

SEARCHING FOR 15-MINUTE CITY IN LARGE-SCALE HOUSING ESTATES: SERVICE PROXIMITY AND DIVERSITY IN THE CONTEXT OF POPULATION DENSITY

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Abstract. The “15-minute city” concept develops a sustainable mobility paradigm in the context of the city’s central neighbourhoods and outlines clear planning parameters. Since in many cities most of the population lives outside the city core, a sustainable city needs the adaptation of the “15-minute city” concept to other contexts. Large-scale housing estates (LHE) are home to a significant proportion of the population in many European cities, especially in Eastern and Northern Europe. LHE were planned with the idea that a neighbourhood is a unit that provides both housing and essential daily needs within walking distance. Although the political, social and economic context has changed significantly since the LHE concept was developed in the mid-20th century, the physical environment of LHE has largely retained the principles of the original urban idea. The aim of the paper is to investigate the multifunctionality of large housing estates and assess the correlation between the centres of gravity associated with four travel destinations - public transport stops, groceries, recreation and education. The study analysed four LHEs in two cities - Riga and Vilnius, assessing the proximity and diversity of their services in the context of population density. The methodology is based on simulative mathematical modelling. The calculation of the gravitational centrality allowed for a spatially functional analysis, revealing movement patterns and better reflecting the functionality of the city in monofunctionally zoned large housing zones. The main results confirm that in all studied LHEs the average population density within 1 km was higher than the average in both cities. The density of other indicators was different in each case. They even exceeded the average values, showing that post-war large housing districts could have the critical mass of objects necessary to implement the 15-minute city concept in the neighbourhoods of Riga and Vilnius. **Keywords:** proximity-based planning, urban regeneration, sustainable cities and communities, sustainable mobility

Introduction

The move towards implementing the sustainable mobility paradigm at the regional and local levels is currently a trend in many places. In this context, the essential goals of sustainable urban development are to reduce the dependence on cars in urban areas and to reduce daily travel needs [2]. However, the aim of these planning activities is not to ban the use of private cars but to build such human-friendly environment that people won't need to use them.

The “15-minute City” concept is an approach that develops the idea of a sustainable mobility paradigm in the context of the city neighbourhood and outlines clear planning parameters. The 15-minute accessibility to essential consumer goods and services determines the neighbourhood's size and the potential population density so that these basic needs can be effectively provided. The original idea and the subsequent numerous studies are mainly focused on the central parts of cities, where effective provision of everyday needs is possible by improving the infrastructure for pedestrians, cyclists, and public transport. However, in many cities, most of the population lives outside the city core, so adapting the “15-minute City” concept to other contexts is necessary for a sustainable city. Moreno, the author of the “15-minute City” concept, has emphasised the need to create context-specific solutions while continuing to develop his idea.

Large-scale housing estates (LHE) are home to a considerable proportion of the population in many European cities, particularly in Eastern and Northern Europe. Many large-scale housing estates were planned with the idea that a neighbourhood is a unit that provides both housing and essential daily services, including education, healthcare and food purchases within a walking distance [29]. Since the context of their conception, planning and construction have changed significantly in terms of political, social, and economic settings, the physical environment of large-scale housing estates has mostly preserved the principles of the original urban idea. The aim of the paper is to study the multi-functionality of the large housing estates and assess the correlation between gravity centralities associated with four

travel destinations - public transport stops, groceries, leisure, and education. Four LHE in two cities - Riga and Vilnius, were analysed by evaluating their service proximity and diversity in the context of population density.

Background

The 15-minute city concept is an urban planning model which aims to create compact populated areas where all the essential daily services are accessible within a 15-minute walk or bike ride from home. This urban planning model aims to reduce the population's dependence on cars, promote sustainable transport development, and promote public involvement in community life and the liveability of cities. [1, 16]. The cornerstone of the 15-minute city model is a well-planned integrated public transport network that provides efficient connections to the other parts of the city. This reduces dependence on private cars and the time spent on the way to work, health care and other services, thereby improving the overall quality of life [17, 28]. Supermarkets and local markets should be within walking distance, providing quick and convenient access to daily necessities and fresh food [4; 31]. Recreational functions also should be accessible without long journeys and located strategically to ensure social cohesion and support a vibrant community [19; 24]. The attractiveness of the residential environment to different age groups and families is essential for community stability, and in this context, the placement of necessary institutions, including educational ones, in the city and residential areas is critical [7, 10]. In general, the 15-minute city concept approach to urban planning aims to promote sustainable living in the city, increase the overall quality of life and build sustainable, dynamic communities, making convenient accessibility of services and functions to residents through proximity-based planning.

Proximity-based planning is an urban design approach that focuses on the accessibility of services necessary to people in residential areas. This planning paradigm aims to create an environment where residents have all significant amenities

within a short distance from their homes, including public transportation, grocery stores, recreational facilities, and educational institutions. In this way, people's daily travel distances and their dependence on cars are reduced, sustainable urban development is promoted, and citizens' quality of life is improved [1; 28]. An essential component of the proximity-based planning, to promote sustainable mobility of citizens, is the availability and location of public transport stops and the ability of public transport to connect neighbourhoods with employment centres, educational institutions and recreational areas. Accessible and, therefore, more frequently used public transport in daily activities in a neighbourhood, according to research, can contribute to a higher level of social interaction and community involvement than in neighbourhoods without an efficient and accessible public transport system [7; 17]. The availability of grocery stores within walking distance of where one lives allows buying food more often, thus promoting more frequent access to fresh products and supporting the maintenance of healthier eating habits. Regular use of local grocery stores helps local people meet more often, and through regular interaction and building relationships, it also contributes to a sense of community [4; 31]. The availability of leisure facilities (parks, sports facilities, cultural venues, etc.) provides both a health-improving function and, as an outdoor activity, serves to promote social interaction [19; 24]. Access to schools and educational institutions near the place of residence significantly reduces the time spent on the road for families and improves the overall educational experience for children. At the community level, the proximity of educational institutions can attract young families to the specific neighbourhood and have a beneficial effect on property values, thus contributing to the stability and growth of the community [10; 16].

The large-scale housing estates built in the post-war period form an essential part of the urban environment in many cities. These LHEs were built quickly and at the lowest possible cost to eliminate the lack of housing and deal with the problem of the growing population. For this reason, LHEs consist of high-rise multi-apartment type buildings spread over a large area, providing housing for many residents in a relatively small city area. Considering the high population concentration, the time when the estates were created, and the current situation, these estates serve as an object of discussion regarding the issue of easy access to basic services, including public transport, grocery stores, recreational opportunities and educational institutions [15; 26]. The availability of quality schools in large-scale housing estates is essential for improving the living environment of families. If quality educational institutions are located far from residents' homes, this can affect children's success and the choice of families to live in a given area [10; 13] or an increase in the time spent on the way to the available or chosen educational institution can be noticed, which contradicts the primary setting of the 15-minute city concept. Analysing availability of basic services in LHEs, it should be emphasised that the situation of different estates within the same city and in different countries may vary, and since the emergence of these estates, both the demographic situation and the structure and location of workplaces have changed. The availability of grocery stores in LHEs is an aspect that can be evaluated differently. On the one hand, many LHEs have retail spaces available. However, changes in the structure of trade since the construction of these estates, incl. the emergence of many new supermarkets outside these districts near transit roads and other factors [25; 31], can affect the profitability

of local stores in LHEs, with residents still preferring to take long distances for a more diverse grocery supply. Large-scale housing included green areas for rest and recreation in their initial designs. However, since their construction, the structure of the properties has changed, the number of private car transport in the courtyards has increased significantly, some of the previously accessible areas have been built over, and some are not adequately maintained. Consequently, there is a risk that the green areas necessary for many leisure activities in LHEs could be insufficient [27]. Well-developed green areas are an essential prerequisite for promoting the socialisation of residents, which can be considered within the framework of the 15-minute city concept. In general, large-scale housing estates within the framework of the 15-minute concept are a place for both opportunities provided by a large concentration of residents and generally well-conceived infrastructure within the framework of earlier planning, as well as challenges caused by the change of the social and economic structure since the creation of large-scale residential areas, the life, work and movement of residents changing habits, and the wear and tear of previously built infrastructure.

Methodology

The methodology for comparing four selected post-war housing neighbourhoods in Riga and Vilnius is founded on simulative mathematical modelling. This approach was chosen because a city, or its part, can be conceptualised as a complex system. According to Siegfried [22], such systems require specific simulative models that enhance our understanding and provide predictive capabilities critical for managing the dynamic nature of cities. Simulative modelling not only aids in comprehension but also reduces research time, can partially replace in situ observations if the model is validated successfully, and helps fill data gaps—such as by simulating inhabitant movement, which is otherwise difficult to capture.

In this study, a mathematical graph-based model was employed. This model type has been pivotal in urban analysis since Hillier's development of the Space Syntax theory [11]. Additional researchers, including Porta and Latora, with their multiple centrality assessment models [18], Batty's advocacy for graph theory as a foundation for the "New Science of Cities" [3], and Sevtsuk's analyses [21], have furthered this approach. Recent work by Cooper and Chiaradia has integrated mathematical graph-based analysis into the GIS environment [5]. The sDNA tool was selected for this analysis due to its versatility and effective GIS integration with the software utilised [6].

In mathematical graph theory, cities are represented as networks. For this analysis, the network comprised street segments based on Open Street Map (OSM) data. Graph theory calculations focused on evaluating the centrality of nodes or segments, with centralities such as closeness (indicating the most accessible areas within varying radii, including pedestrian or 1 km radius, thus highlighting potential urban centres), betweenness (identifying streets with the highest transit flows), street network length within different radii (identifying active social interaction zones), and gravity, which combines network density with closeness. These indicators were calculated in the initial model and used for model validation, correlating Spearman's rho with densities of Points of Interest (POIs, e.g., shops, restaurants, schools, bus stops) density within 400 meters and national census data on inhabitant density within grid 1 km on 1 km. The study also calculated the multi-functionality of the LHE and assessed the correlation between gravity centralities

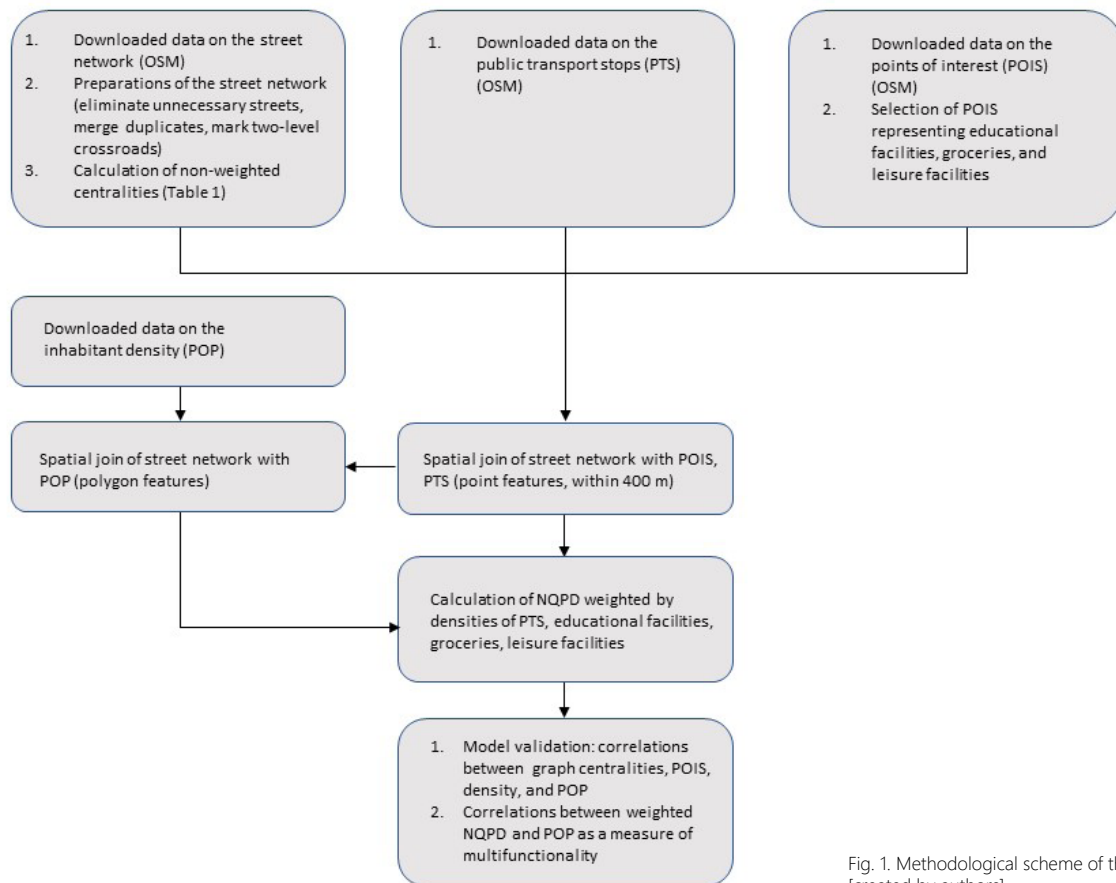


Fig. 1. Methodological scheme of the study [created by authors]

associated with four travel destinations [30]: public transport stops, educational facilities, groceries, and leisure facilities (e.g., restaurants). OSM data allowed for intercity comparability. Gravity centrality calculation enabled a spatial-functional analysis, revealing movement patterns and better reflecting urban functionality in monofunctionally zoned LHE. The Network Quantity Penalized by Distance (NQPD), also known as gravity, was calculated according to the following formula [23], where $dM(x,y)$ denotes the distance between node x (where calculations are centred) and all other nodes y in the graph, $W(y)$ is the weight of each node (equal to 1 for the initial validation of the model and replaced by specific densities for multifunctionality analysis), and $P(y)P(y)$ is the portion of the street segment within the calculation radius, ranging from 0 to 1. In this study, a 1000 m calculation radius was applied, using default values for the degrees $nqpdn$ and $nq added$, both set to 1. Elevated NQPD values (without additional weighting) reveal denser urban zones, indicating potential urban or local centres with heightened precision (Fig.1.).

Case study areas

In many major European cities, LHEs constitute a significant part of the housing stock. This trend is particularly pronounced in Central and Eastern European countries, where large-scale industrialization took place in many cities after World War II. The LHE approach made it possible to address the acute housing shortage for the growing number of urban residents. The capitals of Latvia and Lithuania, Riga and Vilnius, are typical examples of this process. Even today, the majority of the population of these cities lives in LHEs built in the second half of the 20th century. Two different LHEs in each city were chosen as case studies for this study. Imanta in Riga and Lazdynai in Vilnius were built at the same time with a similar number of populations. Their initial development concepts accurately illustrate the complex nature of the LHE approach.

Ziepniekkalna LHE in Riga and Žirmūnai LHE in Vilnius are LHEs with the highest population density in their cities, consequently the population demand for services in the defined district area is expected to be the highest.

Riga is the capital city of Latvia and an important centre of industry, business, culture, sports, and finance in the Baltic States, as well as a port city. With 605,273 inhabitants (2024), it is the largest city in Latvia. The total area of the city is 307.17 sq. km. To preserve the diversity of Riga's urban environment, emphasizing the identity of different parts of the city, thus increasing the sense of belonging of the inhabitants to a certain part of the city, in 2008, the Riga City Council introduced the division into fifty-eight neighbourhoods.

Imanta is a neighbourhood of Riga located in the western part of the city. Its total area is 9.00 sq. km, while the large-scale housing estate occupies 3.23 sq. km. In 1967, a detail plan for Imanta development was worked out to provide housing for 60,000 inhabitants, introducing the principle of the micro-district structure. Each micro-district consisted of five to six groups of residential buildings around a central courtyard. The park, enclosed by the boulevard semicircle, was planned as a recreational area. Five micro-districts with local commercial and public centres, as well as kindergartens and schools in each of them, were built. At present, the Imanta neighbourhood is home to more as 42,000 inhabitants (2024), the most significant part of whom reside in the large-scale panel residential buildings.

Ziepniekkalna neighbourhood is located at the southern boundary of the city. The total area of it is 10.92 sq. km. A significant part of the neighbourhood area is occupied by detached housing, while 0.85 sq. km is under the development of one of the LHEs of Riga. The detail plan for constructing a large-scale housing estate was developed in 1972 and reworked in 1987. Four micro-districts were designed, including a public and shopping centre and park

area, but only two were constructed. At present Ziepniekkalns neighbourhood is home to more than 29 000 inhabitants (2024), a significant part of them in the large-scale housing estate.

Vilnius is the capital and the largest city in Lithuania and the second-most-populated city in the Baltic states, with a population of 605,270 (2024). Vilnius area covers 401.00 sq. km, of which one-fifth is developed; the other area is greenspace and water. The city is known as one of Europe's greenest capital cities. The present city area consists of 21 neighbourhoods. Neighbourhoods around the Old Town (Antakalnis, Žirmūnai, Naujamiestis, and Žvėrynas) have a variety of apartments and green space, while more distant neighbourhoods (Lazdynai, Karoliniškės, Viršuliškės, Šeškinė, Justiniškės, Pašilaičiai, Fabijoniškės and Naujininkai), incorporate more affordable housing.

Žirmūnai is the most populated neighbourhood in Vilnius. Its area reaches a size of 5.70 sq. km. The area was named during the early 1960s when it became the site of an award-winning residential construction project; it was the first large-scale housing estate in Lithuania. Designed in 1962, the estate consisted of three micro-districts – residential and industrial sections centred around public facilities. The new residential housing in the micro-districts consisted almost exclusively of five-story prefabricated concrete block apartment buildings, with some higher buildings constructed later. At present, Žirmūnai neighbourhood is home to about 43,000 inhabitants. Lazdynai is a neighbourhood of Vilnius, situated on the right bank of the Neris River. It covers an area of 9.90 sq. km and has a population of about 30,945 (2021).

The LHE in **Lazdynai** was constructed based on studies of experience in developing large-scale housing estates in Finland. The project was recognised by awarding the Lenin Prize to the authors of the urban development project. For the first time in Lithuanian urban design practice, Lazdynai represents a large residential district built far from the city centre, where a completely new block configuration was tested. The construction works started in 1969, and the last buildings were erected in 1985. A system of four micro-districts was created, each connected by a 3.5 km long Architektų Street (which resembles the defensive wall of old Vilnius in both shape and length). The location for Lazdynai was chosen so that residents on the first could conveniently reach the expanding Žemiejų Paneriai industrial zone, where many jobs were concentrated. Today, Lazdynai is largely forgotten and is not considered prestigious. At present Lazdynai neighbourhood is home to about 31,000 inhabitants.

Results and Findings

The following data was obtained for the modelling and comparison of the four neighbourhoods:

- central lines of streets in both Riga and Vilnius from the OpenStreetMap (OSM) are used as background data for mathematical simulative modelling while constructing mathematical graph models from interconnected street segments.
- data on the points of interest (POIS) from OSM was used for two purposes: validating the initial model and identifying specific travel destinations, such as groceries, schools, etc., for more precise modelling and analysis of multifunctionality.
- open data on inhabitants' density was downloaded from Geostat [9]. It was used for both: validation of the initial model and analysis of the multifunctionality of the territories.
- specific categories of travel destinations were identified while using POIS from OSM:

- **groceries** as 'bakery', 'butcher', 'convenience', 'department_store', 'greengrocer', 'market_place', 'supermarket',
- **leisure objects** such as 'bar', 'biergarten', 'cafe', 'cinema', 'fast_food', 'food_court', 'nightclub', 'pub', 'restaurant', 'sports_centre', 'swimming_pool', 'theatre',
- **educational objects** as 'college', 'kindergarten', 'school'.

Densities of those objects, together with public transport stops within a radius of 400 meters as an optimal urban resolution grid which is not sensitive to some big buildings and corresponds to 5 minutes of walking time, were used as weights while calculating NQPD and making multifunctionality analysis.

During the first stage of analysis, the Space syntax models with usage just of the street network without any additional weights were prepared for both Riga and Vilnius. Besides NQPD calculations, the other space syntax indicators were identified within radius 1000, 5000, and 11000 (unlimited radius):

- Mean Euclidean distance (MED) and mean angular distance (MAD) distance which simply represents a sum of distances from each street segment to all the other segments counted either in metres or degrees of turns taken at turns. The idea behind the usage of metric and angular distance is that people, while walking, can feel metric distance better and for drivers (radiuses 5000 and 11000) number of turns becomes more important. MED and MAD show the most reachable zones within the network just without consideration of the density of the street network as NQPD does.
- BtE and BtA as metric and angular between which represents simple transit flows while simulating movement of inhabitants from every street segment to all the other segments in the shortest route.
- Len1000 or length of street network within a radius 1000 metres which represents more dense networks of streets.

This syntactic model was validated while calculating correlations between the above-mentioned graph centralities and densities of POIS and inhabitants. The idea behind validations is the following: the most reachable, dens, transit attractive zones in the model should demonstrate either positive or negative correlations with both densities as a reflection of natural attraction for inhabitants and various functions of certain places because of configurations of street network or city plan if the simulative model is "working".

The obtained correlations are presented in Table 1. It could be concluded that in both cities, the space syntax model reflects real urban processes. Very strong significant correlations are observed in Riga between POIS, inhabitants' density (POP), and NQPD1000, Len1000; POP and NQPD5000, Len5000. Medium correlations are found in both POIS and BtE1000, etc. If Riga is compared to Vilnius, it could be noted that strong correlations are observed more in higher radiuses and not found in radius 1000. In essence, it could be concluded that Riga demonstrates better suitability of its urban form for the 15-minute city concept while Vilnius is a more car-oriented city. It should also be noted that practically all correlations have 0.01 level significance meaning that the probability that they demonstrate accidental processes is just 1 percent.

After the validation of the model weighted NQPD was calculated as described in the Methodology chapter. The graphical results of the modelling are represented in Figure 2.

If graphical results are compared then, based on the allocation of the high NQPD weighted values represented in red colour in the maps, large-scale housing estates should demonstrate

TABLE 1

Correlations between the density of points (POIS400) of interest within a radius of 400 metres, inhabitants' density (POP) within 1 km on a 1 km grid, and Space Syntax indicators. All correlations marked by ** have a significance level of 0.01. Orange colour marks strong and yellow – moderate correlations

Vilnius		15 minutes city or neighborhood level				Neighborhood group level				The whole city level			
		MED1000	NQPDE1000	BIE1000	Len1000	MAD5000	NQPDA5000	BIAS5000	Len5000	MAD11000c	NQPDA11000	BIAS11000c	Len11000c
Spearman's rho	pois400	.230**	.648**	.433**	.635**	.018**	.711**	.321**	.702**	-.204**	.704**	.264**	.713**
	POP	.350**	.597**	.435**	.656**	.087**	.805**	.369**	.621**	-.114**	.762**	.299**	.798**
Riga		15 minutes city or neighborhood level				Neighborhood group level				The whole city level			
		MED1000c	NQPDE1000c	BIE1000c	Len1000c	MAD5000c	NQPDA5000c	BIAS5000c	Len5000c	MAD11000c	NQPDA11000	BIAS11000c	Len11000c
Spearman's rho	pois400	.279**	.717**	.584**	.757**	-.023**	.685**	.410**	.660**	-.246**	.603**	.311**	.566**
	POP	.358**	.728**	.618**	.786**	.007**	.725**	.437**	.705**	-.189**	.642**	.333**	.607**

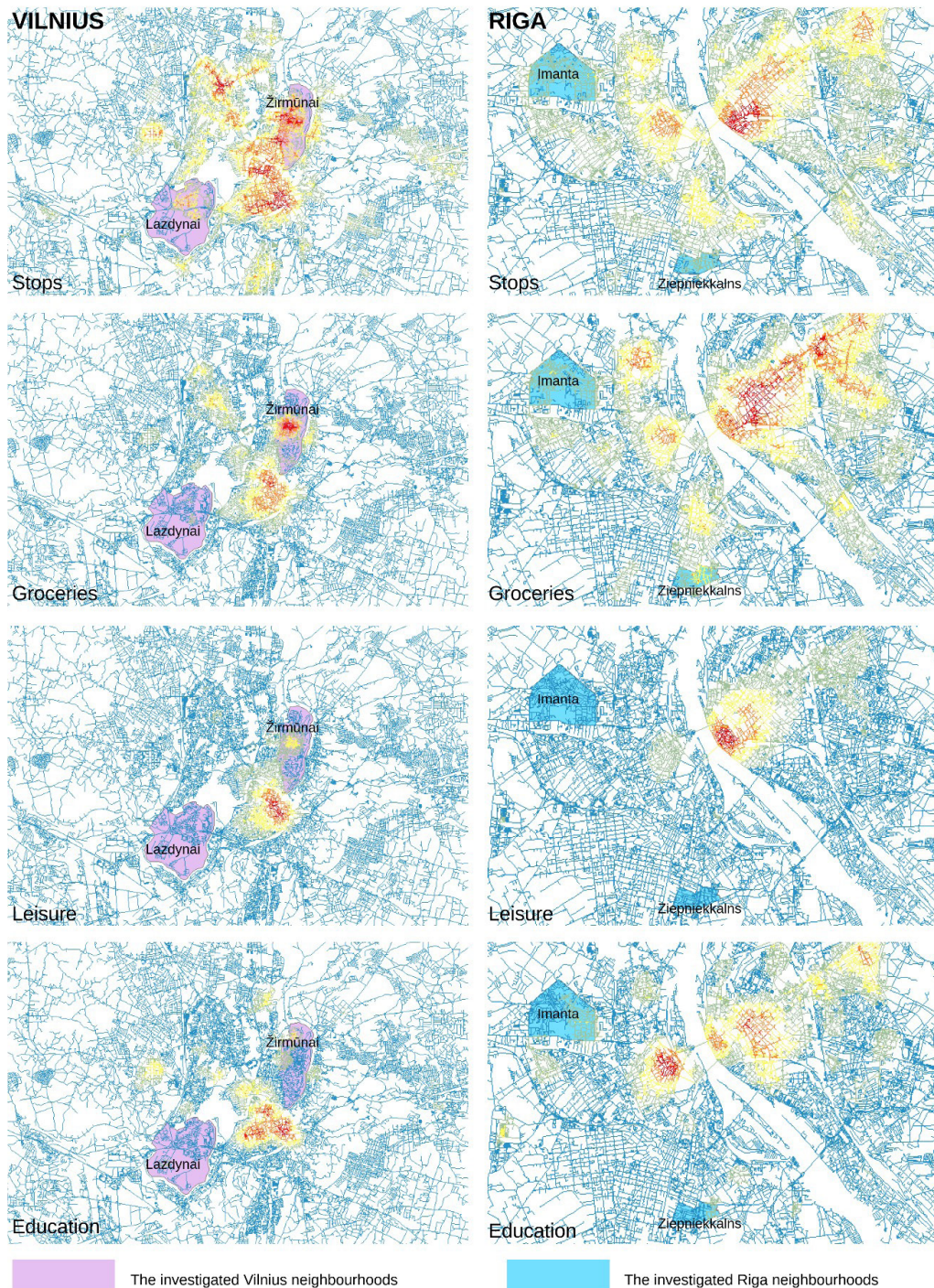


Fig. 2. Network quantity penalised by distance (NQPD) and weighted by the density of stops, groceries, leisure, and educational objects within a radius of 400 metres. Red represents the biggest values, and blue represents the lowest [created by authors]

TABLE 2

Multifunctionality as correlations between NQPD weighted by four types of travel destinations and inhabitant density.
 All correlations have a significance level of 0.01. Orange colour marks strong and yellow – moderate correlations

Lazdynai						Ziepniekkalns					
	Education	Leisure	Groceries	Stops	Pop		Education	Leisure	Groceries	Stops	Pop
Education						Education		0.054	0.573	0.37	-0.211
Leisure	-0.35		0.918	0.887	0.716	Leisure	0.054		0.787		0.543
Groceries	-0.347	0.918		0.799	0.781	Groceries	0.573	0.787		0.902	0.388
Stops	-0.291	0.887	0.799		0.656	Stops	0.37	0.83	0.902		0.383
Pop	-0.32	0.936	0.89	0.922		Pop	0.037	0.839	0.741	0.825	

Žirmūnai						Imanta					
	Education	Leisure	Groceries	Stops	Pop		Education	Leisure	Groceries	Stops	Pop
Education		0.274	0.202	0.265	-0.503	Education		0.191	-0.134	0.338	-0.541
Leisure	0.274		0.929	0.817	-0.474	Leisure	0.191		0.598	0.902	-0.199
Groceries	0.202	0.929		0.74	-0.337	Groceries	-0.134	0.598		0.506	0.375
Stops	0.265	0.817	0.74		-0.274	Stops	0.338	0.902	0.506		-0.372
Pop	-0.074	0.569	0.655	0.775		Pop	-0.029	0.524	0.793	0.426	

lower multifunctionalities if compared to historical and central parts of both cities. Such a result is not unexpected, so the next question is how much these multi-functionalities are lower, and do they differ between compared modernistic neighbourhoods?

To make a precise multi-functionality comparison Spearman's rho between weighted NQPD values and POP within a radius of 1000 metres was calculated in the four neighbourhoods. The results can be seen in Table 2.

A stronger correlation between weighted NQPD (e.g., public transport stops and groceries or POP and educational objects, etc.) means that densities of those objects and gravity or attraction fields around them created by street networks, overlap more, thus meaning more multifunctional urban structure. A commonly seen tendency is that there are concentrated clusters of groceries and leisure objects and stops with educational objects set apart in all four neighbourhoods. Negative correlations between educational objects and the rest of travel destinations make this segregation even stronger. Allocation of people far away from groceries, leisure, education, and stops differs in each neighbourhood, as can be observed in Table 2: the strongest negative correlations are seen in Žirmūnai, positive moderate or even strong collections are observed in Lazdynai and Imanta.

To clarify how those LHE look within the whole city concept, additional analysis was conducted while taking each weighted NQPD1000 value and counting its average correlation value with all the other NQPD1000 values. As a result, we can see a slightly more generalised picture where it is possible to clearly state that, e.g.: education objects, in essence, have worth or better correlations with other objects, etc. The comparison is presented in Figure 2 with the whole Riga and Vilnius

data included.

Based on the comparison presented in Figure 3, it could be concluded that in terms of multifunctionality within radius 1000, Riga represents higher and better mean values than Vilnius. Ziepniekkalns demonstrates the best results, Imanta the worst except for the allocation of education establishments far away from the other indicators. The differences and similarities between the analysed case studies are quite clear, with the remark that the presented pilot research is based on open data from OSM, which is not always reliable as some of the objects could be not marked there or some earlier marked objects could already be not functional. In this case, the presented results are more important to demonstrate the possibilities of the proposed methodology and if applied to real urban planning, it should be based on more reliable data obtained from national agencies or registry centres, etc.

The presented multi-functionality analysis, which is based on the calculation of correlations of different groups of travel destinations within a radius of 1000 metres, says nothing about densities of destinations, street network, or even inhabitants as good correlation could be achieved based on the proper allocation of the actual objects even within lower densities. To compare the neighbourhoods in those terms, the mean values of various NQPD were calculated and compared with bigger values meaning that there are bigger densities of the named objects accessible within 1000 based on the street network. The results of the comparison are presented in Figure 4.

As follows from the study, street network density is similar to or even higher in the investigated areas than the mean values of the whole city. The results would possibly be different if a comparison were made just with historical areas, but it still demonstrates that the situation is not the worst in terms of

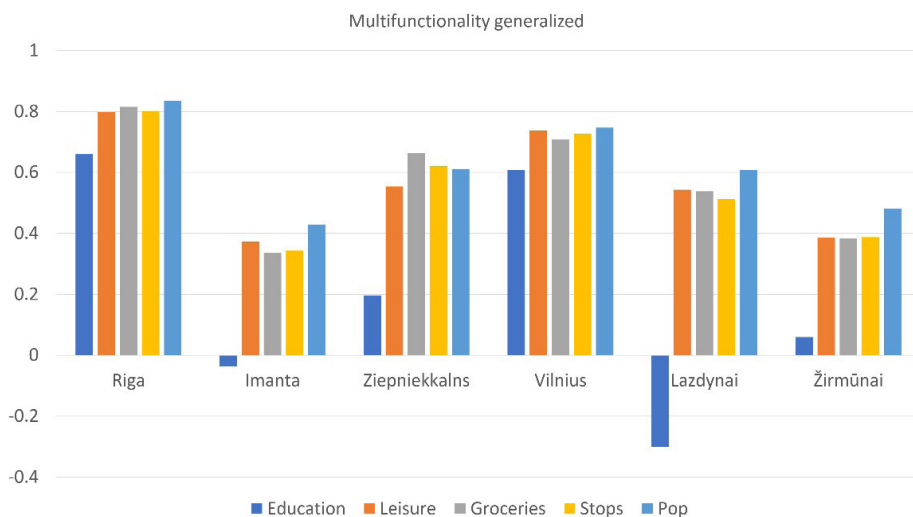


Fig. 3. Generalized multifunctionality indicators as average correlations between NQPD weighted by four types of travel destinations and inhabitant density

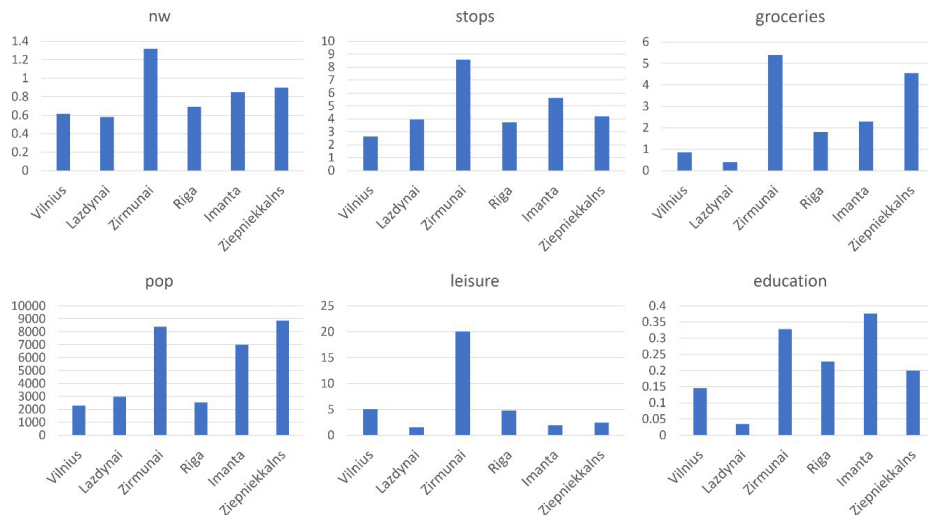


Fig. 4. Average values of NQPD of not weighted (nw), weighted by four types of destinations and inhabitant density within 1 km radius [created by authors]

street network thinning. Education density demonstrates different situations in different neighbourhoods, from very low in Lazdynai in Vilnius to high in Imanta in Riga – again, such a conclusion should be treated with care as the results are based just on OSM. The present number of public transport stops is not insufficient in all four areas. The densities of other objects vary and demonstrate quite good results in Imanta (education), Žirmūnai, and Ziepniekkalns (groceries). If compared to multifunctionality analysis results, which in terms of education (Figure 3) were not good for Imanta, it might mean that simply schools or kindergartens are located not in the most accessible spots. At the same time, it might give a clue for the adaptation of the LHE for the 15-minute city - one of the keys here could be not an increase in the number of objects but positioning them in the „right“ urban spots.

Discussion

The 15-minute City concept focuses on the sustainability of cities and neighbourhoods by providing people with access to primary services – education, healthcare, shopping, recreation, etc. – within a 15-minute walk or bike ride from their homes [1; 16; 17; 28]. LHEs, on the other hand, were created with a primary focus on providing housing for a growing population [26; 27; 29]. Although their concept also included the creation of infrastructure for primary services, they usually prioritised high-density housing. As in many cities, still, a significant part of the population resides in LHEs, the shift towards creating a more diverse, human-centred mixed-use environment responds to the up-to-date urban regeneration interventions where pedestrian-friendly and cyclist-friendly infrastructure is prioritised while reducing reliance on cars [2; 4; 14; 17; 20]. It should become the new paradigm where various activities – residential, commercial, educational and recreational – are integrated and well-connected close to residences.

In this study, the 15-minute City concept was compared with the spatial environment of LHE in the neighbourhoods of the capitals of Lithuania and Latvia – Vilnius and Riga, where the distribution of the most frequently needed primary service facilities — public transport stops, groceries, leisure enterprises and educational institutions – was evaluated. Each LHE was found to have a relatively unique overview, the components of which could be accurately assessed by equating these neighbourhoods to the 15-minute City concept. In all studied LHEs, the average population density within 1 km was higher than the averages in both cities, thus confirming the fact that a large part of the population

still lives in these areas. The density of other indicators was different from case to case. They even exceeded mean values, demonstrating that LHE might have a critical mass of objects needed for the 15-minute City concept implementation within the Riga and Vilnius neighbourhoods.

Despite the similarities between the LHE and 15-minute City concepts in proximity-based planning, the LHE situation in both cities showed lower multifunctionality than the city-wide average values. It encourages daily migration from the neighbourhood to the neighbourhood or city centre for various services that are not available nearby, or the range or quality of choice is insufficient. Due to the long distances between attractions and climatic conditions, people often prefer private cars or public transport to walking or cycling. Thus, the expansion of the services offered in the immediate vicinity can positively affect the perception and evaluation of the LHE environment [7; 8; 17; 28]. Therefore, the regeneration of the urban environment in LHE should aim not only at expanding the service offer but also at attracting new active residents of different ages; otherwise, there is a risk that they may turn into residential areas for the elderly [7; 12; 24; 31] or social assistance recipients, resulting in a deterioration of the quality of the social climate and LHE. The needs of new residents, both in the layout of apartments and in the quality of outdoor spaces, may differ from those living longer [19; 20]; this topic leaves room for further research.

Although the case study areas discussed are typical examples of LHE in Vilnius and Riga, a more comprehensive overview can be obtained after more extensive data analysis in other neighbourhoods. The study reveals that, despite the common planning approach of unifying large housing areas, quite significant differences have been found in the location of stops, groceries and rest areas and the multifunctionality of the facilities. The results can be used to create individual strategies for adapting the 15-minute City in each neighbourhood.

Conclusions

The 15-minute city concept, in contrast to LHE that were designed with a primary focus on providing housing for a growing population, focuses on the sustainability of cities and neighbourhoods, ensuring that people have access to basic services, including education, healthcare, shopping, recreation, etc., within a 15-minute walk or bike ride from their homes. Each post-war LHE has a relatively unique overall picture, the components of which can be accurately assessed by comparing these neighbourhoods with the 15-minute city concept.

The spatial syntactic model reflects real urban processes. The proven methodology allows for a reliable overall picture, and when applied to real urban planning, it should be based on verified data obtained from government agencies or registry centres, etc. Regardless of the initial urban design and subsequent development, LHEs have lower multifunctionality compared to the historical and central parts of cities. Each LHE demonstrates both certain similarities caused by the same basic model of post-war era urbanism and significant differences at the same time. Such diversity of the analysis results supports the idea that the 15-minute city model could function in the LHE.

Lower multifunctionality compared to the city's average values encourages daily migration from one neighbourhood to another or to the city centre to receive various services that are not available nearby or that are of insufficient choice or quality. Due to the long distances between attractions and climatic conditions, people often prefer private cars or public transport to walking or cycling. Thus, expanding the range of services offered nearby can have a positive impact on the perception and assessment of the local environment.

As in many cities, a significant proportion of the population still lives in LHEs, the transition to a more diverse, people-oriented mixed-use environment responds to contemporary urban renewal interventions that prioritise pedestrian- and cyclist-friendly infrastructure while reducing car dependency. It should become a new paradigm in which different activities – residential, commercial, educational and recreational – are integrated and well-connected close to places of residence. Urban regeneration is not limited to the expansion of service provision; it also entails the attraction of new active residents across different age groups. In the absence of such a balance, there is a risk of LHE becoming predominantly inhabited by the elderly population or recipients of social assistance; a process that may contribute to the deterioration of the social climate and undermine the quality of local health care facilities.

Future studies focused on a broader set of LHEs and city cases will deepen understanding of the challenges and solutions related to implementing the 15-minute city model, thereby offering a foundation for strategies that promote a more liveable urban environment.

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Kopsavilkums

“15 minūšu pilsētas” koncepcija attīsta ilgtspējīgas mobilitātes paradigmu pilsētu centrālo apkaimju kontekstā un nosaka skaidrus plānošanas parametrus. Tā kā daudzās pilsētās lielākā daļa iedzīvotāju dzīvo ārpus pilsētas centra, ilgtspējīgas pilsētas attīstībai nepieciešama šīs koncepcijas pielāgošana arī citām pilsētvides situācijām. Lielmēroga dzīvojamie rajoni ir mājvieta ievērojamai iedzīvotāju daļai daudzās Eiropas pilsētās, īpaši Austrumeiropā un Ziemeļeiropā. Šie rajoni tika plānoti, balstoties uz ideju, ka apkaimei jābūt funkcionālai vienībai, kas nodrošina gan dzīvošanu, gan būtiskākās ikdienas vajadzības gājiena attālumā. Lai gan politiskais, sociālais un ekonomiskais konteksts kopš 20. gadsimta vidus, kad tika izstrādāta šī koncepcija, ir būtiski mainījies, lielmēroga dzīvojamo rajonu fiziskā vide lielā mērā ir saglabājusī sākotnējās pilsētubūvnieciskās idejas pamatprincipus. Pētījuma mērķis ir izpētīt lielo dzīvojamo rajonu daudzfunkcionalitāti un novērtēt korelāciju starp “smaguma centriem”, kas saistīti ar četrām pārvietošanās galamērķu grupām — sabiedriskā transporta pieturām, pārtikas veikaliem, atpūtas zonām un izglītības iestādēm. Pētījumā analizēti četri lielmēroga dzīvojamie rajoni divās pilsētās - Rīgā un Viļņā - vērtējot to pakalpojumu pieejamību un daudzveidību iedzīvotāju blīvuma kontekstā. Metodoloģija balstīta uz simulācijas matemātisko modeļošanu. Gravitācijas centralitātes aprēķins ļāva veikt telpiski funkcionālu analīzi, atklājot pārvietošanās modeļus un precīzāk raksturojot pilsētas funkcionālo struktūru monofunkcionāli zonētos lielmēroga dzīvojamajos rajonos. Galvenie rezultāti apstiprina, ka visos analizētajos dzīvojamajos rajonos vidējais iedzīvotāju blīvums 1 km rādiusā bija augstāks nekā vidējais rādītājs abās pilsētās. Citi rādītāji atšķiras katrā gadījumā, dažkārt pat pārsniedzot vidējos lielumus, kas liecina, ka pēckara perioda lielie dzīvojamie rajoni varētu nodrošināt nepieciešamo objektu kritisko masu “15 minūšu pilsētas” koncepcijas īstenošanai Rīgas un Viļņas apkaimēs.