiālu, literatūras un tā laika periodisko izdevumu analīzi, kā arī uz jaunākajiem darbiem, kas veltīti konkrētajai tēmai. Teksts papildināts ar sabiedrisko un dzīvojamo ēku projektu paraugiem. Rakstā parādīts, ka pat Vācijas okupācijas apstākļos Lietuvā joprojām tika pievērsta ievērojama uzmanība sabiedrisko un dzīvojamo ēku attīstībai, un šajā jomā procesi norisinājās diezgan aktīvi. Tā kā lielākā daļa plānoto būvju tajā laikā netika realizētas, pētījumā secināts, ka arhitektūras aktivitātes šajā periodā galvenokārt saistītas ar nepieciešamo būvju plānu izstrādi, civilās būvniecības projektu attīstību un teorētiskām diskusijām par Lietuvas arhitektūras stilistiskajām iezīmēm.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.10

# SEASONAL URBANISM: LANDSCAPE ARCHITECTURE FOR WINTER-ACTIVE PUBLIC SPACES

**Ilze Stokmane, Agnese Vasiļjeva**

*Latvia University of Life Sciences and Technologies, Latvia*

**Abstract. The research explores the contemporary topic of landscape seasonality, with a particular focus on the winter period, which is often an 'afterthought' in landscape planning. The issues affecting the urban environment of many municipalities during the winter season are brought into focus by changing weather conditions, when roads become impassable, car parks inaccessible and pavements impassable. The collection or beneficial use of snow on site poses new challenges for urban planning, as creating a safe environment is an essential aspect of the speciality of landscape architecture, reducing any health risks for citizens in every possible way. In order to be able to adapt the infrastructure of public outdoor spaces to seasonal use, it is necessary to define qualitative seasonal urban planning approaches by looking at the existing problems, therefore it was developed criteria for the evaluation and analyses of specific landscape spaces. The study examines the experience of several municipalities in seasonal landscape planning, conducting a survey of citizens and interviews with experts in the field, thus looking in depth for solutions to these problems in Latvia. The study has led to the development of illustrative detailed urban examples for the seasonal landscaping and use of different public outdoor spaces.**
**Keywords: seasonality, urban landscapes, white landscapes, public spaces**

## Introduction

Despite the fact that cities have been planned since the beginning of urbanization, the term urban planning did not exist until the 1890s. Due to the broad international interest in improving industrial cities, it came to be used as a word for the layout and design of cities and residential neighborhoods. Planning was associated at the time with a number of social reform initiatives that sought to enhance working-class living standards. Land use planning, regional and spatial planning, and, more recently, environmental planning are some of the planning processes that have been linked to urban planning [1].

Urban renewal, which involves applying current best practices in urban planning to deteriorating cities, is another aspect of the urban planning process. With numerous application scales ranging from the block or street scale to the metropolitan and regional landscape scale, urban planning practice has grown increasingly complex in recent years. Numerous facets of modern public policy, such as multiculturalism, the ideals of healthy cities, environmental justice, economic growth, climate change, energy conservation, nature preservation, sustainable development, public involvement, and so forth, are confronted by urban planning. The foundational knowledge of urban planning today is derived from a long history of concepts, paradigms, principles, instruments, studies, and applications that have been enhanced by the influence of the social sciences, natural sciences, and electric humanities [2].

We can make a number of fundamental claims regarding urbanism in general and urban planning in particular. Prior to examining them through the lens of conventional planning standards on the usage of spaces and buildings, the shape and assessment of physical locations should come first [3]. The transient patterns of usage that buildings and urban open spaces undergo may change once a year, twice a year, or more frequently. The concept of the role and form of the urban environment has changed significantly over the past 50 years, especially in the USA. It is now acknowledged that planning for a certain region has frequently not been done with the evolution of the site complex in mind.

Urban design theories and real-world examples constitute the foundation of many modern urban design concepts. According to the American New Urbanists' initiatives to build more ecologically friendly and socially just cities, as well as the British government's policy on sustainable communities, traditional urbanism is the greatest way to foster a diverse and multicultural civic life. Because they are neutral and non-deterministic yet fundamentally human, spaces like the park, boulevard, square, and street serve this purpose. Because they are universal spatial kinds, they can fade into the background and let public life in all of its manifestations take center stage. This is significant because, in today's globalized culture, urban design aims to provide spaces where individuals of all ages can lead fulfilling lives. The numerous little, varied activities that comprise a community are best carried out as pedestrians, meeting and mingling with friends, acquaintances, and strangers on the street, in the plaza, or in the park, according to Danish urbanist Jan Gehl [4].

Community life revolves around informal interactions in public areas, and when urban areas are badly planned, people move through them as fast as they can without sitting, relaxing, or stopping. People who live there can also stay and engage in so-called "secondary activities" like relaxing in the shade for a while or, in the winter, taking a seat in a sunny nook if the public area is appealing and integrated with residences, businesses, and offices. Additionally, passersby may pause to get a cup of coffee, converse with friends, or take in a vista, sculpture, or fountain. Since community is centered on connection, this type of activity - meeting new people and trying something new - can validate and enhance the bonds between neighbors [5].

The field of urban planning is focused on the use of public space in urban settings as well as the design, administration, and regulation of the built environment. Various ideas have been developed over time to direct and influence urban design practice [6].

Urban planning in the 20th and 21st centuries differs from one another, according to these beliefs. In the former, the economic development model relied on expanding cities by whatever means, even if doing so could have a detrimental effect on the environment and the world. Finding the means to advance and alter urban behavior while preserving economic sustainability and environmental viability has become a new issue over time.

The literature on the nature of urban design places a lot more emphasis on design paradigms and product forms than on process forms. Numerous theories about new cities concentrate on the architectural design of locations rather than the processes that led to their creation or the dimensions that determine its success or failure. This is a result of place design's mimetic approach, which adapts well-known or

generic forms of urban design to particular contexts [7].
Land management and organization, land use, spatial morphology, resource allocation, and social and economic relations are all included in the broad category of spatial planning, of which urban planning is one type. According to modern definitions, spatial planning is a component of "place-making" initiatives, which use spatial development procedures to support and improve environmental attributes that people find valuable [8].
Around the world, the built environment has a significant impact on whether outdoor urban activities like "soft" mobility are supported or hindered. Public outdoor areas have the power to either inspire people to engage in outdoor social activities or deter them from doing so [9].
When designing human communities, seasonality is frequently taken into consideration. The way that urban public places fluctuate with the seasons and climate should be given more consideration in land-use plans and urban planning procedures. Because of its location and climate, Latvia experiences extremely little sunlight during the winter months. The Central Statistical Bureau of Latvia reports that there were barely six hours of sunlight in December 2023. Over the course of three months, the average duration of daylight hours drops by nine hours as astronomical winter sets in. As a result, public open spaces are used at varying intensities. People's preference to remain indoors is frequently caused by public areas that are not adjusted to the changing seasons, rather than the weather or the approach of night.
Cities serve as hubs for social interaction, employment, recreation, personal growth, and inspiration. Streets, squares, and plazas are managed by cities as areas for seasonal events. These significant areas are kept active and useful throughout the year thanks to winter utilization. It is uncommon to find locations in Latvia's public open spaces that are intentionally designed for seasonality or that are utilized year-round, irrespective of weather and seasonal factors.

**Climate impacts on urban planning**

In many parts of the world, European traditions follow a calendar of four seasons - summer, autumn, winter and spring - that reflect European culture and environment rather than the local one. Seasonality in a landscape context refers to phenomena and activities that occur or are available at certain times of the year, or to features of the physical environment that change with the seasons and are thus only visible in the landscape at certain times of the year. It also refers to changes in people's perception of their physical surroundings associated with the changing seasons. The European Landscape Convention, in force since 2004, defines a landscape as an area perceived by people, the character of which is determined both by nature and by the action and interaction of human factors. According to these criteria, strong seasonal changes are expected to be a determinant of Northern European landscapes and therefore require systematic research [10].
Settlements are generally thought of as being in a state of independent development or change, rather than as static or complete. Similarly, for those involved in open space design and planning, such changes are most often associated with physical, social, cultural or economic conditions, but are rarely explored in the context of seasonal climate change.
According to research, individuals think that a neighborhood's appearance and structure change in the winter. Those responsible for maintaining a location's connectivity should make an effort to comprehend these changes and develop a winter travel plan for the city. Similar to their summer counterparts, the goal of these locations should be to create a desirable winter urban fabric that includes high-quality and usable winter public open space along with connected streets and spaces that provide an understandable townscape. This will ensure easy mobility and activity throughout the winter months. Urban planners should also concentrate on minimizing the winter "whiteness" effect's impact on the public realm and look for design solutions that clear up any misunderstandings regarding local user priorities.
Attempts to create a climate-appropriate northern urban form are a relatively recent phenomenon, which has been the focus of a separate field of research. The international "winter cities" movement has created a need for clear, systematic research focusing on national and local measures to improve the comfort and lifestyle of all northern inhabitants. It is critical to realize that winter causes discomfort and that planning theory and practice must take this into account. Winter's negative effects must be minimized while its positive aspects must be increased for northern cities to operate more effectively. Not every summer activity should be abandoned, even though some cannot be done in the winter. Maintaining human life outdoors requires proper microclimatic management. Due to the high level of insulation inside, the outdoor season should also be prolonged [10].
Contact with nature, year-round usability, user involvement, cultural continuity, and the establishment of cozy microclimatic conditions in the majority of the city's open spaces are the main design tenets that should be included in the blueprint for a model "winter city." In adverse environmental conditions, it is essential to create the best possible conditions for human well-being, living, working, and intellectual development in each of the four seasons. Particularly during the lengthy winters marked by high northern latitudes and harsh cold, a climate-responsive approach to urban design and planning policies can reduce the stress of daily living [11].
People can experience several climate impacts at the same time, at different stages or times of their lives. A person's vulnerability to climate change impacts depends on three main factors: exposure, sensitivity and adaptivity.
Not all cities are constructed in the same manner - while many urban design concepts are taken from warm-climate nations, these techniques are not advised for cities that experience freezing temperatures and snowfall since they impact urban infrastructure and restrict community socializing and recreational options. The majority of the time, such urban planning fails to satisfy the year-round needs of the populace. It is reckless and irrational to disregard the arrival of winter. For the built environment to work more effectively, winter elements must be specifically considered in architecture, development policy, architectural design, and urban planning. This will lessen the negative effects of winter conditions on the environment while maximizing its good aspects. A city's ability to attract people, maintain economic growth, vitality, and civic pride can all be greatly impacted by the way it is planned, regardless of how safe, comfortable, desirable, and visually pleasing it is thought to be. Designing winter cities with thermal comfort in mind is crucial, particularly for outdoor and semi-public structures and areas. Planning the microclimate carefully is necessary to keep people from hibernating. Instead of fighting the climate, we should form partnerships with it [12]. Norman Pressman's work focuses on solutions such as wind protection and maximum access to natural light. He also argued that effective interventions in winter cities should take a holistic approach, addressing four different areas: the physical environment, local culture, human biophysiology and economics [13].
In addition to the harsh winters of today, winter cities are

also more likely to encounter erratic, high temperatures and the severity of their fluctuations. Significant health issues and thermal discomfort are already being shown by the effects of urban heat islands. Urban microclimates are already at risk, and estimates of climate change indicate that these risks will only increase. These concerns have arisen primarily because most cities are not built to handle the new difficulties brought on by climate change. By creating a winter urban planning strategy or modifying their public spaces to capitalize on the season and solve winter issues, certain winter cities have tackled this issue [13].

## Methods

For the purposes of this comparative study, four cities within the Vidzeme region of Latvia were selected. This region was chosen due to its characteristically cold and prolonged winters, which are more severe than those in other parts of the country. Within each of the selected cities – Valmiera, Cēsis, Smiltene, and Limbaži – five representative urban locations were identified for investigation: a main street, a public institution, a school territory, a pedestrian zone, and a park. These locations were chosen as they represent the most intensively used public spaces and are central to daily urban life and public gathering.

The study employed a mixed-methods approach to assess and characterise the phenomenon of urban seasonality in Latvian municipalities.

Fieldwork was conducted using a structured **site assessment matrix**, organised around three primary evaluation categories:

- Functionality (adaptability, use, architectural small forms, management, availability);
- Aesthetics (diversity, structure, depreciation);
- Environmental Quality (precipitation, sun exposure, green structure, wind).

The selection of these criteria was grounded in theoretical considerations of seasonality within urban planning. Observations were conducted repeatedly throughout each season to evaluate how landscape spaces adapt to seasonal variations. Each location was assessed with regard to its spatial structure, landscaping, pathway network, maintenance quality, physical deterioration, and environmental responsiveness, with a focus on sustainability, quality, and cyclical transformation.

**Geo-localised Photography** – photographic documentation of the study sites was carried out concurrently with field assessments. These photographs served as visual records to capture spatial conditions, functionality, and quality of the selected urban areas across different seasons and weather conditions. The images were later analysed to identify and compare seasonal changes in the urban landscape.

Semi-structured **expert interviews** were conducted with municipal professionals from the selected Vidzeme cities, including urban planners, landscape architects, and real estate management specialists. The objective of these interviews was to gain insight into the planning and management challenges associated with seasonal dynamics in urban public spaces, as well as to gather expert perspectives on best practices and accumulated experience.

**Public survey** was conducted targeting residents of Valmiera, Cēsis, Smiltene, and Limbaži, although participation was also open to respondents from other Latvian regions. The aim of this survey was to capture public perceptions and experiences regarding the seasonal use and quality of outdoor urban spaces. A total of 144 individuals participated in the survey at the time of data collection.

## Results

**Valmiera** is a dynamically developing urban centre, where continuous improvements are being made to enhance the quality of the built environment. Investments are directed toward maintaining and upgrading street infrastructure, improving blue-green networks, and renovating educational facilities, including both schools and preschools. In parallel, the city is experiencing growth in entrepreneurial activity and a diversification of its cultural life. These elements constitute integral components of the urban fabric, serving residents in both everyday functions and recreational use. The climatic conditions of Valmiera are characterised by relatively cool and humid weather, largely influenced by the proximity of the Gauja River. The average vegetation period in the region spans approximately 130 days. Snow cover typically lasts for 105 days per year, with an average thickness of 25 cm and a recorded maximum of 43 cm. Soil frost reaches an average depth of 70 cm, with extreme cases extending to 120 cm. On average, blizzard conditions are observed on 22 days annually, while fog occurs on up to 36 days. The predominant wind directions are from the south and southwest.

Considering the spatial diversity of Valmiera's public outdoor environments—many of which are structured around key social, educational, and commercial functions—five representative urban landscape sites were selected for detailed analysis within the framework of the research. These include: the territory surrounding the shopping centre "Valleta," the major thoroughfare Rīgas Street, the pedestrian street Ziloņu Street, Jāņparks (a central urban park), and the grounds of Valmiera Viesturs Secondary School. These sites reflect varied typologies of urban space and differing intensities of public use across seasons. The same choises of urban fabric made in other selected cities.

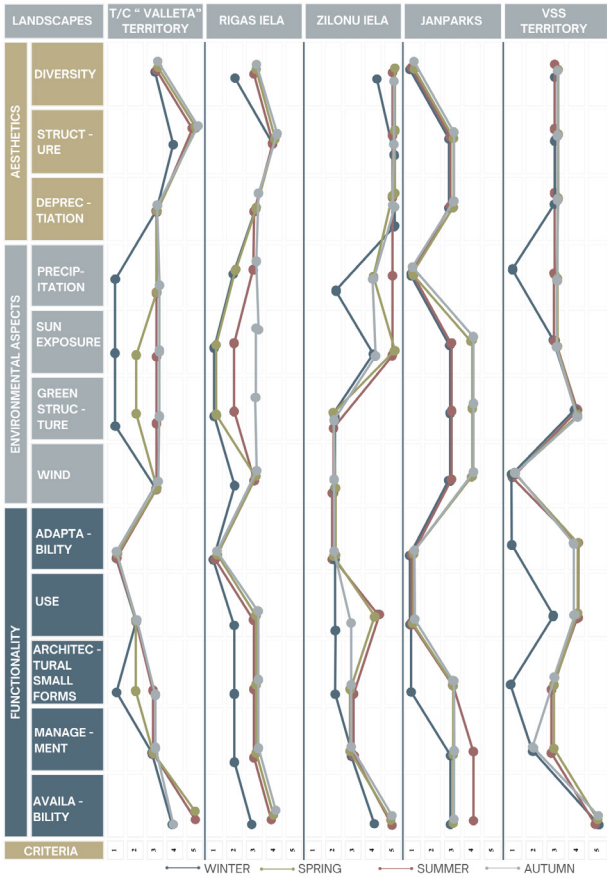



Fig. 1. Results of the Site Assessment Matrix Survey of the Case Study Areas in Valmiera [created by authors]

The territory surrounding the shopping centre "Valleta" is located in the very centre of Valmiera and holds strategic significance within the city's urban structure. Despite its central location and overall adequate maintenance and physical infrastructure, the space lacks adaptation for long-term recreational use throughout the seasons. Its functional potential is currently utilised in a limited and episodic manner—primarily during public events such as the city festival, when the area is temporarily activated through interventions such as street food stands, hammocks, and decorative lighting. However, seasonally responsive design solutions are largely absent. This limits the site's capacity to support everyday social life and reduces its potential to serve as a vibrant, multi-functional urban space that could contribute to the continuous activation of Valmiera's city centre.

Rīgas Street functions as the main arterial road in Valmiera, where during the summer season, the street is characterised by extensive sun exposure and a lack of shaded areas, limiting pedestrian comfort during periods of heat. The street's spatial and functional potential remains underutilised, and it lacks long-term activation strategies. Currently, Rīgas Street comes to life primarily during annual public events, such as the city festival, when it serves as a venue for parades and open-air cinema. However, the existing urban furniture and landscaping elements are not designed for year-round use, particularly lacking adaptability for the winter season.

Ziloņu Street (a pedestrian thoroughfare) was renovated in 2019 and designed as a multifunctional public space intended to host artistic, recreational, and cultural events, while simultaneously highlighting and preserving the scenic natural and cultural-historical values of Valmiera's central area. According to the results of the site assessment matrix, the street's functionality and aesthetic appeal significantly diminish during the winter season. Snow removal is inadequately managed in key zones, which leads to the degradation of plantings and green areas due to negligent maintenance practices. These impacts become especially evident in spring, when traces of vehicular damage—such as tire marks on grassed areas, broken ornamental shrubs, and worn lawn surfaces—are clearly visible. Given the site's location adjacent to a water body, it is also characterised by pronounced wind exposure. Nevertheless, the balance between sunlit and shaded areas is relatively even, as the spatial structure features both dense tree groupings and open hardscaped zones. The space currently lacks also features that support long-term recreational use throughout all seasons.

Jāņparks is located within a residential district primarily composed of detached single-family homes. Due to its spatial positioning and permeability, the park often functions as both a recreational area and a pedestrian transit route for local residents of the surrounding Jāņparka neighbourhood. According to the results of the site assessment matrix, the park demonstrates significant potential for the development of seasonally adaptable recreational infrastructure. The area is currently maintained on a regular and satisfactory basis, and its environmental conditions—such as a balanced distribution of sun exposure and shading, as well as natural wind ventilation—contribute to a pleasant and comfortable atmosphere for users. Despite these favourable conditions, Jāņparks currently lacks recreational offerings specifically adapted to different seasons.

According to the results derived from the site assessment matrix, the outdoor territory of Valmiera Viesturs Secondary School demonstrates seasonal imbalances in spatial quality and functionality. The southern part of the territory is predominantly shaded, while the northern section is highly sun-exposed and subject to noticeable wind corridors, resulting in a fragmented spatial experience. During the winter season, the usability of the area significantly declines, as no structured or long-term outdoor recreational opportunities are provided for students. The lack of winter-specific design solutions limits the functionality of the space during the colder months. Following the recent reconstruction of the school and associated landscape upgrades, improvements have been made to paved surfaces and urban furniture. However, the adjacent sports field area remains undeveloped, despite its considerable size and potential for adaptation to seasonal outdoor activities. Importantly, the school grounds are accessible to the wider public during evenings and throughout the summer period. Local residents frequently utilise the site's disc golf course, outdoor table tennis zone, and the basketball and sports courts, indicating the space's multifunctional potential beyond school hours.

**Cēsis** is one of the oldest towns in Latvia, located in the northern part of the Vidzeme Upland. The city's development has been significantly influenced by the Gauja River, which flows through the area, with the ravines of the Gauja Valley extending into the urban fabric itself. Cēsis is distinguished by a rich concentration of cultural and historical heritage, which forms a central component of its identity. The city's development strategy is oriented towards the well-being of its residents, aiming to ensure a high quality of life and overall prosperity. When comparing the climatic standard norm (1991–2020) with the reference period (1961–1990), the average annual air temperature in the Cēsis municipality has increased by 1.2 °C, while the total annual precipitation has risen by 50.2 mm. During the standard climate period (1991–2020), the average snow cover thickness was 6.4 cm. According to data collected by the Latvian Environment, Geology and Meteorology Centre, projections indicate a decline in snow cover thickness by the end of the century. In a scenario of moderate climate change, the average snow depth is expected to decrease to 3.2 cm, whereas under a significant climate change scenario, it could reduce to as little as 1.7 cm.

The "Globuss" shopping centre lies in close proximity to the Cēsis railway station, the intercity bus terminal, and several other key urban landmarks of significance to the city. According to the findings of the site assessment matrix, the spatial characteristics of the "Globuss" territory remain largely unchanged throughout the seasons. The site is currently used exclusively for vehicular parking, with no provisions made for public outdoor activities or seasonal engagement. The green structure within the area is minimal and lacks functional value, which contributes to an uncomfortable microclimate characterised by strong wind exposure and excessive sun. The spatial accessibility of the territory is limited due to the narrow layout of the parking area and variations in terrain, which become particularly problematic during the winter season. Despite these limitations, the territory is regularly maintained, and the immediate surroundings appear clean and orderly.

Piebalgas Street is one of the main arterial roads in the city of Cēsis. The is relatively monotonous and lacks designated public rest areas. The absence of basic urban infrastructure significantly reduces comfort and accessibility, particularly for older residents. Additionally, public transport stops along the street are not equipped with shelters, making it difficult for users to find protection from rain, snow, or intense sun. Although some tree plantings provide intermittent shade during the warmer months, longer stretches of the street

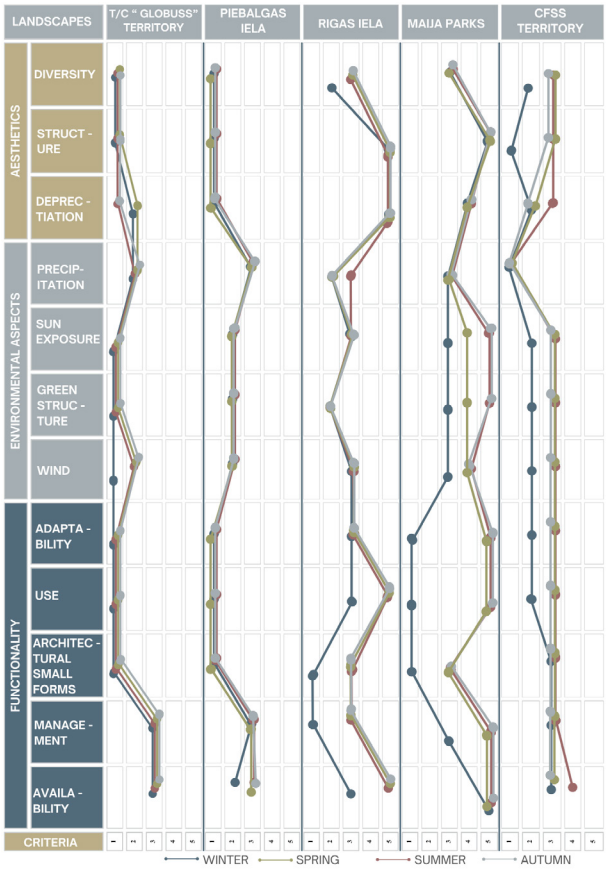



Fig. 2. Results of the Site Assessment Matrix Survey of the Case Study Areas in Cēsis [created by authors]

remain exposed, resulting in pronounced solar radiation and heat during summer. Wind exposure increases in several parts of the street due to a more open landscape structure, leading to uncomfortable microclimatic conditions such as drafts.

Rīgas Street holds a distinctive role within the urban structure of Cēsis, as it is seasonally transformed into a pedestrian and cyclist-friendly zone. From June 1st, each weekend throughout the summer, the street is closed to motorised traffic and temporarily adapted with various public realm enhancements, including benches, tables, planters, and outdoor terraces, effectively revitalising the street and fostering vibrant public life. The transformation of this space is closely tied to the city's resident- and culture-oriented development strategy, which places emphasis on tourism, creative industries, and the quality of public space. As a result, Rīgas Street features a high concentration of cafés, cultural venues, and outdoor dining areas, contributing to its identity as a dynamic social and leisure destination. Based on the site assessment matrix, the adaptability and management of the street significantly improve during the spring and summer seasons. The diversity of small-scale architectural forms increases, and temporary installations enhance the vibrancy and usability of the space. However, during autumn and winter, maintenance becomes more challenging due to the reintroduction of motor vehicle traffic and the narrow, irregular street geometry characteristic of historic city centres. Snow removal, in particular, is complicated by both parked vehicles and the confined spatial layout. The street contains limited permanent green structure – only a few individual trees – therefore, its visual and ecological qualities are seasonally supplemented with ornamental plants in movable planters. Despite the dense built environment typical of the old town, Rīgas Street maintains a relatively high degree of accessibility. It accommodates a designated bicycle lane, organises one-way vehicular traffic, and ensures pedestrian movement along both sides of the street, supporting inclusive urban mobility.

Maija Park is one of the central urban green spaces in the city of Cēsis, located along Valmieras Street. It functions both as a key pedestrian connector to nearby cultural and recreational destinations and as an accessible everyday leisure space for residents and visitors alike. According to the results of the site assessment matrix, the park features a diverse and well-integrated path network, with multiple access points that ensure year-round permeability and connectivity. The park offers a wide range of recreational amenities. Overall, the area is well-maintained; however, during the spring season, surface erosion and the formation of informal footpaths due to pedestrian shortcuts are observed. In the summer months, these issues are mitigated through the use of temporary barriers. The park is characterised by a rich and layered green structure, including ornamental plantings and numerous tree groupings that provide a visual identity and a balanced microclimate. The presence of mature vegetation ensures an effective distribution of sun and shade, contributing to thermal comfort and wind mitigation. As a result, the park environment is generally perceived as pleasant and inviting throughout the warmer seasons. Despite the park's vibrant character in spring and summer, its functionality declines significantly in winter. Most amenities and uses are oriented toward the warmer months, and as vegetation sheds its foliage, the elevated topography – particularly noticeable from the northwestern side of the city – leaves the area more exposed to wind, increasing discomfort and reducing the attractiveness of the park during the cold season.

Cēsis City Secondary School is located adjacent to the Cēsis Sports Complex. Overall, the territory exhibits low spatial diversity and lacks adaptation to seasonal changes. Winter snow cover enables informal use of the sloped terrain for recreational activities, while spring reveals worn-out lawn areas and soil erosion. The school's main entrance zone has been renovated with flower beds, benches, and bicycle shelters, also featuring the highest concentration of greenery – most notably, aligned linden trees along streets. In contrast, the eastern section suffers from limited vegetation, creating a noticeable heat island effect in warmer months. The path network is varied in surface type, with worn concrete slabs forming puddles during wet weather. The stadium in the northeastern area is accessible to the public outside of school hours. The terrain's relief offers partial wind protection, though some areas remain wind-exposed, particularly during leafless seasons.

**Smiltene** is a well-maintained, traditionally Latvian small town located in northern Latvia. Its urban structure is defined by low-rise residential buildings, distinctive hilly terrain, green spaces, and several lakes formed by damming the Abuls River. The town has seen notable infrastructural and economic development due to its favourable geographic location, enabling local enterprises to compete successfully in both national and European markets. Smiltene lies within a moderately humid Atlantic–continental climate zone. It is characterised by relatively cool summers and mild winters with frequent thaws. The town experiences more stable winter temperatures and lower precipitation levels compared to the surrounding Vidzeme Upland. Due to the undulating terrain, the local microclimate is cooler, with shorter growing seasons, fewer frost-free days, and a longer-lasting snow cover. The average January temperature is +6.2°C, while in July it reaches +16.3°C. Temperature fluctuations are most pronounced in summer, with more stable conditions during

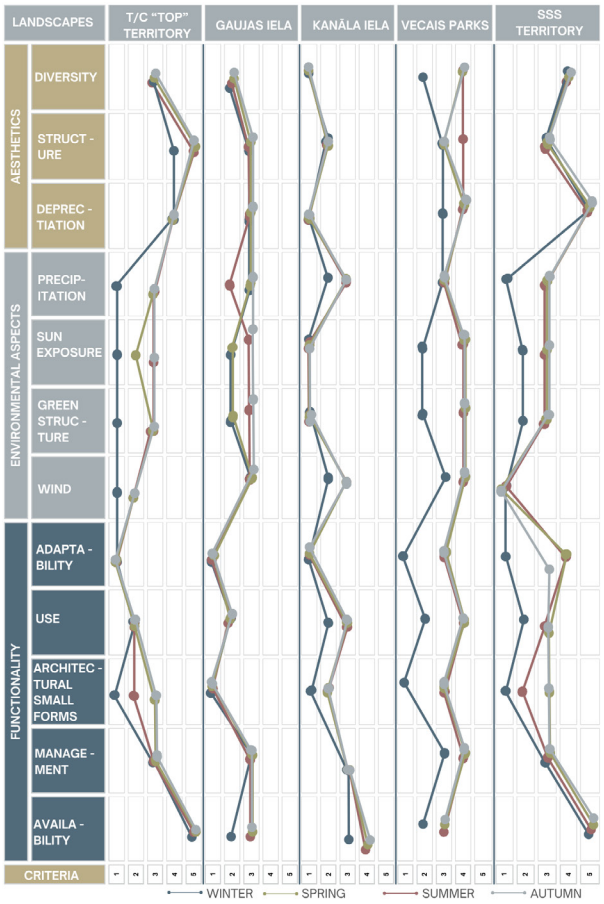



Fig. 3. Results of the Site Assessment Matrix Survey of the Case Study Areas in Smiltene [created by authors]

winter. The average snow depth is approximately 26 cm.

The "TOP" shopping centre is located in the heart of Smiltene, adjacent to the bus station and the Evangelical Lutheran Church. The building's scale and appearance contrast with the surrounding historic small-town low-rise development. According to the site assessment matrix, the area is well-maintained, featuring cohesive and high-quality urban elements, including large flower pots, benches, waste bins, and information stands. Recently planted tree lines, supplemented by flower beds and seasonal arrangements in large metal containers, contribute to visual greenery. However, these green elements are visually and functionally outweighed by the expansive adjacent parking lot, which causes significant sun exposure and reduces comfort in warm seasons. The area lacks seasonally adaptable public space activities throughout the year. Nevertheless, accessibility is ensured for various user groups, with nearby parking spaces and a designated cycle lane running alongside the site.

Gaujas Street is one of Smiltene's four main thoroughfares, extending across much of the town and connecting with Atmodas Street in the city center. According to the site assessment matrix, Gaujas Street features many positive elements but also areas needing improvement. The road infrastructure is well-developed, with tactile guiding lines at intersections for visually impaired pedestrians. Both sides of the street have green structures, though these require enhancement to better mitigate sun exposure. The right side hosts an electric vehicle charging station, a skate park, and a children's playground; these areas would benefit from seasonally adaptable recreational activities. Currently, the street segment contains only one waste bin and a single bench, indicating a need for additional urban furniture. The street is regularly maintained. During winter, roads and sidewalks are cleared of snow, and no significant water accumulation is observed during rainfall. Adjacent green spaces on both sides hold potential for development into more functionally diverse zones.

Kanāla Street is one of several pedestrian streets in Smiltene, connecting to a smaller pedestrian section of Dakteru Street. The Abuls River flows alongside Kanāla Street, passing near the adjacent Tepera Lake. The street runs parallel to Smiltene's territorial boundary and lies close to the Sports Complex and Smiltene Old Park. The street surface consists of two types: asphalt concrete from Dakteru Street to the bridge, and gravel beyond. During spring, rising water levels in the Abuls River slightly affect the adjacent gravel section. Kanāla Street is fully exposed to sunlight year-round, causing notable discomfort during summer due to the lack of green structures. The area experiences pronounced wind flow. On the southern side, a large meadow is regularly mowed. Throughout the year, the street remains very quiet and primarily serves as a connection between the residential area of Smiltene and Tepera Lake.. The riverside area lacks significant amenities or small architectural elements, though lighting poles are installed along the street.

Vecais Park is one of Smiltene's largest green spaces, situated between Tepera and Vidusezers Lakes, and shaped by prominent terrain with the Abuls River flowing through it. The park features diverse green structures across multiple levels, with a significant presence of mature trees providing extensive shade. Thanks to the dense greenery and varied topography, the park is sheltered from strong winds, and rainwater drains effectively into the Abuls River without pooling. A well-developed network of asphalt paths ensures accessibility for both pedestrians and cyclists. The park's small architectural elements are harmonious and varied, contributing to its unique character. During winter, the park lacks seasonally adapted leisure options. Maintenance is consistent throughout the year, with organized autumn leaf collection involving local community participation.

Smiltene High School is located near Vecais Park, surrounded by detached houses. The recently developed and well-maintained school grounds feature a spacious main square and decorative landscaping. According to the site assessment matrix, the area is in good condition with a diverse network of paths ensuring accessibility. However, many paved areas are exposed to intense sun during the hottest parts of the day. The school grounds include various sports fields, offering opportunities for students and locals to engage in physical activities. To increase usability throughout the year, more seasonal activity options are recommended. The open layout results in noticeable wind exposure. Maintenance practices lack strategic planning, such as uniform lawn mowing without zonal variation in summer. Rainwater is managed through lawn infiltration and drainage systems.

**Limbaži** is one of the oldest towns in Latvia, located within the North Vidzeme Biosphere Reserve's landscape protection zone. The town is situated on a hill, with Limbažu Lielezers lake nestled in a valley depression. The historic city layout, established in 1385 following the construction of protective walls, is largely preserved. The Old Town, developed in the 18th and late 19th centuries, is a nationally significant urban monument. Climatically, Limbaži belongs to the Northern Latvia region, with an average January temperature of –6°C and July around +17°C. Annual precipitation ranges from 750 to 900 mm, higher than in many other parts of Latvia. The growing season lasts about 180–190 days. Prevailing winds come from the south and southeast.

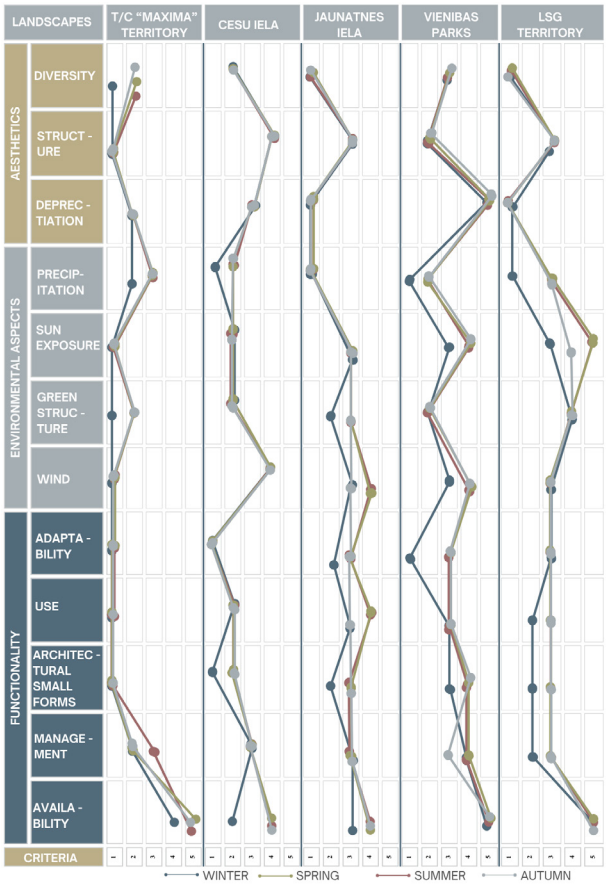



Fig. 4. Results of the Site Assessment Matrix Survey of the Case Study Areas in Limbaži [created by authors]

The Maxima shopping center is located in the center of Limbaži, near various public service buildings, multi-story residential areas, and industrial zones. According to site assessment results, the public outdoor space around the center is of low quality. The area is easily accessible to pedestrians and cyclists and is maintained but lacks seasonally adapted innovations. The center is surrounded by a large parking lot, which negatively impacts the functional and visual quality of the landscape. Due to missing green structures, the space feels highly exposed to sunlight and wind. The area remains monotonous throughout the year, with limited diversity in use, few architectural small forms, no highlighted sightlines, and lacks seasonally adapted activities.
Cēsu Street is one of Limbaži's seven main streets, running through the historic old town toward Valmiera. According to the site assessment matrix, the dense old town buildings define clear sightlines and prevent wind drafts along the street. However, the entire street suffers from strong sun exposure due to a lack of green structures, especially around Baumaņu Kārļa Square. The street also lacks small architectural elements, and there are very few benches and trash bins in the studied section. Some parts of the street have been renovated with sidewalks featuring bicycle lanes and tactile paving, but most sidewalks remain narrow. The street shows visible signs of wear, with outdated asphalt causing water accumulation during rainfall. In winter, snow accumulation on sidewalks limits accessibility. Seasonal activities are missing. Overall, the street is clean and well-maintained but requires updates to its infrastructure and street furniture.
Jaunatnes Street stretches from Rīgas Street to Lielezers and is divided into three sections: the middle part for motor vehicles, while the beginning and end are reserved for pedestrians and cyclists. Nearby are the Limbaži Open-Air Stage, Main Library, and Swimming Pool. The site assessment shows the area is accessible to diverse social groups. The street is lined with extensive tree plantings, which reduce wind and balance sun exposure, though the variety of greenery is limited and could benefit from seasonal decorative plants. Linden tree rows along parts of the street create defined sightlines. Due to the pronounced relief, the street does not accumulate much rainwater and serves as a winter activity spot for sledding and skiing. Outdoor sports like disc golf are available, and various events take place at the nearby open-air stage. Overall, Jaunatnes Street is well-maintained and regularly managed.
Located in the city center near the Culture House and municipal administration, Vienības Park features a theater house and a children's playground. The park has been renovated, with well-maintained paths and facilities showing no signs of wear. While there are enough small architectural elements, increasing their variety would enhance the park's seasonal usability and overall diversity. The extensive pathway network ensures full accessibility. Large tree clusters create heavy shading in some areas, causing uneven light distribution, though sunlight reaches the decorative flowerbeds mainly in the park's center. Thanks to the mature trees, wind is minimal. The park is clean and well-maintained year-round. Incorporating seasonal innovations could improve management by adopting smarter maintenance practices.
Limbažu Valsts ģimnāzija outdoor public space around the school is noticeably outdated and in need of improvements to create a more interesting and motivating environment for students. The area has a diverse network of paths that provide good access to the school, but the pavement is worn out and should be replaced. Due to the poor quality of the surface, water tends to accumulate during rainfall. Large tree plantings cover much of the area, creating extensive shade. While the northern part of the territory receives sunlight, this space is not utilized to create pleasant spots for relaxation or free time. The outdoor environment lacks clear sightlines and is quite monotonous, with a shortage of varied small architectural elements such as benches, shelters, or decorative features. During the winter season, an outdoor ice rink is set up nearby, which is publicly accessible to residents of Limbaži. Maintenance during the warmer months is generally adequate; however, in winter, snow accumulation sometimes makes parts of the area difficult to access.
During the **interviews** with specialists from Vidzeme municipalities the main focus was on identifying seasonal urban planning and maintenance challenges in their respective cities, highlighting that:

- Most attention to seasonality is given from a maintenance rather than urban planning perspective.
- Winter-specific planning is lacking; public spaces are often designed for warmer months.

So, when it comes to adapting infrastructure for different seasons, most municipalities prioritize maintenance aspects such as mechanized cleaning. However, winter season considerations are often overlooked in the initial design and planning phases. Public outdoor spaces tend to be optimized mainly for use from early spring to late autumn. Some municipalities, like Cēsis and Smiltene, do incorporate planning for snow storage and seasonal plantings to balance usability, safety, and aesthetics throughout the year. The specialists reported several recurring challenges, primarily adverse weather conditions—such as heavy snow, strong winds, and rain—and a lack of sufficient funding to respond

adequately to emergencies and routine maintenance. Safety concerns, like icicles forming during winter (noted in Cēsis), also complicate maintenance work. Additionally, the unpredictability of weather makes budgeting for maintenance difficult. Maintenance activities include regular inspections of roads, sidewalks, green zones, and playgrounds. In Valmiera, inspections during winter happen as often as hourly to ensure safety and timely snow removal, while Limbaži aims to minimize snow removal to save resources. Leaf collection is organized both mechanically and manually, with leaves composted afterward. Community initiatives, such as Smiltene's annual "Spodrības mēnesis" (Clean-up month), engage residents in city maintenance efforts. Examples of good practice:

- Valmiera aims to design multifunctional outdoor spaces usable year-round.
- Cēsis considers snow storage during the planning phase to avoid conflicts with green zones.
- Smiltene emphasizes seasonal plantings that do not hinder visibility or winter maintenance.

To optimize costs, municipalities employ strategies like reducing the frequency of cleaning and focusing snow removal efforts based on snow depth thresholds. Some maintenance contracts fix costs regardless of weather fluctuations, providing financial predictability. Suggestions from specialists include reducing mowing areas in warmer months and promoting flower meadows to lower maintenance expenses. Munucipal specialists highlighted difficult-to-maintain areas:

- Historic centers (Cēsis, Limbaži) require manual cleaning due to dense layouts.
- Valmiera struggles with poorly executed work at intersections.
- Narrow streets and parking areas in Smiltene require night shifts in winter.

Historic city centers present particular challenges for both development and maintenance due to their dense structures. Collaboration between planners and maintenance teams is emphasized to create solutions that are both functional and manageable year-round. The interviewed specialists expressed strong support for developing seasonal urban planning guidelines. Such guidelines would provide continuity during staff changes and help preserve the city's character while guiding year-round design and maintenance.

**The survey** aimed to gather opinions from residents and visitors of several Latvian cities regarding the seasonal use, aesthetic, and functional quality of outdoor spaces. Most respondents (47.9%) were aged 19 to 29. A total of 144 people participated, including 49 from Valmiera, 20 each from Cēsis, Smiltene, and Limbaži, and 35 from other regions of Latvia.

Key findings showed that a significant portion of respondents experienced issues with insufficient and low-quality outdoor facilities—ranging from 15% in Smiltene to 48.6% in other Latvian regions. Environmental negative impacts on people were also frequently reported, especially in areas outside the four main cities. Poor maintenance was a notable problem, particularly in Valmiera (40.8%). The most commonly identified issue across all cities was the lack of seasonal activities tailored to outdoor spaces. Regarding public involvement in planning outdoor spaces, opinions were mixed. Only a small percentage (around 8% in Valmiera) strongly supported active citizen participation, while most respondents chose a moderate level of involvement. When asked about the availability of seasonally adapted activities, most respondents gave mid-range ratings. Valmiera respondents tended to rate outdoor space adaptability between 6 and 8 out of 10, while Limbaži respondents rated it lower, indicating a perceived lack of seasonal activities. Smiltene received relatively higher ratings for seasonal adaptability.

Overall, the survey highlights the need to improve outdoor space quality and maintenance and to develop more seasonally adaptable activities, while also considering greater public involvement in planning processes. When summarizing respondents' opinions on the use and maintenance of outdoor spaces during the winter season, clear views emerge about several areas and their upkeep. Most complaints concern insufficient clearing of streets and pedestrian paths from snow. This issue is partly attributed to changing weather conditions and the transition from manual cleaning (by street cleaners) to mechanical clearing with tractors, which often results in lower quality. Respondents from Valmiera specifically mentioned that pedestrian path maintenance in the areas around Rīga Street and the "Valleta" shopping center is critical, especially regarding snow accumulation. The promenade near Dzirnavu Lake received praise for adequate maintenance of some trails, although many places lack cleanliness and proper care during winter.

Respondents emphasized a lack of maintenance in playgrounds and recreational zones, noting that despite the winter season, children still want to use these spaces, which are generally not adapted for year-round use. Sports and active recreation areas were reported to lack skiing opportunities. Several improvements are needed, including better lighting installations, to make outdoor spaces usable during dark winter evenings. Residents expressed willingness to use disc golf courses in winter if snow-cleared tracks were purposefully created.

Many respondents indicated that city infrastructure is insufficiently adapted to support quality outdoor leisure activities in winter. For example, ice formation on sidewalks creates hazardous conditions for safe movement. There is a strong desire for better-adapted and well-maintained outdoor spaces specifically designed for the winter season. Targeted organization of activities such as skiing, sledding, and walking would be important to encourage greater use of outdoor spaces during winter months.

As a result of the research, development **models** and proposed seasonal landscape solutions were created. These include targeted **recommendations** for improving specific outdoor spaces for both summer and winter use. The proposals aim to enhance aesthetic and functional quality by integrating seasonally appropriate design elements, promoting year-round use, and fostering a more inclusive and engaging public realm.

When designing **primary urban streets**, it is crucial to integrate considerations of seasonal variability and weather conditions. Street networks and pedestrian routes should provide multiple routing options and incorporate structural elements that mitigate prevailing wind effects. Urban areas that are sheltered from wind and exposed to direct sunlight tend to offer higher environmental comfort and extended usability throughout the year.

In pedestrian and transit-dominated zones, the inclusion of wide, unobstructed sidewalks is essential to ensure barrier-free movement. Street layouts must also allocate sufficient space for municipal maintenance equipment, particularly in winter conditions. From a functional and economic standpoint, boulevard configurations are preferable to uninterrupted linear streets, as they can accommodate snow storage during winter, thereby reducing operational costs associated with snow removal.

Sidewalks in areas of commercial activity should be designed with designated furnishing or equipment zones to maximize


Fig. 5. The main street development model during the summer season [created by authors]

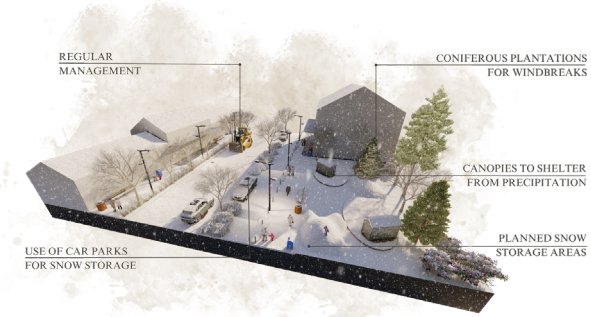



Fig. 6. The main street development model during the winter season [created by authors]


Fig. 7. A pedestrian street development model for the summer season [created by authors]


Fig. 8. A pedestrian street development model for the winter season [created by authors]

pedestrian circulation capacity. In zones prioritized for non-motorized mobility, the width of vehicular lanes should be minimized to promote a more balanced and user-friendly streetscape.

The most critical component of seasonally adaptive public space in winter is consistent and effective maintenance. Strategies should include designated snow storage areas within open lawn spaces or the temporary reduction of on-street parking. The decision between snow retention and removal should be informed by the specific urban context.

Vegetative planning should incorporate evergreen species to provide wind buffering and visual structure during dormant seasons. Street trees not only reduce wind speed but also enhance the spatial separation between pedestrian pathways and vehicular traffic. Tree species should be carefully selected for tolerance to de-icing salts, and protective measures – such as temporary guards – should be installed to shield trunks from mechanical damage during snow clearance operations. Additionally, the integration of seasonal infrastructure – such as shelters or canopies – can enhance comfort by offering protection from wind and precipitation, thereby extending the usability of public spaces during colder months.

When designing **pedestrian streets**, it is essential to consider a range of guidelines that enhance both the functional and aesthetic quality of the street throughout all seasons. Bicycle traffic should be separated from pedestrian flows using buffer plantings, thereby improving safety and contributing to a more visually appealing streetscape.

Along the pedestrian corridor, provisions should be made for cafés and weather-adapted pavilions to support commercial functions year-round. In proximity to these pavilions, the integration of parklets can foster a stronger sense of community and offer residents opportunities to enjoy food and beverages outdoors. The inclusion of multifunctional public spaces that can accommodate small-scale events further increases the adaptability and vibrancy of the pedestrian environment. Appropriately scaled street furniture and pedestrian-oriented lighting enhance comfort and safety, reinforcing the identity of the street as a space designed for people.

In winter, pedestrian streets can transform into ideal locations for Christmas markets that complement existing cafés and businesses. To maintain visual interest and attract users during colder months, streetscapes should incorporate environmental enhancements such as murals, string lighting, heated canopies, and other seasonally responsive elements. Allocating designated zones for snow storage ensures that pedestrian routes remain accessible and safe even following heavy snowfall.

Seasonal lighting is particularly effective in creating a distinctive winter ambiance. Broader sidewalk margins may serve as temporary snow storage zones during the winter season. Slightly elevated pedestrian crossings help slow vehicular traffic and prevent the accumulation of melted snow or ice along curb edges. Buffer planting zones should be sufficiently wide to accommodate snow buildup and should be raised above the level of adjacent parking areas to reduce salt infiltration from surface runoff.

Finally, building placement should be carefully considered to prevent excessive shading of pedestrian zones that are frequently used throughout the year, thereby enhancing thermal comfort and spatial quality.

In **park** design, the inclusion of a diverse and interconnected pathway network is essential to ensure accessibility for all users. Parks should feature multifunctional zones that can adapt to different seasonal needs. For example, artificial mounds may serve as sledding hills in winter, while in parks lacking natural water bodies, lawn areas can be seasonally transformed into ice rinks.

Multifunctional sports fields, outdoor gym areas, and picnic zones equipped with designated fire pits should be incorporated to enhance recreational use throughout the year. Heated shelters and cafés with restrooms represent a crucial park infrastructure component, offering not only user comfort but also space for storing maintenance equipment such as ice-clearing devices, pumps, and control systems.

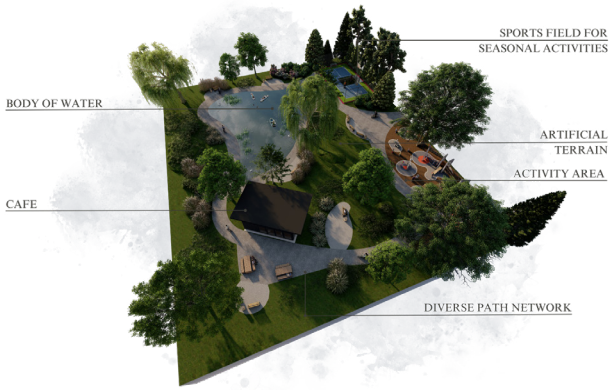



Fig. 9. The park development model for the summer season [created by authors]

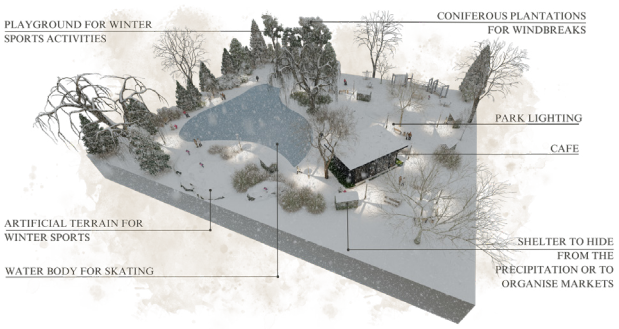



Fig. 10. The park development model for the winter season [created by authors]


Fig. 11. A development model for an educational institution territory during the summer season [created by authors]


Fig. 12. A development model for an educational institution territory during the summer season [created by authors]

Designated zones for winter sports – such as cross-country skiing, ice hockey, or snowman building – encourage year-round use of public outdoor spaces. Heated pavilions may provide refuge from precipitation and also serve as venues for seasonal events and small-scale commerce. In winter, areas used for summer activities (such as multifunctional sports fields) can be repurposed for snow-based recreation.

Planting strategies should include coniferous trees along the northern and western boundaries to serve as windbreaks, while deciduous trees in more central areas allow sunlight to penetrate and warm the most actively used zones. To further enhance winter ambiance, parks should incorporate seasonal lighting or decorative illuminated installations that create a welcoming and visually engaging environment.

The integration of solar-powered infrastructure can increase the park's environmental sustainability. Snow storage areas must be appropriately sized and located to accommodate pathway dimensions and maintain circulation. Ideally, snow piles should be situated in sun-exposed areas to accelerate melting and reduce the burden of manual removal.

The integration of outdoor classroom zones into **educational environments** supports a more diverse and experiential learning approach. These zones should be designed to accommodate seasonal variation, enabling educational activities throughout the year. Allocating areas for school gardens further enriches the curriculum by allowing students to engage in seasonal horticultural practices and hands-on environmental learning.

A spacious, multifunctional gathering area should be included to serve as a representative outdoor venue for events such as graduation ceremonies, the first day of school celebrations, and other school-wide gatherings. Artificial topography can be strategically integrated into the landscape to connect play and sports zones, enhancing spatial diversity and encouraging creative interaction. Due to varying weather conditions, a covered bicycle shelter is also essential.

The inclusion of public outdoor space in educational processes remains important during the winter season. Activity zones should remain functional year-round by incorporating elements such as artificial ice rinks, sledding hills, and designated winter sports areas. Building façades should include large windows to maximize natural daylight and support a healthier indoor learning environment.

To enhance the spatial experience during the darker months, seasonal lighting fixtures and decorative light installations can be employed to create a warm and inviting atmosphere. Additionally, the incorporation of solar energy solutions can improve the environmental sustainability of school


Fig. 13. A development model for public centre areas during the summer season [created by authors]


Fig. 14. A development model for public centre areas during the summer season [created by authors]

infrastructure.

The facades of shopping centres should be designed with expansive glazed windows, allowing natural sunlight to penetrate indoor spaces while visually connecting the public outdoor environment with the interior.

These commercial areas offer excellent opportunities for diverse greenery integration. Vertical landscaping can be employed not only to enhance air quality but also to enrich the architectural expression of the building façade. Seasonal plantings in flower boxes enable the creation of visually appealing compositions even during the winter months. Large-scale planting containers, suitable for hardy species, may also serve a dual function as urban furniture.

To ensure pedestrian comfort and safety, broad planting strips should be used to separate car parking zones from footpaths. For optimal use of the outdoor space, south-facing terraces equipped with seating areas should be established to take advantage of sunlight exposure.

During winter, it is essential to designate specific areas within commercial centre precincts for snow storage to prevent obstruction of parking areas and primary circulation routes. Maintaining the functionality of terrace shelters during colder seasons allows for the hosting of local markets or simply for weather protection. Grouping trees enhances their resilience against strong winds and contributes to reduced surface evaporation, ensuring improved water retention for root systems. When planning ground cover, salt-tolerant shrubs and perennials should be prioritized. Raised planting beds further reduce salt absorption and protect vegetation during winter maintenance operations.

## Conclusion

The study highlights how public outdoor spaces are often poorly adapted for winter use. Experts and respondents identified key problems such as insufficient snow removal, icy sidewalks, limited lighting, and a lack of winter-specific infrastructure like sledding hills, skating areas, or heated shelters. To improve usability and comfort in winter, the study proposes:

- Designing multifunctional spaces usable in all seasons (e.g., artificial hills, skating rinks).
- Using evergreen vegetation for visual appeal and wind protection.
- Installing lighting, seasonal décor, heated pavilions, and promoting outdoor events (e.g., Christmas markets).
- Ensuring safe, barrier-free access for all user groups, including seniors.
- Adapting streets, parks, schools, and commercial areas with better planning, maintenance zones, and snow management solutions.
- More specific, based on these findings, the research proposes seasonal development models for public landscapes, offering spatial and functional solutions for both summer and winter use. These recommendations include:
- In the context of urban development planning, it is crucial to account for the seasonal functionality of primary public spaces. Based on research findings, outlinedF spatial and functional strategies to enhance the usability of public environments during both summer and winter periods:
- Street and Transit Planning: Streets should be designed with seasonal climate conditions in mind. Pedestrian and vehicle routes must allow for multiple alternatives and incorporate wind-blocking structures such as buildings or evergreen tree lines. Boulevards, rather than wide continuous roads, are preferred for snow storage and cost-effective maintenance.
- Pedestrian Streets: Prioritize barrier-free movement with wide sidewalks and integrate seasonal commerce such as cafés and parklets. Elevated crossings and buffered planting strips improve pedestrian safety and provide snow storage in winter. Seasonal lighting and public art installations enhance spatial quality during the darker months.
- Parks and Green Spaces: A diverse pathway network should ensure accessibility, while multifunctional zones – like artificial mounds or skating rinks – support year-round recreational use. Parks should also feature outdoor gym equipment, picnic spots with fire pits, and heated shelters that double as storage for maintenance tools.
- Education and School Grounds: Outdoor classrooms promote experiential learning throughout the year. Spaces for school gardens, sports, and seasonal events (like graduation ceremonies) can enrich student engagement. Key infrastructure includes protected bicycle storage, large windows for natural light, and sustainable energy solutions such as solar power.
- Commercial and Public Centres: Shopping centres can support vibrant outdoor space design through glazed façades, vertical greenery, and planters for seasonal vegetation. South-facing terraces and designated snow storage areas help maintain functionality and comfort in winter. Salt-tolerant species and raised planting beds are recommended to withstand harsh conditions.
- Thoughtful landscape planning that accommodates both summer and winter dynamics can significantly enhance public space usability, safety, and attractiveness throughout the year.

## References

1. **Bibri, S. E. un Krogstie, J.** Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society*, 2017, 31, 183–212. Pieejams: https://www.sciencedirect.com/science/article/pii/S2210670716304073
2. **Banerjee, T. un Loukaitou-Sideris, A. Companion to urban design**. London: Routledge, Taylor & Francis Group, 2011.
3. **Stokmane, I.** Landscapes within urban environment. *Acta Horticulturae*. International Society for Horticultural Science, 2022, 285–290. Pieejams: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85141863489&doi=10.17660%2FActaHortic.2022.1345.38
4. **Gehl, J.** *Life between buildings: Using public space*. Copenhagen: The Danish Architectural Press, 2001.
5. **Walters, D. R.** *Designing community: Charrettes, master plans and form-based codes*. London: Routledge, 2007.
6. **Urban Design Lab.** *Top 15 Theories in Urban Planning*. 2003. Pieejams: https://urbandesignlab.in/top-15-theories-in-urban-planning/
7. **Lang, J.** *Urban design: A typology of procedures and products. Illustrated with over 50 case studies*. Oxford: Architectural Press, 2005.
8. **Huxley, M. un Inch, A.** *Urban Planning*. Kobayashi, A. B. T. (ed.) International Encyclopedia of Human Geography (Second Edition). Oxford: Elsevier, 2020, 87–92. Pieejams: https://www.sciencedirect.com/science/article/pii/B9780081022955102288
9. **Chapman, D.** *Urban Design of Winter Cities: Winter Season Connectivity for Soft Mobility.* 2018. Pieejams: https://www.researchgate.net/publication/327768380_Urban_Design_of_Winter_Cities_Winter_Season_Connectivity_for_Soft_Mobility
10. P**alang, H., Sooväli-Sepping, H., Printsmann, A.** *Seasonal landscapes*. Dordrecht: Springer, 2007.
11. **Bergum, C., Beaubien, L. A.** *Smart growth and winter city design. Smart Growth Bulletin*, 2009, 1. Pieejams: https://carrefour.vivreenville.org/storage/app/media/publications/Articles-de-fond-Encyclopedique/design-actif-en-contexte-hivernal/smart-Growth-and-winter-city-design.pdf

12. **Pressman, N.** *Developing climate-responsive winter cities*. *Energy and Buildings*, 1988, 11, 11–22. Pieejams: https://www.sciencedirect.com/science/article/pii/0378778888900199
13. **Nuttall, S.** *Crafting a Winnipeg Winter Planning Strategy with Lessons from Other Cities*. 2022. Pieejams: https://umanitoba.ca/architecture/sites/architecture/files/2023-02/CP_Capstone2022_Nuttall%28report%29.pdf

## Authors

**Ilze Stokmane**, Dr. oec. is a technical text editor of the internationally cited journal "Landscape Architecture and Art". Dr. oec., Associate Professor, leading researcher at the Faculty of Forestry and Environmental Sciences, Institute of Landscape Architecture and Environmental Engineering, Latvia University of Life Sciences and Technologies. E-mail: ilze.stokmane@lbtu.lv
ORCID ID: https://orcid.org/0000-0002-5509-7458

**Agnese Vasiljeva**, Mg.arch., Landscape Architect at the Spatial and Urban Planning Division in Valmiera Municipality. Research interests - exploration of seasonality within the fields of landscape architecture and urban planning, with particular attention to seasonal changes, especially during the winter period, and their influence on the functionality, aesthetics, and sustainability of public outdoor spaces.

## Kopsavilkums

Pētījums aplūko aktuālu ainavu arhitektūras un pilsētplānošanas tēmu – ainavas sezonalitāti, īpašu uzmanību pievēršot ziemas periodam, kas praksē nereti tiek uztverts kā sekundārs vai maznozīmīgs aspekts ainavu plānošanā. Mainīgie klimatiskie apstākļi ziemas sezonā aktualizē virkni problēmu pilsētvidē, tostarp transporta infrastruktūras nepietiekamu funkcionēšanu, autostāvvietu nepieejamību un gājēju kustības apgrūtinājumus. Sniega uzkrāšanās un tā apsaimniekošanas jautājumi rada jaunus izaicinājumus pilsētas teritoriju plānošanā, jo drošas un kvalitatīvas publiskās ārtelpas nodrošināšana ir viens no ainavu arhitektūras pamatprincipiem, kas ietver arī iedzīvotāju veselības un drošības risku mazināšanu. Lai nodrošinātu publisko ārtelpu infrastruktūras pielāgošanu sezonālai lietošanai, pētījumā izstrādāta metodoloģiska pieeja kvalitatīvu sezonālās pilsētplānošanas principu definēšanai, balstoties uz esošo problēmu analīzi. Šim nolūkam ir izstrādāti kritēriji ainavu telpu izvērtēšanai un analīzei, kas ļauj novērtēt teritoriju piemērotību dažādos sezonālos apstākļos. Pētījumā analizēta vairāku Latvijas pašvaldību pieredze ārtelpu plānošanā, veikta iedzīvotāju aptauja un intervijas ar nozares ekspertiem, lai identificētu efektīvus risinājumus ziemas sezonas izaicinājumiem pilsētvidē. Pētījuma rezultātā izstrādāti ilustratīvi un detalizēti piemēri, kas demonstrē dažādu publisko ārtelpu sezonālās labiekārtošanas un izmantošanas iespējas, veicinot integrētu un ilgtspējīgu pieeju pilsētvides plānošanā visos gadalaikos.

Scientific Journal of Latvia University of Life Sciences and Technologies
**Landscape Architecture and Art**
Volume 26, Number 26

DOI: 10.22616/j.landarchart.2025.26.11

# THE LANDSCAPE FOOTPRINT OF POLLUTION: HEAVY METALS IN SNOW ACROSS URBAN LAND USE TYPES

**Inga Grīnfelde[1], Inga Straupe[1], Kristaps Siltumēns[1], Oskars Purmalis[2], Māris Bērtiņš[2], Jovita Pilecka-Uļčugačeva[1]**

[1]*Latvia University of Life Sciences and Technologies, Latvia*

[2]*University of Latvia, Latvia*

**Abstract. Urban landscapes play a critical role in shaping air and water quality, influencing the distribution of heavy metals and other pollutants. This study investigates the spatial and temporal variations of heavy metal concentrations in urban snow water within Jelgava City, Latvia, over three winter seasons (2017–2019). The study examines the relationships between heavy metal accumulation and urban land use categories, including residential, natural, transport, apartment, public, and industrial zones. Snow samples were analyzed for lead (Pb), nickel (Ni), chromium (Cr), and vanadium (V) using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), with statistical analyses performed to determine pollution trends and influencing factors. Results revealed significant spatial and temporal variations in heavy metal concentrations, with Pb exhibiting the highest mean concentration of 7.07 µg/L, followed by Ni (1.93 µg/L), Cr (2.77 µg/L), and V (2.08 µg/L). Maximum recorded values reached 72.26 µg/L for Pb, 40.75 µg/L for Ni, 71.35 µg/L for Cr, and 64.16 µg/L for V, highlighting extreme pollution events. Statistical analysis confirmed significant year-to-year variations for Pb ($p = 0.0047$), Ni ($p = 0.00028$), and Cr ($p = 0.00030$), whereas V remained relatively stable ($p = 0.0696$), suggesting a continuous pollution source. The study also highlights the influence of urban density on heavy metal accumulation, emphasizing the impact of vehicular emissions, heating systems, and industrial activities. The findings underscore the need for integrated urban planning strategies to mitigate heavy metal pollution and improve environmental quality in urban settings.**
**Keywords: heavy metals, urban snow, urban landscape, air pollution, spatial analysis**

## Introduction

Urban landscapes are recognized as dynamic systems shaped by complex interactions among built, natural, and socio-economic elements. In the context of growing urbanization, these systems significantly influence environmental quality, particularly air pollution [1–3]. Urban planning decisions, including the distribution of green areas, play a critical role in mitigating pollution. Green infrastructure—such as parks, forests, and water bodies—not only lowers particulate matter levels [4] but also enhances ecological functions such as microclimate regulation, pollutant filtration, and biodiversity support [5; 6]. Conversely, urban areas dominated by impervious surfaces and dense traffic can intensify pollution through increased emissions, resuspension of road dust, and limited dispersion of pollutants [7, 8]. Urban form—particularly the layout of roads, residential density, and industrial zones—can directly affect the distribution and accumulation of airborne contaminants, including heavy metals. Heavy metals such as lead (Pb), nickel (Ni), chromium (Cr), and vanadium (V) are particularly concerning due to their persistence, toxicity, and bioaccumulation potential [9; 10]. These pollutants primarily originate from anthropogenic sources, including vehicle emissions, industrial activities, and fossil-fuel-based heating systems [11–14]. Once deposited on surfaces, heavy metals can be transported via runoff into soil and water systems, increasing ecological and human health risks [15].

Snow, especially in northern urban regions, offers a unique medium for assessing short-term air pollution levels. Acting as a passive sampler, snowflakes capture airborne particles and soluble pollutants during precipitation events and atmospheric deposition, effectively integrating pollution loads over time. This makes snow cover a valuable indicator of urban air quality and a suitable matrix for identifying spatial patterns of heavy metal accumulation [16–18]. Snow's seasonal presence also allows for consistent sampling across urban gradients, particularly during periods of increased emissions from heating systems and reduced pollutant dispersion due to atmospheric stagnation [4–6].

The present study investigates the spatial and temporal distribution of heavy metal concentrations in snow within Jelgava City, Latvia, over three consecutive winter seasons (2017–2019). It aims to identify key pollution sources by analyzing the relationships between heavy metal levels and urban landscape structures, including green areas, transport infrastructure, and residential density. By integrating land use analysis with snow chemistry and statistical assessments, this research highlights how urban planning decisions influence pollution accumulation. Understanding these interactions is essential for designing targeted strategies that enhance urban resilience, reduce pollutant exposure, and support healthier urban ecosystems.

## Materials and Methods

### *Study Area and Sampling Locations*

The study was conducted in Jelgava City, Latvia [19], with a focus on assessing spatial variations in pollution accumulation across different urban environments. A total of 20 monitoring points were strategically selected to ensure comprehensive coverage of the city's diverse land use patterns and pollution sources (see Figure 1).

The monitoring points encompassed a wide range of land use categories, including residential areas, natural land, transport infrastructure, apartment building complexes, public spaces, and industrial zones. Each category was evaluated as a percentage of the total land cover within the respective monitoring point, enabling a comparative assessment of how different urban functions influence pollution accumulation.

### *Evaluation of urban structures*

The first stage of the assessment involved analyzing Jelgava City's official territorial plan to determine designated zones and their relative proportions. These zones included residential, natural, transport, apartment, public, and industrial areas.

The territorial plan was imported into a Geographic Information System (GIS) platform, ensuring that all spatial data shared a common coordinate system. Within the GIS environment, a 150-meter-diameter buffer was delineated around each monitoring point, and the proportion of land-use classes within each buffer was then calculated. This initial

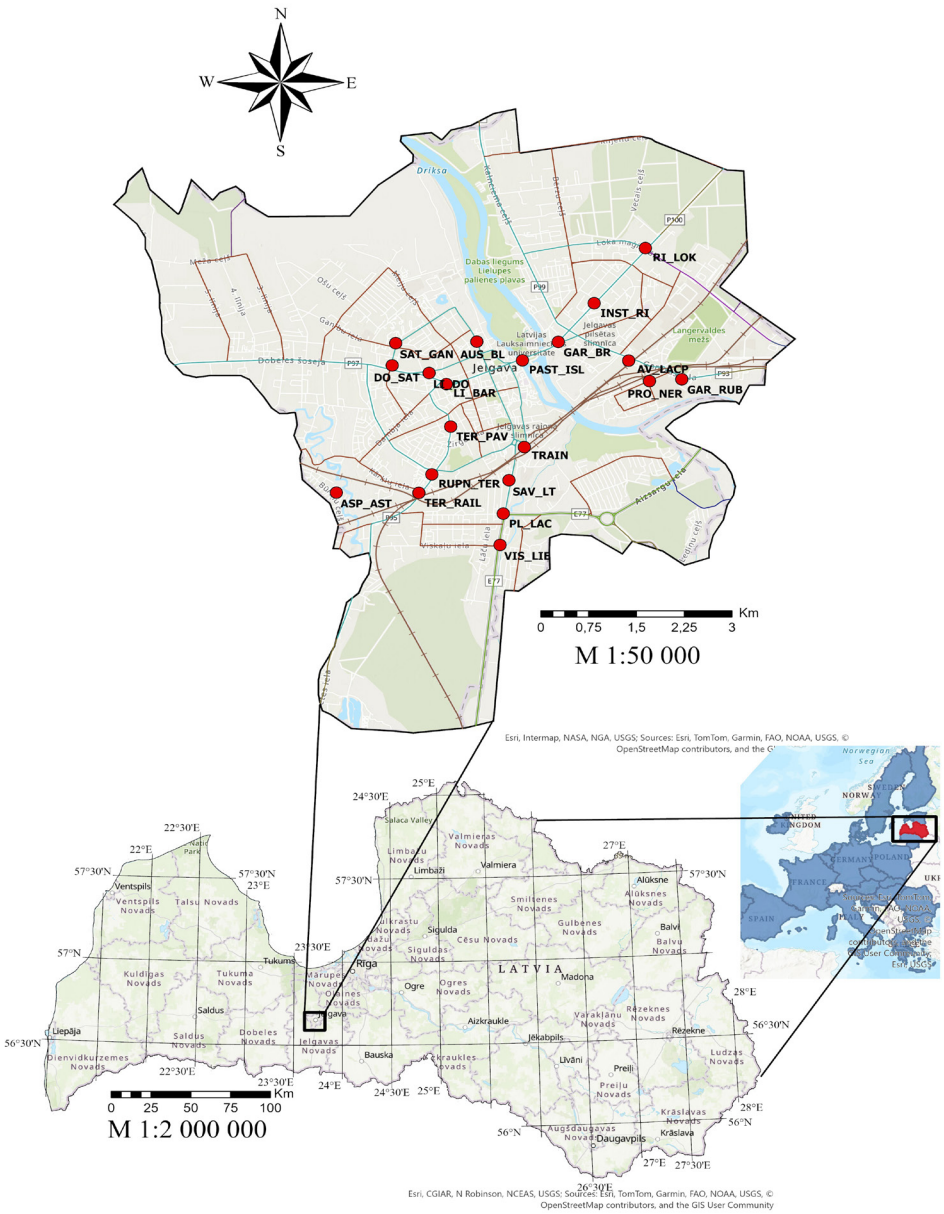



Fig. 1. The area of research and abbreviations of monitoring points [created by authors]

step provided a foundational understanding of the planned urban landscape distribution.

In the second stage, high-resolution satellite imagery was collected and analyzed to cross-check and refine the zoning information derived from the territorial plan. By visually interpreting features such as buildings, roads, and green spaces—supplemented where possible by semi-automated classification techniques—researchers identified any disparities between official designations and observable land-use patterns. For instance, recently developed residential buildings or newly reforested areas might not have been fully captured in the territorial plan. Updated or corrected land-use proportions were then computed within each monitoring point's buffer, enabling a more current and accurate overview of existing conditions.

The third stage consisted of on-site evaluations, aided by 360° panoramic photographs taken at each monitoring point. By physically visiting these locations, the research team confirmed that categorized land uses (residential, natural, transport, apartment, public, and industrial) matched actual conditions. The panoramic images offered a comprehensive perspective, allowing quick detection of mixed-use spaces, transitional zones, or unclassified parcels. Where discrepancies surfaced between the territorial plan, satellite data, and on-site observations, adjustments were made in the GIS database. This final validation step ensured that the resulting dataset captured both the planned and de facto land-use structure, supporting a robust analysis of Jelgava City's urban landscape.

### *Data Processing and Statistical Analysis*

Summary statistics, including mean, median, standard deviation, quartiles, and range, were calculated for each heavy metal to evaluate concentration variability across years and monitoring points.

The temporal trends of metal concentrations were analyzed using four step approach. 1. Descriptive trend analysis, where mean concentrations were plotted across 2017–2019. 2. Quartile-based trend analysis, identifying changes in the distribution of concentrations over time. 3. Statistical comparisons (ANOVA and Kruskal-Wallis tests) were conducted to determine whether significant differences existed between years. 4. Post-hoc pairwise comparisons (Mann-Whitney U test) were performed to identify specific year-to-year differences.

To assess spatial variation in metal concentrations across monitoring points were used extreme analysis approach.

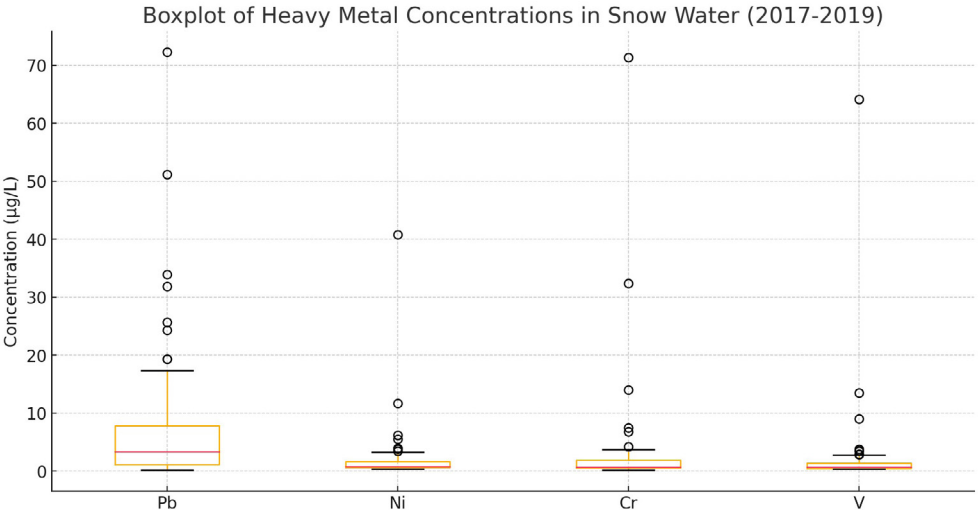



Fig. 2. The concentrations of heavy metals in snow water [created by authors]

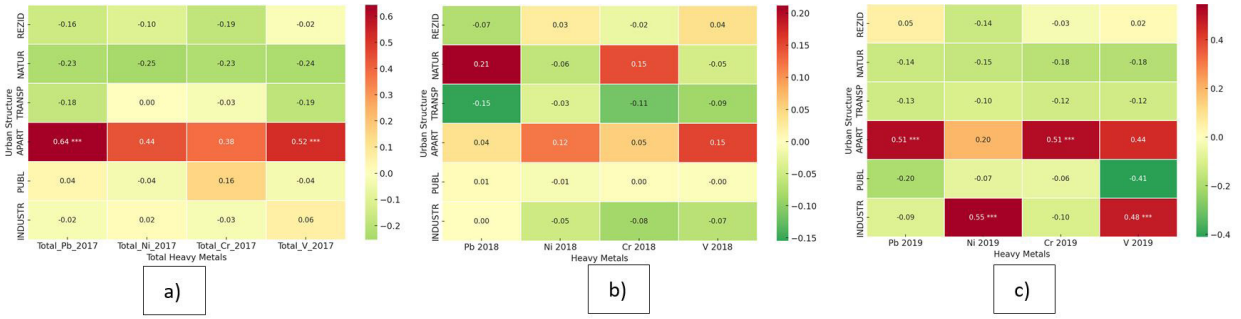



Fig. 3 the correlation between proportions of urban structures and heavy metal concentrations a) year 2017; b) year 2018 c) year 2019 (red positiv correlation; green negativ correlation) [created by authors]

Monitoring points with the highest and lowest heavy metal accumulation were identified based on metal concentrations. Urban structure influence was analyzed by correlating heavy metal levels with land use percentages (residential, natural, transport, apartment, public, industrial). Correlation matrices (Pearson correlation and significance testing) were generated to explore relationships between metal concentrations and urban structures across all years and individually for 2017, 2018, and 2019. Heatmaps with statistical significance were used to visualize correlations, with red indicating positive relationships and green indicating negative correlations, while significant values were marked with asterisks ($p < 0.05$).

## Results

### *Descriptive Statistics of Heavy Metals in Snow Water*

The analysis of heavy metal concentrations in snow water samples from Jelgava City over the period of 2017–2019 reveals significant variations in their distributions (See Figure 2). Lead (Pb) exhibited the highest mean concentration of 7.07 µg/L, with a median of 3.36 µg/L, indicating a right-skewed distribution. The standard deviation of 11.33 µg/L and variance of 128.43 suggest substantial variability among sampling locations and years. The maximum recorded concentration of Pb reached 72.26 µg/L, while the minimum was 0.19 µg/L. The skewness value of 3.63 and kurtosis of 15.98 further confirm that Pb concentrations are heavily skewed and exhibit a leptokurtic distribution, implying the presence of extreme values.

Nickel (Ni) concentrations displayed a lower mean of 1.93 µg/L, with a median of 0.79 µg/L, suggesting a distribution influenced by a few high outliers. The standard deviation was 4.69 µg/L, and the variance reached 21.99, indicating substantial dispersion. The Ni concentration ranged between 0.40 µg/L and 40.75 µg/L. The skewness (7.49) and kurtosis (61.27) highlight the extreme deviation from normality, with a strong right-skewed pattern.

Chromium (Cr) concentrations showed an overall mean of 2.77 µg/L, with a median of 0.70 µg/L. The wide spread of data is reflected by a standard deviation of 8.72 µg/L and variance of 75.95. The minimum detected concentration was 0.25 µg/L, while the maximum reached 71.35 µg/L. The skewness (6.85) and high kurtosis (51.10) indicate a highly non-normal distribution, dominated by occasional extreme values.

Vanadium (V) concentrations followed a similar trend, with a mean of 2.08 µg/L and a median of 0.70 µg/L. The observed standard deviation was 7.26 µg/L, with a variance of 52.78. The lowest recorded concentration was 0.40 µg/L, while the highest measured value was 64.16 µg/L. Vanadium exhibited the strongest skewness (8.16) and kurtosis (69.83), indicating an extremely right-skewed distribution with highly concentrated extreme values. Overall, the statistical characteristics of all four heavy metals indicate strong right-skewed distributions with high kurtosis, signifying occasional extreme pollution events at certain monitoring points. This suggests that localized pollution sources may have significantly influenced metal accumulation in urban snow during the study period.

### *The Correlation Between Concentrations and Urban Structures*

The correlation analysis between heavy metal concentrations in snow water and urban structure types revealed varying relationships across different years and for total heavy metal loads (See Figure 3). In 2017, apartment area coverage showed the strongest positive correlation with Pb ($r = 0.64$, $p < 0.05$) and V ($r = 0.52$, $p < 0.05$), indicating that increased residential density may contribute to higher metal accumulation. No significant correlations were observed for other land use types. In 2018, no statistically significant relationships were

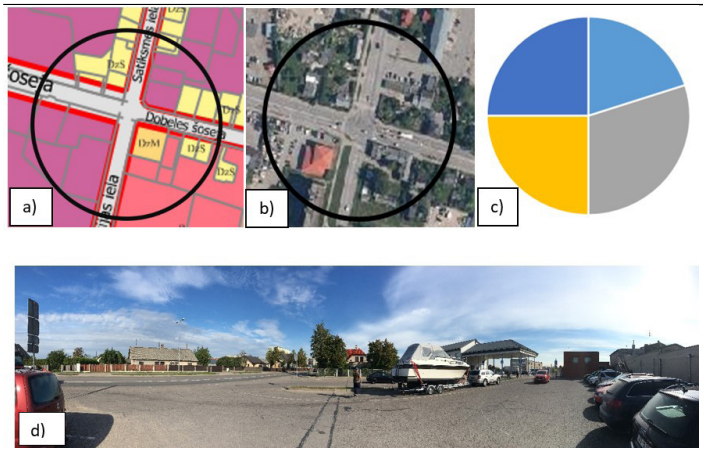



Fig. 4. The monitoring point do_sat with urban structure [created by authors]

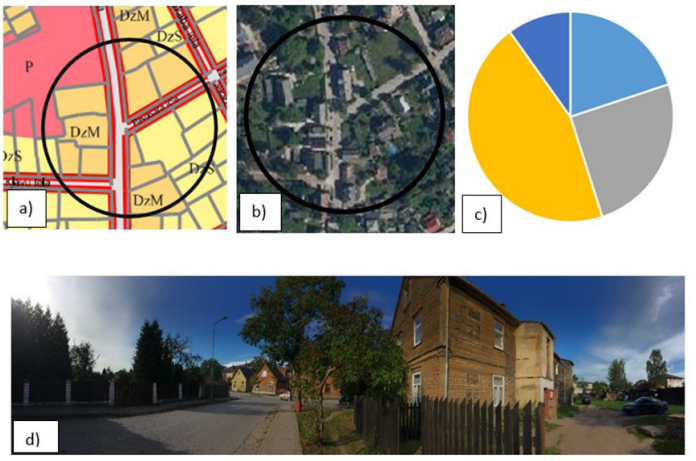



Fig. 5. The monitoring point ter_pav with urban structure sources and mitigation measures [created by authors]

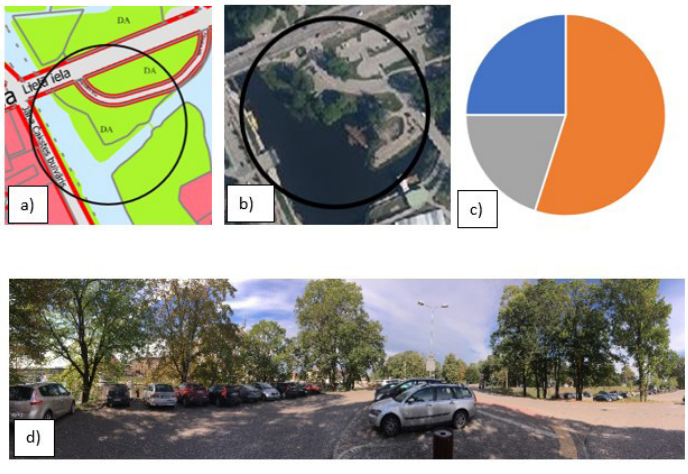



Fig. 6. The monitoring point past_isl with urban structure [created by authors]

found, suggesting a more even distribution of heavy metal contamination without strong urban structure dependencies. In 2019, similar trends to 2017 were observed, with apartment area again demonstrating the most substantial correlations, particularly with Pb and Ni, possibly due to traffic emissions or heating system influences. The total correlation analysis across all years confirmed these findings, as apartment area coverage exhibited consistently positive relationships with Pb ($r = 0.59$, $p < 0.05$) and V ($r = 0.25$, $p < 0.05$), reinforcing the link between residential zones and heavy metal deposition. Other land use types, such as public, natural, and transport areas, generally showed weak or negative correlations, with no significant trends across multiple years. These results highlight the potential impact of urban density and land use patterns on localized heavy metal accumulation in urban snow.

*The Trend Over Time*

The analysis of heavy metal concentrations in snow water from 2017 to 2019 reveals distinct patterns and trends, supported by both descriptive and statistical approaches. Lead (Pb) exhibited the highest concentrations in 2018, followed by a notable decline in 2019. This trend, along with a decrease in median and upper quartile values, suggests a reduction in pollution from sources such as traffic emissions or industrial activity. Statistical testing confirmed significant temporal variation ($p = 0.0047$), especially between 2018 and 2019. Nickel (Ni) remained relatively stable across 2017 and 2018, with a slight decrease in 2019, and while quartile analysis showed minor fluctuations, statistical results ($p = 0.00028$) indicate dynamic pollution patterns likely influenced by changing environmental factors or emission controls. Chromium (Cr) concentrations were mostly stable, with a moderate rise in the 75th percentile in 2018, followed by

stabilization. Statistically significant year-to-year differences ($p = 0.00030$) suggest episodic pollution events or varying deposition processes. In contrast, vanadium (V) displayed a gradual increase across all years, with a more pronounced rise in the upper quartile, indicating growing emissions potentially linked to industrial sources or heavy fuel oil combustion. However, statistical tests did not show significant differences across years ($p = 0.0696$), implying a steady emission source. Overall, these findings point to both declining and emerging pollution trends, highlighting the importance of targeted environmental monitoring, assessment of emission sources, and the development of effective mitigation policies.

*The Urban Landscape Structures*

Monitoring point 17 (DO_SAT) is characterized by a diverse urban structure, with 20% residential areas, 30% transport infrastructure, 25% apartment buildings, and 25% public spaces, while no industrial areas or natural land cover are present (see Figure 4). This location exhibits high heavy metal accumulation, with Pb (64.19 µg/L) as the dominant pollutant, followed by Cr (74.06 µg/L), V (67.26 µg/L), and Ni (43.22 µg/L). The elevated concentrations of Pb and Cr suggest significant pollution sources, likely linked to high-density traffic, urban runoff, and residential heating emissions. The presence of extensive transport infrastructure and apartment areas may contribute to heavy metal deposition from vehicle exhaust, road dust, and construction activities, while the absence of natural land cover reduces the potential for pollutant retention or filtration. The high public space coverage also suggests possible human exposure risks, emphasizing the need for targeted pollution mitigation measures in this urban environment.

Monitoring point 14 (TER_PAV) is primarily composed of 20% residential areas, 25% transport infrastructure, 45% apartment buildings, and 10% public spaces, with no industrial or natural land cover present (see Figure 5). This location exhibits an extremely high Pb concentration (117.26 µg/L), significantly exceeding the levels of other heavy metals, while Ni (2.76 µg/L), Cr (3.57 µg/L), and V (2.62 µg/L) remain relatively low. The dominant presence of apartment buildings and transport infrastructure suggests that traffic emissions, road surface wear, and residential heating systems may be major contributors to Pb pollution. The lack of natural land cover may reduce pollutant retention capacity, leading to higher heavy metal accumulation in snow. The relatively low concentrations of Ni, Cr, and V indicate that specific Pb-related emission sources, such as historical leaded gasoline residues or localized construction activities, may be influencing this site. Given the high Pb concentration in an area with dense residential and public spaces, potential human exposure risks should be considered, necessitating further investigation into pollution.

Monitoring point 7 (PAST_ISL) is predominantly covered by 55% natural land, 20% transport infrastructure, and 25% public spaces, with no residential, apartment, or industrial areas (see Figure 6). This location exhibits moderate Pb accumulation (48.77 µg/L), while Cr (35.23 µg/L), V (11.75 µg/L), and Ni (8.96 µg/L) show varying levels of concentration. The high percentage of natural land suggests that metal deposition here may result from atmospheric deposition or long-range transport rather than direct urban emissions. However, the presence of transport infrastructure and public areas indicates possible road dust resuspension and human activities contributing to pollution levels. The relatively high Cr concentration may be linked to natural soil composition or erosion processes, while Pb and Ni levels suggest some influence from vehicular emissions and historical contamination. Despite the high percentage of natural land cover, the observed metal concentrations indicate potential contamination sources, warranting further investigation into atmospheric deposition and transport-related emissions in the area.

Monitoring point 1 (GAR_RUB) is characterized by 50% natural land, 30% transport infrastructure, and 20% residential areas, with no apartment buildings, public spaces, or industrial zones. The total heavy metal concentrations at this site are relatively low, with Pb (8.78 µg/L), Ni (2.75 µg/L), Cr (2.75 µg/L), and V (2.3 µg/L). The dominance of natural land cover suggests that this area is less affected by direct urban pollution sources, likely benefiting from vegetative buffering and lower anthropogenic emissions. However, the presence of 30% transport infrastructure may contribute to the detected metal levels through road dust, vehicular emissions, and atmospheric deposition. The comparatively low heavy metal concentrations suggest that this site experiences less industrial or urban influence, with metal deposition likely driven by regional atmospheric transport and occasional runoff from transport surfaces. The findings indicate that GAR_RUB represents a lower pollution risk area, serving as a potential reference point for assessing background contamination levels in urban snow.

Monitoring point 18 (SAT_GAN) is composed of 20% residential areas, 25% transport infrastructure, 15% apartment buildings, and 40% public spaces, with no natural land or industrial zones present. The total heavy metal concentrations at this site are relatively low, with Pb (11.15 µg/L), Ni (3.45 µg/L), Cr (3.50 µg/L), and V (2.51 µg/L). The relatively high proportion of public spaces and transport infrastructure suggests that metal deposition may be influenced by road dust, vehicular emissions, and human activities in public areas. The lack of natural land cover may reduce the site's ability to naturally filter pollutants, allowing heavy metals to accumulate in snow. Overall, SAT_GAN exhibits moderate contamination levels, with transport and public space usage likely playing a role in metal distribution.

Monitoring point 12 (TER_RAIL) is primarily dominated by 90% transport infrastructure and 10% public spaces, with no residential, natural, apartment, or industrial areas present. The total heavy metal concentrations indicate moderate pollution levels, with Pb (10.00 µg/L), Ni (6.25 µg/L), Cr (5.61 µg/L), and V (3.88 µg/L). The overwhelmingly high proportion of transport infrastructure suggests that vehicle emissions, tire and brake wear, road dust resuspension, and railway-related activities are likely the primary sources of heavy metal accumulation. The relatively high Ni and Cr concentrations could be linked to railway operations, metal corrosion, and fuel combustion residues, while Pb levels remain moderate, possibly due to historical pollution from leaded fuels or industrial transport emissions. The absence of natural land cover further reduces the ability of this area to retain and filter pollutants, leading to higher deposition rates in snow. Given its transport-oriented nature, TER_RAIL represents a high-risk zone for metal contamination, particularly influenced by urban mobility and transport-related emissions.

## Discussion

The findings highlight pronounced spatial and temporal variations in heavy metal concentrations, with lead (Pb) frequently presenting the highest mean values [20–22]. Urban snow cover, recognized as an indicator of atmospheric pollution [23, 24], often registered elevated Pb near high-traffic roads and residential heating sources, particularly in winter [25–27]. Areas dominated by transport infrastructure (e.g., TER_RAIL) showed increased nickel (Ni) and chromium

(Cr), reflecting substantial vehicular and rail emissions [28, 29]. Descriptive statistics confirmed that Pb and Cr surged after 2017 and stabilized in subsequent years, hinting at shifts in fuel use or regulatory measures [30–32]. By contrast, Ni exhibited year-to-year fluctuations, likely driven by meteorological variability or sporadic industrial activities [33, 34]. Vanadium (V) remained stable, implicating continuous industrial or heavy fuel oil combustion as a persistent source [35–37]. Overall, ongoing monitoring and adaptive strategies are necessary to manage such diverse pollution dynamics [38–43, 31, 44].

Correlation analysis underscores that apartment areas strongly align with Pb and V, suggesting that dense residential zones heighten exposure from vehicular traffic and fossil-fuel heating [31, 45–49]. In contrast, natural and transport zones displayed weaker or negative correlations, indicating potential buffering effects or lesser direct contamination [50–54] Notably, sites with abundant vegetation, such as GAR_RUB, exhibited lower heavy metal loads, echoing evidence that green infrastructure captures airborne pollutants and improves soil conditions [55–60]. As traffic, industrial, and residential sources intensify with urban growth, measures like emissions regulation, expanded green spaces, and improved zoning are essential [61–64]. Continuous, site-specific monitoring [44] can guide targeted interventions to mitigate heavy metal risks and foster healthier urban environments.

## Conclusions

This study provides a comprehensive assessment of heavy metal contamination in urban snow water, offering insights into the influence of urban land use patterns on pollutant accumulation. The results indicate that Pb and Cr concentrations increased after 2017, stabilizing in subsequent years, while Ni exhibited significant year-to-year fluctuations, and V remained relatively stable. The highest Pb concentrations were recorded in apartment-dense areas, reaching 117.26 µg/L, while Ni and Cr were most prevalent in transport-heavy zones, with peaks of 43.22 µg/L and 74.06 µg/L, respectively.

The strong positive correlation between apartment areas and Pb ($r = 0.64$, $p < 0.05$) and V ($r = 0.52$, $p < 0.05$) highlights the role of high-density residential zones in pollution accumulation. Transport infrastructure also exhibited a strong association with elevated Ni and Cr levels, emphasizing the impact of vehicular and railway emissions. Conversely, monitoring points with higher proportions of natural land cover demonstrated lower heavy metal concentrations, reinforcing the importance of urban green spaces in mitigating pollution.

The study's findings emphasize the need for targeted pollution management strategies, including stricter traffic regulations, expansion of green infrastructure, and improved urban air quality policies. Future research should focus on long-term monitoring and expanding the dataset to include additional pollutants and meteorological influences. These efforts will support more effective urban sustainability strategies aimed at reducing heavy metal contamination and protecting public health in urban environments.

## References

1. **Wang, C., Guo, M., Jin, J., et. al.** Does the Spatial Pattern of Plants and Green Space Affect Air Pollutant Concentrations? Evidence From 37 Garden Cities in China. *Plants*, 2022, No.
2. **Wu, J., Xie, W., Li, W., et. al.** Effects of Urban Landscape Pattern on PM2.5 Pollution—A Beijing Case Study. *Plos One*, 2015, No.
3. **Park, S.** A Preliminary Study on Connectivity and Perceived Values of Community Green Spaces. *Sustainability*, 2017, No.
4. **Li, C., Zhang, K., Dai, Z., et. al.** Investigation of the Impact of Land-Use Distribution on PM2.5 in Weifang: Seasonal Variations. *International Journal of Environmental Research and Public Health*, 2020, No.
5. **Dong, W.** Analysis on the Impact of Regional Air Quality in Industrial Cities: A Case Study of Huinong District of Shizuishan City. *E3s Web of Conferences*, 2020, No.
6. **Fernández, E. I., Jara, A. J., Fernández-Breis, J. T.** Improving Air Quality Zoning Through Deep Learning and Hyperlocal Measurements. *Ieee Access*, 2024, No.
7. **Sohrab, S., Csikós, N., Szilassi, P.** Connection Between the Spatial Characteristics of the Road and Railway Networks and the Air Pollution (PM10) in Urban–Rural Fringe Zones. *Sustainability*, 2022, No.
8. **Han, L., Zhou, W., Li, W., et. al.** Meteorological and Urban Landscape Factors on Severe Air Pollution in Beijing. *Journal of the Air \& Waste Management Association*, 2015, No.
9. **Akomolafe, O. O., Olorunsogo, T., Anyanwu, E. C., et. al.** Air Quality and Public Health: A Review of Urban Pollution Sources and Mitigation Measures. *Engineering Science \& Technology Journal*, 2024, No.
10. **Subramanian, A., Kunisue, T., Tanabe, S.** Recent Status of Organohalogens, Heavy Metals and PAHs Pollution in Specific Locations in India. *Chemosphere*, 2015, No.
11. **Chen, J., Lan, Z.** Study on the Relationship Between Economic Growth and Air Pollution in the Pearl River Delta Region. *E3s Web of Conferences*, 2023, No.
12. **Naghipour, D., Amouei, A., Nazmara, S.** A Comparative Evaluation of Heavy Metals in the Different Breads in Iran: A Case Study of Rasht City. *Health Scope*, 2014, No.
13. **Hankey, S., Marshall, J., Bräuer, M.** Health Impacts of the Built Environment: Within-Urban Variability in Physical Inactivity, Air Pollution, and Ischemic Heart Disease Mortality. Environmental Health Perspectives, 2012, No.
14. **Illgner, T., Lad, N.** Data to Improve Air Quality Environmental Justice Outcomes in South Chicago. *Frontiers in Public Health*, 2022, No.
15. **Wang, L.-J., Chen, M.-H., Su, C.-H. (Joan).** Do Hotel Industry Operations Deteriorate Air Quality? *Tourism Economics*, 2021, No.
16. **Xu, L., Liu, Y., Zhang, X.** Study on Comprehensive Assessment of Air Quality Of Energy Consumption in Industrial Parks: Take Nanjing HX Industrial Park in China As an Example. *Polish Journal of Environmental Studies*, 2022, No.
17. **Mei, D., Meng, W., Xu, X., et. al.** The Influence of Wind Speed on Airflow and Fine Particle Transport Within Different Building Layouts of an Industrial City. *Journal of the Air & Waste Management Association*, 2018, No.
18. **Bel, G., Rosell, J.** Effects of the 80km/H and Variable Speed Limits on Air Pollution in the Metropolitan Area of Barcelona. *Transportation Research Part D Transport and Environment*, 2013, No.
19. **Grinfelde, I., Pilecka-Ulcugaceva, J., Bertins, M., et. al.** Dataset of trace elements concentrations in snow samples collected in Jelgava City (Latvia) in December 2020. *Data in Brief*, 2021, No. ()38
20. **Siudek, P., Frankowski, M., Siepak, J.** Trace Element Distribution in the Snow Cover From an Urban Area in Central Poland. *Environmental Monitoring and Assessment*, 2015, No.
21. **Krastinytė, V., Baltrėnaitė, E., Lietuvninkas, A.** Analysis of Snow-Cap Pollution for Air Quality Assessment in the Vicinity of an Oil Refinery. *Environmental Technology*, 2013, No.
22. **Adamiec, E., Wieszała, R., Strzebońska, M., et. al.** An Attempt to Identify Traffic Related Elements in Snow. *Geology Geophysics & Environment*, 2013, No.
23. **Kujawska, J.** Concentration and Risk Assessment of Metals in Snow Cover Monitoring in Urban and Rural Areas. *Annals of Agricultural and Environmental Medicine*, 2024, No.
24. **Liu, Y., Su, C., Zhang, H., et. al**. Interaction of Soil Heavy Metal Pollution With Industrialisation and the Landscape Pattern in Taiyuan City, China. *Plos One*, 2014, No.
25. **Krasnopyorova, M., Gorlachev, I., Kharkin, P., et. al.** Trace Element Composition of Surface Water in Almaty City and Human Health Risk Assessment. *International Journal of Environmental Research and Public Health*, 2024, No.
26. **Pìzarro, J., Vergara, P. M., Cerda, S., et. al.** Contaminant Emissions as Indicators of Chemical Elements in the Snow

Along a Latitudinal Gradient in Southern Andes. *Scientific Reports*, 2021, No.
27. **Seleznev, A. A., Yarmoshenko, I., Malinovsky, G., et. al.** Snow-Dirt Sludge as an Indicator of Environmental and Sedimentation Processes in the Urban Environment. *Scientific Reports*, 2019, No.
28. **Du, K., Li, F.-D., Tu, C., et. al.** Effects of simulated warming on carbon emissions from farmland soil and related mechanisms. *Journal of Agro-Environment Science*, 2020, No. 4(()39, p. 691–699
29. **Yan, W., Liu, D., Peng, D. Z., et. al.** Spatial Distribution and Risk Assessment of Heavy Metals In the Farmland Along Mineral Product Transportation Routes in Zhejiang, China. *Soil Use and Management*, 2016, No.
30. **Zhang, P., Hu, L., Gao, B., et. al.** Spatial–temporal Variation and Source Analysis of Heavy Metals in Different Land Use Types in Beilun District (2015 and 2022). *Scientific Reports*, 2024, No.
31. **He, Y., Zhang, Y., Peng, C., et. al.** Distribution Characteristics and Risk Assessment of Heavy Metals in Soil and Street Dust With Different Land Uses, a Case in Changsha, China. *International Journal of Environmental Research and Public Health*, 2021, No.
32. **Kowalska, J. B., Mazurek, R., Gąsiorek, M., et. al.** Pollution Indices as Useful Tools for the Comprehensive Evaluation of the Degree of Soil Contamination–A Review. *Environmental Geochemistry and Health*, 2018, No.
33. **Shi, J., Jin, Z., Zhou, Z., et. al.** Heavy Metal Pollution Characteristics of Soil Around a Copper-Nickel Mine Tailings Pond in the Northwest Arid Area of China and Evaluation of Desert Phytoremediation Potential. 2022, No.
34. **Bayraktar, E. P., Isinkaralar, Ö., Işınkaralar, K.** Usability of Several Species for Monitoring and Reducing the Heavy Metal Pollution Threatening the Public Health in Urban Environment of Ankara. *World Journal of Advanced Research and Reviews*, 2022, No.
35. **Weber, C. J., Santowski, A., Chifflard, P.** Spatial Variability in Heavy Metal Concentration in Urban Pavement Joints – A Case Study. *Soil*, 2021, No.
36. **Pal, R., Dubey, R. K., Dubey, S. K., et. al.** Assessment of Heavy Metal Pollution Through Index Analysis for Yamuna Water in Agra Region, India. *International Journal of Current Microbiology and Applied Sciences*, 2017, No.
37. **Cao, B., Sun, Z., Bai, D., et. al.** The Identification of Soil Heavy Metal Sources and Environmental Risks in Industrial City Peri-Urban Areas: A Case Study From a Typical Peri-Urban Area in Western Laizhou, Shandong, China. *Sustainability*, 2024, No.
38. **Ren, P., Zhu, H., Sun, Z., et. al.** Effects of Artificial Islands Construction on the Spatial Distribution and Risk Assessment of Heavy Metals in the Surface Sediments From a Semi-Closed Bay (Longkou Bay), China. *Bulletin of Environmental Contamination and Toxicology*, 2020, No.
39. **Affum, A. O., Osae, S., Kwaansa-Ansah, E. E., et. al.** Quality Assessment and Potential Health Risk of Heavy Metals in Leafy and Non-Leafy Vegetables Irrigated With Groundwater and Municipal-Waste-Dominated Stream in the Western Region, Ghana. *Heliyon*, 2020, No.
40. **Lv, Y., Kabanda, G., Chen, Y., et. al.** Spatial Distribution and Ecological Risk Assessment of Heavy Metals in Manganese (Mn) Contaminated Site. *Frontiers in Environmental Science*, 2022, No.
41. **Wang, Z., Nie, K.** Measuring Spatial Distribution Characteristics of Heavy Metal Contaminations in a Network-Constrained Environment: A Case Study in River Network of Daye, China. *Sustainability*, 2017, No.
42. **Jounaid, H., Hachimi, E. M. El, Chakri, N., et. al.** Heavy Metal Contamination in Surface Water of Mohammedia Wetland, Morocco. *E3s Web of Conferences*, 2021, No.
43. **Wang, C.** Translocation Coefficients of Heavy Metals in the Soil-Rice System and Their Environmental Implication. *Plant and Soil*, 2025, No.
44. **Sanleandro, P. M., Delgado-Iniesta, M. J., Sáenz-Segovia, A. F., et. al.** Spatial Identification and Hotspots of Ecological Risk From Heavy Metals in Urban Dust in the City of Cartagena, SE Spain. *Sustainability*, 2023, No.
45. **Chen, X., Xia, X., Zhao, Y., et. al.** Heavy Metal Concentrations in Roadside Soils and Correlation With Urban Traffic in Beijing, China. *Journal of Hazardous Materials*, 2010, No.
46. **Lallawmzuali, G., Devi, A. S., Thanhmingliana, et. al.** Assessment of the Heavy Metal Contaminations of Roadside Soil in Aizawl, Mizoram (India): An in-Depth Analysis Utilising Advanced Scientific Methodologies. *Asian Journal of Water Environment and Pollution*, 2024, No.
47. **Ayinde, K. O., Omotosho, S. M., Oyesiku, O. O., et. al.** Evaluation of Heavy Metal Pollution From Vehicular Exhausts in Soils Along a Highway, Southwestern Nigeria. *International Journal of Environment Agriculture and Biotechnology*, 2020, No.
48. **Saeed, H., Al-Jaf, S. H.** Determination of As, Cu, Sr, and Zn in Some Plant Leaves Grown in Different Places of Kalar City by ICP-OES. *Journal of Garmian University*, 2019, No.
49. **Chemerys, I., Myslyuk, O., Chemerys, V.** Effect of Vehicle Emissions on the Morphological and Physiological Changes of Taraxacum Officinale Web. *Ukrainian Journal of Ecology*, 2020, No.
50. **Liu, R., Wang, M., Chen, W., et. al.** Spatial Pattern of Heavy Metals Accumulation Risk in Urban Soils of Beijing and Its Influencing Factors. *Environmental Pollution*, 2016, No.
51. **Xia, X., Chen, X., Liu, R., et. al.** Heavy Metals in Urban Soils With Various Types of Land Use in Beijing, China. 2011
52. **Shi, Y., Lau, K. K., Ng, E.** Developing Street-Level PM2.5 and PM10 Land Use Regression Models in High-Density Hong Kong With Urban Morphological Factors. *Environmental Science & Technology*, 2016, No.
53. **Wang, S., Zhang, Y., Cheng, J., et. al.** Pollution Assessment and Source Apportionment of Soil Heavy Metals in a Coastal Industrial City, Zhejiang, Southeastern China. *International Journal of Environmental Research and Public Health*, 2022, No.
54. **Simon, E., Vidic, A., Braun, M., et. al.** Trace Element Concentrations in Soils Along Urbanization Gradients in the City of Wien, Austria. *Environmental Science and Pollution Research*, 2012, No.
55. **Silveira, R. S., Corrêa, S. M., Magalhães Neto, N. de.** Possible Influence of Shipping Emissions on Metals in Size-Segregated Particulate Matter in Guanabara Bay (Rio De Janeiro, Brazil). *Environmental Monitoring and Assessment*, 2022, No.
56. **Staszewski, T., Łukasik, W., Kubiesa, P.** Contamination of Polish National Parks With Heavy Metals. *Environmental Monitoring and Assessment*, 2011, No.
57. **Tuohy, A., N. Bertler, N. A., Neff, P. D., et. al.** Transport and Deposition of Heavy Metals in the Ross Sea Region, Antarctica. *Journal of Geophysical Research Atmospheres*, 2015, No.
58. **Taptich, M. N., Horvath, A.** Bias of Averages in Life-Cycle Footprinting of Infrastructure: Truck and Bus Case Studies. *Environmental Science & Technology*, 2014, No.
59. **Korzeniowska, J.** <i>Polytrichum Formosum</I> and <i>Vaccinium Myrtillus</I> as Phytoindicators of Pollutants From Long-Range Emissions of Environmentally Important Protected Areas (The Tatra National Park, the Central Western Carpathians, Poland). 2022, No.
60. **Peng, C., Wang, M., Chen, W., et. al.** Mass Balance-Based Regression Modeling of Cd and Zn Accumulation in Urban Soils of Beijing. *Journal of Environmental Sciences*, 2017, No.
61. **Wang, J.** Characteristics and Correlation Analysis of the Spatial Distribution of Heavy Metals in Arable Soils With Different Soil-Forming Matrices. *Sustainability*, 2024, No.
62. **Wang, X., Sun, Y., Li, S., et. al.** Spatial Distribution and Ecological Risk Assessment of Heavy Metals in Soil From the Raoyanghe Wetland, China. *Plos One*, 2019, No.
63. **Jose, J., Teja, K. V., Ranjan, M., et. al.** Influence of Commonly Used Endodontic Irrigants on the Setting Time and Metal Composition of Various Base Endodontic Sealers. *Polymers*, 2021, No.
64. **Fu, C., Li, X., Ma, J., et. al.** Heavy Metal Contamination Assessment of Soils in Shendong Coal Base of the Kuye River Basin, China: Spatial Distribution, *Source Identification and Ecological Risk*. 2022, No.

## Authors

**Inga Grinfelde**, Ph.D., Mg.paed. Associated professor, Expert in hydrology, Academic and research experience for more than ten years, currently working at the Institute of Landscape Architecture and Environmental Engineering, Latvia University of Life Sciences and Technologies. Her main research interests include air pollution, soil contamination, and environmental quality assessment.
E-mail: inga.grinfelde@lbtu.lv
ORCID ID: https://orcid.org/0000-0002-3220-1777

**Inga Straupe**, Dr. silv., Professor, leading researcher, she is a professor and leading researcher at the Institute of Forestry, Latvia University of Life Sciences and Technologies. She has extensive academic and research experience in the fields of forest ecology, biodiversity conservation, and vegetation dynamics. Her scientific work focuses on forest ecosystem structure and functioning, the effects of human activity and climate change on forest vegetation, invasive plant species, and habitat protection.
E-mail: inga.straupe@lbtu.lv
ORCID ID: https://orcid.org/0000-0002-2098-7194

**Kristaps Siltmens**, Mg.sc.env., Research Assistant at the Scientific Laboratory of Forest and Water Resources, Latvia University of Life Sciences and Technologies. His research focuses on environmental sustainability, waste management, circular economy solutions, and innovative material development.
E-mail: kristaps.siltumens@lbtu.lv
ORCID ID: https://orcid.org/0009-0004-9803-7764

**Oskars Purmalis**, Dr. geogr., Associate Professor, Faculty of Science and Technology, University of Latvia with extensive experience in water quality, limnology, soil chemistry, and environmental pollution research. His work focuses on the geochemistry of aquatic ecosystems, humic substances, and the sustainable management of natural resources, including the control and utilization of invasive plant species.
E-mail: oskars.purmalis@lu.lv
ORCID ID: https://orcid.org/0000-0001-9167-0613

**Maris Bertins**, Mg.sc., Researcher, environmental and analytical chemist, he is a researcher at the Faculty of Chemistry, University of Latvia, where he has been working since 2018. His scientific expertise lies in environmental and analytical chemistry, materials science, and isotopic analysis. His research explores the elemental composition and isotopic signatures in environmental samples, as well as the development of innovative materials for environmental and biomedical applications.
E-mail: maris bertins@lu.lv
ORCID ID: https://orcid.org/0000-0002-0504-4163

**Jovita Pilecka-Uļčugačeva**, Ph.D., Assistant Professor, environmental engineer. Academic and research experience for more than ten years, currently working at the Institute of Landscape Architecture and Environmental Engineering, Latvia University of Life Sciences and Technologies. Her main research interests include air pollution, soil contamination, and environmental quality assessment.
E-mail: jovita.pilecka@lbtu.lv
ORCID ID: https://orcid.org/0000-0001-5556-0345

## Kopsavilkums

Pētījumā analizētas smago metālu (Pb, Ni, Cr, V) koncentrācijas sniega ūdenī Jelgavā trīs ziemas sezonās (2017–2019), sasaistot piesārņojumu ar pilsētvides zemes izmantojumu. Izvietojām 20 monitoringa punktus dažādos apbūves tipos un katram 150 m rādiusā noteicām zemes izmantošanas proporcijas, bet metālus noteicām ar ICP-OES. Kopumā reģistrējām izteiktas telpiskās un laika svārstības: vidēji visaugstākais bija Pb (7,07 µg/L), kam sekoja Cr (2,77 µg/L), V (2,08 µg/L) un Ni (1,93 µg/L), ar atsevišķiem ekstrēmiem pīķiem (piem., Pb līdz ~72 µg/L). ANOVA/Kruskal–Wallis testi apstiprināja nozīmīgas gada starpības Pb, Ni un Cr ($p < 0,01$), kamēr V saglabājās statistiski stabils ($p = 0,0696$), norādot uz pastāvīgu emisiju avotu. Korelāciju matrica parādīja ciešākās pozitīvās saites starp daudzdzīvokļu apbūves īpatsvaru un Pb/V, savukārt transporta teritorijās biežāk pieauga Ni un Cr. Vietās ar lielāku dabas teritoriju īpatsvaru metālu līmeņi bija zemāki, apliecinot zaļās infrastruktūras buferfunkciju. Rezultāti izgaismo pilsētas struktūru, satiksmes un siltumapgādes sistēmu ietekmi uz metālu uzkrāšanos. Pētījums sniedz pierādījumus integrētas pilsētplānošanas un emisiju pārvaldības pasākumu nepieciešamībai (satiksmes regulējums, zaļo zonu paplašināšana, siltumapgādes modernizācija), lai mazinātu smago metālu slogu un uzlabotu pilsētvides kvalitāti.