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SCOPE AND AIMS

The review is concerned with a multi-disciplinary approach to spatial, regional and urban planning and architecture, as well as with various aspects of land use, including housing, environment and related themes and topics. It attempts to contribute to better theoretical understanding of a new spatial development processes and to improve the practice in the field.

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EDITORIAL

Dear readers,

While thinking about the introduction to issue No. 47 of *Spatium*, which is in front of you, I was guided by the idea and significance of the notion to 'reclaim', whether it be a place, freedom of choice, one's life, or something else. This presumes renewed contact with our broader surroundings, which we have distanced ourselves from, both in physical and cognitive ways, and in an accelerated manner, driven by myriads of reasons set by the challenges of modern living. And yet we have a chance, for example, to act as creative professionals – architects, urbanists and planners – who improve the conditions of particular spatial contexts without compromising the public interest. Sometimes, it is all about reconciling the main planning goals and the market demand, as the paper from Bulgaria pinpoints, or scrutinising the issue of urban boundaries in planning and design within patchwork cities, as outlined in the paper presenting case studies in Budapest. Similarly, an interesting topic about raised awareness of the priority of knowledge, the values of human life, and the spatial organisation of a state territory, from Ukraine, in the most difficult time of its recent history, is part of this issue of *Spatium*. Sustainability is also one of those themes which are always represented in *Spatium*. Having in view the sustainability of transportation, authors share important insights on collective consciousness about cycling, as well as the accessibility of urban facilities. The next paper includes environmental psychology based on the preferences of individuals representing various ethnic groups in urban public spaces in major Lithuanian cities. The penultimate paper of this issue of *Spatium* is dedicated to the prefabrication of modular student housing and adequate design for user-friendly, ecologically and economically efficient accommodation in dormitories. The final research is on the application of mapping methodologies from a network-based approach, aiming to chronologically identify the most relevant authors on urban design, and to theoretically connect the existing literature on urban design.

Jasna Petrić
Editor-in-Chief

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COORDINATING PLANNING WITH THE MARKET IN POST-SOCIALIST SOFIA, BULGARIA

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Although the interaction between planning and the market in urban development has been the subject of extensive research, its treatment in the literature is still problematic and controversial. Issues regarding this interaction remain topical for post-socialist urban planners, who are still lacking sufficient experience with planning in market conditions, especially when it comes to practice. The contribution of this study is that it identifies two practical approaches, through which urban planners can coordinate plans with markets. First, when setting planning goals, planners must critically assess the relationship between these goals and market demand. If market demand is distorted by market deficiencies, planning must look for opportunities to counteract and rectify distortions, but if market demand properly reflects the interests of stakeholders in urban development, planning must critically reassess its definition of the public interest. Second, when developing urban plans, planners must employ fiscal (financial, monetary) and market-oriented tools for their implementation. To study these relationships, the paper explores different aspects of development in Sofia, the capital of Bulgaria, as Sofia is a relevant example of the urban trends in post-socialist cities.

***Key words*: planning-market relationship, post-socialist development, value capture tools, market-based instruments, fiscal zoning.**

INTRODUCTION

For decades, the problems of the relationship between planning and the market in urban development have been discussed extensively by numerous researchers (e.g., Alexander, 2002, 2008; Bertaud, 2004, 2018; Lai, 2005). Yet despite this impressive body of literature, these problems remain topical, arguably because of the major difficulties that urban planners face when implementing plans in market conditions. This indicates a significant gap between planning theory and practice – an insufficiently developed link between theoretical research on the market nature of urban development and planning practices, especially with regard to the two key phases of the methodology of planning: the elaboration and implementation of plans (Taylor, 1998). This fully applies to the situation in post-socialist countries, where urban planners have insufficient experience with market processes (Vujošević *et al*., 2012; Slaev and Nedović-Budić, 2017). Unfortunately, planners tend to view the market as a vicious mechanism generating various negative urban trends and major threats to sustainability (e.g., Asparuhov, 2020; Yanev, 2019). Many planners fail to distinguish between properly functioning markets and market failures (Adams and Tiesdell, 2010). This often indicates issues of institutional capacity (Čolić *et al*., 2021), including a lack of specific knowledge of the functioning of urban land markets (Zeković *et al*., 2015) and cooperation through the market mechanism (Bengtsson and Kock, 1999). As a result, the public interest (Alexander, 2002; Moroni, 2004) and the goals of planning will be inaccurately defined (Slaev *et al*., 2017). Furthermore, poor knowledge of the planning-market relationship is a major reason for the insufficient use of market-oriented tools – the most effective type of planning policy instruments (Alexander, 2012; Huxley, 2009; Peterson, 2009). In short, two of the main problems faced by planners in market

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conditions are neglect of the need to coordinate planning with market demand, and the lack of knowledge of practical methods to achieve such coordination. This article works towards filling the gap.

The contribution of this study is that it identifies two practical approaches, through which urban planners can coordinate plans with markets. First, when setting the planning goals, planners must critically assess the relationship between these goals and market demand. If market demand is distorted by market deficiencies, planning must look for opportunities to counteract and rectify the distortions, but if market demand properly reflects the interests of stakeholders in urban development, planning must critically reassess its definition of public interest. Second, when developing urban plans, planners must employ fiscal (financial, monetary) and market-oriented tools for their implementation.

To justify the two approaches, this study identifies two key questions that planners must investigate:

- When should the operation of the market be corrected and when should the planning goals be adjusted according to market demand?; and
- What tools should planners use to coordinate planning with the market or regulate the action of the market when needed?

The following section provides a theoretical justification of the two practical approaches that follow from the two questions. To illustrate these approaches, we shall present characteristic aspects of the development of Sofia, the capital of Bulgaria, over the past 14 years. Sofia is a good example because it clearly demonstrates the issues relating to the planning-market balance in a post-socialist context. Then we shall discuss the extent to which the case study of Sofia confirms the findings of the theoretical framework and sets the basis for the final conclusions.

THEORETICAL FRAMEWORK

In this section, literature sources are reviewed to identify key aspects of the coordination between planning and the market. In principle, urban planning and the urban market should "work" in the same direction (Alexander, 2008) – towards satisfying the needs of the participants in urban development. But in practice, their directions are often conflicting. In the general methodology of planning (Taylor, 1998), we identify two stages in which planning may conflict with the market mechanism:

- first, when identifying the main goals of development. For example, planning may aim to establish certain development densities, but market demand may stimulate completely different densities. To mitigate this conflict, planners need to conduct in-depth analysis of market demand; and
- second, when developing tools for implementing plans. For example, the establishment of urban standards is a popular planning tool, but their effect on market demand is often inverse – e.g., if low development standards are established in an attractive residential area, market demand in the area will remain high or even rise further. To mitigate this conflict, planners need to develop relevant market-based implementation tools.

The following subsections explore these two planning issues.

Determining the goals of planning in correlation with the market

Planners are often sceptical about the functioning of the market (Balaban, 2012; Asparuhov, 2020). This is characteristic of most urban planners in post-socialist countries. Among them, the prevailing perception is that the market mechanism primarily reflects the developers' aspiration for profit and that this aspiration inevitably contradicts the normal, positive and sustainable development of the urban and natural environment. But there are at least two reasons why planning needs to consider the market mechanism when defining its goals. First, planners must recognise that, in urban development, the power of the market mechanism is often greater than that of planning. This is because urban development is an extremely costly process, and the market tends to generate larger financial flows than planning (Daskalova and Slaev, 2015). Second, the market mechanism is dominated by market demand that reflects the interests and preferences of consumers, who, in urban development, are the residents, households and businesses (Alexander, 2008). Therefore, at least in theory, planning and the market should "work" in one direction – to meet the needs of residents, households and businesses.

There are two possibilities in which the direction of the goals of planning is different from the direction of market demand. The first possibility is that the market does not function properly. This is due to market failures such as externalities and shortages of public goods (Adams and Tiesdell, 2010). The second possibility is that the goals of planning are not properly formulated due to a poor definition of the public interest. The point is that in a pluralistic society, different social groups have different and sometimes conflicting interests. In urban processes, some social groups may benefit, and others may be disadvantaged (Bajić *et al*., 2016). The problem, then, is to define the public interest as a balance between the interests of different groups (Slaev *et al*., 2019). In principle, if the interests of the different social groups are properly presented in the marketplace, market demand reflects the balance between these interests, that is, the public interest. To assess whether the market is distorted or functions properly, planners need to study market demand in more detail and analyse thoroughly the motives of stakeholders (Bertaud, 2004; Anderson *et al*., 2012; Slaev and Nedović-Budić, 2017). Unfortunately, such analyses are often conducted superficially, as planners consider primarily (or only) the motives of developers. Developers, however, do not generate market demand, they just follow it. To identify market distortions, planners should consider primarily the motives of social groups who generate market demand.

In brief, planners should conduct market analysis to decide when the operation of the market should be corrected and when the planning goals should be adjusted according to market demand.

Appropriate tools for implementing plans and better planning-market correlation

Modern cities are complex socio-economic systems generating complex problems. To deal with the problems of complex systems, most urban planners tend to rely on information and computer technologies to improve central management (Bakardjieva and Gradinarova, 2004; Bakardjieva and Gercheva, 2011). However, according to many researchers, planning complex systems requires the application of self-regulating mechanisms (Alfasi and Portugali, 2007; Moroni, 2010; Moroni *et al*., 2019; Cozzolino, 2020), such as the market system. In cases of urban market failures, planners can regulate them by adjusting the market framework (Needham, 2000). Alain Bertaud (2004, 2018) defines three types of tools, through which planning determines the market framework of urban development:

- urban standards and rules;
- financial (fiscal or monetary) levers – i.e., local fees and taxes; and
- the development of primary infrastructure.

In fact, urban planners are well aware of the importance of their role in defining urban standards and rules, but usually overlook their relationship with the market mechanism. Urban planners also understand the role of infrastructure as well as that of financial instruments, but very rarely focus on the latter.

However, financial instruments (fees and taxes) are critical not only in cases of market failures (Chauvet and Ferry, 2021). There are two reasons why fees and taxes are essential in all situations and forms of urban planning. First, the implementation of urban plans inevitably requires huge investments, otherwise plans will not be implemented. Second, if the "positive role" of financial instruments is to fund and thus realise beneficial urban activities, they also have a "negative role" that is no less useful and important – they charge, and thus help to limit activities that cause public inconvenience, costs, and losses (Fischel, 1985). When the aim of planners is to limit such activities, fees and taxes are much more reliable and effective tools than "traditional" standards and bans. The problem with bans is that they do not change the motivation of the participants in urban development. Consider, for instance, a private owner who is interested in building a house in a valuable natural area. Establishing a ban on this activity does not change the motivation of the owner, on the contrary – violating the ban may earn higher profits, maybe even higher than eventual fines. The market participants' responses to administrative command-and-control tools are difficult to predict. Nevertheless, if high fees are set for this activity, the owners' interests change radically. By employing financial tools, urban planners can predict the response of participants in urban development with much greater success (Bertaud, 2018).

Developing a set of efficient financial tools is difficult though. To this end, it is important:

- which activities should be stimulated/funded and which functions should be restricted;
- who should provide the funding and to whom it should be paid; and
- how funding should be provided.

For example, financing recurring or continuing activities (such as infrastructure maintenance) requires funding at regular intervals and the taxes that raise funding should be collected annually or monthly. In contrast, because many other activities are carried out by individual projects, funding for such activities should be provided accordingly – on respective occasions rather than regularly. In this case, fees are usually more appropriate than taxes. Timing is crucial for the effectiveness of financial instruments.

To this group of planning tools, we must add various types of market-based and value-capture instruments (Alexander, 2012; Huxley, 2009; Peterson, 2009) – such as impact fees, Transferable Development Rights (TDRs) and Floor Space Area bonuses. Usually developed by the local government (in contrast to "traditional" fiscal tools established by the state), value-capture and market-based instruments are more specific and innovative, and are usually tailor-made. These instruments often include non-monetary components; thus, they are much more accessible to local authorities.

In brief, to facilitate the desired market response and achieve planning goals in market-driven urban development, planners should use relevant fiscal/financial and market-based tools.

CASE STUDY AND RESULTS

Goals of the 2007 GUDP

This section describes an empirical example which will serve to check the relevance of the theoretical framework developed in the previous section. It explores the application of the General Urban Development Plan (GUDP) of the Bulgarian capital Sofia, adopted in 2007 and updated in 2009. Sofia is a suitable example for the purpose of this study because it is a typical post-socialist city which demonstrates the typical characteristics of the transition from socialism to a market economy. The GUDP's role in all aspects of Sofia's development is evident – in the morphology of the urban structure (Slaev and Kovachev, 2014), the structure of the public service (Ivanov, 2018; Georgieva, 2015, 2016; Davcheva, 2015), the transport system and forms of mobility (Nozharova and Nikolov, 2019; Slaev *et al*., 2019), and the aesthetic organization of the built environment (Davchev, 2013). In this paper, we emphasise a key objective of the GUDP – facilitating the socio-economic transition in urban development from state socialism to a democratic market society. One of the GUDP's main priorities was explicitly defined as synchronisation between planning and the market in urban development. However, the plan adhered to the prevailing critical view of the impact of markets on urban trends. With the plan's implementation, this perception grew even stronger, as the market mechanism was and still is considered the main source of urban problems and failures (Yanev, 2019).

To illustrate the applicability of the theoretical framework, this and the next sections examine the planning goals and

results of implementing the plan in four respects:

- the general characteristics of the development of central areas;
- urban trends in suburban areas;
- changes in urban form towards monocentricity, polycentricity or dispersion; and
- the development of green areas in suburban territories.

As the plan is dominated by the understanding that the central city areas are already too "congested", it aims to reduce the city's degree of monocentrism, unburden the centre and stimulate polycentric and dispersed development. The main objectives of the GUDP regarding the four outlined aspects are defined as:

- unburdening the urban centre from some urban functions and reducing the degree of monocentrism of the urban structure;
- stimulating low-density and single-family housing forms in all suburban areas;
- establishing a polycentric structure of service centres in the northern suburban areas and boosting their development; and
- developing a green system in the capital city and integrating green areas extensively along the entire periphery of the capital, with a particular focus on protecting the open spaces planned as green areas in the southern suburban territories.

Importantly, the 2007 plan did not consider sprawl a threat to urban development. Neither did planners realise that by stimulating low-density and single-family housing forms in all suburban areas they were encouraging urban sprawl. Regarding the green system, the GUDP has planned for an ambitious development of the city's green infrastructure. In the plan, the total area of all parks and green spaces is almost 3800 ha, but more than half of these spaces are not yet realised (just planned), and nearly all new land for greenery is under private ownership. That is, to implement the plan the municipality has to buy about 2000 ha of private land – that is, expropriate the land, but compensate the owners at the market price. It seems, however, at the time, nobody considered it necessary to assess what costs this compensated expropriation would incur.

Implementation of the plan: Is Sofia's development a case of coordination or a conflict between planning and the market?

Since 2000, the development of Sofia has accelerated due to economic recovery and the influx of numerous new residents. Under market pressure, the 2007 GUDP allowed higher development densities in almost all city areas. During the construction boom between 2004 and 2009, the rates of development were highest in the central and southern suburban areas. After the burst of the property bubble, the trends slowed down and revived after 2012. Development densities in central areas grew substantially, but large territories in the southern suburban areas were also subject to market pressure and were built up with multi-family housing of medium density/intensity, while only less than 5% of the new areas were developed with single-family houses (Daskalova and Slaev, 2015).

To answer the question of whether Sofia's development is a case of coordination or a conflict between planning and the market, we refer to the findings of a study funded by the 7th Framework Programme (Slaev *et al*., 2017; Slaev *et al*., 2018). This study found no indication of trends towards polycentric or dispersed development; instead, an increase in the degree of monocentrism is observed. Table 1 summarizes the results of the study on the balance between the goals of planning and market demand concerning the four aspects studied, and the actual results of Sofia's development over the past 14 years.

The observations reported in Table 1 support the inference that whenever planning conflicted with the market, planning failed. This emphasises the crucial need for planning to coordinate with the market.

Of the four aspects of urban development considered in the case study of Sofia, the protection of green areas in the southern suburbs is probably the most serious. In the last

Table 1. The balance between planning and the market in the development of Sofia since 2007

Type of area	Goals of the GUDP	Market demand	Actual results
Central city areas	Need to "unburden" the central areas, and limit the intensity of new developments as much as possible	Very high demand for housing, commercial, and service properties	Increase in the intensity of new developments. Many new urban functions accommodated
Southern suburban areas	Dispersed development of low-density high-quality housing, incl. single-family	Very high demand for housing and most types of retail and service properties	Large housing areas developed with low-to-medium (largely medium) density
Northern suburban areas	Polycentric structure of service centres and dispersed low-density (largely single-family) housing	Poor housing and industrial property demand	Very few housing units and industrial premises developed
Open and green spaces	Preservation of open and green spaces	High development demand, esp. in the southern periphery	Loss of open spaces, threatened green areas, esp. in the southern periphery
Urban form	Reduced monocentrism, increase of polycentrism, dispersed low-density sub-urban development	Not applicable	Increase in the degree of monocentrism, compact suburban development

decade, the municipality has purchased less than 1% of the private land that it must acquire for constructing the planned public parks. According to a decision by the Constitutional Court, the deadline for these purchases expired in 2017.

DISCUSSION

The discussion aims to check whether the development of Sofia under the 2007 plan confirms the findings of the theoretical section. This discussion first draws some general observations on the relationship between planning and the market in the development of Sofia, and then provides answers to the two questions.

When should the operation of the market be corrected and when should the planning goals be adjusted according to market demand?

Regarding the need to coordinate planning goals with market demand, the application of the 2007 GUDP offers examples of both cases of market distortions and poorly defined goals due to erroneous assessment of the public interest. As pointed out in the theoretical section, in both cases, urban planners must explore the interests and roles of the social groups involved in market-driven urban development processes and assess whether these interests are properly reflected by market demand.

Regarding the development of the central areas of Sofia, a key question is: Whose interests does the highly intensive development of these areas reflect? The popular answer both among planners and citizens is that this trend is driven by the interests of developers striving for maximum profit. Yet in the market, developers have no choice – they must build housing and retail and service premises where demand and profits are highest. If a developer does not follow market demand, he/she will fail against the competition and go bankrupt. If developers build housing in central city areas, the reason is that city residents want to live in these areas and are willing to pay the highest price for housing there. Urban planners try to keep development densities as low as possible in these areas, because this is better for residential zones. But in this way, planners only promote the interests of the residents who have already settled in central areas and newcomers are unwelcome. Hampering newcomers' access to attractive urban areas would result in social segregation and the potential emergence of deprived communities in suburban areas (Bajić *et al*., 2016; Petrić, 2017). On the other hand, any thriving city attracts immigration flows. In the period 2001-2019, Sofia's population grew by 13.49% (National Statistical Institute, 2012, 2022) and so did population densities, although at a lower rate. As many Bulgarians prefer central and semi-central city areas (Daskalova and Slaev, 2015), the demand for housing in these areas is highest. When many residents are willing to settle in central city areas, market demand drives a powerful market mechanism that raises the already high degree of monocentrism. However, according to Bertaud (2004, 2018), convenient access to central areas guarantees the high efficiency of the monocentric urban structure. "Burdening" the city centre with urban functions creates jobs, improves the performance of the labour market, and raises the level of commercial and cultural activities. Therefore, the growing intensity of development in central urban areas may contradict the interests of already established residents, but it serves the interests of newcomers and all other citizens. Therefore, market demand properly reflects the public interest. This observation supports the conclusion that when the market mechanism is not distorted, planners should "learn" from the action of the market.

The assessment of the issues faced in Sofia's suburban territories leads to opposing conclusions. While accelerated market-driven growth is evident in the southern suburban areas in the attractive scenic foothills of Vitosha Mountain, growth is much slower (if at all) in the agricultural suburban areas to the north. This imbalance does not in itself jeopardize the public interest, except in one critical respect – the loss of land designated for greenery. As this too is a result of market demand, we should analyse the interests of social groups involved in the market process (Slaev and Collier, 2018). Private landowners form an important group. Their interest is to develop their properties to earn high revenues. Considering next the developers, we have already explained that their interests are determined by the interests of the buyers – new settlers in the suburban areas. According to Hirt (2007a, 2007b), the new settlers in the southern suburban areas are mainly well-off and well-educated city residents. Due to the high market pressure, development densities have grown and become medium (not low, as predicted by the GUDP). In principle, such densities are not harmful to the city. But the loss of open spaces, no doubt, harms the interests of all Sofia's residents. This situation is a typical case of market failure, due to the inability of the market to supply sufficient public goods, such as open and green spaces. Planners thus face a major challenge – how can they adjust the functioning of the market? In the absence of sufficient funding, how can the municipality protect the public interest and preserve the "green lungs" of Sofia? As the municipality has purchased less than 1% of the land needed for the construction of public parks, evidently, the 2007 GUDP has failed to provide an effective solution to this problem. Some possible solutions are discussed in the next subsection.

What tools should planners use to coordinate planning with the market or regulate the action of the market when needed?

The development of Sofia under the 2007 GUDP is a good example of how the lack of efficient financial and market-based instruments hinders coordination between planning and the market, thus distorting urban processes. Three types of taxes are the primary funding sources for the development of Bulgarian cities: real estate tax, vehicle tax and property transfer (property acquisition) tax. The three taxes make a similar contribution to the funding of urban development – i.e., each tax funds about 1/3 of the development costs (Sofia Metropolitan Municipality, 2021). As stressed in the theoretical section, to perform their role effectively, fees and taxes must be properly defined: they should restrict harmful urban activities and stimulate/fund (the most) beneficial functions. Furthermore, fees and taxes should be collected from the actual users. For example, the real estate tax and vehicle tax are collected from property and vehicle owners on an annual basis. Thus, these two taxes are appropriate tools for funding the maintenance

of transport and social infrastructure (schools and kindergartens); however, the funding raised by these taxes is insufficient to finance the development of important urban functions, such as green infrastructure. In Bulgaria, like in other post-socialist countries (e.g., Romania and Lithuania), the real estate tax is less than 1/10 of the level in Western Europe (Taxation and Customs Union, 2021). Another major problem relates to the property transfer tax, which is used to fund urban development, despite this tax having little to do with urban development. This tax is collected at each property transaction, although only the first sale of a property (e.g., house or apartment) can be linked to an act of urban development. Newly built property items require infrastructure and for them the tax is reasonable, but when that property is sold for a second, third or fourth time, this does not represent an act of urban development, and then the tax on the transaction is irrelevant and distorts the market system.

While in the above case the local government collects taxpayers' money for an irrelevant purpose, another major problem arises when the relevant taxes and fees are insufficient to raise funding for infrastructure development. The problem is particularly challenging when land is being urbanised, that is, being converted to building land. In Bulgaria, the fee for land conversion is only 0.5-0.8% of the land's market value, paid as compensation for the loss of agricultural land to the Ministry of Agriculture (2012). In Sofia (and in Bulgaria in general) urbanisation fees for infrastructure development are not charged. In the municipal ordinances, fees related to the urban environment are exclusively fines, providing a negligible share of the finance for urban development. The only fee directly relating to urban development is the building permit fee, but its value is also negligible. While the current market prices of building land in Sofia's attractive suburban areas vary from 200-300 and 600-800 €/sq. m, depending on the permitted density/intensity of construction (Imot.bg, 2022), the building permit fee in suburban areas is 1.5-2.5 €/sq. m. In central city areas, the price of land may be as high as 1500 €/sq. m and even higher, but the fee is only 7 €/sq. m. In contrast, in Western Europe, the fees for urbanisation and building permits are many times higher. In Rome, for instance, urbanisation fees amount to 61 to 94 €/cub. m, i.e., 180-280 €/sq. m (Roma Capitale, 2017).

Another fundamental problem is that none of the fees relating to urban development, construction or building design (including the building permit fee) are linked to the provisions of the master plan, despite the plan defining the development of infrastructure and funding needed for this purpose. The lack of such a relationship is evident from the comparison in Figure 1. It means that the GUDP has deployed only command-and-control measures to steer urban development in the desired directions, while economic instruments, such as fees and taxes, have been ignored as a means to achieve the plan's objectives. That is, on the one hand, the GUDP is not providing incentives for the participants in urban development (residents, households and businesses) to follow the directives of the plan, while, on the other hand, substantial sources of funding for implementing the plan have been missed. We maintain that funding raised through the collection of fees could be crucial for the provision of green areas.

Undoubtedly, low development fees stimulate private initiatives, but the fees must be sufficient to provide funding for infrastructure development (Aghion *et al*., 2016). Taking Rome once again as an example, urbanisation fees in that city are directly linked to infrastructure costs – for streets, landscaping, and social infrastructure (e.g., schools). In Sofia, in contrast, funding is lacking, because of the low development fees. As already noted, in the 2007 GUDP, parks occupy almost 3800 ha, of which about 2000 ha is land that Sofia Municipality should buy from private owners. According to the municipal planning company Sofiaplan (Georgiev, 2021), the value of private land needed for green development is about €2 billion, at the lowest estimate. Due to the lack of finance, 14 years after the adoption of the GUDP, the municipality has expropriated only 0.06% of the needed land. Despite planners' scepticism of the market mechanism, they must employ financial and/or market-based and value capture tools to serve the public interest through the market mechanism, as suggested below.

Issues and opportunities related to employing financial or market-based tools for Sofia's development

To emphasise the need for financial and market-oriented tools, we should start with taxes and fees. Generally, collecting high fees and taxes slows down economic growth, but this is a complex issue (Chauvet and Ferry, 2021). To define the proper level of taxes and fees, the relevant criterion is the value of the public resource: fees and taxes higher than the value of the resource create deadweight loss and distort the market (Fischel, 1985; Needham, 2000). However, so do fees and taxes lower than the resource value – underpaid resources are undersupplied (Aghion *et al*., 2016; Chauvet and Ferry, 2021), and all related economic and urban activities suffer. This is precisely the problem with road, social, and green infrastructure in Sofia's suburban areas. The urbanisation of new territories, for instance, generally occurs through the conversion of agricultural into urban land. In agricultural areas rural roads occupy 2-3% of the territory. Urbanisation requires a significant increase in public land – for transport, schools, theatres, other public facilities, as well as parks and street greenery infrastructure. According to Bulgarian law, to provide the necessary public land, up to 25% of private property can be expropriated in the process of urbanisation without compensation. When more land is needed for public uses, owners must be paid at the market price. In Bulgaria, however, municipalities lack funding and seek to expropriate land at the lowest possible prices. Respectively, private owners oppose the expropriation of more than 10-15% of their land and file lawsuits. Thus, municipalities can satisfy only the most urgent needs for public land – for streets with a minimum width, while land for public parks is particularly scarce.

In such situations, planners should consider not only local taxes and fees, but also the use of various market-based instruments (MBIs) and value capture (VC) tools for the implementation of planning measures that lack funding. Because any VC tool has advantages, disadvantages and specific context requirements, different MBIs and VC tools

a) Sofia's 2007 GUDP (Source: Sofiaplan (public document))

Legend:

- Central areas
- Housing areas
- Public areas
- Green areas
- Industrial areas

b) Urban zones defining the building permit fees (Source: Sofia Metropolitan Municipality (public document))

Legend:

- Zone 1 - 14 lv./sq. m
- Zone 2 - 12 lv./sq. m
- Zone 3-10 lv./sq. m
- Zone 4 - 8 lv./sq. m
- Zone 5 - 6 lv./sq. m

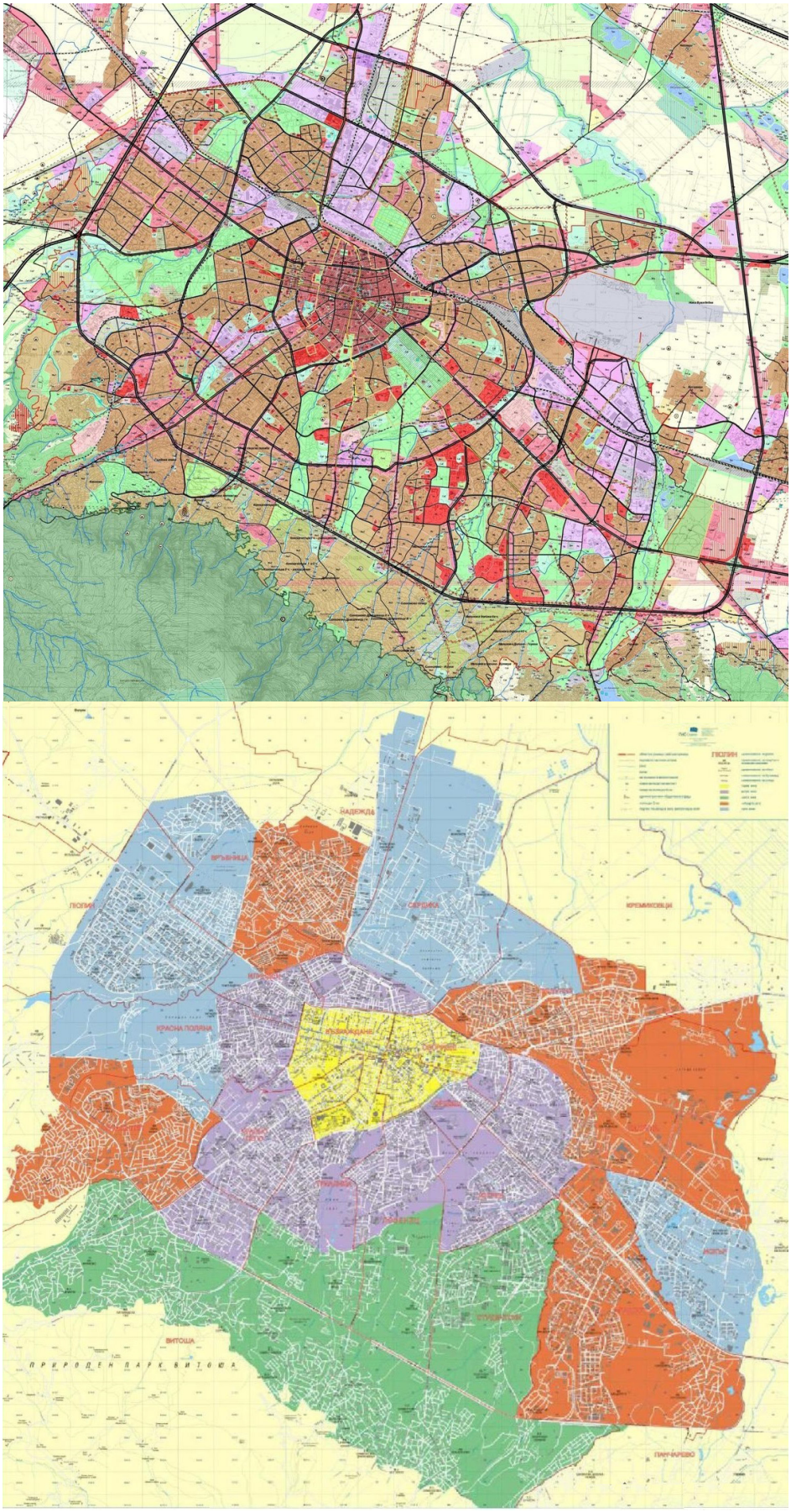

Figure 1. Comparison between the GUDP and the structure of the zones determining the level of the development fees (Source: Sofiaplan (public document) and Sofia Metropolitan Municipality (public document))

will be relevant in different situations and for different purposes. Consider first density/floor space bonuses, also termed FAR (Floor Area Ratio) bonuses. In many countries, this tool is used in various situations, probably because of its essential advantage – it is a tool consuming virtually no financial resources. In addition, through this tool, various benefits can be provided to the community or specific social groups. While it does not consume public funding, it provides to landowners "in kind" benefits that may be of very high value. For example, if an owner has a lot in one of Sofia's suburban areas with the permitted intensity of FAR = 0.6, the municipality may offer him/her an increase in the intensity of FAR = 0.8 (i.e., a FAR bonus of 0.2) provided that the owner donates an extra 10% of his/her land for public use. Thus, the value of the building rights of this owner will increase, and extra area for street landscaping will be provided "for free". Similar market-based levers could also be used to provide social housing or public amenities.

However, while FAR bonuses may help provide wider streets with landscaping, it is impossible to provide large plots of land for public parks through this tool. Obviously, a relevant tool for the provision of large plots is land assembly/land readjustments. In Sofia's southern suburban areas, plots of 0.1 to 0.3 ha prevail and very few plots exceed 1.0 or 1.5 ha. In view of this relatively small existing scale of ownership, land consolidation is necessary. Still, the main problem is the form of ownership. In the master plan, all parks are public and, therefore, the municipality should still find a way to expropriate all private lands. As already stressed, expropriation is an expensive tool that the municipality cannot afford, because of the lack of funding. However, there are several other instruments for "in kind" payments to compensate the owners, apart from the already considered FAR bonuses. These are tools such as land swaps or the developer's contribution to public infrastructure development, or land transfers in leu of charges. All these can be viewed as forms of in-kind compensation – the provision of land or air rights instead of money transfers.

Another efficient instrument is the Transferable Development Rights (TDR) tool. This tool is used to "transfer" building rights from an area where development should be restricted (e.g., environmentally sensitive zones, which we term here "Type 1") to areas where high densities are acceptable (termed here "Type 2"). To employ the TDR tool for the protection of open and green spaces in suburban areas, the municipality may determine a reasonable "universal" basic development density/intensity standard in suburban territories – e.g., FAR = 0.6. Then, the municipality can prohibit new development or enforce minimal densities in the "Type 1" zones and allow high densities in "Type 2". In the "Type 2" zones, developers will be able to make extra payments for extra building rights to "gain" a FAR higher than the "universal" standard. Respectively, the funding raised from the extra payments will be used to pay compensation to the owners in "Type 1" zones for the "lost" building rights. In other words, the provision of open and green spaces in the "Type 1" areas will be financed at the expense of extra development in the "Type 2" areas.

CONCLUSION

This study aimed to draw useful conclusions for urban planners in (but not only in) post-socialist countries on the need and the possibilities with regard to coordinating planning and the market. The research findings were illustrated by key aspects of the development of Sofia during the implementation of the 2007 GUDP. The study highlights two key approaches of planning that promote its effectiveness in contemporary market societies. First is the approach aimed at reconciling the main planning goals with market demand. Urban planners must be able to assess when the differences between planning goals and market demand are due to market failures. If no significant market failures are observed, the differences may be due to an improper definition of the public interest. In this case, urban planners should have more trust in the market mechanism and study market demand in depth. Alternatively, if market deficiencies are encountered, again an in-depth market analysis will allow urban planners to find the right approach to balancing the interests of different social groups. To this end, financial and market-based instruments are the most useful tools of planning. The use of such tools is the second planning approach that is key in market conditions.

Most urban planners believe that setting local fees and taxes is not their job, but rather a job for economists. Nevertheless, planners must assume key responsibility in this activity because they are best informed about the many implications of each urban function and all kinds of externalities and indirect public costs. Planners should be fully capable of setting local fees, taxes and market-based levers, because these are the most powerful tools of urban planning. Local fees and taxes and other market-based instruments are characterized by important advantages, which:

- provide essential means for realisation of urban activities. Without funding, activities would not be possible – for example, the development of a city's green system;
- regulate and, when necessary, restrict activities that hamper beneficial urban processes;
- give high predictability and certainty of the response of the participants in the urban development;
- secure various positive impacts at an acceptable price – for example, reducing water pollution through market incentives can be many times cheaper to the local authorities than building water-treatment facilities; and
- guarantee high effectiveness and efficiency – because they change the motivation of the participants in urban development but are relatively inexpensive as a tool.

Due to these important advantages of financial and market-based instruments, further research on their application in Eastern European cities is urgently needed.

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BORDERLANDS OF HOUSING NEIGHBOURHOODS AS RESIDUAL OR LIMINAL SPACES: COMPARATIVE STUDY OF CASES IN BUDAPEST

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This paper aims to analyse and classify urban borderlands. The formation of urban boundaries is influenced by natural, infrastructural, property (social), and urban design principles. Based on the categorisation of urban residual space, the spatial configurations of three regular homogeneous residential areas (historical, socialist-modern, contemporary) in Budapest are presented by combining a quantitative and qualitative approach. The role and presence of their boundaries in the city are explored through map-based and SpaceSyntax analysis. In addition, their qualitative attributes – such as lost space, neglected space, liminal space, and border vacuums – are introduced based on the literature and fieldwork. The objective of this research is to draw attention to under-represented and under-managed urban situations, in order to better understand the impacts of borderlands on the use of space and their role in creating spatial segregation. Moreover, in post-socialist cities like Budapest, the analysis of these spaces is crucial for further complex and successful urban development.

***Key words*: urban borderlands, post-socialist cities, open space, border vacuum, liminality, Budapest.**

INTRODUCTION

There are different narratives of urban history, and the traditional morphological approaches within architecture are increasingly being complemented by new overviews based on social (Straub, 2015) or natural (Rahm, 2020) factors. Two different but interdependent developmental attitudes shape the life of cities. On the one hand, we can speak of a more responsive system that works with existing structures, constantly transforming and recycling them. The palimpsest city (Kroessler, 2015) functions as a whole, and every new intervention takes away and/or adds something to the existing physical and social environment. On the other hand, there are new greenfield developments or projects in which the extant urban context is completely erased and replaced by something brand new. These areas created by rapid and drastic action are "aliens" in the city at the moment of their birth. Thanks to their uniform architectural appearance and clear spatial limits, these urban fabrics maintain isolation for the long term. They become cities within the city. However, their external boundaries play a prominent role: they draw the limits for the autonomous urban unit, even though the new urban unit and the surrounding city can communicate only in these areas. With the help of these boundaries, the city can be more than just a patchwork of juxtaposed urban forms (Neutelings, 1991), and instead be a heterogeneous fabric that is unified in its diversity. Consequently, it is crucial to shape urban boundaries consciously.

Since the beginning of the 20th century, the growing need for urbanisation has led to the shaping of the city by large-scale, action-based, island-like developments, rather than by the context-sensitive palimpsest method. The new parts completely rewrite the historical fabric or incorporate former natural landscapes. Before the Second World War, the form of most European cities – including the capital city of

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Hungary, Budapest – was characterised by the Alonso theory (Alonso, 1964; Bertaud, 2004). The city centre was most intensive in its form (density and height of the buildings) and usage (population density, real estate position, etc.), while all these indicators decreased as the distance away from the urban core increased. However, in the socialist era (between 1950 and 1990 in Hungary) nationalisation of the land and housing stock created a new situation. The land value became independent of its position within the city. The centrally planned economy, the need for mass housing construction, and the negation of the values of the past resulted in a completely different spatial distribution logic (Kiss, 2019). In Budapest, most of the new housing estates were built in the transition zone around the city centre or in the new outer zone attached to the city (Losonczy *et al*., 2020). The city became an enormous, polycentric patchwork with intensive, high-density, city-within-a-city areas. The new modernist urban form, with its panel technology, differentiated the new mass housing areas from their surroundings. After the regime change in 1990, this type of mass housing development stopped, and in addition, 95% of the housing stock became private. However, even today new types of large-scale housing developments continue to shape the city, and these international real estate developments are based on the market value of re-privatised land.

This research is based on the quantitative and qualitative analysis of the urban boundaries in three urban residential neighbourhoods of Budapest. How are their boundaries shaped? How is it possible to characterise their spatial qualities? How does the quality influence their use of space and their role within the city? If the urban boundaries are spatial and social edges between two homogeneous urban units, they make the city into a patchwork, but they can also behave like an invisible thread in the heterogeneous fabric of the city, helping integration. If the boundaries between homogeneous urban units are strong, then the city is a patchwork, composed of spatially and socially fragmented parts. Alternatively, boundaries can work as stitches, helping the communication and integration of differently developed parts.

LITERATURE REVIEW: CATEGORIES OF URBAN BORDERS

Urban boundaries

A border or boundary separates two or more territorial units. It can be natural or built, physical or mental, visible or invisible, permeable or impermeable. There are different spatial scales of boundaries between countries, regions, counties, areas of countryside, agglomerations, cities, districts, neighbourhoods, blocks, and plots. These separations between properties or administrative units are established to avoid potential conflict (Paasi, 1998; Brambilla, 2010; Roßmeier and Weber 2021). Physical borders, e.g. walls, ditches, fences between neighbourhoods, gated communities or plots, etc., provide control of the passage between two territorial units, and they show the limit between the outside and the inside. Indeed, they not only separate two sides physically, but also mentally (e.g., my house, my rules) (Rumford, 2006).

There is a medieval German saying that goes 'Stadtluft Macht Frei' ('city air makes you free'), because the city was a walled refuge from the outside world, from the countryside, where internal security was guaranteed by the laws and military body of the city. However, the role of the city wall has changed throughout history, and the pressures of urbanization pushed city walls further out, eventually tipping them down and reusing their place. In many cities, these walls still stand, but without their original everyday function. At the same time, the natural need for an enclosure, a sense of protection and defensibility, persists, not at the level of the whole city, but rather the level of a neighbourhood, block, plot, house, or apartment (Minton, 2009). Therefore, the enclosure or at least the demarcation of a territory is both a historical and a contemporary phenomenon. As a consequence, the areas of cities are socially and spatially segregated, reflecting specific economic, educational, and other differences and culture (e.g., medieval castles or ghettos in European cities, or contemporary gated communities, business districts, etc.). Some of the current developments tend to work again to this division, but most projects only recreate or reinforce them. The smallest unit of boundaries is linked to the protection of private property. In general, the boundary between different owners' land is built elements providing physical, visual, or mental limits: e.g., high closed walls, translucid, transparent or green fences, low hedges of indicative value, or even changes in the pavement, which all fragment the urban space.

Types of boundaries

Following the classical urban morphology, we talk about the boundary elements of urban areas, defined by natural, infrastructural, property (social), and architectural facts (Pinon, 1991). Their sequence also reflects temporality: the large-scale natural environment is in most cases unchanged in the long term; the infrastructural elements are the result of main state investments, and generally, they reuse the lines of the past; property relations are related to the geographical and infrastructural conditions, and they already change more rapidly (e.g., in post-socialist countries, nationalisation and privatisation redrew the land property system twice in the second half of 20th century). Architecture – buildings and urban space among them – should use these three previous boundary types as clear preconditions.

Natural border

In many cases, cities were created at the crossroads of different natural areas, taking advantage of natural border situations. The historical development of Budapest reflects this phenomenon well. The Romans used the Danube as the Limes of the Empire and built their cities only on the right bank. In the Middle Ages, both sides were already inhabited: Pest occupied the plain and the river, Buda the hills and the river's edge, and their existence was based on mutual trade based on the control of the passage across the Danube. The river, hundreds of metres wide, also acted as a solid natural boundary, isolating the two cities. Therefore, before the first permanent bridge (1849) and the unification of the cities as Budapest (1873), the river also functioned as an administrative border. Today, eight bridges connect the two banks, but the mental map of the city's inhabitants still shows a strict differentiation between Buda and Pest.

Infrastructural border

Building, strengthening, and operating transport links with the surrounding settlements is the driving force of the city's development. Urban infrastructure lines, such as railways, highways, and multi-lane main roads fragment every city. They are essential elements of the urban network that are necessary for providing rapid transport, but they cut through existing neighbourhoods for kilometres. Between the separated sides only a few problematic passages (elevated, underground, polluted, etc.) provide some connections. It is no coincidence that the design of these infrastructural nodes is defined as fluid space, reflecting the flow of vehicles (Jerković-Babović *et al*., 2020). Nevertheless, the provision of pedestrian and cycling passages within cities is a crucial urban acupuncture tool (Lerner, 2016; Apel-Muller, 2018). In addition, contemporary, large-scale urban regeneration programmes also try to change and humanize inherited transport-based infrastructures.

Property and social border

Spatial and social segregation has always been found in cities. Inner walls within protected cities appeared as conscious segregation, achieved by the spatial demarcation of the ruling class in both Western (e.g., castles, palace complexes) and Eastern (e.g., Beijing's Forbidden City) culture throughout history. In addition, the first gated communities appeared at the beginning of the 20th century, and today, real estate development based on broadly understood security (economic, social, natural, etc. components) has become a common feature of new investments worldwide (Kovács and Hegedűs, 2014; Benkő, 2017). Controversially their residents and workers are constantly using other parts of the city, because the gated area provides only the desired security, novelty value, and protected housing or a protected workplace, with open space that goes with it, but nothing more. In the ever-growing metropolises of Asia, South America, and Africa, global real estate development has also turned urban development generally into a private affair. The city within a city concept is based on vast real estate, creating neighbourhoods isolated from their surroundings. New developments are being built further and further away from the centre, sometimes creating not only gated communities, but gated cities with housing, jobs, educational institutions, and shopping, and leisure centres. The urban form follows modern open block patterns, but the first step in construction – as in ancient and medieval town foundations – is the creation of a defensive wall (or impenetrable fence) and controlled gates. By contrast, the Downtown Dubai project (Firley and Grön, 2013), a 200-hectare city centre built between 2004 and 2013, is surrounded not by walls but by highways. It gives the appearance of a modern form of openness, but in reality, the Downtown Dubai project is a contemporary private world based on surveillance and discipline.

Urban form borders

In addition to the boundaries given by nature, infrastructure, and property, buildings and their urban forms impose physical and visual urban boundaries. In historical European city centres, enclosed blocks form explicit, continuous walls of space. The boundary between public and private space coincides with the walls of buildings, or transitional space between public urban space and private interiors (Benkő, 2020). In contrast, in modern housing estates, building masses are free-standing in open space, and the built form is independent of both the street and the property system. Most contemporary developments combine the architectural advantages of modern free-standing buildings with the legibility and the controllability of traditional block structures drawn by fences. In these situations, the public realm is present exclusively outside the development blocks as in the historical patterns. Nevertheless, in inherited modern housing estates, at least in most post-socialist countries, the spaces between buildings are still public. The urban blocks function as a continuous public green park with solitary residential slabs and towers.

Qualitative spatial categories of urban borders

The abandoned, underused, and under-managed public spaces of cities have been the subject of increasing attention in urban studies since the 1960s. Jacobs' (1961) *border vacuums*, Trancik's (1986) *lost space*, and Koolhaas' (2002) *junkspace* designations are similar neglected urban spaces, and several other notions have also been introduced e.g. *residual space, urban wastelands, terrains vagues, dead zones, no man's lands, vacant lands* and *liminal space* (Mariani and Barron, 2014). Carmona (2010a, 2010b) summarizes *under-managed* space and describes several subtypes of different qualities. The qualitative dimensions of this type of urban space (Schneller, 2005) are increasingly dominant in theory, analysis, and assessment (Gehl and Svarre, 2013), because they are more and more dominant parts of contemporary cities.

The research highlights four theories. Jacobs (1961), a classic today, points out that large monofunctional units fragment the city, and that everyday communication and urban life cease to exist between the individual units. She states: "a border – the perimeter of a single massive or stretched-out use of territory – forms the edge of an area of 'ordinary' city. Often borders are thought of as passive objects, or matter-of-factly just as edges." (Jacobs, 1961, p. 257). In addition, it should be pointed out that border zones are often influenced by railway tracks, busy roads, highways, or large institutional and industrial premises (Douvlou *et al*., 2008). Thus, their boundaries are a kind of *dead zones*, or *urban vacuums*. Jacobs bases her findings on the American zoning system and sees the main problem in the endlessly spreading suburbs. However, the theory of the modern functional city (van Es *et al*., 2014) that became the background of post-war housing-estate developments all over the world, is based on spatial and functional division creating *border vacuums* on the edges of cities.

Trancik (1986), in addition to the *border vacuum*, identifies two additional types of spaces as *lost spaces* for users. The first is *in-human spaces* (underpasses, overpasses) caused by complex, intricate and multi-level transport systems. The second is cold, dirty, and abandoned public spaces created by the lack of ownership or a perceived sense of ownership of open space and the resulting lack of care (such as open spaces left in public ownership in former socialist housing estates). They are *no man's lands*.

To define the quality of public spaces in cities, Carmona (2010a) creates two groups, *over- and under-managed spaces*, and then breaks these down into further sub-groups. Among the five types of Carmona's *under-managed space categories* (*neglected, invaded, exclusionary, segregated, and third space*), the *neglected* and the *invaded* space are the most relevant for the analysis of urban boundaries.

Carmona's *neglected space* is similar to spaces that Trancik defines as *lost space*, but Carmona's viewpoint highlights its positive aspects. *Neglected space* is unused, abandoned, and undervalued, but that is why it could have community-building power (e.g., for subcultures) that we cannot find in *lost spaces*. For those users who are not accepted by the majority of the city (e.g., homeless people), these spaces represent a sense of calm and openness (Bene, 2020). For them, it is the space of the community (Worpole and Knox, 2007).

In contrast to *neglected space*, *invaded space* is an urban space that has been taken over by the increased car traffic of the 20th century, displacing pedestrians and separating drastically the two sides of a road. In addition to the land requirements of car traffic – passing or parking vehicles – *invaded space* imposes constraints and negative impacts (e.g., dirt, noise, visual pollution) on spatial experience that severely weaken ordinary urban life, or even make it impossible (Gehl and Gemozoe, 2001).

In addition, it is meaningful to explore the potential of transport nodes: namely, their liminality (Zukin, 1991; Shields, 1991; Sennett, 1990). *Liminal space* is used simultaneously and intensively by crowds of people from different social classes, ethnicities, religions, etc. Excessive use creates tension, but at the same time, it provides opportunities for encounters and communication.

Based on the literature overview, the research uses the following qualitative space categories to describe urban borders: *lost space* and its subtypes (*border vacuum, in-human space, no man's land*), *over- and under-managed space* and its subtypes (*neglected space, invaded space*), and *liminal space*.

METHODOLOGY AND CASE STUDY SELECTION

Methods

The research focuses on the borderlands of three residential areas in Budapest. Each of them can be considered relatively homogeneous from a complex urban planning point of view, in relation to their physical and social context. They are located close to the historical city centre, they are densely built-up, and are a kind of mega-projects of their construction period. Their dimensions are different, but they each represent one of 173 administrative units, in this case, the so-called "urban neighbourhoods" of contemporary Budapest. Újlipótváros is a product of the first half of the 20th century, a traditional grid in which the street network is filled with various closed-block patterns, József Attila housing estate is Budapest's first modern housing estate from the 1960s and 1970s, while Nádorkert is an example of contemporary large-scale real estate development (Figure 1 and Table 1).

The boundary zones of the three districts were assessed according to the boundary categories (natural, infrastructure, property, urban form) and spatial quality characteristics as described in the literature review. In addition to theory, the comparative analysis was based on SpaceSyntax analysis and fieldwork (mapping). The methods for the boundary categories used were mixed.

Figure 1. Map of Budapest with the three case studies.
1. Újlipótváros 2. József Attila housing estate 3. Nádorkert
(Source: made by authors using SchwarzPlan plan - schwarzplan.eu)

The *natural boundaries* were found on professional maps of the Budapest Green Strategy (Budapest, 2021) and they were easily visible and interpretable through observation of reality.

In the case of *infrastructure boundaries*, the integrity and segregation of the street network were investigated by SpaceSyntax analysis. SpaceSyntax makes it easier to see which parts of the street network are more connected to their surroundings and which are less, simply by their geometric design. The geometric design has a major impact on the quality of urban life – geometrically highly segregated areas attract insecure environments and segregated populations, while neighbourhoods around highly integrated streets are characterised by excessive car traffic and in-human spaces.

The *social boundaries* resulting from *property* ownership were analysed using a free online map based on the 2011 Hungarian census (KSH, 2013), which shows the income of the inhabitants of each neighbourhood on a 100x100m pixel scale. Using these economic and social factors, it was possible to infer whether a social boundary is drawn at the border of each neighbourhood.

In the case of *urban form borders*, the SpaceSyntax analysis was based on the open space between building masses and the fenced areas within them. The geospatial analysis in open space showed areas that are locally integrated (or segregated) by geometry. However, these data-driven maps only reveal the potential of the area, which does not necessarily translate into real spatial quality.

Study areas

Újlipótváros

Újlipótváros is one of the latest historical residential areas of Budapest. Located in the northern part of the city centre, its first development phase at the turn of the 19th and 20th century resulted in typical inner courtyard buildings following the traditional closed block pattern. At the beginning of the 1930s, the development continued with a new urban planning and architectural concept, following the theory of the Bauhaus School. The whole neighbourhood is characterized by an orthogonal, chessboard-like road network, closed urban housing blocks (with inner courtyards, joint-courtyards, or frame-like buildings), and highly structured, well-designed open spaces (Körner and Kissfazekas, 2022).

József Attila housing estate

The József Attila housing estate was built in the southern part of Budapest on the site of a former sprawling emergency housing settlement. After the demolition, the construction began in 1957, and József Attila housing estate became the first large-scale modern area in Budapest, composed of stand-alone cubes, slabs, and towers. In the state-socialist era, the land and the buildings were public. There is no more traditional urban structure, but a huge green park with an organically designed street network. A kind of spontaneity can be observed both in the urban morphology pattern and in the use of different types of building design (Gyergyák *et al*., 2017).

Nádorkert

In 2022, the whole of the Nádorkert neighbourhood has just been completed as BudaPart, a new mixed-used contemporary area in the southern part of Budapest. It is an international, market-based development with 3,000 flats, 250,000m^2 of offices, and 15,000m^2 of commercial space (Mizsei, 2017). Moreover, this investment is one of the largest housing developments in the capital since the change of regime in 1990. The master plan used typical contemporary solutions: transparent urban blocks with closed and continuous street lines and tower buildings, providing high-density, high-rise urban fabric.

RESULTS

Natural borders

Each of the three areas has one important natural border (Figure 1). While Újlipótváros and Nádorkert are located on the banks of the Danube River, the József Attila housing estate is protected by an urban forest lane, the so-called Kiserdő (Small Forest). The Újlipótváros waterfront is developed within the historic city centre, but a multi-lane motorway embankment separates pedestrians from the Danube. Therefore, the area can be defined as *invaded space*, but it is not a typical *under-managed space*. The pedestrian promenade follows the waterway, and on the side of the residential zone, the well-kept fenced parks from the 1930s provide green leisure facilities. The natural boundary of the József Attila housing estate is a forest which used to mark the former border of Budapest. Today, the forest is abandoned and unmaintained, and as a consequence, this *neglected space* is often used and inhabited by subcultures and homeless people. Nádorkert's waterfront is a brand new *over-managed space*, owned by a private investor but opened for public use. In addition, the Kopaszi-gát green zone, a high-quality river beach, was developed next to the new high-rise residential neighbourhood.

Infrastructural borders

On the maps showing the intensity of the road network, the best-connected roads are highlighted in white (Figures 2, 3, and 4). This implies that these roads are also the ones with the highest traffic volumes, creating invaded spaces. Three of the four border roads in Újlipótváros can be considered *invaded spaces* (the Danube embankment, the Great Boulevard on the southern border, and the main road running along the eastern side). The Great Boulevard and the eastern, main road are fully embedded on both sides. Therefore, they also function as *liminal spaces* – as evidenced by the functions they contain (shops, pubs, restaurants, offices). Because of a few under- and overpasses, the eastern border of Újlipótváros is full of *in-human space* (Figure 5). The József Attila housing estate is bordered by two radial arterial roads, the main road from the north and a highway access road from the south. The "protection strip" next to the highway creates a *border vacuum*, while the main road creates a *liminal space*. There is a multi-lane and multi-level infrastructure to the north of the Nádorkert, while to the west it is bordered by the main road. The northern and western boundaries are both lost space, but the northern boundary zone is also home to tents inhabited by homeless people, hence it is a *neglected space*.

Figures 2, 3 and 4. The road network of Újlipótváros, József Attila housing estate, and Nádorkert (Source: made by authors using DepthmapX)

Figure 5. Infrastructural border in Újlipótváros East (in-human, invaded, and liminal space) (Source: Authors)

The results reflect the morphological characteristics of the sites well: Újlipótváros, as a typical well-connected orthogonal grid; József Attila housing estate, as a large-scale island-like territorial unit within the city; and Nádorkert, as an isolated inclusion, with only a few entrances and a really weak connection with the road-network.

Property and social borders

The Hungarian Central Statistical Office prepared economic and social data-based open access maps using the 2011 census. These maps show the spatial division of the city into residential and non-residential areas. Then, the distribution of pixels of different shades within residential areas reflects its social composition. The historic city neighbourhood, Újlipótváros is heterogeneous, but the social border in the south side (near the city centre) is well visible. The omitted pixels reveal a largely uninhabited area on the eastern side that includes one of the main railway stations and one of the biggest shopping malls in Budapest. Although the negative effects of the railway tracks could affect this boundary zone, the plaza compensates for it (Figure 6). The map of the József Attila housing estate shows that it is surrounded by

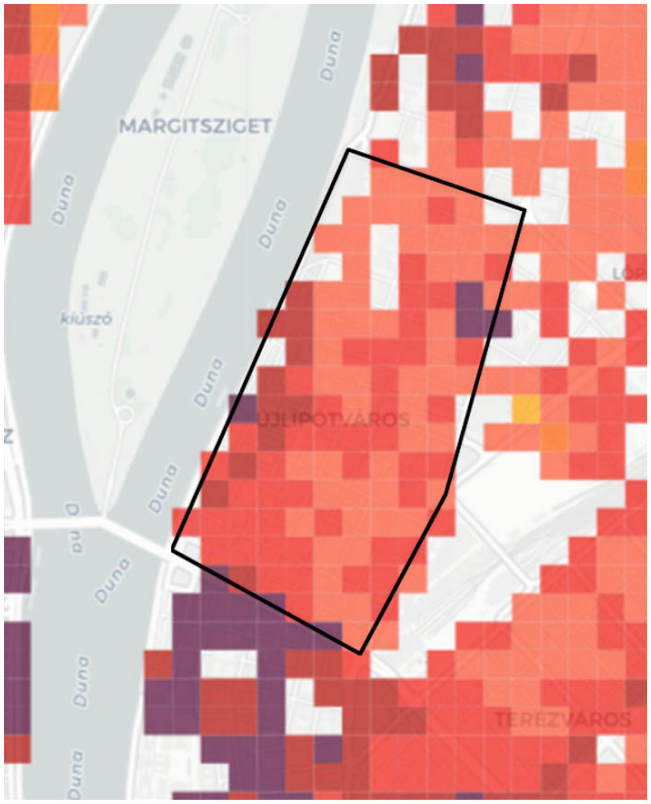


Figure 6. The income map of Újlipótváros lighter pixels mean lower income, darker pixels mean higher income (Source: https://geoxmap.carto.com/viz/fc6f49ac-d288-11e6-9805-0ee66e2c9693/public_map)

other functional inhabited land. Two areas (west and south) could be classified as *no man's land*, and the third is the forest mentioned above, a natural *neglected space* (east). In addition, this forest is not only a physical boundary but also a social one because the other side of the forest has a different shade to the József Attila housing estate. No data is available for the Nádorkert area, which was a former industrial zone, an undeveloped urban wasteland waiting for investments at the time of the 2011 census. Well defined by its natural

and infrastructural borders, its northern neighbour is a university campus, while to the west is a changing office area, and to the south, industrial land, a *lost space*.

Urban form borders

SpaceSyntax maps, built from the geometric shape of roads, show where local centres can develop. Újlipótváros as a whole has a balanced, unified spatial system, thanks to its orthogonal street grid. Three boundaries of the area (north, south, west) are of the same shade as the surrounding streets, while the eastern boundary is much lighter. It suggests that the eastern boundary may have a positive effect, acting as a *liminal space*. It is confirmed by the infrastructure map and the variety of functions attached to this street: a market, a church, a plaza, and shops. In the case of the József Attila housing estate, the importance of the public space in the centre of the district and the roads leading to it in terms of urban design is striking. Looking at the boundaries of this area, the south part is darker (which reinforces the presence of the adjacent *border vacuum*), while the lightness of the north boundary indicates the strength of its liminality. Although it is true that many features are attached to this street, it is still an *under-managed space* due to the nature of the multi-lane arterial road. No localised densification is observed in the area of Nádorkert. More important spatial connections have developed in its surroundings, making this area a quiet, segregated unit without a centre. Of its boundaries, only the location of the western main road is whiter than its surroundings. Therefore, it would be an ideal location for integrated functions, but at present, it is still only enclosed office space and space dominated by cars. It has the potential to transform into a *liminal space*, although right now it is more of an *invaded space* (Figures 7, 8, and 9).

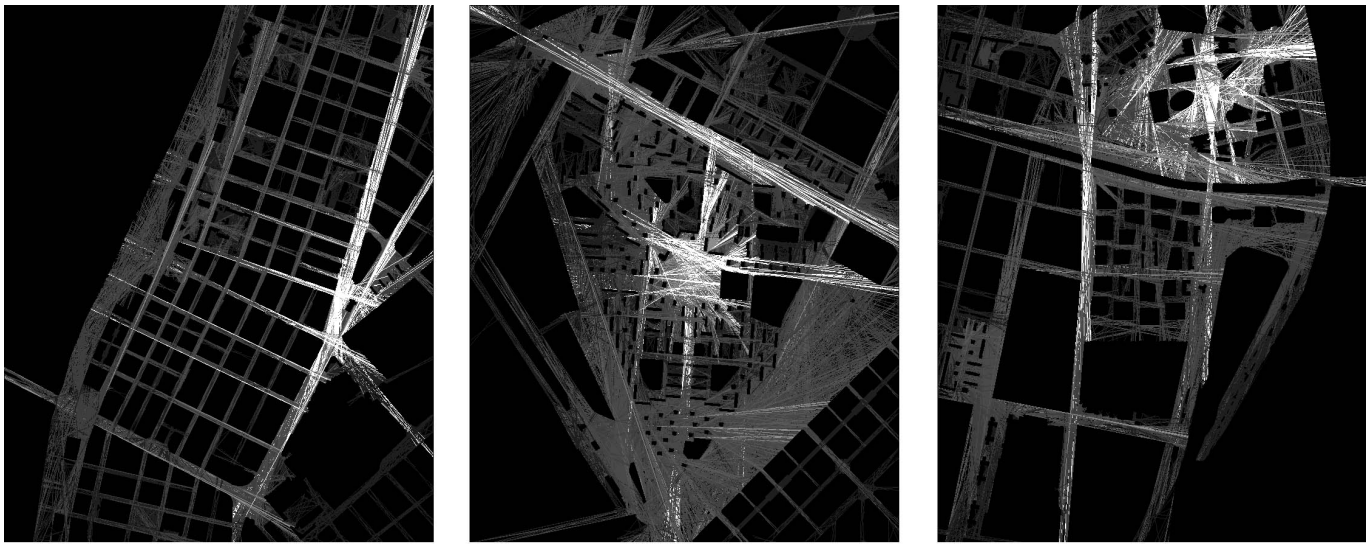
Comparison of the borderlands

To summarize the results, the table shows the relevant data, including the type and quality of the boundaries for each area (Table 1). After examination of the 12 boundary zones, most of them (10/12) could be characterized as negative qualitative units of the city (*under-managed, neglected, invaded, lost space, border vacuum, in-human space*, or *no man's land*). As an exception, Újlipótváros-North cannot be considered an urban boundary. Although the administrative boundary is located there, no special natural, infrastructural, social, or architectural boundary has been established. In addition, Nádorkert-East is an over-managed boundary with a high-quality riverbank. Overall, the border zones of the study areas are under-represented, poorly functioning, and insufficiently integrated. While the presence of urban boundaries is universal and necessary for social safety and controllability, their form, design, and quality largely determine whether they contribute to the social and psychological safety of urban users and are fit for human use (Lynch, 1984). Unfortunately, edges are formed between the different urban forms, reinforcing the patchwork structure of Budapest. In order to develop an organic, liveable, and usable urban fabric, these areas need to be redefined and put on a human scale.

DISCUSSION AND CONCLUSION

The research is based on the quantitative and qualitative analysis of the urban boundaries in three urban residential neighbourhoods of Budapest's urban core, completed in different periods. Although the three sites under study (historical, socialist-modern, and contemporary) are characterised by different spatial and socio-cultural contexts, it can be said that the presence of urban boundaries is a key feature of them. The borderland should function as a liminal space connecting and separating the neighbourhoods, but in most cases, it can simultaneously be classified as residual space.

For example, the position of the major linear urban infrastructures (highways, railways) often has a negative impact on the land value, provoking not only spatial but also social segregation. These lines create multidimensional, sharp boundaries within the city, which act as a kind of invisible wall breaking the organic, inclusive, open, and people-centred system of the city. However, these liminal spaces have particular spatial characteristics. The research proved that the urban boundaries at the edges of the mainly



Figures 7, 8 and 9. The open space maps of Újlipótváros,József Attila housing estate, and Nádorkert (Source: made by authors using DepthmapX)

Table 1. Summary of the three case studies: basic data for the three housing areas and the spatial quality of their borderlands (Source: www.ksh.hu)

Policy unit/name of Budapest's neighbourhood		**Újlipótváros**	**József Attila Housing Estate**	**Nádorkert**
Population 2011		36888	12748	planned 5000
Name of the analysed housing areas		Újlipótváros	József Attila housing estate	Budapart
Dimension		125 ha	100 ha	30 ha
Dwelling units		23294 (2011)	8524 (2011)	3000 (2021)
Dwelling density/ha		186	85	100
Construction period		1876-1940	1957-1981	2014 onwards
Architectural style		late historicism & Bauhaus	modern large housing estate, partly prefabricated	contemporary development
Property system (2022)		by plot	private plots within the public land	by block
Urban fabric		enclosed urban blocks, each block consists of 6-20 different plots with one building	open blocks, green park with stand-alone buildings	transparent block with closed ground floor and towers
Density		middle-rise/high density	middle-rise/high density	high-rise/high density
Technology		traditional (masonry, bricks)	industrial technology (partly prefabricated)	reinforced concrete
Open space		traditionally structured and well-formed	continuous public open space	well-structured and limited
Private outdoor space of the residential buildings		inner courtyards of a building or of a block	no private or semi-private outdoor space	inner courtyards of the block
Urban boundaries		N=Natural, I=Infrastructural, P=Property and Social, U=Urban Form		
North	Type	no border	I + U	I
	Quality	no border	liminal/under-managed	lost/neglected
East	Type	I + P + U	N + P	N
	Quality	liminal/invaded/in-human	neglected	over-managed
South	Type	I + P	I + P + U	P
	Quality	liminal/invaded	no man's land/border vacuum	lost
West	Type	N + I	P	I
	Quality	invaded	lost	lost/liminal

homogeneous residential neighbourhoods are generally grouped into negative qualities. However, the original goals were different, because in the pre-modern period, the traditional urban grid (Újlipótváros) was intended to create a unified network for the city, meanwhile, the borderlands of the modern (József Attila housing estate) and contemporary development (Nádorkert) were shaped to create introverted neighbourhoods. But the results are the same, and nowadays, their borderlands are characterised by desolation (lost space, urban wasteland), deprivation of property (no man's land), the excessive appearance of infrastructure, and occupation of human spaces (invaded space). In addition to the negative connotations, it is necessary to highlight the potential of borders as breeding grounds for subcultures, or the more and more relevant role of natural borders (waterway, forest) within the contemporary city. Overall, apart from a few positive examples, the boundaries of the study areas are under-represented and under-managed, and their spatial quality is inferior to their inner parts.

Nevertheless, the study highlights the importance of urban boundaries in planning and design to ameliorate the everyday experience of urban users. Several questions can be raised on this issue, which may have implications for future urban use and development. How can we live in our patchwork cities if most of the boundaries of the neighbourhoods, even in the urban core, are invaded or neglected space? How can we develop these un-formed borderlands in the future to provide a more human-centred and ecological urban environment? How can we influence urban policy and real estate to understand the importance of the transformation and the maintenance of borderland zones? Moreover, how can we work against spatial and social segregation in fragmented cities?

While the research does not aim to provide simple answers to these complex questions, perhaps one point could be highlighted about new investments and the rehabilitation of existing elements. A global trend is that more and more investments are being characterised as brownfields, redefining an area within an existing urban framework. Much more effort needs to be invested in the planning stage to ensure that new developments become living parts of the city rather than a brand-new patch within it. Consequently, it would then be more likely to fit in with existing natural, infrastructural, social, and urban form by reusing urbanised residual spaces. Therefore, in addition to adapting to the existing system, there is a great opportunity for these projects to rewrite the urban framework, erase and refine boundaries, and create more liveable, human-centred, environmentally conscious, and responsible border zones.

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MERITOCENTRIC MODEL OF SPATIAL DEVELOPMENT IN UKRAINE: UPDATING THE GENERAL SCHEME OF PLANNING OF THE STATE TERRITORY

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This paper substantiates the meritocentric model and changes in the methodological tools for spatial development in Ukraine. The proposed meritocentric approach emphasizes the research and evaluation of processes in the state, as well as the qualitative characteristics of its space and spatial transformations, bringing knowledge, values, human potential, creativity, technology, and information to the forefront. The national level in the spatial planning of Ukraine is represented by the General scheme of planning of the territory of the state. The paper assesses the spatial situation in the state, including any challenges and threats that have arisen, and it determines the directions of spatial organization and development in the territory. It also establishes criteria for assessing the spatial situation and changes in space, the main conditions and factors of development of individual territories, and the regulators of development.

Key words: **General scheme of planning of the territory of Ukraine, meritocentric model, spatial organization, system development, spatial planning.**

INTRODUCTION

Spatial planning is an important activity in the development of modern society and in the substantiation of strategies for the spatial organization and development of cities, regions, and other territories. Spatial development strategies for European countries are part of the overall development strategy of the European Union, enshrined in the guidelines of CEMAT and the directives of the European Parliament (CEMAT, 2000). The focus is on three elements: territorial resources and development conditions; integration measures in institutional systems; and the dynamization of development mechanisms in the zones that form the territory.

The spatial planning of Ukraine is represented by the General scheme of planning of the territory of the state, which was developed in 1999-2000 (*General scheme of planning of the territory of Ukraine*, 2002) and expired in 2020. The General scheme of planning of the territory of Ukraine remains in force, but there is an urgent need to update this document. The scale of the problem and the complexity of the tasks involved require changes in the theoretical and methodological tools used. The state must find its own effective model of spatial development and identify the tools for its implementation.

The meritocentric model proposed by the authors will be especially relevant after the current war between Russia and Ukraine, namely, in relation to aspects of the social sustainability and integrity of Ukraine's territory as one of the priorities of its future spatial development strategy.

CLARIFICATION OF CONCEPTS AND ANALYSIS OF EXISTING DEVELOPMENTS

Meritocentrism is a concept based on the understanding and awareness of the priority of knowledge, the values of human life, and spatial organization. It is the realization that the safe existence and development of humanity is possible only under the development and effective use of knowledge, and the formation of a new system of social values.

Spatial organization is the structural-parametric and spatial-temporal arrangement and adjustment of spatial elements and links that secure the efficiency of the exploitation and

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development of territorial systems (Habrel, 2004, p. 17). System development means making qualitative changes to the material basis, structure, organization, and functions of a system under the impact of internal and external factors, that should provide the balanced development of human beings and nature in the present and future. Spatial planning and development is the triune process of the forecasting, scientific rationale, and implementation of efficient spatial organization and state (regional) development decisions.

The analysis of research in this subject was divided into three groups:

- current geopolitical processes and their impact on the country;
- the principles of meritocracy; and
- urbanism and territorial (spatial) planning.

Current geopolitical processes, challenges, and ideas. The formation of the theoretical foundations of spatial planning and urban design of large territorial systems in the context of global challenges is influenced by the philosophy of science from the past (Stanford Encyclopedia of Philosophy, 2017; Toynbee, 1955) and present (Scholvin, 2016). American researcher and futurologist Toffler (1980), formulating the theoretical foundations of the transition to a civilization of the "third wave – superindustrial/ postindustrial" society, notes the collapse of all social institutions of the society (production, family, political institutions), the change of direction in political views, the acceleration of social and technological processes, and the gradual absorption of modern society by the crisis of values. The third wave of civilizational development is destroying the principles of the industrial economy (standardization, centralization, specialization, synchronization, concentration, and maximization), consumption opportunities are expanding, as well as other values of individuals and society; in addition, other types of behavior and humanization in the society are being formed.

Meritocracy. (The power of "worthy", capable and knowledgeable people). It is the principle of governance according to which the leading positions should be held by the most capable people regardless of social background and economic status. The term was first used in a negative sense by Young (1958) in describing a futuristic society, where the social position was determined by IQ. Subsequently, Bell (1972) presented a positive interpretation of this concept – as a system that can eliminate bureaucracy and improve the social structure of society. Brzezinski (1997) held similar views in Western sociology. American scientist, Parsons (1966), considers values to be the highest principles developed by any social system in order to preserve unity and integrity, and to ensure self-regulation and consensus both in different subsystems and in the system as a whole. Meritocracy has been the subject of much research (Knight, 1995; Wilson and Corey, 2008; Tan, 2008; Imbroscio, 2016; Pettit, 2018).

Ukrainian scientists Mamchyn and Yarychevska (2021), Naumenko (2013) and Okhotnikova (2018) pay a lot of attention to meritocracy as a form of government in Ukraine. Despite critical remarks, meritocracy is considered by these Ukrainian scholars to be the perfect form of government in a post-industrial society.

The idea of the Earth's noosphere as a sphere of mind by Vernadsky (1988) played an important role in understanding the phenomenon of meritocentrism and substantiating the meritocentric model of spatial development in the state. He believed that reason and scientific thought will dominate the planet and intelligently transform it; and he considered that the main cause of crises and contradictions in society is "the eternal conflict of material and spiritual in man". The scientist argued that moral ideals and values, as well as knowledge of the laws of biosphere development, are the keys to the rational use of nature. In this regard, a statement by the thinker and religious figure Sheptytsky (2009, p. 1057) is also constructive: "Not investment – business – profit, but wisdom – creativity – well-being should become the basis of society."

Spatial planning of large territorial objects. Schumpeter (1934; 1976) considers inventions and innovations to be the "driving force" of the development of territories; they change the management structure and fill it with new content. Reinert (2007) identifies two types of economic activity: the Schumpeter-type, in which constant innovations contribute to prosperity and development, and the Malthus-type, which keeps a subsistence minimum by depleting resources and creating low added value. Thus, the emergence of fundamental concepts of social and human capital, innovativeness, and creativity in the spatial development of socio-economic systems changes the trajectory from resource dependence to innovative activity. Daly, in "Economics in a Full World" (2005), points out that mankind resides within the "full" world, where everything is limited. The development of systems is not identified with capital but with physical boundaries (the surroundings, the environment).

In Ukraine, such economists and economic geographers as A. and S. Mazur (2014), Mezentsev *et al*. (2017), as well as urban planners Nudelman (2001), Dyomin *et al*. (2020), and Pleshkanovska (2011) have studied the transformation and spatial development of large territorial systems and urban planning processes. The conflicts around land management and construction in Ukraine serve as a sign of the spatial management model crisis, while the situation looks like chaotic and random activity. The existing models of spatial organization and development of large territorial systems in Ukraine are currently inefficient. A new spatial development model must be developed in the country.

To date, the "Comprehensive Plan for Spatial Development of the Community", which is being developed on the basis of present and previous community activities, has become the main document of spatial and urban planning in Ukraine. At the lower level, master plans of settlements and DPT (detailed plans of territories) have been developed, on the basis of which town planning conditions and restrictions are issued. The problems persist:

- DPTs are still carried out for only small parts of the territories and these docu-ments do not create a systemic integrity, thus bringing chaos to the spatial structure of settlements;
- the practice has been preserved in which lower-level

documents ignore the requirements of or make changes to higher-level documents;

- regional and agglomeration planning is not developing;
- standards and requirements for the management and development of territories are ignored; and
- there are no effective institutional mechanisms to support the development of spatial planning in the state.

The existing literature describes the system of spatial planning in European countries and reveals the benefits of applying European experience to the practice in Ukraine. The analysis of the reformation and the spatial planning system developed in Ukraine indicates the use of the experience of Russia, which, in turn, is based on the experience of Germany (Neugebauer, 2021). The experience of Poland is also used, especially in the area of decentralization and spatial planning at the local level (commune) (Djemin *et al.*, 2020). Official spatial planning in Ukraine is characterized by "inertia" and remains under the influence of the Soviet system of spatial planning and urban planning (Gnatiuk and Melnychuk, 2020).

Analysis of the current General scheme of Ukraine and assessment of the effectiveness of its implementation

The General scheme of planning of the territory of Ukraine was developed by the Ukrainian State Research Institute "Dipromisto" and approved by the Law of Ukraine on February 7, 2002 (*General scheme of planning of the territory of Ukraine*, 2002). Its developers (Bilokon, Gubenko, Prysyazhnyuk, Nudelman, Shapovalov, Mukha and Palekh) received the Ukrainian state award in the field of architecture in 2003. The documentation consists of 28 maps, an explanatory note and tabular materials. The cartographic materials were made on the basis of a digital electronic map of Ukraine at a scale of 1: 500,000. This is the urban planning documentation that determines the conceptual solutions for planning and land use. Its main purpose is to establish state priorities for rational types and modes of land use in the country, taking into account socio-economic needs, environmental constraints, resource opportunities and regional differences (Figure 1).

The scheme sets out the prerequisites that contribute to the

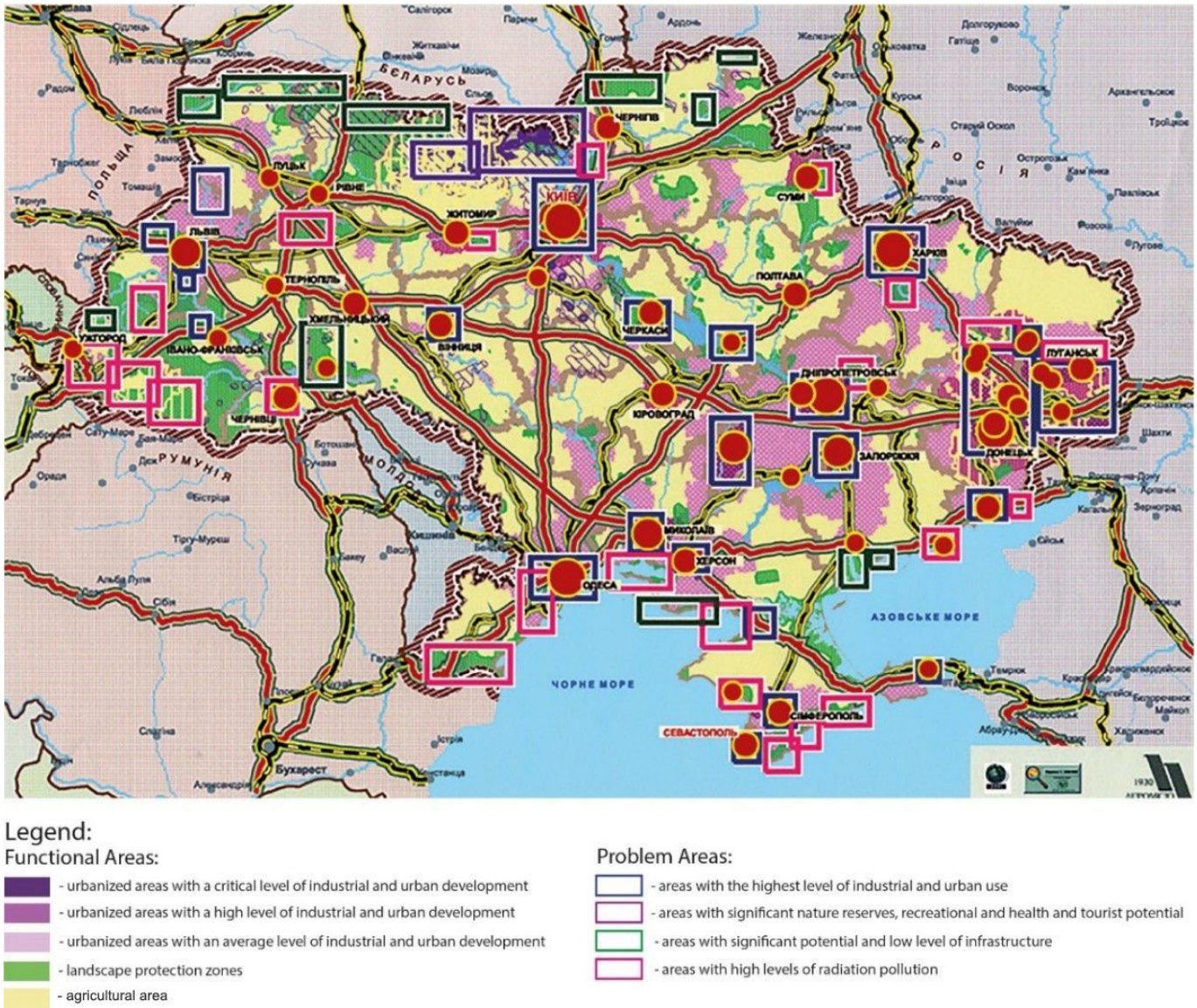

Figure 1. Planning structure and types of land use. The General scheme of planning of the territory of Ukraine. (Source: Urban development platform, 2002)

use of the state's spatial potential, namely:

- the favorable geopolitical position of the country in the center of Europe;
- significant deposits of various mineral resources;
- natural and climatic conditions favorable for human activity;
- the quality and high bio-productivity of the land;
- availability of highly qualified labor resources;
- multi-industry production base;
- developed network of settlements, including cities; and
- well-developed transport and communication infrastructure.

Problems that complicate the use of the potential of Ukraine and its regions have also been identified:

- its unfavorable demographic situation;
- low water supply along with excessive water usage by industry;
- deformed structure of the economy; and
- the presence of areas with ecological imbalance as areas of potential threat to the health and life of the population, etc.

The ratio of favorable conditions, constraints and problems was determined in this research, and the results reveal the real possibilities for the spatial development of Ukraine.

To assess the effectiveness of the implementation of the General scheme, basic monitoring indicators were taken, but only during the first three years after the approval of the document. Accordingly, criteria for evaluating its implementation were selected: efficiency, environmental friendliness, comfort, safety. Analysis of the implementation of the General scheme's provisions and assessment according to the system of defined criteria indicate how inefficient implementation has been, with a lack of compliance with the requirements. One of the reasons for this is the restricted access to the General scheme, since the documents were available only as hard copies for a long time (the graphics were published on the official website of the Ministry in raster format 13 years after their approval). Another disadvantage is the "inertia" of the General scheme: any changes to its decisions are possible only with the adoption of the relevant legislation. A number of changes in Ukraine, covering all spheres of society, are not reflected in the General scheme and are not systemic. There is also a deliberate disregard for the decisions contained in this document by those who are responsible for it.

Construction of a meritocentric model of spatial development of the state

We used the meritocentric approach in the context of spatial planning tasks for large territorial objects (in the state). It differs from the variously applied practices of spatial planning, urban design, functional-economic, socio-institutional, etc. The construction of the meritocentric model is based on two principles: meritus (from lat.), which means worthy (related to the concept of meritocracy), and centrism not as a compromise (middle) position, but as something that is at the center of the system and should be the basis for justifying decisions regarding its development. The term meritocentrism is not widely used in urban and spatial planning and is interpreted by the authors as a system of knowledge, as well as moral and ethical content related to the dignity and system of individual values, the attitude of an individual to him/herself and society to the individual, and the spatial integrity of the state (its geopolitical role, location, history, etc.).

The idea of meritocentrism is also associated with logocentrism (logos is a word, thought, reason or law), which is interpreted as an absolute idea, and in Christianity and Eastern philosophies is associated with the idea of the divine.

A model of five-dimensional space was used (Habrel, 2004), which made it possible to organize the indicators and characteristics of the system, to evaluate it and justify the ways of development on the methodological platform of the system approach.

The essence of the approach was to identify the elements of urban space and their interactions to find compatibility and consistency of their characteristics in order to justify urban planning decisions. The spatial model of the state included dimensions: "man M – function F – conditions U – geometry G – time T" (Habrel, 2004, pp. 50-137).

In the human dimension M we distinguished the following components: population, spirituality, culture, needs, values, social potential. Certain needs specific to each person or social group are functional characteristics. In the functional dimension F, we distinguished between internal and external functions, and coordination functions: the internal functions of the state relate to the availability of facilities to meet the residents' needs; external functions are related to the profile functions and role of the state at the supranational level; and coordination functions relate to the management and coordination process. The measurement of conditions U characterizes the available resources of life and development: natural, territorial, financial, political and legal, as well as the quality of natural resources and landscapes, territorial reserves, restrictions and requirements for management and development. The geometric dimension G is:

- the geopolitical position;
- the location of elements in the system; territorial features (configuration, structural planning);
- super-system connections;
- forms of structure; and
- planning.

The temporal dimension T takes into account the historical past, the present and the prospects of the state, the age characteristics of urban objects, the functioning and duration of projects, the condition and quality of the environment, the historical potential, etc. (Table 1).

The meritocentric model for the development of spatial systems assumes spatial development of the state on the basis of systematic ideas and new knowledge, which define the priority of new values, innovations, the latest technologies and the uniqueness of Ukraine's space (Figure 2).

The results were achieved by increasing the spatial potential

Table 1. Double interactions of dimensions of state space

Factors	Man M	Function F	Contidions U	Geometry G	Time T
Man M	**Population, spirituality and culture social potential**	economic activity, humanitarian policy; information policy; functional accessibility	living standard; environmental safety; crime situation	territorial structure; population density; distances in the communication system	time priorities; population dynamics; social development prospects
Function F	efficiency of functions; their complexity; employment; economic potential of the population	**economic efficiency; state support of enterprises; foreign economic relations**	competitiveness; investment attractiveness; technological conditions	functional structure of the territory; degree of land development; structure of areas	production development; infrastructure development; quality of performance
Contidions U	living conditions, resource opportunities; level of social benefits; political and legal conditions	investment potential, resource dependence of functions; technological impacts on the environment	**quality of natural resources; territorial reserves; requirements and restrictions**	protected areas recreational areas; contaminated areas	dynamics of conditions; consumption rate natural resources rehabilitation
Geometry G	development of territories and the size of the area	length of highway connections; density of functions; functional structure of territories	length of borders, special regime territory; distribution of conditions on the territory	**form structure; development of planning; super-system connection**	dynamics of functions on the territory; dynamics of network development; dynamics of territorial changes
Time T	social stability; social structure; migration	functional stability; dynamics of functions; their seasonality	stability of conditions; environmental preservation	territorial stability; network development; structure change	**state of the environment; historical potential; dynamics of territorial development**

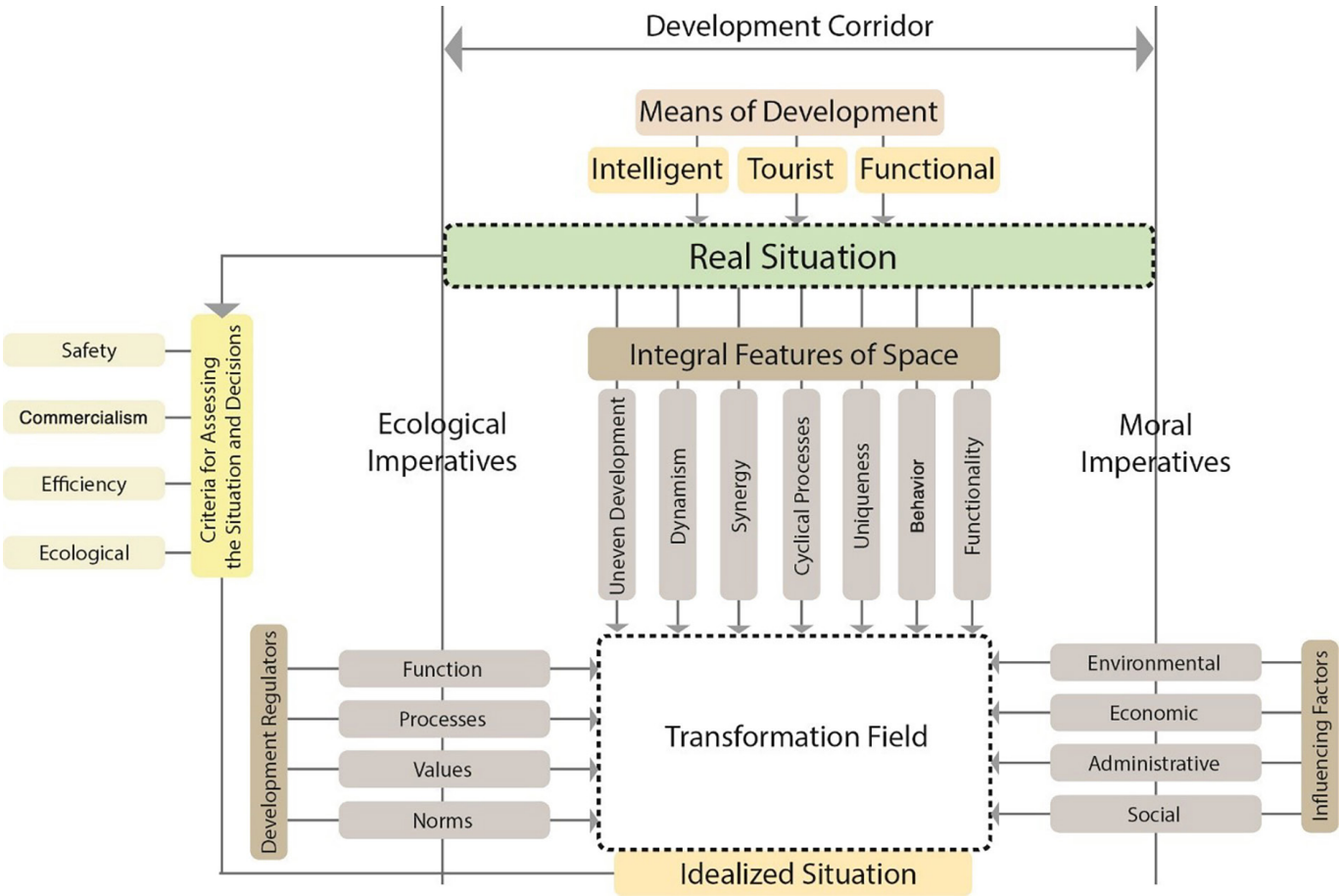

Figure 2. Meritocentric model of spatial development of Ukraine.
(Source: Authors, 2021)

utilization factor, knowledge intensity, and knowledge in substantiation of their organization and development, as well as the information component. The meritocentric model covers the systems of different hierarchical levels in the state, and different components of development. Accordingly, it is a matter of constructing a multitude of models that reveal different facets of spatial reality in the state at different hierarchical levels. For example, the System Spatial Harmony Index is related to the Human Development Index, but is significantly complemented by the use of resources, and the functional, historical and geometric potential, not just the human dimension. The spatial organization of cities, regions and states and their development is influenced by a set of factors (political, natural, landscape, economic, social, religious and ideological), safety requirements, efficiency, comfort, environmental friendliness, and aesthetics, but in practice we have fundamentally different cities and settlement systems. According to the authors, much of this phenomenon is due to the intangible in the architecture and city space. One of the key ideas is the development of territorial systems through disclosing the unique, exceptional, and rare properties of the space.

Spatial conditions, processes and phenomena in Ukraine

The system of indicators and method of collecting initial data are of fundamental importance for the assessment of the state's space. The sources used in this study were Ukrainian statistical publications, project materials, updated strategies and programs for the development of regions and the state (General scheme of planning of the territory of Ukraine, Regional scheme of planning of the territory of Ukraine, Strategy of sustainable development of Ukraine until 2030, and annual statistical publications). The measurement indicators introduced and their spatial interactions, classified according to homogeneous properties, made it possible to distinguish the integral characteristics of the spatial situation in order to substantiate the meritocentric principles of the state's spatial development. These are seven spatial properties: functionality, system behavior, uniqueness, dynamism, cyclical processes, synergy, and uneven development. In a generalized way, the assessment of the spatial situation is revealed by groups of indicators such as comfort, efficiency, environmental friendliness and safety.

Philosophical and geopolitical conditions include the analysis of:

- dichotomies (tangible – intangible in development, universalism – individualism, regulation – self-organization and free market, industrialization – deindustrialization, totalitarianism – democracy, faith – disbelief; integration – differentiation; leap – evolution; openness – closed systems); and
- the latest challenges and factors of influence (geopolitical imbalance; failure of global governance and leadership; populism; information falsifications; corruption and deepening of social differentiation, injustice and the reduction of cooperation). Global processes and changes determine three global trends that should be taken into account when justifying the spatial development of Ukraine: interdependence, dynamization, and complexity, which are determined by the increase in the amount of information available and the number of components in the system.

Ukraine is geopolitically at a high level of importance: its position is favorable and at the same time difficult; it is one of the largest states in Europe – an area of 603.7 thousand km^2, located at approximately equal distances from non-European centers of world politics (Washington and Tokyo), relatively close to the capitals of Europe and the capitals of neighboring countries. The population of Ukraine has significantly declined: in 1993 it was 52.2 million people, in 2020 (according to the UN) - 43.7 million people together with the Autonomous Republic of Crimea. In terms of centralization and concentration of industrial production, Ukraine occupied a leading position in the world in the early 1990s, significantly surpassing all post-socialist countries, including Russia (there were about 40,000 state-owned medium-sized and 6,000 large enterprises, which accounted for 75% of total production; small businesses were insignificant in volume and role). Today, small and medium-sized businesses in Ukraine bring 55% of GDP to the country's economy. In the spatial development of the state, we substantiate an alternative philosophical and ideological platform that includes: harmonious development; partial departure from the principles of globalism, the disclosure of individualism and the uniqueness of the system; post-industrialism; and digitalization.

Socio-mental and spiritual processes include social conditions, relationships, and needs; demographic processes; values, identity, and national solidarity; psychology and mentality. The causes and sources of development are the needs of the population, demographic potential and spatial potential. Weber (1978) emphasized that values are the foundation of motivating people's behavior, and the basis of the integrity of the social system.

Modern Ukrainian society is an example of a value system crisis:

- the landmarks and values of the previous historical period are a thing of the past, new ones have not become established, and they are only declared;
- there is a value nihilism of a large part of society; and
- the expansion of needs and consumption is not accompanied by the creation of conditions for the increase of social and spiritual values, the spiritual is replaced by the material.

A priority for modern Ukrainian society should be knowledge and values that would unite the polyethnic community, for example: civil rights and freedoms, a common civic position on the development of the state and society, tolerance for all parts of society, respect for the nation, and equality of all nationalities. The primary priority is the formation of spiritual heritage, the harmonious combination of values of scientific, artistic, cultural and political activity on the basis of universal standards, which should become a factor of social progress and national consolidation. Priorities related to behavior as the ability of the system to respond to change should be the basis of the state's spatial development.

New economic conditions and activities are centered around:

- general economic principles of the economic system;
- social responsibility of business, powers and participation of the state; and
- oligarchy and profit-making mechanisms.

The financial and banking type of economy, formed at the end of the twentieth century, is in contradictory relations with the new economy. With regard to the selected conditions and factors in Ukraine, the phenomenon of oligarchy – the formation of an oligarchic economy and an oligarchic form of government with its consequences and problems – needs special analysis. The question of technological singularity in the spatial development of the state has arisen due such factors as a rapid increase in the volume of information, uncertainty and unpredictable new conditions, man-made and biological threats, a reduction in the number and objectivity of measurable criteria, etc., which all together have made socio-economic forecasts impractical nowadays. What was based on human authority is rejected, and expert methods become irrelevant because usually experts tend to shows subjectivity. It is important for Ukraine to find the optimal combination of urban and agricultural subsystems, to prevent parasitism of one system over the other, and to reveal and take into account the uniqueness of conditions and the heterogeneity of economic activity.

The natural resource potential and ecological condition of the state are considered through these characteristics: resource potential and use; non-renewable resources; territorial potential; challenges and threats (food security, environmental issues). The fundamental position is the uniqueness of the space. Analysis of the spatial resource structure and natural wealth of Ukraine gives grounds to say:

- almost every region of the country has key components of natural wealth, which indicates the potential for creating conditions to increase the competitiveness of the regional economy; and
- the spatial concentration of natural resources shows a significant differentiation in their parameters in the regional context. The regions with the highest spatial concentration of natural potential (over UAH 3 million/ km^2) include the Dnieper (3.84 million); with an indicator from 2 to 3 million – Kyiv (2.98), Lviv (2.61), Transcarpathian (2.52), Chernivtsi (2.51) regions; average indicators in Kharkiv (1.56 million), Poltava (1.46), Odesa (1.12), Zhytomyr (1.09), Zaporizhia (1.01), Vinnytsia (1.03), Ivano-Frankivsk oblasts (1.85), Rivne (1.23), Volyn (1.05) and Ternopil (1.42); other regions of Ukraine are among the oblasts (regions) with the lowest indicators.

Land as the national wealth and unique resource of Ukraine works inefficiently for the state, due to the destruction of local flora and whole ecosystems of forests (10 million hectares), while more than 20 million hectares of fertile arable land has been intensively exploited by the agricultural industry without any observable advantage for the state budget. Losses caused by environmental, economic and bureaucratic actions such as problems with water, nature reserves, recreational, health, etc. amount to more than 140 billion USD annually. Land cannot be treated as a commodity and the orthodox laws of the market cannot be applied, because it is a non-renewable resource with a huge value for the nation.

Institutional and legal processes and conditions of development. The state policy is implemented in the direction of improving and developing: national security; basic values, economic interests, the humanitarian sphere and the environmental situation. The major institutions are the administrative system, international law, and the systems of national law, including on spatial planning. In general, the institutional environment and the implementation of administrative and legal policy in Ukraine is a rather complex, branched, and sometimes even contradictory multilevel system. On the one hand, the system is characterized by a single general direction of a functional basis, but on the other it is distributed into separate areas of state regulation taking into account the specifics of its components and to make matters worse, those departments sometimes duplicate each others' functional authority.

Settlement and spatial planning of Ukraine. The geopolitical location in the supersystem, urban and rural resettlement and the system of roads and communications. Most urban settlements in Ukraine have lost their city-forming functions and are searching for new ways (functions, powers) of spatial development. Some cities have reached the threshold of their capabilities, and are now stagnating or even degrading. The state has not developed a unified urban policy of urban development and urban settlements; the ideas of new urbanism have not been accepted. The dynamic growth of housing construction in Ukraine's large cities, due to the desire to make a quick profit, has created an increase in the spatial chaos and disorder due to ignoring the master plans for settlements, and urban planning legislation in general. Image of cities are homogenized while their uncontrolled spread take place, which together causes the alienation of residents from the environment. The state policy on infrastructure and transport development (implementation of large infrastructure projects) and an effective regional policy are important in order to substantiate an effective spatial policy for cities.

Technological and innovative processes and factors include*:*

- the structure of the state network;
- the development infrastructure; and
- the digitization of different aspects of human life.

The innovative factor in the processes of the spatial development of the state directs the economy and social sphere from resource to innovation, and it gives impetus to the development of human and social capital related to knowledge, information, technology, ideas, abilities, and more. In Ukraine, centers of scientific research and new technologies that produce inventions and innovations have been preserved. However, these proposals do not appear on the market in the form of new products and processes, and today they do not result in any changes in the state. The creativity and ability of Ukrainians to offer new ideas is indicated by the contribution of a number of Ukrainians to world science and technology, and the presence in the country of a large number of IT companies

working for global companies. The Ukrainian IT industry currently employs approximately 200,000 professionals and the contribution of IT to the country's economy is 4% of Ukraine's GDP, against 0.8% in 2012. Basic infrastructure is being developed, including high-speed communications, and digital technologies being introduced in all spheres of life, and in addition, access to information technology is improving.

Let us summarize the assessment of losses, conflicts and inconsistencies in the national space. The insufficient efficiency of systems is mainly due to the irrational use of space and the loss of resources (labor, energy, materials, information, time). For the specifics of territorial and urban planning tasks, it is advisable to use the dimensions of space and its functional components. The main idea of constructing a table of losses and conflicts is to use algorithmic procedures for forming a list of their possible sources and causes, as well as a scale for estimating the size of the losses. The loss of potential and conflicts are possible in every dimension of the national space in various forms: human, functional, conditions, and geometric and temporal characteristics. Each of the measurements includes a set of components that relate to the quantitative indicators of the measurement, its qualitative properties, and the level of use of available opportunities. Thus, an arbitrary number of components is possible for five dimensions, but, according to the authors, the number of those influencing the situation does not exceed ten in each of the dimensions.

Along with the assessment of individual components of space, it is important to assess its quality as a whole system. Expert and sociological methods were used to assess the problems and conflicts in the country. The parameters measuring the importance of quality indicators play an important role in assessing the impact on the final result. When determining the parameters of the severity of problems and conflicts, the methods of ranks (advantages) and comparisons (pairwise and sequential comparisons) were used. The assessment was performed on a 10-point scale. Higher indicator values show a more significant impact of this characteristic on spatial problems. The biggest conflicts, problems and inconsistencies are most closely related to the characteristics of training, knowledge, values, quality processes and intangible components of space.

Conceptual principles of spatial development of the state (to update the General scheme of planning of the territory of Ukraine)

The concept of spatial development in Ukraine provides substantiation of basic ideas, principles and macrocharacteristics, and it is based on a model of spatial harmonization and development using a meritocentric approach. An important component of the concept is the disclosure and consideration of the spatial properties: functionality, behavior, cyclical development, uniqueness, dynamism, synergy and uneven growth.

That is, the needs of humanity and society, which are inseparable from values, should be the center of developing a concept. We consider meeting the needs of the community to be the main vector of spatial development. Having a multilevel nature needs the following properties:

- reproduction – satisfaction in a certain period of time does not mean the non-appearance of needs in the future;
- cyclicity – manifested in periodicity;
- motivation – needs act as a pathogen;
- individualization for an individual or social group. Needs can be real and virtual; short-, long-term or permanent (depending on the time of manifestation); and
- they may depend on economic and financial aspects, organizational and managerial possibilities, urban planning tools and the means of their implementation.

The implementation of the main vector of development requires the substantiation of priority areas in the development of certain elements regarding the interaction between the dimensions of the state space and clarification of such issues as:

- "urbanization – deurbanization" of the region;
- the "monofunctional – multifunctional" structure;
- "concentration – deconcentration" of economic functions;
- the "monocentric – polycentric structure of support centers as centers of development;
- "closed" centers or "open" centers and how they fit into the external environment; and
- the integration – isolation of protected natural objects.

Selected dichotomies, their analysis, comparison and evaluation make it possible to set priorities. We specify some of the priority areas: the degree of openness of the state's spatial structure of the environment, and coordinated development that is determined by geopolitical location. Comparison of mono- and multifunctional concepts of development involves the expansion and flexibility of functions.

Ukraine has been developing as an industrial state for a long time, with both industrial facilities and production infrastructure and nowadays advanced industries are developing rapidly. When searching for priority areas of spatial development, it is necessary to predict the dynamics of changes in the scenario of urbanization/deurbanization. The future must be connected with the intensification of urbanization, the spread of the urban way of life, and support for the development of small towns and villages.

The concept of the spatial development of Ukraine on the basis of meritocentrism provides a justification for the integrated principles of development. We highlight the principles of unity, harmony and individuality. The principle of unity is associated with the function of transit and the change of intrasystem connections. Throughout the history of the state, interactions have not been characterized by unity, and this has been influenced by the specifics of its conditions (especially political) and resources. The principle of unity requires space dynamization, transport development, engineering and information communications. The principle of individuality has not changed throughout the whole history of Ukraine and the development of its regions and individual subsystems; individuality is emphasized by the uniqueness of regions and agglomerations, as well

as the presence of local ethnic groups and their mentality and spirituality. The principle of harmony is based on the principles of integrated development of the center and the "periphery", ensuring balanced connections between territorial systems of different levels. The basis of this is the idea of decentralization, the characteristic features of which are: ensuring comparative living conditions in all partial spaces; sustainable development; and providing conditions for living and self-development.

The macrocharacteristics in outlining the prospects for the state's spatial development should include functionality, density, dynamism of space, and development of the structure. It is expedient to substantiate the criteria for evaluating the options, the main characteristics of which should be: the usefulness of the proposal, cost-effectiveness, safety for people and the environment, and the duration of implementation. The main vector and priority directions, integral principles of organization and spatial development of the state together with many macrocharacteristics of space make it possible to achieve a meritocentric model of spatial development concerning Ukraine and to substantiate certain decisions. Below are some observations in this regard.

Strengthening the integrity of the spatial system covering the settlements and functional-planning structure of the territory includes the integration of its recreational, agricultural and other functions. In Ukraine, the practice of the Soviet period of division of the territory into zones of different functional content has been preserved. The war currently being waged on the territory of Ukraine by the Russian invasion has become a point of transition from the "Russian-Soviet Middle Ages" to modern times. Important for the future General Scheme of Spatial Organization and Development of Ukraine is its development from the scratch and with complete rejection of the rudiments of the Soviet era. Religious, behavioral and psychological differences that exist between the regions of Ukraine are insignificant, not due to their ethnogenetic features, but because they are formed by the social conditions of the inhabitants. The approach proposed by the authors is to return to the integrity of the spatial structure and increase the multifunctionality of land use. In terms of the social aspect, such rapprochement will solve many rural problems and return remote settlements that are degrading to active life.

Development of the domestic planning framework of local areas should consider the structure of international transport corridors. The general scheme envisages the development of transport corridors, which are integrated into the European TIN network: 3rd, 5th and 9th Cretan, Baltic - Black Sea, Europe-Asia, North-South and Eurasian. The domestic road network, the system of main railways and the development of port infrastructure need to be reorganized. It is important to align the linear elements of the planning framework with the system of growth poles. When developing the General Scheme, it is necessary to identify the boundaries of the main functional types of regions (Azov-Black Sea coast, Ukrainian Carpathians, border regions, areas of influence of international transport corridors, urban agglomerations, etc.) and identify conceptual directions for their further development.

The attitude to urbanization and the formation of urban policy in the state and its agglomerations should acquire special significance. Reforms in society outline a new direction for the development of urban settlements – the restart of urban growth on new principles rooted in pre-socialism, which was characterized by the significant role of small towns and cities in Ukraine. The intensive development of small-sized urban settlements and an increase in the dispersion of urban settlement structure through the development of small elements should take place under the current conditions in Ukraine.

The idea of creating refugee settlements seems wrong to us. It is perceived more correct that the distribution of the population, which will decide to stay in the western regions of Ukraine will proceed at small towns and villages. There are significant reserves of inefficient housing in the region, which can be transferred to the use of migrants under appropriate social and legal conditions.

The main focus should be on job creation, creating conditions for companies that are willing to move to these areas. This will ensure the efficient use of existing infrastructure, activate the development of settlements and avoid possible social tensions. The relationship coefficient should be taken into account, as three generations of one family are moved together, as a rule, and so on. In this regard, the provisions of meritocentrism will be effective in justifying decisions of spatial organization, reconstruction and development in post-war Ukraine.

The strengthening of the multifactorial differentiation of the state's spatial structure according to the criteria of efficiency and role of the territory in the settlement system, taking into account the specifics of natural and landscape conditions, the nature of settlement and management, historical and cultural features. The development of new types and forms of management and expansion of the functional and typological diversity of spatial elements of the state is offered.

In particular, this includes the improvement of tourism and recreation in the relevant areas, especially along the Azov-Black Sea coast due to growing demand after the annexation of Crimea. Halasiuk (2019) ranks the following among the most promising ten industries in Ukraine: agricultural machinery and food industry, infrastructure, aerospace industry, chemical, car production, pharmaceuticals and medicine, IT technologies, "green" industries, and transport, tourism. It is necessary to develop rural green tourism with the support of the state, to create a network of specialized tourist infrastructure facilities located near the national network of international transport corridors, tourist routes and historical and cultural centers.

Improving the efficiency of the use of spatial potential and development is associated with the systematization of problems and removal of those that are artificially introduced and self-eliminated over time. A special place is occupied by the development of engineering infrastructure, alternative energy sources (bio-resources, wind and solar energy), and the development of its own oil and natural gas fields on the Black Sea shelf, as well as energy-saving technologies. The social infrastructure will receive dynamic

development taking into account the transformation of the population's demand for these services and facilities, which is due to the rapid development of information technology and the formation of new values in society. Special attention needs to be paid to eliminating regional disparities in the population's access to social, communal, administrative, transport, information and other services.

Ukraine's spatial potential is linked to land resources – land structure is being transformed. It is a question of essential growth of the area of settlements, first of all rural.

Preservation and development of ecosystem diversity and wholeness in the state. The environmental component in the new General Scheme will relate to the implementation of the principles of landscape planning and environmentally-oriented planning decisions. This is especially relevant for Ukraine in connection with the exclusion territory formed as a result of the accident at the Chernobyl nuclear power plant in 1986. The General Scheme should also provide for the formation of a system of landscape and recreational areas by establishing legal boundaries for existing zones, as well as their use and the development of inter-park territories, bringing their total area to the normative indicator. The reduction of harmful emissions is associated with the shutdown of many industrial enterprises, and hence a reduction in the share of freight transport, and the mass replacement of obsolete cars. The trend of increasing harmful emissions from vehicles is obvious due to the increasing level of motorization.

CONCLUSIONS

The meritocentric model and changes in the methodological tools of spatial development in Ukraine are substantiated taking into account the in-depth analysis of new conditions, processes and phenomena at different levels such as: settlement and planning, administrative and legal and innovation processes, economic and natural resources, social, philosophical and spiritual human needs.

Without rejecting the analysis of official statistical information and traditional indicators and characteristics, attention has been paid to the factors and characteristics that today affect the justification of decisions. The proposed meritocentric approach includes analysis of the functional component, but shifts the emphasis to researching and evaluating processes in the state, the qualitative characteristics of its space, spatial transformations, and bringing to the forefront knowledge, values, human potential, creativity, technology and information.

Using the meritocentric model, the spatial situation was assessed, as well as challenges and threats that arise, and the current spatial organization and development of Ukraine were identified. The integral properties of space were substantiated: functionality, behavior, uniqueness, dynamism, cyclicity of processes, synergy and uneven development. In addition, criteria for assessing the spatial situation were established – comfort, efficiency, environmental friendliness, and safety. The main conditions and factors of development regimes of separate territories were determined: environmental, economic, social, administrative, etc., as well as the development regulators – functions, processes, values, norms.

Ukraine's spatial development is formed on a hierarchically balanced network of growth poles, which is able to stimulate and support the socio-economic development of territories of all levels, increase the number of dynamic elements, and improve their quality characteristics. This applies primarily to the acquisition of the poles of development of interregional and metropolitan features, as well as its importance for social development functions that ensure interaction with the global system thus strengthening innovation in the spatial development of the state.

By substantiating the conceptual provisions of spatial development in Ukraine, it was possible to make the following specific practical proposals: the reservation of territories for urban development needs; the development of a transport network and transport systems; the development of engineering infrastructure and life support facilities; the placement of investments objects in the spatial structure of the state; and the preservation and development of ecosystem diversity and wholeness.

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AN ANALYSIS OF THE BICYCLE NETWORK IN BANJALUKA: PHYSICAL VS. DIGITAL INFRASTRUCTURE

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This article focuses on the relationship between the physical structures which enable cycling in a city, and the modern digital services supporting this type of transport. The contemporary urban context is conditioned not only by global technological trends, but also by the growing environmental awareness. The case of Banjaluka provides the background for the analysis of this ongoing urban process, emphasizing the importance of cycling, as well as the efficiency and functionality of its networks. After presenting the general condition and physical features of the cycling infrastructure in Banjaluka, the article analyzes both the potential of digital upgrading through the use of bicycle applications and the possible benefits of a dockless cycling system. As a result, suggestions and recommendations for the overall improvement of the cycling network are provided, on the level of both the physical and digital infrastructure. By introducing these emerging global concepts to the local level, the article also contributes to the popularization of cycling as a sustainable mode of transport.

***Key words*: urban cycling, sustainability, infrastructure, digitalization.**

INTRODUCTION

The modern city is changing rapidly, generating new challenges which need to be addressed in a sustainable manner during the process of urban upgrading and further development. However, although considered to be one of the major imperatives for every urban agenda, the current level of sustainability is still far away from the 2030 goals, especially in the developing and underdeveloped areas of the world. Additionally, it should be noted that the sustainable city represents just one of 17 goals set by the UN towards achieving human prosperity (UN, 2015). According to studies conducted by organizations dealing with urban mobility in the former Yugoslavia, Banjaluka (Bosnia and Herzegovina) lags behind Novi Sad (Serbia) and Ljubljana (Slovenia) regarding the number and length of bicycle paths and lanes (CZZS, 2020), while simultaneously providing the most expensive public transport and the cheapest hour of car parking (VOA, 2020). This approach to urban development is in sharp contrast to the goals set by an agreement between the mayors of European cities (Covenant of Mayors), also signed by Banjaluka. It further accelerates the misuse of spatial resources and the decline of urban efficiency, environmental quality and overall sustainability. Therefore, by giving priority to cars over bicycles and/or public transport (an average of one car per three inhabitants), the CO_2 reduction targets set in the document Sustainable Energy Action Plan of the City of Banjaluka (Grad Banjaluka, 2010) have become unattainable. In this agreement, Banjaluka also committed itself to the popularization of bicycles as a type of transport and an indisputable global trend, but action related to this aim has been slow and insufficient. Currently, the construction of roundabouts that do not recognize bicycle traffic as a separate category represent a priority, while the construction and marking of new bicycle paths and lanes is still not on the agenda of the city officials. Consequently, the traffic safety of cyclists has not increased and the expected popularization is slow, leading to problems already recognized in many other cities: an apparent gap between declarative cycling promotion and actual policies and ongoing planning practice, conditioned by different political settings and a power (im)balance (Plyushteva and Barnfield, 2020); the prioritization of the concept of motorized traffic (Koglin and Rye, 2014); and the promotion of the 'utility' transport model, resulting in the marginalization of cycling (Koglin and Rye, 2014; Aldred, 2015). However, the construction of a third-generation public bicycle system with associated terminals has improved the general impression of this type of alternative transport in Banjaluka.

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Considering that the rapid development of internet connections and mobile phones has also generated a huge number of cycling applications intended to enable and facilitate the use of bicycles, overall improvement is possible. In addition to the need for building and connecting the physical cycling infrastructure, it is also necessary to implement modern public bicycle systems, supported by applications for finding, navigating and parking. As a result, the opportunity to achieve a sustainable modern city is created by connecting all these elements into a complete, logical and functional network of efficient bicycle traffic. Currently, in Bosnia and Herzegovina activities in the field of cycling are mostly noticeable at the level of local communities, but there are also regional and interstate projects indicating a supranational character of bicycle networks (European Cyclists' Federation, 2016). Countries such as the Netherlands, which invest heavily both in the use of bicycles and the cycling infrastructure facilities, instruct the lower levels of government to provide adequate facilities for this mode of transport, and examples of where this has been successfully achieved (e.g., Copenhagen) indicate the necessity for developing better policies and infrastructure to support and emphasize cycling (Koglin, 2015a; Freudendal-Pedersen, 2015a). Additional focus should be given to the level of activism and advocacy, contributing to the establishment of better cycling networks (Aldred, 2013).

Having in mind the (im)balance between international trends and local application, the article studies the relationship between the physical cycling infrastructure and its digital upgrading, focusing on the case study of Banjaluka. The main aim is to determine their current features and the efficiency of the preferred synergy (or a lack thereof) in achieving urban sustainability and environmental awareness, while identifying the potential and limitations with regard to the overall improvement of the cycling system, its public perception and use. The methodology is based on the analysis of available studies and other sources (e.g., plans, strategies, projects, agreements) related to the selected international examples and the local case study. The main emphasis is given to their socio-economic context, the level of cycling infrastructure and its development, as well as the specificities of its use. The case study focuses on several elements targeting cycling infrastructure – planning legislation and the level of its implementation, and the structure of the bicycle network (length, capacity, efficiency, safety), as well as its current condition and the level of maintenance.

After the introduction, the theoretical framework is presented, considering the relevant concepts and authors, as well as representative international examples. The case study of the bicycle infrastructure in Banjaluka is analyzed in the third section. The position of the public bicycle system and its physical features are considered, as well as the use of bicycle applications within the current system of urban mobility. The discussion section considers the future of cycling infrastructure in Banjaluka, its further development and the policies which could enhance the number of urban cyclists. The conclusion provides recommendations for improving bicycle traffic in the local context, at the level of both legislation and the physical structure (network and facilities).

CYCLING NETWORKS IN A CONTEMPORARY CITY

The phenomenon of cycling and its increasing popularity in a sustainable vision of the urban future have been highlighted and studied by many authors across various disciplines dealing with the contemporary city and society. Conceptually grounded in social and/or mobility theories, they highlight a number of issues contributing to the further understanding of urban bicycling, its position, role, specificities and modes. This goes from comprehensive insights into the rising popularity of cycling (Cox, 2019), the challenging relationship between cycling and the economy (Spinney and Lin, 2019; Spinney, 2020) and issues of promotion (Koglin, 2020), to the problems of shifting public perception and the fragile role and importance of all participants (Freundendal-Pedersen, 2015a; Freundendal-Pedersen, 2015b). All these contributions reveal both positive and negative examples of planning practice, which declaratively supports cycling as a preferred mobility mode, while frequently limiting its application, decreasing its effectiveness and sustainability through politically-driven transportation policies (Koglin, 2015a; Koglin, 2015b; Koglin, 2017).

Developing cycling systems: physical infrastructure

The positive effects of cycling have been recognized by many cities, resulting in an increased number of studies and charters dealing with sustainable development and sustainable traffic (Puecher and Buehler, 2017). Some of them have shown that the implementation of public bicycle systems can encourage new groups to use cycling as a mode of transport, thus increasing their incidence in the total traffic (Buehler, 2013). Furthermore, this accelerating trend has had an impact on the urban physical structure (Pucher and Buehler, 2017). Consequently, new bike paths, lanes and other service facilities (e.g., garages, special bridges and loops for cyclists, bicycle highways) will be needed to support the requested functionality of a growing cycling system and its network (Transport for London, 2010). Fleming (2012) claims that many developing cities, whose policy is to increase the number of cyclists in urban traffic, will need at least one bicycle garage – not only as a parking space, but as a message that cycling is officially recognized.

The main communication lines (paths, lanes and bicycle paths) define the basic dimension of a network, as well as its directions, while both individuals and organizations have to be involved in creating the concept of a cycling infrastructure. Consequently, the Strategy of the European Cycling Federation (European Cyclists' Federation, 2017) states that the cycling infrastructure should provide safe and attractive riding with the intention of increasing the number of bicycle users, at the expense of automobile traffic. It should also provide safe, direct and attractive routes and roads in a connected network. Building the right infrastructure represents a direct incentive to increase the number of bicycle users in a city, but similar impact has also been detected through the introduction of individual systems, such as bicycle sharing – e.g., *Cycle Superhighways* in London (Li *et al*., 2018). However, by observing the bike-sharing system as a form of transport, the opportunity for improving the cycling infrastructure might be missed, as well as a potential increase in cycling (Koglin and Mukhtar-Landgren, 2021).

Upgrading cycling systems: digital infrastructure

London Since both direct and indirect contacts and joint activities represent our everyday reality, new modes of mediation have been developed, influencing all areas of our lives – including cycling. Through micro and nano technology these interactions have created countless networks. In this context, the importance of developing synergy between physical cycling structures and digital infrastructure should be highlighted, since it affects the social level of our communication. This emerging network consists of individual elements, technological innovations and users. According to Castells (2018), our societies increasingly strive for a structure formed around a dual opposition between the network and the individual. Based on this assumption, a new model of social development – informationalism – also reflects in the way bicycles are used as a mode of transport. In this particular case, the interaction between bicycles and information technologies forms a new urban paradigm. The digitalization of modern society has become an omnipresent imperative and the emergence of digital services serving and upgrading public bicycle systems influences both the efficiency of organization and economic profitability.

The information age has also brought networks of public bicycles into the system of cycling infrastructure, organized according to different schemes. These schemes include both old and new spaces, triggering structural transformation and creating new forms, processes and networks which reflect an ongoing social transition. Form vs. process is a duality, complementary and opposite, existing both together and separately. The applications for using public bicycle systems are not tangible like a bicycle path, or a bicycle parking canopy, but they still exist and communicate with users. Castells also claims that communication through computer systems enables real-time dialogue in an interactive and multilateral environment, gathering people around common interests. This kind of networking provides completely new possibilities in cycling, enabling the discovery of shortest routes or parking spaces.

For example, the application *Strava* offers the opportunity to socialize with other users, analyze and select individual routes, access GPS maps, and have an insight into comments and photos (Delaney, 2020). The *Nextbike* application primarily provides bicycle rental, as well as navigation between individual terminals on city maps. In addition, it provides driving history or an account balance, also allowing the report of bicycle breaks. Similar applications offer an upbuilding of collectivity and, through various campaigns, motivate users to ride bicycles more. For example, via the *Bike Citizens* platform, it is possible to bid for any campaign whose purpose is to promote bike commuting on a daily or weekly basis, within school or business activities. Smartphone apps can also trigger and upgrade the sense of community between bicycle users, ultimately causing positive effects on their behavior (Cheng and Lee, 2015). Consequently, the use of applications to improve and promote bicycle traffic has an impact on reducing pollution and noise, creating cities for people and their wellbeing. Additionally, a bike-friendly city transformation, based on bicycle apps, contributes to flexible mobility, reduced pollution, savings, and positive health effects for users (Shaheen *et al*., 2010).

The logic of networks (Castells, 2014) could be also applicable in the case of public bicycle systems, especially their third and fourth generation, which are emphasized in this article. The potential of networks and networking has increased with the help of technological changes, and wireless communication has become a platform through which various digitized products are delivered. Dockless bike systems are a good example of this concept, confirming that new technologies increase the ability of people to adopt both new forms of communication and new forms of transportation. For example, the evolution of the third generation (bicycles with stations) into the fourth generation indicates the shift from the material to the digital realm. The physical terminals for parking rented bicycles have been replaced by geofencing technology, which determines the space for picking up or leaving bicycles on a digital level. Consequently, some studies indicate that the users of dockless bike-sharing create slightly different paths and habits compared to the users of station bike-sharing (Wergin and Buehler, 2017). Based on this, it can be concluded that the introduction of new systems enriches existing networks. Furthermore, the new hubs can include parking islands, which are often positioned in the areas of car parking spaces, pushing motorized traffic out of urban centers. Dockless bike-sharing, as the fourth generation, can also contribute to the reduction of all types of pollution and diminish users' stress, positively affecting urban life.

Raising cycling awareness: the synergy of physical and digital networks

Considering all the benefits of cycling, it is necessary to continuously work on the popularization and integration of cycling into society. The area of Southeast Europe (SEE) still does not perceive bicycle transport as modern and competitive, relating bicycles to poverty. Therefore, the education of users, and potential users, is an important factor in creating an environment for the acceptance and development of all public bicycle systems. Cities in SEE, such Zagreb, Novi Sad and Sarajevo, which surround Banjaluka, already have public bicycle systems with fixed stations, which could be upgraded to the fourth generation, and it is only a matter of time before cities, especially large and congested ones, develop this type of transport to some extent. As a result of their bicycle networks, cities will reduce pollution and harmful emissions and residents will get more diverse and efficient public transportation. Since 2015, the fourth generation of bicycle-sharing (*dockless bike-sharing*) has had the most predominant growth. While the third generation is rooted in Europe and the USA, the precipitous growth of the fourth generation has been launched in China, by the Ofo and Mobike companies. In 2017, some cities in the USA and Europe also started to apply this system. Over time, several names have been used to describe its main feature – dockless, free-floating or stationless. This system provides the possibility of picking up and leaving bicycles anywhere within the designated urban zone. According to the European Bicycle Manufacturers Association (EBMA, 2019), in 2019 the dockless system also appeared in cities in Austria, Belgium, the Czech Republic, France, Germany, Italy and the United Kingdom, with oscillating numbers of both bicycles and operators. However, it is not present in

SEE, except in Tirana (Albania), which introduced it in 2018 (Mobike, 2020). Unfortunately, after only seven months of operation, the operator reduced the service area, and by the beginning of 2020, the system in Tirana had stopped working. Considering all the pros and cons of the dockless system, its availability, flexibility, efficiency and affordability should be underlined as positive characteristics. On the other hand, the negative features include the appearance of scattered (so-called "zombie") bicycles, blocked sidewalks and exposure to vandalism. Since the system relies primarily on the use of smartphones (for locating available bikes, payment, malfunction reports, inappropriate parking, etc.), it is less accessible to the elderly population. The use of applications that serve the use of bicycles in the city (*Nextbike* and *Bike citizens*) could be perceived as a possibility which enables both the development and upgrading of urban systems and networks in bicycle transport. Furthermore, the scope and the manner of use of these sharing systems should be regulated by means of several parameters, one of which is appropriate legislation at both the state and local community levels (Lin and Spinney, 2020).

However, it is not enough to pass legislation or even build infrastructure. It is necessary to promote, learn, and work toward the culture of using bicycles as a form of transport, involving the whole society in the process. The dockless bike-sharing system is a type of shared micromobility. Some studies show that this form of transport could represent 8-15% of all trips up to 5 miles (Shaheen and Cohen, 2019). These distances can be covered by bicycle in less than half an hour. Medium-sized cities, such as Banjaluka, do not have city centers of this size, so all points of interest in the city center area can be reached by cycling within 15 minutes. This approach should enable new public spaces and improve the quality of existing ones, and as a whole it will contribute to a better quality of life in cities. For example, the idea of Carlos Moreno's "fifteen-minute city", based on the assumption that most daily activities must be at a maximum distance of 15 minutes of walking or cycling (Moreno, 2019), has already been introduced in Paris. In this way, networks are limited by a time distance of fifteen minutes, but they have no restrictions because they can use the internet platform, which makes them global.

Both physical and digital cycling infrastructure are important for the future of cities, especially in the era of global warming and the COVID-19 distress. Simultaneously, it is estimated that the number of cyclists will increase in the coming years as a result of technological progress, largely due to the growing number of innovations in this field. However, the application and development of urban cycling are still conditioned by local specificities and numerous limitations generated by administrative frameworks, socio-cultural background and the level of environmental awareness.

BANJALUKA CYCLING INFRASTRUCTURE

Banjaluka is a medium-sized city in Southeast Europe (Figure 1), with less than 200,000 inhabitants (Grad Banjaluka, 2021). It is the administrative, political, financial and cultural center of Republika Srpska, one of the entities of Bosnia and Herzegovina. With a predominantly flat topography and promenades lined with trees, largely inherited from the reign of the Austro-Hungarian monarchy, Banjaluka has more than adequate conditions for the development of bicycle transport. In addition to developing its own cycling network, Banjaluka needs to initiate activities which would bring it closer to higher-level networks, such as Eurovelo.

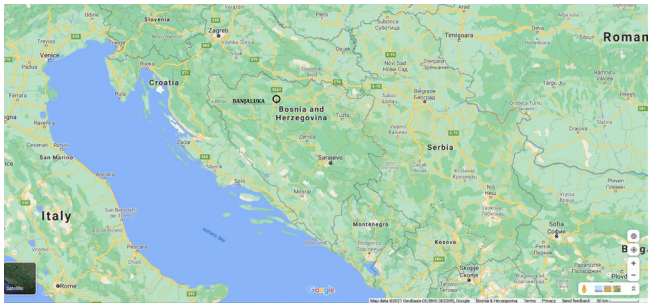

Figure 1. Position of Banjaluka on the map of the region/Europe (Source: Google maps, 2021)

Unfortunately, unlike regional centers of similar size, e.g., Novi Sad and Ljubljana, Banjaluka is currently not included in any of the 17 Eurovelo cycling routes covering a total length of over 90,000 km across Europe (Eurovelo, 2021).

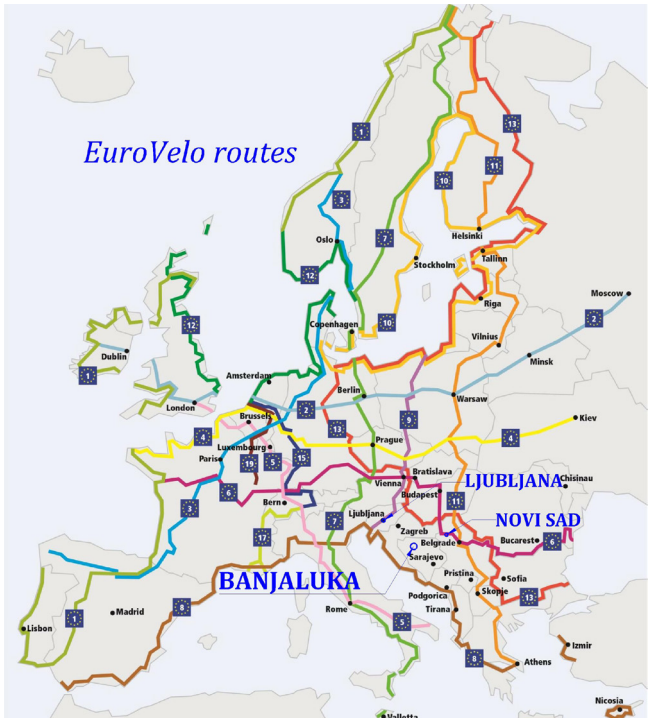

Figure 2. Eurovelo routes 2021 vs. the position of Banjaluka, Novi Sad and Ljubljana (Source: Eurovelo, 2021)

For example, Novi Sad is located on the Eurovelo 6 route, connecting the Western and Eastern European countries, while Ljubljana is on the Eurovelo 9 route, connecting the northern and southern parts. Meanwhile, Banjaluka is between the eighth (marked light brown) and thirteenth (marked red) route, so their potential connection would represent a chance for entering this network (Figure 2). As one of its hubs, Banjaluka would become closer to more developed European cities. Furthermore, membership in the *Civinet Slovenia – Croatia – Southeast Europe* network, dedicated to sustainable planning and mobility

management, could also be beneficial since it consists of cities and other participants from Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, Macedonia and Serbia (Civinet, 2021). Simultaneously, Banjaluka should strive to be recognized by the *Copehnagenize* list, on which Ljubljana already occupied eighth place in 2017, as a city with a high level of implementation policies related to bicycle traffic.

Physical cycling infrastructure network

Considering the planning of cycling infrastructure in Banjaluka, the most interesting document comes from the 1970s – *Banjaluka Planning Advice I (UN Development Program, 1971)*. Its content was later included (almost unchanged) in the 1975 Master Plan of Banjaluka, and the unfinished Master Plan from 1991, defining the concept of bicycle paths (*Studija razvoja biciklističkog saobraćaja na urbanom području grada Banjaluka*, 2008). Unfortunately, through analysis of the existing planning documents, as well as their implementation, it can be concluded that the parties involved in the planning and construction of the city did not follow the stated guidelines (*ibid*.). Banjaluka is currently in the process of drafting and adopting the Master Plan 2020-2040 and it still has to prepare and adopt its own sustainable mobility plan (SUMP), already developed by cities like Ljubljana and Novi Sad. These steps will hopefully highlight the actual importance of sustainable transport, especially cycling.

Nowadays, the physical bicycle infrastructure of the city is mostly based on bicycle paths and lanes, with an insufficient number of bicycle parking lots and a few canopies. Furthermore, there are numerous examples which testify that the cycling infrastructure is neglected comparing to motor traffic. This problem is seen in the fact that either the cycling infrastructure does not exist, or it is below the standards and recommendations of experts. A common problem is the discontinuity of bicycle paths or lanes, as well as the lack of suitable interconnections, which directly affects the safety of cyclists. The GPS recording of the cycling network (*.kml* file) provides an insight into its anatomy (Figure 3). The network fragmentation is evident – there are numerous interruptions resulting from undefined integration into the lanes of motorized traffic, while multiple intersections of cycling routes collide with bus stops, or their flow is interrupted by the installation of bus stop canopies. Consequently, certain bicycle routes are incomplete and the absence of network hubs is visible. Although local authorities declaratively support the development of this type of transport and refer to the positive practices from cities in developed countries of the European Union, the condition of the cycling system and its incomplete network violate the safety of cyclists.

The current state of the built bicycle infrastructure is reflected in a total of 31 km of paths and lanes, out of which about 15 km are usable (CZZS, 2020). The degree of usability is influenced by the level of interconnections between network segments, the degree of physical damage, and the unintended and illegal use of areas reserved for cyclists for the purpose of parking motor vehicles, which is the most common case. These barriers can be perceived as malignant points and cannot be considered as integral parts of the network.

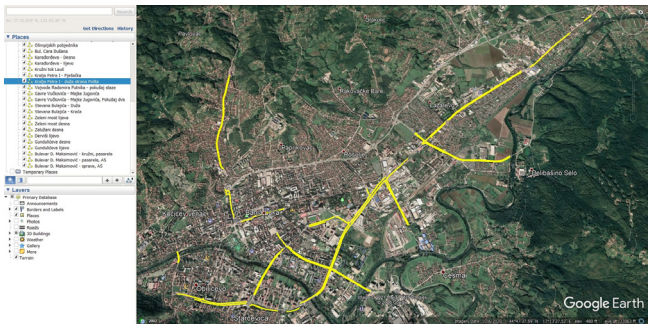

Figure 3. Map/network of existing bicycle paths and lanes in Banjaluka (Source: Authors, 2021)

The data provided in Figure 4 demonstrates the current condition of cycling infrastructure in Banjaluka, even though it does not consider the size of the selected cities and their populations. However, the comparison between Banjaluka and Ljubljana (twice as populated) reveals that the length of cycling paths in Banjaluka should be at least 200 km.

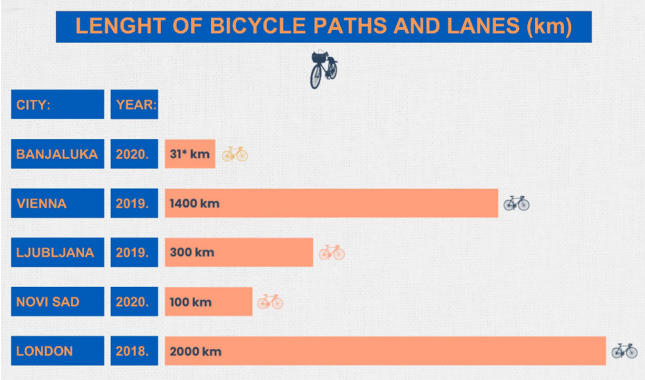

Figure 4. The length of existing bicycle paths and lanes: Banjaluka vs. selected cities
(Source: drawn by authors using Center for the Environment data, 2021)

Additionally, it should be mentioned that Banjaluka has a number of basic cycling infrastructure problems, such as insufficient and inadequate bike paths and lanes. Although authors suggest the construction of bicycle lanes with a minimum width of 1.5 m, or bicycle paths with a minimum width of 2.0 m (Janković and Janković, 2018), institutions and individuals do not recognize such information during planning and implementation, creating substandard lanes (e.g., Vojvode Radomira Putnika Boulevard, Gavre Vučković Street and Put srpskih branilaca). Tsar Dušan Boulevard (Figure 5) also demonstrates ambiguities and illogical decisions since it includes a (future) hub which should become a part of the network and several unconnected linear elements. To solve this specific problem, it is necessary to make a new hub, as well as to add the missing segments for bicycle paths/lanes.

Unfortunately, this is not the only problem. The emerging cycling network is often blocked by improperly parked cars, dumpsters for communal waste, inadequately constructed sewage and water shafts, weather conditions (Figure 6) or poorly maintained urban greenery. Another severe problem is the arrogance, carelessness and inattention of motor vehicle drivers, who largely do not perceive cyclists as equal participants in traffic, in spite their extreme vulnerability.

Figure 5. Tsar Dušan Boulevard: existing cycling network (yellow) and missing sections (red)
(Source: drawn by Authors using Google Maps, 2021)

Figure 6. Cycling path, Gavre Vučkovića street, Banjaluka
(Source: Authors, 2021)

Digital cycling infrastructure network

Simultaneously with physical changes, the cycling infrastructure in Banjaluka has been upgraded by digital tools, which could contribute to the popularization of bicycle transport. Some of the recent applications supporting public cycling systems have found their place in Banjaluka – e.g., *Nextbike* and *Bike Citizens* app (Milaković and Stupar, 2019). They are constantly being improved and perfected as new versions come out, which should be a pattern for the maintenance and improvement of bicycle paths, lanes, canopies and other physical forms enabling the use and development of bicycle transport. The system of public bicycles with stations requires initial registration (a physical visit) and payment (for a one-off, monthly or annual ticket, with the last two categories providing 30 min free cycling per day). After that, the use of the application is quite simple and bicycle rental is further simplified by using a QR code. The added value of this application is the ability to use it in any city where this system is represented (e.g., Germany, Austria, Croatia etc.), connecting cities both outside and inside the EU. The bike-sharing system and the *Nextbike* application are now featured with recognizable bikes and parking places (Figure 7).

Another application is *Bike Citizens*. It is a navigation tool and travel guide for over 450 European cities (Sexty, 2017). It is still in a trial phase in Banjaluka, and in the future it should be fully active. Its database is constantly updated,

Figure 7. Nextbike sharing system and print-screen with the map of Banjaluka
(Source: Authors, 2019)

offering the choices of longer or shorter routes, asphalt or pebble. This application is a very useful tool for navigating according to personal interest, offering the opportunity to select one of the possible combinations during a ride. Exploring the city is possible with voice control, which can be very useful while cycling. Application maps can be purchased or obtained for free if the user cycles for long enough each day. Like the *Nextbike* application, *Bike Citizens* also stimulates urban cycling in a positive sense (Figure 8), reducing traffic jams and improving ecological parameters.

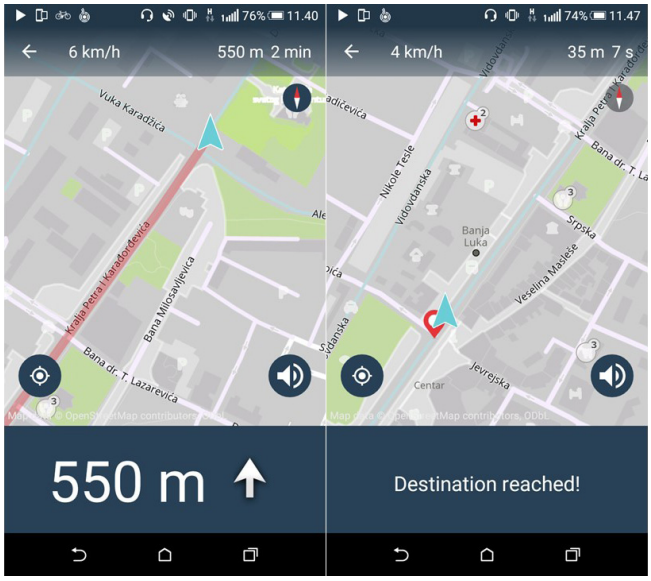

Figure 8. Bike Citizens screen with the map of Banjaluka
(Source: Authors, 2019)

Banjaluka is not an exception with regard to this practice of stimulating urban cycling. The presence of a public bicycle system with an accompanying application for rental (*Nextbike*) has led to an increased number of cyclists, their higher visibility and the construction of new parking lots and canopies. Building a digital network at the local level, based on these and similar IT platforms, is leading to positive processes, at least declaratively. Digital technology allows us to develop new bicycle transportation systems and Banjaluka is the owner of a third-generation bicycle rental system. However, its evolution into the fourth generation requires time and effort. The presence of GPS signals and mobile and wireless internet has enabled this transformation, as

well as a system of public-private partnership. Banjaluka still does not have a system for renting public bicycles of the fourth generation, but a new system and a new way of using bicycles as a mode of transport can affect the way infrastructure networks are formed and used in the future (Milaković and Stupar, 2019). Complementing the existing system of public bicycles with the fourth generation would certainly be a challenge for the city, but it would represent an additional incentive to reduce the intensity of motor traffic in urban areas and reduce pollution, as well as improve general wellbeing.

DISCUSSION

In order to increase the level of sustainability and the quality of life, Banjaluka needs more investments in cycling infrastructure. While keeping the focus on new tracks and lanes, the local administration should also deal with the existing elements of cycling infrastructure, maximizing the level of utilization by adding missing lines and hubs.

During the COVID-19 pandemic the importance of bicycle transport in Banjaluka and the communication through modern technological platforms have been emphasized. Many European cities have used this fact as an opportunity for changing their physical environment. For example, Paris is abolishing a half of its 140,000 parking spaces, creating new zones for pedestrians, cyclists and greenery (Forbes, 2020). The environmentally sustainable transformation is, therefore, a direction which should be followed at both the global and the local level, and Banjaluka has to find the best model to be applied in this challenging moment.

The existence of cycling infrastructure affects the use of bicycles as a means of transportation, and medium-sized cities should include a largely separate cycling infrastructure (Heinen *et al*., 2013). Consequently, Banjaluka should focus on the construction of bicycle roads as a separate infrastructure, in the form of bicycle paths. Paths have an advantage over bike lanes since they offer a higher level of safety, which is one of the main parameters when selecting a preferred form of transportation. In addition to the primary physical facilities of cycling infrastructure, which are undoubtedly paths and lanes for cyclists, the existence of parking facilities largely determines the number cyclists, and the manner of bicycle use. Some studies indicate that facilities at the micro level greatly influence the choice of the bicycle as a mode of transportation (Rybarczyk and Wu, 2014). If used as transport to the workplace, it is desirable that the bicycle parking is as close as possible to the goal, protected from theft and atmospheric influences. Furthermore, employers inclined to the green city concept should provide a suitable place for showering and changing in addition to the parking space. In short, by providing the necessary infrastructure and increasing its total share in the urban matrix, the number of cyclists and their total trips will be increased. To solve these and similar problems, political will and strict law enforcement are needed to ensure both the existence of a quality cycling infrastructure and its full functionality. Cyclists are looking for fluidity in the use of their resources, and these problems should be addressed without any delay.

At the level of digital infrastructure, these problems could be solved by reprogramming and removing ambiguities, but also by supplementing the content with the items requested by users. In a study carried out in Portugal, the authors found that users of digital cycling infrastructure are looking for GPS options, interactivity, a list of places of interest, route calculation etc. (Meireles and Ribeiro, 2020). Any improvement is a chance to increase the share of cyclists in urban transport, and thus a chance to achieve sustainability goals, which should be an absolute imperative for all stakeholders. Therefore, the introduction of a fourth-generation bicycle-sharing system is a challenge, which has also been recognized in Banjaluka. However, there are many questions regarding the mode in which it is planned, conducted, regulated and implemented. Certainly, the emergence of a dockless bicycle-sharing system in Banjaluka would help increase the total number of bike rides with a minimal investment, without a need to build fixed stations. With the existence of the third generation, the preconditions for the emergence of a hybrid bike-sharing system are already present. Complementing the existing network with new features toward a stationless system would be possible primarily at the digital level, but the duality of the cycling infrastructure would also be achieved. Namely, the new network would include new users, additionally motivate the use of bicycles and achieve the effect of putting additional pressure on decision makers. That would result in creating new bicycle paths, lanes, parking lots, canopies and other elements of physical infrastructure. An enriched network of bicycle resources leads to the enrichment of the general content in urban cycling, resulting in the popularization of bicycles. Given the limited infrastructure and the relatively small current number of potential users, the future of a dockless public bicycle system in Banjaluka could rely on the existing third generation, or it could be supplemented. Today, there are 5 user terminals with 36 bicycles (Grad Banjaluka, 2021) and over 1,100 subscribers from around 200,000 inhabitants, and this number is growing. According to the available data, the average number of daily rents during a working day is 60-70, most of them taking place between 7 and 8 AM, and 4 and 5 PM. Consequently, with the potential introduction of the dockless system in Banjaluka, around one percent of the existing bicycle rides would belong to the stationless system, and the total number of rides would increase. The conditions for the installation of the fourth generation are similar to the previous one. The existence of an internet connection on the territory of the entire city (with already widespread smartphones) already meets the basic technical and technological requirements. What is noticeable is the fact that bicycles from the rental system are often used at the time of departure to/return from work. In this way, workstations become secondary hubs, and the third-generation public bicycle system terminals become the primary hubs of the network. In the case of the fourth-generation public bicycle system, the notion of a secondary hub would become the notion of a primary hub, since a non-stationary bicycle is not bound by the position of the terminal. If the intention is to suggest an exact location for parking bicycles, it is feasible to install adequate and quality parking solutions in any targeted area. Some innovative solutions can be found in Novi Sad, where the realization of the initiative "*binacikl*" is in progress. Representing urban

furniture, it combines the function of parking for bicycles and a stage for performing and promoting cultural and artistic content (Promeni Srbiju, 2021).

The application of both systems would enrich and improve the bicycle infrastructure network at all levels, as well as public transport in general. Banjaluka still has to take a few steps toward this kind of change. One of them is the activation of new hubs, such as the Vrbas University Campus, which has a large number of potential bicycle users. The next step would be building new bike paths and lanes. After that, it is necessary to create a quality data system on the cycling infrastructure, through which it will be possible to obtain information about and within the network. Also, it is necessary to perform a partial or complete survey of public transport that includes the bicycle-sharing systems, with a special emphasis on mastering the "last mile" in using the dockless systems. The introduction of transporting bicycles inside buses should be also formally enabled, at least for folding ones, which would be a way of implementing intermodal travel. Funding of the public bicycle system and its supplement (dockless bicycles) would be enabled through sustainable transport subsidies, which would also be used to purchase all kinds of bicycles that can be used as a transportation vehicle. Furthermore, the construction of a bicycle parking space near important and busy facilities and institutions is conceptually extremely important. Whether it is a marked place, a canopy or even a bicycle garage, these facilities represent the starting and ending points of linear travel within a network (Figure 9). They also represent hubs from which network directions are further developed, offering users more connectivity within city matrices. It is possible to achieve the concept of duality of the bicycle infrastructure network by including these nodes into navigation applications, or into apps enabling the operation of public bicycle systems.

Figure 9. A canopy for bicycle parking, city center, Banjaluka (Source: Authors, 2021)

CONCLUSION

Cycling infrastructure nowadays exists on two levels – physical and digital (technological), together forming a network of a wider system in which a city operates. The need for a better, cleaner, more environmentally and energy-conscious city exists as an imperative, but its actual implementation often lags behind. The use of bicycles as a mode of transport promotes better connectivity between inhabitants, the urban environment and its *genius loci*. This symbiosis, if achieved, should provide greater wellbeing of local communities. Banjaluka should prepare and adopt documents such as the Sustainable Mobility Plan, already common in the cities of the European Union and some regional centers (e.g., Belgrade and Sarajevo). Through these plans, the position of the cycling infrastructure is strengthened, stimulating the movement of pedestrians and cyclists in the indicated directions, preferring the green areas of cities, without traffic jams. Also, through these documents, legal measures for the removal of advertising facilities, catering facilities (especially restaurant gardens, as in Banjaluka), and other obstacles from cycling routes could be implemented. These documents should also indicate the importance of certain systems (e.g., the park and ride system), providing the necessary elements. The example of Ljubljana, as one of the regional centers and role-models for Banjaluka, reveals many creative solutions which might be used (Ljubljanainfo, 2021). Unfortunately, cycling in Banjaluka is still under-appreciated, and even in winter, snow is often cleared onto cycling lanes, indicating a low level of general awareness.

Therefore, it is also necessary to change the collective consciousness, perception of the significance of cycling, and its sustainability, emphasizing the importance of cycling as a transport mode. Planning professionals certainly have their share of responsibility for the current situation, but the final direction of urban development depends on political and financial decisions, which are often delayed or unsynchronized with sustainable goals, and without an updated legislative framework.

Considering all these premisses, some recommendations for improving the cycling network and transport in Banjaluka could be created:

- The completion, rehabilitation and improvement of the existing physical parts of the network, primarily bicycle paths and lanes (e.g., Tsar Dušan Boulevard). It is necessary to make the existing infrastructure functional;
- The construction of new bicycle paths and lanes, with the technical characteristics modeled according to the successful examples from the European Union;
- Enabling and marking the movement of cyclists in both directions of one-way streets, especially in the center (e.g., Srpska Street, King Alfonso XIII Street etc.);
- The conversion of roads, whereby roads intended for motorized traffic will become areas reserved for pedestrians and cyclists; and
- The removal of physical disturbances from cycling infrastructure, such as improperly parked cars, or municipal waste dumpsters.

Regarding the setting of significant hubs in the network, it is necessary to act according to the following goals:

- The completion, rehabilitation and improvement of hubs within the network, places where certain bicycle routes intersect, whether they are intersections or

roundabouts;

- The construction of new bicycle parking lots, canopies and bicycle garages. The position of these facilities should follow the position of important institutions and facilities (e.g., schools, higher education and administrative institutions); and
- The establishment of a *park and ride* system, which implies the existence and use of public parking garages for cars. These systems are situated on the outskirts of the city, or at least on the outskirts of the city center, from where users continue to the city center by public transport, or by bicycle. These garages thus become hubs of paramount importance in a cycling network.

The digital level of the network should be improved by:

- The maintenance and improvement of existing digital services in Banjaluka used for bicycle transport;
- The initiation, development and implementation of new digital services, both for public bicycle systems and the users of private bicycles;
- Installing the necessary equipment on/in public transport vehicles to be used for bicycles, achieving intermodality; and
- The establishment of a functional and accessible database on physical cycling infrastructure, terrain characteristics, recommended routes, the characteristics of public bicycles etc.

The improvement of urban mobility in Banjaluka is an important task to be completed for its future development, but the upgrading of its cycling network and its physical and digital infrastructure is certainly an important element of its sustainability. Whether this aim is achieved or not depends on many factors, but the first step should be related to general environmental awareness, both at the level of governing structures and the local community.

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SIMULATION OF PEDESTRIAN ACCESSIBILITY TO ASSESS THE SPATIAL DISTRIBUTION OF URBAN AMENITIES

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A city can be perceived as a framework for the everyday activities of its residents, whose movements create complex network patterns as consequences of their individual decisions. Given that there are apparent differences in the use of urban amenities among residents of different ages, we examined the spatial distribution of urban amenities with regard to the preferences of various age groups and the pedestrian accessibility of amenities. In this paper, we propose an algorithm for detecting the most favorable combinations for the spatial distribution of urban amenities, in order to minimize the total walking distances and maximum frequencies of pedestrians of different age groups. The proposed method focuses on the parametric interpretation of various age groups, their preferences for urban amenities, the mutual proximity between residential and non-residential areas, and crowd intensity. Since residents act as agents whose individual decisions are not predictable, we used agent-based modeling to simulate pedestrian movement in order to optimize the spatial distribution of amenities. The digital environment, which allows the parameterization of different types of data, is used for simulation performance. The simulation outcome is quantitatively presented through two criteria of pedestrian accessibility, whose mutual relationship is used to detect the final, optimized combination for the spatial distribution of amenities. This approach can assist with a better understanding of pedestrian dynamics and support pedestrian-friendly choices in urban systems. Finally, the algorithm is applied to the case study of real space in a brownfield location.

***Key words*: urban simulation, agent-based modeling (ABM), accessibility, people's preferences, urban planning.**

INTRODUCTION

Urban populations are a part of the dynamics of urban systems, and as such, have been subject to analysis in many urban studies (Benenson, 1998; Bonabeau, 2002; Crooks *et al*., 2008; Evans and Kelley, 2004; Hatch and Dragicevic, 2018; Karbovskii *et al*., 2018; Ligtenberg *et al*., 2001). In this context, a city is considered to be the framework for its inhabitants' daily activities and the buildings hosting them, where individuals create complex network patterns of movement.

There are some differences in the way residents of different ages use urban amenities (Arnberger *et al*., 2017; Tao and Cheng, 2018). For example, it is known that children do not go to the bank alone, and that adults without children will not go to kindergarten or primary school except if they work there. In this paper, we simulate the way residents visit specific amenities and, in this way, suggest improvements for their spatial distribution. Consequently, we focused on different age groups and their preferences, since different amenities attract different age groups. The paper focuses on finding the most favorable spatial combination of amenities in terms of pedestrian accessibility based on the age structure of the population. Patterns of residents' movements are not predictable by simply aggregating a particular person's behavior. That is because one person affects the behavior of others and, in aggregate, changes the route of others, thus avoiding collisions, primarily when crowds are gathered. Agent-based modeling (ABM) is used to simulate such behavior.

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Agent-based modeling is a simulation modeling tool that has generated a great deal of interest in the past decade (Huang *et al*., 2014; Lawlor and McGirr, 2017). ABM allows one to simulate the individual actions of diverse agents, measuring the resulting behavior and outcomes over time. Initially, this technique was utilized to simulate urban dynamics on a micro-scale (Benenson, 1998). Despite its many benefits as a tool for simulating the micro-diversity of dynamic systems and their emergent properties, an agent-based model only began to emerge noticeably in social simulation and geographical information science after Epstein and Axtell (1996) pointed out the possibility of its applicability to growing entire artificial cities. Some of the first agent-based simulations developed to improve decision-making processes in urban planning were models like UrbanSim (Waddell *et al*., 2003) and PUMA (Ettema *et al*., 2007). These simulations are based on the notion that agents communicate through collaboration and competition determined by a set of rules. A collection of rules defines the interaction of agents both with the environment and with each other.

The paper aims to create an algorithm to detect the most favorable combination for the spatial distribution of urban amenities, in order to minimize the total walking distances and maximum frequencies of pedestrians. The emphasis in modeling agents and determining their behavior is placed on the demographic age structure, enabling various scenarios for more favorable combinations of amenities. This algorithmic method applies to smaller urban areas, like urban blocks, but is scalable to other metropolitan and regional planning contexts. The method proposed in this paper integrates Rhinoceros and Grasshopper, with PedSim as an add-on, which provides simplified pedestrian simulation to detect the most favorable spatial distribution of urban amenities. Furthermore, the availability of amenities in an urban environment (Ardeshiri *et al*., 2018; Beames *et al*., 2018; Lee and Hong, 2013; Yamu and Frankhauser, 2016) is studied in a new way by parameterizing the residents' age structure and crowd intensity within an agent-based model for spatial simulation.

METHOD

The algorithm proposed in this paper estimates favorable positions for possible applicable amenities on selected lots based on age group preferences and accessibility. The following sections describe how these criteria are defined and how different data sets are integrated.

Age groups preferences and lists of amenities

The age structure and preferences of the residents were treated as variable parameters and used to describe interactions within the model. Firstly, it was necessary to identify age groups that have similar preferences and their needs that can be satisfied in the local urban environment. Then each age group was assigned a list of amenities they like to visit. Finally, to obtain a quantitative assessment scheme, the set of preferences assigned to each age group, in terms of urban amenities that attract them, was translated into digital data. That was achieved by using a cross-reference mechanism, which lists every file name and line number where a given named identifier occurs within the program's source tree. In this way, all possible combinations of distributions of amenities are listed.

Lists of the amenities applied to selected lots were likewise made based on previous urban analysis. Finally, these two types of lists were subjected to check matching to create the conditions for simulations and further studies.

Accessibility

We hypothesized two main factors characterizing accessibility to urban amenities: walking distance from residential buildings and crowd intensity. Walking distances were calculated as the accumulated length of routes traveled by residents from their homes to the preferred facilities in the simulation. Pedestrians are predefined to choose the best route, avoiding collisions with obstacles and other people. Since people are social beings, there are other aspects that can affect accessibility, such as their interactions with each other and various attractions and activities along the way. However, they are randomized in this study because they are not the focus of the paper.

Furthermore, the retention time of virtual pedestrians near some obstacles or other actors is not predefined and is left to the random choice of the software. So defined, pedestrians can change the route on the spot depending on the surrounding events. As a result, different walking distance values were obtained, and it was not enough to calculate the shortest distances between the residential area and amenities.

We used the frequency of pedestrians to show the crowdedness in the spatial simulation of each distribution of amenities. An analysis grid covering the entire area analyzed was used to ascertain how many persons travel through each grid cell. In this paper, the frequency is represented by the maximum number of people who visit one cell. Accessibility, through walking distances and frequencies, were expressed numerically, and the results for different distributions of amenities were later compared with each other.

Used software

To integrate ABM in the CAD environment, which is commonly used in urban planning, we used an integration of Rhinoceros, which is computer-aided design software, and its algorithmic modeling plugin – Grasshopper. Thus, a two-dimensional geometric model, which includes displaying urban morphology determined by lots and roadway patterns that define pedestrian paths, could be generated in Rhinoceros itself or imported from any other software to provide the appropriate digital environment for further analyses.

Grasshopper was used for referencing all geometric elements from Rhinoceros required for further parametric analysis, for listing all possible combinations of amenities described in section Age groups preferences and lists of amenities, and for analysis after the simulations. Simulations were performed using PedSim, a Grasshopper plugin, which made it possible to run simplified pedestrian simulations. PedSim helped agents to find the shortest route, avoiding obstacles and other agents.

ALGORITHM

The proposed algorithm estimates favorable combinations of amenities that meet the needs of different residents regarding their set of preferences and accessibility concepts expressed by reduced total walking distances and reduced maximum frequency.

Input data

The input geometry data included a 2D cadastral plan with the following elements: geometric characteristics of the residential area, lots within the non-residential area for the possible assignment of new urban amenities, roadway, parking lots, and the surrounding lots. The surrounding lots included those under previous protection, and those without permission or intention for a change of purpose. These elements were primarily defined by the shape and size of their outlines, created in CAD software, and then imported into Rhinoceros to provide the digital environment for further parametric and spatial analysis.

Input reference geometry is the identification of all relevant elements from Rhinoceros in Grasshopper. That means that all geometric data used the parameters of polyline curves, in order to be appropriately used in Grasshopper, where the parts were sorted based on previous urban analyses. Residential and non-residential lots were additionally determined by the positions of entrances to the lots. They were represented by points imported, based on the actual situation in the case study or which could be assumed for new active uses. They are the starting points for later agent-based analyses.

The surrounding lots impact the residents' movement because they represent obstacles in their path along with all the other geometric elements. In that way, the surrounding lots greatly influence the length of the walking path, thus the algorithm's ultimate result.

Specific locations within the non-residential area were marked as targets for residents' movements, and they were assigned lists of possible amenities. To determine the most favorable combination of amenities for selected non-residential lots, with regard to the level of crowdedness and walking distances for residents from the urban area, a list of potential amenities for every selected lot was created, and the preferences of different residents' groups were determined. As discussed earlier, the lists of preferable amenities presented by appropriate reference text in Grasshopper were used to make all possible combinations. Thus, they correspond to possible combinations of amenity distribution, which will be examined in further agent-based analyses.

Topographic features can significantly affect walking distances. However, simplified walking simulators adapted for use by urban planners were designed to work in a 2D environment, which means that the slopes of the walking paths could not be taken into account. For this reason, we proposed a way to introduce terrain parameters as a simple topographic configuration. First, the slope coefficient values on the slope sections of the terrain had to be provided. Then, after getting traces of travel of all agents in the simulation, we calculated the lengths of lines in the slope sections using the Trim with Region component. The actual measurements of these lines on the slope were obtained by multiplying these values by the corresponding slope coefficients. This made it possible to calculate the walking distances at the site with the slope terrain. This method can be used for more minor complex terrain configurations.

Agent-based analyses

Considering that the needs of residents drive the demand for new amenities, in this algorithm, we used a set of agents' preferences to describe their behavior and interaction within the model. The agents are represented by four age groups: children (aged 0-14 years), youth (aged 15 to 29 years), middle-aged (30 to 64 years old), and senior residents (aged 65 years or over).

The agent groups were featured with their behavior patterns as the four most dominant groups of individuals to inhabit the urban area. The groups were divided based on statistics related to the population structure of people in the EU (Eurostat, 2017). The algorithm allows the percentage share for every group of residents selected to be applicable for disparate study areas. As indicated previously, each non-residential lot was described with a list of potential amenities, while the set of preferences was attributed to each group of residents, namely, agents. Agents in this model have the primary goal of satisfying their needs as fast as possible, that is to say, that the walking distance between their dwellings and their preferred amenities should be as short as possible. Social interactions and their duration in this study were left to random software selection because they cannot be predetermined.

On the other hand, it was necessary to consider crowds, and the frequency also had to be reduced. For these reasons, PedSim, the Grasshopper plugin, was introduced. It enables real-time simulation of pedestrian movement. In PedSim, agents move from the starting point to the destination point, following the best route, avoiding obstacles and collisions with other agents.

Using the specific type of amenity primarily depends on the individual behavior of the users, Still, it is generally agreed that ensuring good access, for example, to green spaces, can generate certain benefits for specific social groups such as children (Arnberger *et al*., 2017; La Rosaa *et al*., 2018). In most cases, when they are not at school, children mainly require easily accessible spaces with a good number of features, such as playgrounds, leisure areas, basketball courts, swimming areas, food and drink facilities, and services. On the other hand, older adults have different preferences for the social and physical aspects of urban spaces compared to other social groups, as they tend to prefer calm areas with relaxing activities (Loukaitou-Sideris *et al*., 2016). Based on this general information, it can be assumed which type of amenities will be preferred by each of the four age groups. It is important to note that our goal was not to segregate users by age groups but to introduce an additional indicator to determine preferences that often overlap.

Once the lists of potential amenities were attributed to every selected lot, the algorithm calculated all possible

combinations of amenities distribution. Then one combination was chosen and applied as an environment for agent-based simulation.

On the other hand, every group of agents was provided with a set of amenities according to their preferences. After choosing a combination for the lots, agents located their preferred amenities and automatically followed the shortest route to the lots with corresponding amenities. The agents' decision-making process for choosing a facility and avoiding collisions is based on the multiple force model: target force, person repulsion, obstacle repulsion, and anticipatory collision avoidance force (McNeel Europe, 2019). Agents traveled from the starting point to their target without returning. The process ended when all combinations were analyzed.

The ability of agents to make choices based on some decision rules, such as matching demand for and the possibility of applying amenities, finding the shortest route, and avoiding collisions in the proposed model, brings agent-based models closer to human reasoning.

The conceptual flow of data between different software plugins within the proposed algorithm is presented in Figure 1.

Detecting favorable solutions

The shortest walking distance for each combination of the spatial distribution of amenities was calculated as the sum of the lengths of traces obtained for every agent individually. At the same time, the highest number of individual visits per grid cell was adopted as a relevant crowd indicator. Both of these outputs were expressed numerically, and the relationships between the variables displayed graphically. The most favorable combination is the optimum between the total distances and maximum frequency. It was calculated as the shortest Euclidian distance in which one coordinate is the normalized total distance, and the other is the normalized maximum frequency. When favorable values of frequency and the shortest distance are determined, the combination of amenities, which corresponds to the specified results, is detected as well. In this way, the most favorable variety of amenities applied in a specific urban area was discovered, aiming to satisfy residents' lists of preferences and the concept of accessibility.

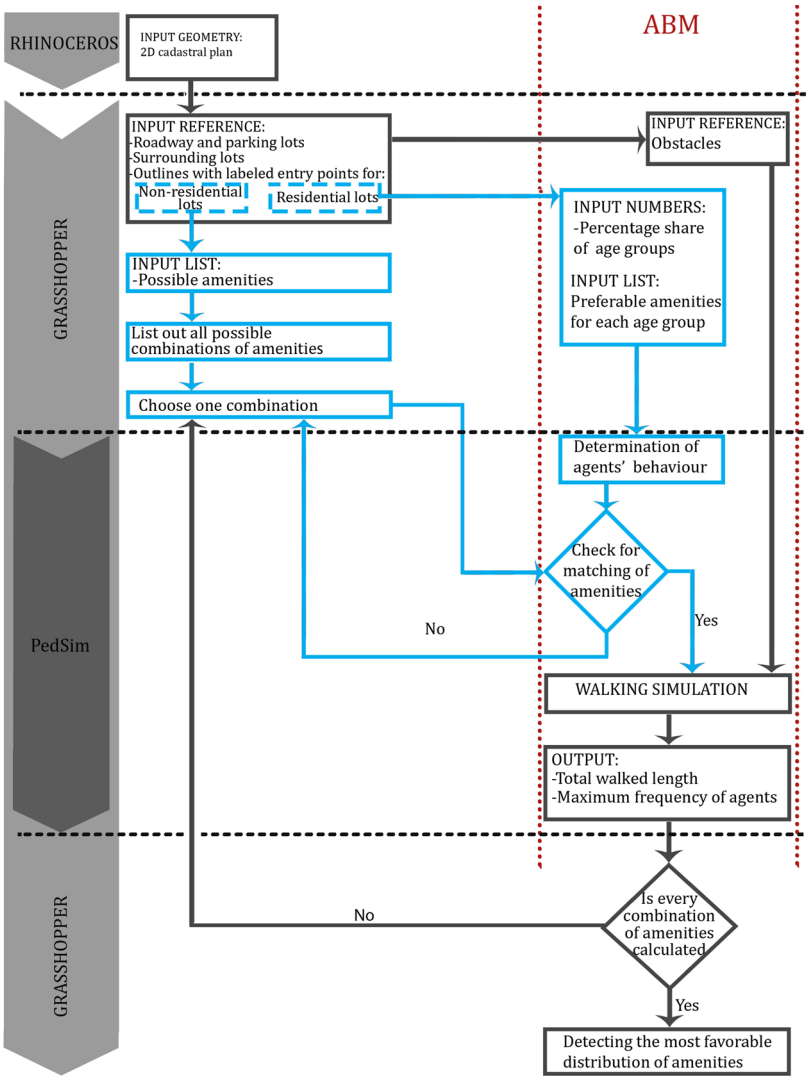

Figure 1. Flowchart of data between different plug-ins within the software (Source: Authors, 2020)

RESULTS

Implementation of the algorithm

The algorithm presented here can be used, for example, for spaces located in an urban setting, in which the future land reuse is the subject of negotiations and planning. In that context, to test this agent-based algorithm, it was applied to the case study of Novi Sad, Serbia. We chose a brownfield site in the working zone in the west part of the city, which is well connected. The area is located near housing and accompanying urban programs (Figure 2). Within the chosen zone, there are complexes that are marked as areas of urban renewal, as well as sites that have been recently built and are well used. According to the detailed regulation plan of this part of Novi Sad (Službeni list Grada Novog Sada, 2006; Službeni list Grada Novog Sada, 2009), existing buildings in complexes that are planned for renewal can be reconstructed or upgraded.

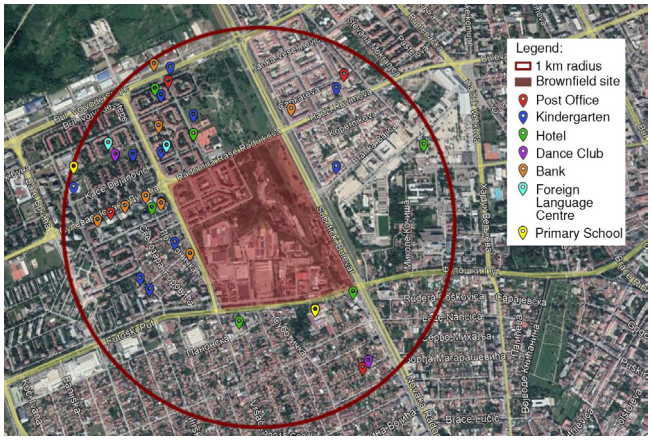

Figure 2. Area analyzed in the working zone in the west part of the City of Novi Sad within a 1km radius and locations of existing amenities (Source: Authors, 2020)

However, three buildings are under previous protection as valuable buildings in terms of the history of technical culture. The plan requires their complete physical preservation, and they must have a purely cultural purpose. Therefore, there is more flexibility in planning uses for other lots. After analyzing the amenities in the surrounding area, it was concluded that the whole region suffers from a lack of cultural programs, such as theatres, cinemas, galleries, and cultural and media centers. Accordingly, we made a list of possible amenities for each selected lot for the purposes of this research at the experimental level, taking into account the condition of the existing programs. For a more precise application of the algorithm, potential amenities in future research can be obtained based on market data and conducting a survey of residents in the area.

Afterward, the preferences of each agent group were defined by following lists of possible amenities. For the purposes of this testing, we involved only the agents from existing dwellings within the marked border of the site. According to data from the Office of Economic Development for the year 2010, the City of Novi Sad has the following age structure of the population: 14.28% children, 25.95% youth, 45.56% middle-aged, and 14.21% senior people (Profil zajednice Grada Novog Sada, 2011). Therefore, we used this information for establishing the percentage share of agent groups in the algorithm.

There are six lots at the location for which we made lists of possible amenities. Figure 3 shows the physical structure of the area studied. Lots with uses strictly defined by the plan were not considered because there was no space for significant variations in their functions. However, their programs were considered when we examined proposals for lots that are subject to change. The existing residential area was used for the spatial distribution of agents. Their boundaries were also marked as obstacles in the algorithm, along with the boundaries of other current amenities, communal facilities, green areas, and complexes planned to be kept. This is because obstacles are necessary input data to run the simulator. We also provided planned residential areas with agents to obtain possible future scenarios for using the urban space. Table 1 shows the input parameters we defined for this case study.

Figure 3. Spatial distribution of lots on the study site with marked entrances (Source: Authors, 2020)

Simulation results

The algorithm was applied for the study area, and 144 combinations were obtained for the spatial distribution of amenities based on age group preferences. Since 19 of them did not match the distribution of applicable amenities, 122 iterations were performed.

The percentage share of agents for all four groups was constant throughout the whole simulation. These percentages were determined based on data on the age structure of Novi Sad, as explained in the previous section. The settings for PedSim, such as body generation time of agents and probability, were set to default values during each iteration. Still, the target force (TF) and radius (R) of pedestrians varied according to the groups. For example, children were assigned a smaller body radius (R= 0.25m) than other groups (R=0.35m). At the same time, the target force was more robust for youth and middle-aged residents (TF=50) because they move faster than children and senior residents (TF=30).

Each iteration was performed for the same number of agents (500). The simulation resulted in a list of values for the total walking distances and maximum frequencies for each spatial distribution of amenities, which represent two evaluation criteria. The most favorable spatial distribution of amenities can be detected by taking into account both requirements.

Table 1. The input parameters: list of amenities for each lot analyzed and the preferred amenities (+) for every age group of agents

LOTS	APPLICABLE AMENITIES	CHILDREN	YOUTH	MIDDLE-AGED RESIDENTS	SENIOR RESIDENTS
Lot 1	Post Office	-	+	+	+
	Dance Club	+	+	+	-
	Wellness & Spa	-	+	+	-
Lot 2	Gallery	-	+	+	+
	Media Center	+	+	-	-
Lot 3	Foreign Language Center	+	+	-	-
	Cinema	+	+	+	+
Lot 4	Outdoor gym	-	+	+	-
	Chess court	-	-	-	+
	Playground	+	-	-	-
Lot 5	Kindergarten	+	-	-	-
	Park with coffee shops	+	+	+	+
Lot 6	Bank	-	+	+	+
	Restaurant	-	+	+	-

The case study in this paper was performed for flat terrain. Figure 4 shows how the lengths of the footpaths can be obtained in the case of a simple dynamic landscape configuration. After receiving the total length of the lines (d_{total}) in the selected area, it was necessary to multiply them by the slope coefficient to obtain the length of the slope.

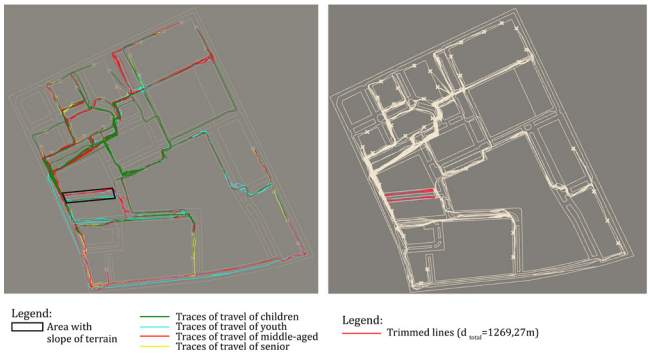

Figure 4. Graphic representation of agent routes throughout the area (left) and representation of trace length determination in the area with sloping terrain (right)
(Source: Authors, 2020)

The final result obtained by the simulation is an iteration with the following combination of the spatial distribution of amenities: lot 1 – wellness & spa, lot 2 – media center, lot 3 – cinema, lot 4 – chess court, lot 5 – park with coffee shops and lot 6 – restaurant. The agents' frequency heatmap for this combination of the spatial distribution of amenities is shown in Figure 5.

Figure 5. Agents' frequency heatmap for the resulting combination of the spatial distribution of amenities
(Source: Authors, 2020)

Figure 6 shows the values of the maximum frequency and total walking distance for combinations of the spatial distribution of amenities resulting from the simulation. These values were analyzed to show the most favorable combination. The iteration with a total walking distance of 150.055m and a maximum frequency of 14 agents per cell was chosen as the optimal solution since it had the shortest Euclidean distance. The combination of the spatial distribution of amenities corresponding to this iteration is presented above as the final result.

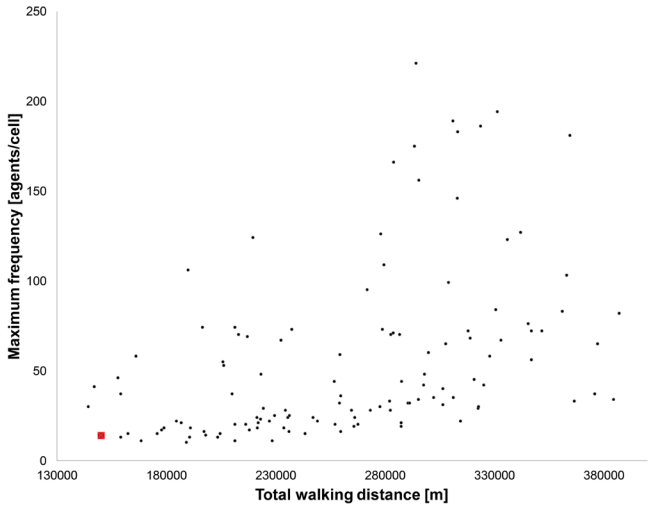

Figure 6. Total walking distances and maximum frequencies of all simulated iterations. The favorable solution is marked as a red square.
(Source: Authors, 2020)

For the model simulation, we manipulated the input data for the agent groups in the zones of the planned residential area, providing different scenarios. We used extreme values for the percentage share of the agent groups for the future residential area to show a clear difference between the outcomes. Here, by assigning a percentage share of the agent groups that differs from the percentage share in the existing residential area, the algorithm gave different combinations, as explained below.

Table 2 shows the results of four different scenarios by setting one of the agent groups as dominant in the future residential area. In contrast, for the existing residential area earlier determined, the age structure characteristics for the city of Novi Sad were used. As a result, the percentage share of age groups varied, while the other input data were the same in each scenario. The first scenario shows the simulation result when the number of senior residents is prevalent in the future residential area. In contrast, the accent is put on middle-aged residents, youth, and children in the remaining scenarios. The algorithm for each scenario calculated the total walking distance for agents to their preferable amenities and the frequency of those walks. As a result, we obtained four favorable combinations of spatial distributions of urban contents for the locations with regard to both of these criteria. These different outcomes point out the importance of the age groups' participation in the spatial distribution of urban amenities, which is in the domain of potentially providing increased accessibility and walkability in the study area.

Table 2. Results for different scenarios of the simulations with a variation in the percentage share of the agents' groups in the future residential area

SCENARIO	AGE STRUCTURE IN FUTURE RESIDENTIAL AREA	ALGORITHM RESULT	DISTRIBUTION OF AMENITIES
1	90% senior residents	Combination No. 50	1. Dance Club
			2. Gallery
			3. Foreign Language Center
			4. Chess court
			5. Park with coffee shops
			6. Bank
2	90% middle-aged residents	Combination No. 126	1. Wellness & Spa
			2. Media Center
			3. Foreign Language Center
			4. Chess court
			5. Park with coffee shops
			6. Restaurant
3	90% youth	Combination No. 84	1. Wellness & Spa
			2. Media Center
			3. Cinema
			4. Outdoor gym
			5. Kindergarten
			6. Restaurant
4	90% children	Combination No. 68	1. Dance Club
			2. Gallery
			3. Cinema
			4. Playground
			5. Park with coffee shops
			6. Bank

DISCUSSION

Accessibility is 'one of those common terms that everyone uses until faced with the problem of defining and measuring it' (Gould, 1969, p. 64). The history of accessibility research can be typically presented as the history of the development of particular measures such as topological features, population potential, or space-time (Weber, 2006). The main accessibility measures can be grouped into two categories: location models and space-time (ST) measures. Location models have long been used and are still the most popular method used in accessibility assessment (Kwan, 1998; Kwan *et al*., 2003). Space-time (ST) measures were proposed to overcome the limitations of location models, such as restrictions resulting from their assumptions about origins and destinations (Kwan *et al*., 2003; Pirie, 1979) and the lack of consideration for space-time constraints and temporal variations (Kwan *et al*., 2003; Pirie, 1979). Neutens *et al*. (2010) expanded Kwan's (1998) comparative research, showing that there is a distinction between the results of assessing accessibility using space-time measures and those using geographic measures. The authors further found a substantial distinction between the results obtained using different ST measures (Neutens *et al*., 2010).

In recent years, significant advances have been made in measuring and calibrating indicators, taking advantage of new data sources, and the development of web platforms and GIS algorithms with regard to different transport modes and variations throughout the day (Geurs and Östh, 2016). However, although these new measures have transcended location models that are limited to measuring travel distance and time, it is generally destination-based geographic indicators that use GIS-based analyses and hardly consider the different preferences of local communities.

Zondag and Pieters (2005) claimed that the use of public facilities cannot be isolated from perceived accessibility, emphasizing that each individual or household has their own perception of access to urban facilities such as parks. Subjective measures are important because the tendency or willingness to act or avoid action is the result of a collective assessment according to the attributes of the object, based on prior knowledge or information (Back and Parks, 2003).

So far, complete knowledge about perceived accessibility – a notion that represents the subjective nature of the accessibility concept – is lacking. For example, when it comes to the use of parks, Byrne *et al*. (2009) found that easier access was a key reason for people's decision to use local parks, rather than large national parks. Therefore, there is a need to develop a more complete understanding of accessibility from an individual perceptual level. How the physical or non-physical construction of accessibility can affect people's perception of accessibility and ultimately their behavior should be explored. Such efforts will significantly contribute to the development of a meaningful accessibility index that can represent the subjective nature of accessibility, which is essential for facilitating decision-making in planning in order to improve the quality of urban life.

Given that previous studies have shown low agreement between perceived and geographic accessibility measures (Gebel *et al*., 2011), this paper is a step forward in bridging the gap between them. Unlike recent studies (Tiznado-Aitken *et al*., 2021) that have used a level of service (LOS) in an attempt to overcome this problem, and considered accessibility on a larger urban and regional scale as well as public transportation, this study is oriented towards pedestrian traffic and smaller urban areas, with a focus on the behavior of residents. This paper has taken a step towards a more sophisticated approach to overcoming the problem of discrepancies between perceived and objectively assessed accessibility attributes.

The use of ABM in this study stems from the understanding that human decision-making plays a major role in the process of spatial change and must be an essential part of the framework of the proposed model. There are several studies that have applied the ABM paradigm to the field of urbanism, within which two directions of research can be identified (Benenson, 1998; Ligtenberg *et al*., 2001). The first focuses on the so-called bottom-up process in which agents are perceived as individuals who choose locations according to their individual preferences. This direction is most often applied to the dynamics of land use. The second line of research attempts to understand the conflict of interest between the various actors involved in the planning process. Here, land use is seen as a mixture of bottom-up and top-down processes in which rules and conflicts define the end result. In this research, we focused on the first direction, the bottom-up approach, in order to understand and improve the concept of accessibility in terms of user preferences. In the algorithm, the accessibility of urban amenities is shown through abstract implementations of agent activities that aim at a more generalized framework of human spatial behavior, but still derive from the typical behaviors of different age groups.

Although the algorithm was applied to a hypothetical environment and therefore could not be fully validated against real-world data, it was nevertheless tested and found to work consistently and provide appropriate outputs consistent with expected results and inputs. The subjective nature of accessibility remains an open discussion: while most authors support that it can be measured on physical grounds, such as distance and travel time, which are universal references, our research findings suggest the need to consider human preferences for decisions on the use of space.

CONCLUSION

The approach presented in this paper shows that ABM simulations can increase pedestrian accessibility for different age groups, by optimizing the spatial disposition of urban amenities. Clarifying the concept of accessibility is an essential prerequisite for any assessment to support sustainable and citizen-friendly planning choices in the urban environment. Spatial simulations can provide informative assistance for urban planners and policy analysts for the purpose of evaluating the consequences of specific planning strategies.

Therefore, this paper proposes an algorithm that can give practical recommendations in terms of accessibility. It helps to minimize the walking distances and maximum frequencies in an urban environment regarding the spatial distribution of urban amenities. Furthermore, the algorithm presented in this article can be considered as a tool, which can give us new empirical insights on the possibilities for the influence of civil society, and thus increase the consciousness of negative and positive side effects of market-oriented planning practices. This could provide academics and policy-makers with new insights that could contribute towards strengthening public interest and civil society in urban planning.

The model presented in this paper is still at an early stage of development, and it aims to present a generalized formalization of human movement in public space. A conscious effort has been made to simplify the model's elements. This is primarily because Rhino and Grasshopper are mostly static computer-aided design programs, and as such have inherent limitations. Multi-agent motion simulations can drastically slow down iterations and thus limit the total amount of agents visualized, thereby reducing the overall realism. In addition, the system so far does not allow the grouping of family and friends. Clustering residents based on their age is one option that proved to be justified, since it showed different results in this research. There are other attributes not considered in this work, such as clustering based on gender, education, income, or other criteria, as well as introducing employees or visitors, which will be considered in further research. On the other hand, the pedestrian traffic taken into account in the simulation may differ from the actual situation due to the interference resulting from other kinds of traffic-related factors (e.g., traffic lights, car traffic).

Further research is needed to identify additional spatial behaviors and extend existing types of activities, in order to extend the scope of the model to other spatial configurations and environments. Much remains to be discovered about the more subtle aspects of behavior that influence user decision-making when choosing urban contents. The availability of very detailed data on the daily routines of households, such as a detailed panel survey of daily activities, could greatly improve our understanding of for example the complex phenomenon of accessibility to urban facilities. The possibility of using parameterization data from other areas which are not directly linked to urban planning, in this case socio-behavioral elements, provides the potential for the further interdisciplinary development of this approach. We also intend to develop additional algorithmic structures that will deal with multiple lots and amenities and more complex terrain configurations in future research.

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MULTICULTURAL NEEDS AND THE PERCEPTION OF CENTRAL PUBLIC SPACES IN MAJOR LITHUANIAN CITIES

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The paper presents an analysis of the needs and perception of different ethnic groups with regard to public spaces in the central areas of major Lithuanian cities, and an evaluation of the possibilities for implementing solutions to them, in order to highlight the needs within the spatial structures. Three research methods were chosen to determine the importance of the needs of different cultures when creating public spaces. The first is a sociological survey of the opinion of different ethnic groups based on three main models of environmental psychology: the natural, physical and the social and behavioural environments. The second is a stimulatory-comparative sociological survey of the opinion of different ethnic groups, and the third is the expert assessment of the level of attractiveness of existing public spaces in major Lithuanian cities based on Nikos Salingaros' parameters according to a classification of visual information into morphological/structural and harmony-related evaluation parameters, which were evaluated by respondents and by observations in situ. The main findings of the research showed the importance of the needs of different cultures in public space, and the principle of harmony between human beings and the environment was highlighted in the main morphological and harmony-related features of public spaces, such as spaciousness, small architectural elements, dominant objects/buildings and the abundance of trees/greenery.

***Key words*: multiculturalism, ethnic diversity, cultural integration, different needs, public spaces.**

INTRODUCTION

Human and public space is an inseparable part of urban and place identity (Bernardo and Palma-Oliveira, 2016). It is a synthesis of physical and tangible environmental features (objective assessment) with human psychological and emotional characteristics (subjective assessment) (Povilaitienė and Kamičaitytė-Virbašienė, 2015). A person in a certain space is surrounded by many factors that are classified into three main models of environmental psychology: the natural, physical, and the social and behavioural environments (Lesan, 2015). These models of environmental psychology form feelings consisting of the sensual and emotional needs of a human in a public space. Public space contributes to a city's social well-being because it is open to society as a whole, regardless of gender, race, religion or age, so it is important to identify the needs of different cultures that can help promote cultural integration by strengthening social ties between different nations.

In a multicultural society, public space can become a tool for connecting different cultures, and the diverse social composition of the local population is an essential ingredient in the creation of a public environment (Lesan, 2015). The formation of different ethnic communities and the social mixing of different people in public spaces undoubtedly manifest themselves in different semantic, aesthetic and functional codes, creating a sense of community in a given area, with a new meaningful expression of place – "home, away from home". It is possible to create a comforting environment for those far away from home who share the same culture, language, nationality or attitude, and a successful model of public space helps to adapt to a multicultural city's cultural whole, providing an opportunity to participate in community activities (Amin, 2008).

Today, architects belonging to one cultural environment are able to create in another cultural environment, making cultural literacy in environmental design especially

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important. Modern multicultural cities need public spaces that are acceptable and comfortable for a diverse population, and it is very important to foster a sense of attachment and topophilia, resulting in questions about which environmental models are acceptable to people of different cultures. This includes both the search for unique aesthetics and the need for cultural literacy (Kamičaitytė *et al*., 2019).

It is also important to understand how different cultures and ethnic groups value and use urban public spaces, and what their attitude is towards the spaces. Different motives for behaviour and participation in public space, depending on the ethnic group, have unique and different cultural characteristics, inherited by individuals from generation to generation over time (Peters, 2011). People of different nations have different habits in public spaces with regard to how they spend their leisure time. Some prefer to spend their time more passively, resulting in a greater need for recreational areas and a social, community-promoting atmosphere, while others feel the need for active leisure that depends on vibrant, physically adapted public spaces.

Taking into account these aspects, the aims of the research are to determine the needs of different ethnic groups in relation to public spaces in the central areas of major Lithuanian cities, to analyse the perception and evaluation of their spatial characteristics, and to present possibilities for implementing solutions to them in order to highlight the needs in the spatial structure.

METHODOLOGY

After processing the latest statistical data on the distribution of national minorities in Lithuania and the major cities of Vilnius, Kaunas and Klaipėda (from the 2011 census, conducted every ten years), the dominant ethnic groups and their distribution in precincts and in each of the city regions or elderships, was highlighted (Figure 1).

The analysis of the ethnic composition of Lithuanian precincts showed that the major Lithuanian cities (Vilnius, Kaunas, Klaipėda) have the largest populations of different cultures – there are from 7,000 to 197,000 foreigners in the counties where these cities are situated, therefore they were selected for further research. The dominant national minorities are the Polish, Russian, Belarusian, and Ukrainian, because of which the choice of respondents to the survey was mainly based on these ethnic groups.

The spatial parameters of public spaces (squares, parks) in the central districts of Vilnius, Kaunas and Klaipėda, and the opinions of respondents from different ethnic groups about these spaces were analyzed and evaluated.

Three methods were chosen for the research: a sociological survey of different ethnic groups, a stimulatory-comparative sociological survey of different ethnic groups and expert assessment regarding the level of attractiveness of existing public spaces in major Lithuanian cities, based on Salingaros' evaluation parameters.

The aim of the first sociological survey was to find out the needs of people from different ethnic groups with regard to public space and to evaluate possibilities for implementing solutions to it in order to highlight the needs in the spatial structure. This was carried out by analysing the public space analogues of multicultural cities on a global scale, based on the principles of theoretical models of environmental psychology (natural, physical, social and behavioural environments). An anonymous sociological questionnaire with a total of 27 questions was compiled according to environmental psychology models: 10 questions related to demographic characteristics and the use of public space; 5 questions about the environmental impact on public space; 5 questions about the importance of physical aspects in relation to public space; and 7 questions about the social and behavioural opportunities gained in public space. Representatives of the above-mentioned Polish, Russian, Belarusian and Ukrainian ethnic groups from major Lithuanian cities (Vilnius, Kaunas, Klaipėda) were invited to participate. The respondents were classified into three main groups according to age, belonging to a particular national minority, and the city in which they live.

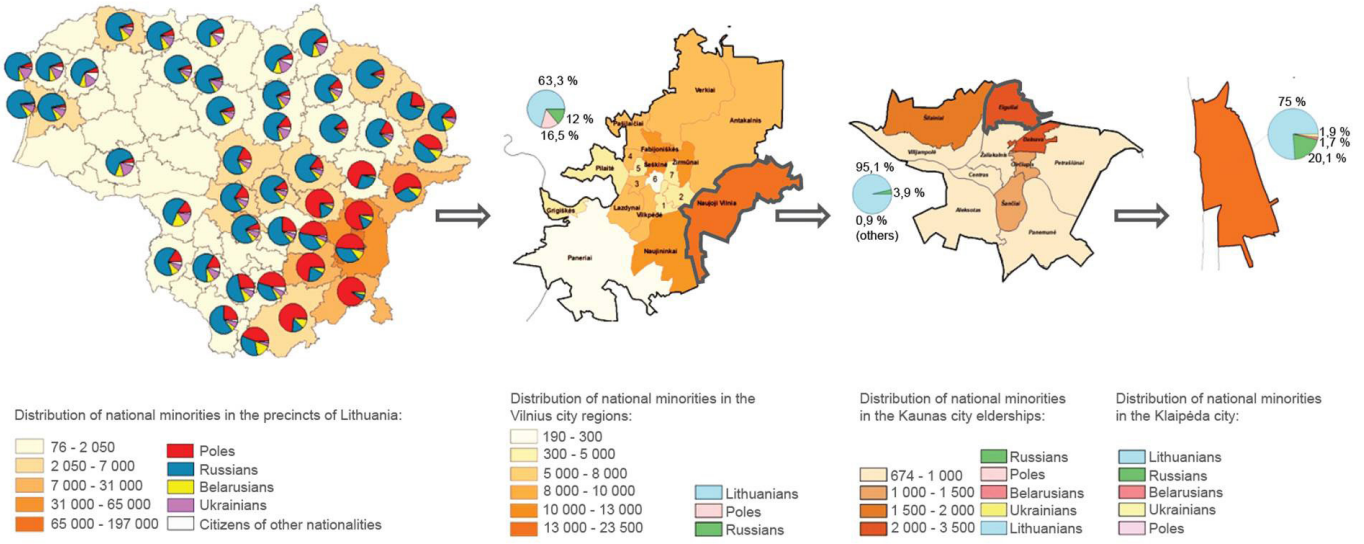

Figure 1. Scheme of distribution of national minorities.
(Source: Authors)

The aim of the stimulatory-comparative sociological survey was to determine the level of attractiveness of typologically similar existing public spaces in three major Lithuanian cities (Vilnius, Kaunas and Klaipėda). The same ethnic groups were invited to participate as in the first sociological survey. To prepare for the survey, the photo-fixation of selected public spaces was performed, according to the seasonality and weather. A photo collage was prepared for the evaluation of each public space, and the same evaluation questions were asked: to evaluate the attractiveness of the public space using a scale from 1 to 10; and to indicate the features that determine the attractiveness of the space. After the evaluation of all public spaces from the same typological group, a stimulating-comparative question was asked about which public city space was the most acceptable for them.

The third research method of determining the level of attractiveness of typologically similar, existing public spaces in major Lithuanian cities according to Salingaros was based on the expert evaluation in situ of each selected public space in Vilnius, Kaunas and Klaipėda.

The spectrum of human vision is particularly wide, but the processing of visual information is quite complex – divided into organized and unorganized complexity (Maddox, 1990). For example, an entity with a minimum physical complexity might provide a high level of visual complexity. The sum of the sub-components of an object can perform one outcome, but the inner relations of the components might lead to more complex organization (Klinger and Salingaros, 2000). Therefore, in order to determine the structural organization of different public space types in major Lithuanian cities, Salingaros' research method was chosen since it helps to process visual information by classifying it into morphological/structural and harmony-related evaluation parameters. The assessment parameters were divided according to the most important perceptible properties of expression and the sense of environment: size/ spaciousness, shape/design elements, composition, fulfilment, design features, connection with the environment, perception/correlation of functions, direct/physical contact, compatibility of objects/elements, and emotion.

The results of the expert evaluation of each typological group were compared with the evaluations of people from different ethnic groups.

We have chosen the following research objects:

- The opinions, role and behaviour of people from different ethnic groups in relation to the environment;
- Typologically similar public spaces in Vilnius, Kaunas, and Klaipėda: central historical squares in the cities (Vilnius, Kaunas, Klaipėda Town Hall Squares):
  a) squares important for statehood (Vilnius Lukiškės, Kaunas Unity, Klaipėda Revival Squares);
  b) recreational squares in the central parts of the cities (Vilnius Cathedral, Kaunas Independence, Klaipeda Theater Square); and
  c) parks (Vilnius Bernardines Garden, Kaunas Santaka Park, Kaunas Peace Park, Klaipėda Danė Embankment).

This was a pilot study, and so the survey results could be more representative if a larger number of respondents from each ethnic group were asked to participate, and if the reliability of the survey results were assessed, i.e., how much respondents' demographic and socio-cultural characteristics reflect the general population, and so on. The expert evaluation of public places in situ would also be more representative if a larger number of experts had participated in the research and the results of their evaluation summarized.

For the reasons of methodological origin listed above, this study should be considered as a pilot study, and the methodology is more important than the research results themselves.

RESULTS

In total 73 people participated in the anonymous questionnaire, with a very similar number of men and women: 51% of women (n=37) and 49% of men (n= 36). The average age of respondents was 43 years. Most respondents were members of the major ethnic groups in Lithuania: 17.8% of those who participated in the sociological survey were Russians (n=13), there were an equal number of Poles, Belarusians, Ukrainians and Jews 11% (n=8) and 8.2% did not indicate their nationality (n=6). Also, there were some single respondents from other nationalities: Roma (n=2), Latvians (n=2), Georgians (n=2), Armenians (n=4), Indians (n=3), Turks (n=1), Czechs (n=1), Pakistanis (n=3), Swedes (n=1), Italians (n=2), Brazilians (n=1). The most active respondents were from Vilnius (47%, n=34) and Kaunas (44%, n=32), and Klaipėda residents accounted for only 8% (n=6).

The current situation with regard to ethnic integration in the public spaces of Lithuanian major cities

Lithuania is in a complex situation in terms of the integration of ethnic groups, which is primarily affected by the historical stereotypes formed after World War II: the Jewish Holocaust, the conflict with neighbouring Poland – the occupation of the Vilnius region, the attitude towards the Russians as occupiers because of the Soviet regime, and the negative attitude towards the Roma minority. These stereotypes make the historical heritage of ethnic communities quite controversial.

Analysis of the relationship between people from different cultures, showed that passive segregation is felt on both sides – from the state and from the ethnic groups themselves, and there is no dialogue. Many ethnic groups are historically formed and already have certain well-established cultural and architectural spaces in which they carry out various activities. Looking at the major Lithuanian cities (Vilnius, Kaunas and Klaipėda), we can mostly see the sacral heritage, which shows that society consists of the legacy of certain ethnic groups, making it easy to read their history. However, there is another important aspect – how many of such spaces are recognizable to us.

For the majority of the Lithuanian population, including many foreigners living there, the main urban public spaces and parks created for historical or recreational purposes,

where most of their daily leisure time is spent, are very important. The results of the anonymous sociological survey showed that all the 13 public spaces analysed were attended by at least one citizen who participated in the survey. Also, all respondents had visited at least one of the listed public spaces. Most of the respondents had visited Vilnius Town Hall Square (97%, n=32), Vilnius Cathedral Square (91%, n=30), Kaunas Town Hall Square (88%, n=29), Vilnius Lukiškės Square (82%, n=27) or Vilnius Bernardines Garden (79%, n=26). These results show that public spaces in major Lithuanian cities can be conducive to multiculturalism and are able to foster the integration of citizens from different cultures.

The needs of different ethnic groups for public spaces and examples of their spatial expression

Three analogues of public spaces were chosen to reflect a different idea of multicultural representation: integration of the landscape representing different cultural regions in the creation of a cultural corridor; the use of symbolism of different cultures; and highlighting a particular ethnic group in a completely different cultural atmosphere. The selected analogues helped to substantiate the needs of people from different cultures assessed during the sociological survey, reflecting a certain model of environmental psychology: the natural, physical or social and behavioural environment.

The first part of the survey sought to find out the importance of the natural environment in public space. Different ethnic groups chose the most important factors that they believe are influenced by the natural environment. Most ethnic groups believed that the greatest impact is on the emotions (92% of Russians, n=12; 63% of Belarusians, n=5; 80% of Ukrainians, n=6; 100% of Jews, n=8; 50% of Poles, n=4; 68% of the mixed nationality group, n=15; 67% of undisclosed nationality, n=4) and lifestyle (69% of Russians, n=9; 63% of Belarusians, n=5; 88% of Ukrainians, n=7; 88% of Poles, n=7; 73% of the mixed nationality group, n=16). Also, a significant number of Ukrainians believe that the natural environment influences their behaviour (63%, n=5), and the majority of the Jews think that their activities also have an impact (80%, n=6).

The participants were asked if they agreed that there should be as much greenery as possible in public spaces, i.e., the space must be densely planted. 33% of respondents fully agreed, 48% agreed, 18% neither agreed nor disagreed, and 1% strongly disagreed. Intensive planting gives the public space a natural character and can help to represent the species composition of greenery from different cultural regions. One such example is the 42,000m^2 corridor on the oldest street in Chapultepec, Mexico, where the aim was to match the vehicle traffic with pedestrian traffic by having a more natural design. The Chapultepec Avenue Cultural Corridor project created an elevated promenade that surrounds the road for commercial and cultural activities. The project also created more convenient transportation functions for passers-by and for foreign citizens in the city, in order to make a high-quality public space that encourages the gathering of people from different cultures (Rosenfield, 2015) (Figure 2).

The second part of the survey explained which characteristics of the physical environment can affect a public space, such

Figure 2. The Chapultepec Avenue Cultural Corridor (Source: www.archdaily.com)

as: the type of space, functional zones, design forms and elements specific to different cultures, and the importance of physical characteristics. The majority of respondents (66%, n=48) stated that the most acceptable type of public space for them was multifunctional (various). A significant number of citizens from various nationalities (Roma, Latvian, Georgian, Armenian, Indian, Turkish, Czech, Pakistani, Swedish, Italian, Brazilian) chose the type of passive public space (41%, n=9). Analysis of the respondents' need for various activities and functional areas in the public space showed that recreation areas for relaxation dominated (82%, n=60). Spaces for social gatherings (60%, n=44), picnic areas (55%, n=40) and communication (52%, n=38) were also quite important. Individual activities (walking, running) (47%, n=34) and areas for families (42%, n=31) were of medium importance, while the least important were sports activities (30%, n=22) and water body zones (30%, n=22). However, when examining the needs of each ethnic group for a particular functional area, some differences between the overall results can also be seen. For example, for Russians, in addition to the most important functional area being for recreation, areas of equal importance were for communication and individual activities (69%, n=9 = 69%, n=9), for Jews, areas of communication were more important than rest areas (75%, n=6 > 63%, n=5), and for Poles, picnic areas were as important as recreational areas (63%, n=5 = 63%, n=5).

In order to find out whether citizens of different ethnic groups would like to see design elements specific to their culture in public space, the respondents were first asked about the need for such elements. Almost all national minorities agreed with the need for culturally acceptable design elements in public space, though some individual citizens from different nationalities disagreed (Roma, Latvians, Georgians, Armenians, Indians, Turks, Czechs, Pakistanis, Swedes, Italians, Brazilians). It seems difficult to combine different cultural symbols, different patterns and colour schemes in one public space; however, this has been perfectly achieved by three famous architects and designers (BIG-Bjarke Ingels, TOPOTEK1 and SUPERFLEX), who created a kilometre-long city park called Superkilen in the centre of Norrebro,

Denmark. The aim of these architectural design companies was to transform the exclusive area into a point of attraction, reflecting the cultural diversity of the neighbourhood, creating the space for people of all ages, genders, religions or ethnic groups and letting them feel at home, regardless of distance from their homeland. The Superkilen project has a large monofunctional area, innovatively transformed into a multifunctional public space that allows residents to enjoy any activity: from more passive outdoor activities and recreation to public meetings and active leisure (AlShehri, 2018).

Colours are one of the most important elements of the park, and certain areas are divided by colour. Red represents the Danish flag, since Denmark has created new home for foreigners. "Stimulating colours – bright red, orange, pink – encourage activity and energy, and the colour-dividing lines between the edges create a beautiful pattern on the floor" (Land8 - Landscape Architects Network, 2014). Black is the colour of the social city site where people meet and interact or play chess. White stripes, convex roller coasters and the application of Islamic elements to the furniture in the space create an optical illusion of movement. Green is also a feature of the park: green hills, large lawn areas, outdoor picnic areas, sports facilities and playgrounds for children.

One of the most striking features of the fame of Superkilen City Park is that its landmarks are collected from more than 60 different countries, and 108 of its imported historical objects have unique national significance (Figure 3).

Figure 3. The landmarks of Superkilen City Park (Source: www.land8.com)

The aim of Superkilen project has been achieved and overachieved, as it is quite difficult to create innovative urban areas that meet international standards in today's multicultural society.

The third part of the survey sought to find out the most important features of the social and behavioural environment: what are the most important feelings experienced in the public space and what opportunities does the space provide? Tolerance and contact with others in public spaces were also analysed. Almost all respondents chose safety (93%, n=68), comfort (93%, n=68) and pleasure (92%, n=68) from the identified feelings (safety, comfort, pleasure, territoriality, individuality and dependence) as being most important in public space. The majority of respondents named convenience/comfort (74%, n=54) from the values they want to receive from public space. The dominance of safety and comfort can also be seen in the choices of each ethnic group, but in addition to convenience, a significant proportion of Russian minority citizens said they would like to receive opportunities for perception (77%, n=10) and diversity (69%, n=9) from the public space. The same number of Ukrainian and Jewish respondents considered establishing relationships with other people (63%, n=5) as the value provided by public space, the same number of Ukrainian and Polish citizens expected to experience emotions in public space (63%, n=5) and initiate communication themselves (63%, n=5), and citizens of different nationalities expressed a wish to be able to explore the environment (59%, n=13).

In order to find out the mutual tolerance of the participants, they were asked how individuals evaluate themselves in relation to other people and how they see others in relation to themselves in public space. The results showed that in the most cases both sides are neutral, but a significant number of respondents also said that they smile at other people (34%). When analysing the social and behavioural environment, it was also important to understand how often people tend to make contact with others in public space. The results of the survey showed that the majority of respondents from different cultures are more likely to initiate contact themselves (64%) than to receive it.

From a social and behavioural point of view, attempts could be made to "resurrect" the least socially integrated cultures by highlighting a particular ethnic group in a completely different cultural atmosphere, but this must be done with great care and reasoning. An example of this has been tested in the creation of a public space for the Afghan Culture Market in Melbourne, Australia. It is a project that reflects the integration of a culturally completely different ethnic group into society in Australia. The aim of the project was to turn the main street into an authentic public space that would express the identity, unity and culture of the community surrounding that street. Afghan ethnic symbolism is used, which enlivens the street with a bright visual character, invites people to come together and catches the eye of pedestrians from any other culture (Rosenfield, 2015).

Figure 4. Afghan Culture Market Public Space in Australia (Source: www.archdaily.com)

The designed coatings not only interpret traditional Arab culture, but also have connections to the context of the Australian state itself – the design pattern is similar to the golden yellow blossoms of the country's bush tree ("Acacia pycnantha"). This provides an opportunity to integrate the ethnic group into society in a way acceptable in Australia. (Figure 4).

This Afghan cultural market project can be recognized as a public space with new cultural and artistic expression, emphasizing the cultural identity of the community and promoting socio-cultural encounters that are important in the context of everyday multicultural urban life.

Attractiveness of existing public spaces in the central areas of major Lithuanian cities according to the respondents

In total 33 people participated in the anonymous sociological survey, of whom 64% were women (n=21) and 36% men (n=12). The average age of the respondents was 42 years. Most respondents were citizens of the major ethnic groups in Lithuania: 27% were Russians (n=9), 15% Poles (n=5), 9% Belarusians and Ukrainians (n=3) and 6% did not declare their nationality (n=2). Also, there were some single respondents combined in a single group of mixed nationalities: Kazakhs n=1, Azerbaijans n=1, Indians n=3, Roma n=1, Arabs n=1, Pakistanis n=1, Americans n=2, Serbs n=1. The most active respondents were from Vilnius (76%, n=25), 21% (n=7) from Kaunas, and Klaipėda residents accounted for only 3% (n=1).

In order to find out how people of different cultures value the existing public spaces of major Lithuanian cities, 13 spaces were selected, which were divided into four typological groups: central historical squares of cities, squares important for statehood, recreational squares in central parts of cities and parks. For each of them, attractiveness was assessed using a scale from 1 to 10. Respondents were also asked to indicate 7 features that determine the attractiveness of the public space: spaciousness, dominant objects/buildings, visibility/accessibility of water bodies, greenery, artistic/sculptural accents, possibility to sit on the grass and small architectural elements (benches, outdoor furniture, lighting elements, fountains, etc.).

The central historical squares of cities, squares important for statehood, recreational squares in central city areas, and parks of major Lithuanian cities were evaluated by the respondents according to the emotions they experienced in the public spaces they had visited, or by the photos provided.

The attractiveness of Kaunas and Vilnius Town Hall Squares was assessed with the highest scores. Their overall average assessment was very similar (8.06 – Kaunas Town Hall Square; 7.93 – Vilnius Town Hall Square). Klaipeda City Square got the lowest evaluation – 7.00. In terms of national minorities, the results showed that Vilnius Town Hall Square was rated the best by Ukrainians (9.33) and the worst by citizens without an indicated nationality (6.50). This contrasted with the assessment of Kaunas and Klaipėda Town Hall squares – both squares were given the highest scores by respondents who did not indicate their nationality (9.50). Kaunas Town Hall Square was given the worst scores by the Belarusian ethnic group (6.67), and Klaipėda by citizens of Belarusian and Ukrainian nationality (6.33).

According to the respondents, the attractiveness of Vilnius City Town Hall was mostly determined by the small architectural elements (82%, n=27) and spaciousness (70%, n=23). According to the opinion of each national minority, there were only differences between two dominant features: for Russians and Belarusians, the attractiveness of Vilnius Town Hall Square was determined by the small architectural elements, for Ukrainians and Poles – spaciousness.

The choice of features that determined the attractiveness of Kaunas Town Hall Square was slightly different from Vilnius, as the majority of respondents chose the features of dominant objects/buildings (79%, n=26), and small architectural elements (76%, n=25) (Figure 5). For individual ethnic groups, it became clear that the characteristics of dominant objects/buildings and small architectural elements were equally important for the mixed nationality group and Belarusians; however, for Russians and Poles the attractiveness of the public space was determined only by dominant objects/buildings.

In the worst rated space, Klaipėda Town Hall Square, people indicated small architectural elements (58%, n=19), artistic/

Figure 5. Kaunas Town Hall Square
(Source: A. Mačikūnaitė)

sculptural accents and spaciousness as equally important features (55%, n=18) (Figure 6). Comparing the choices of different ethnic groups, it was found out that Ukrainians noticed the visibility of trees/greenery and water bodies, which together with spaciousness were identified as the most important features determining the attractiveness of the public space, while Belarusians chose dominant objects/buildings together with artistic/sculptural accents and small architectural elements as equally important.

The assessment of squares important for statehood showed that the attractiveness of Vilnius Lukiškės Square was given with the highest scores: the overall average was 7.09 points. Kaunas Unity Square was rated slightly worse (6.57), and the lowest average rating was given for Klaipėda Revival Square – 5.34. Vilnius Lukiškės Square was best rated by citizens without an indicated nationality (9.50), Kaunas Unity Square by Ukrainians (8.67), Klaipėda Revival Square by the mixed group of nationalities (7.09), and all squares got the worst scores from Belarusians (Vilnius Lukiškės Square – 5.00; Kaunas Unity Square – 3.67; Klaipėda Revival Square – 4.67).

According to the respondents, the attractiveness of Vilnius Lukiškės Square is mostly determined by the abundance of greenery (73%, n=24) and spaciousness (67%, n=22) (Figure 7). The choice of these two features also dominates among all of the respondents: the attractiveness of Vilnius Lukiškės Square for Russians, Poles and the mixed nationality group was determined by the abundance of trees and greenery; for Belarusians and Ukrainians – by spaciousness.

The choice of features that determined the attractiveness of Kaunas Unity Square was slightly different from Vilnius Lukiškės Square, as the majority of respondents, in addition

Figure 6. Klaipėda Town Hall Square
(Source: A. Mačikūnaitė)

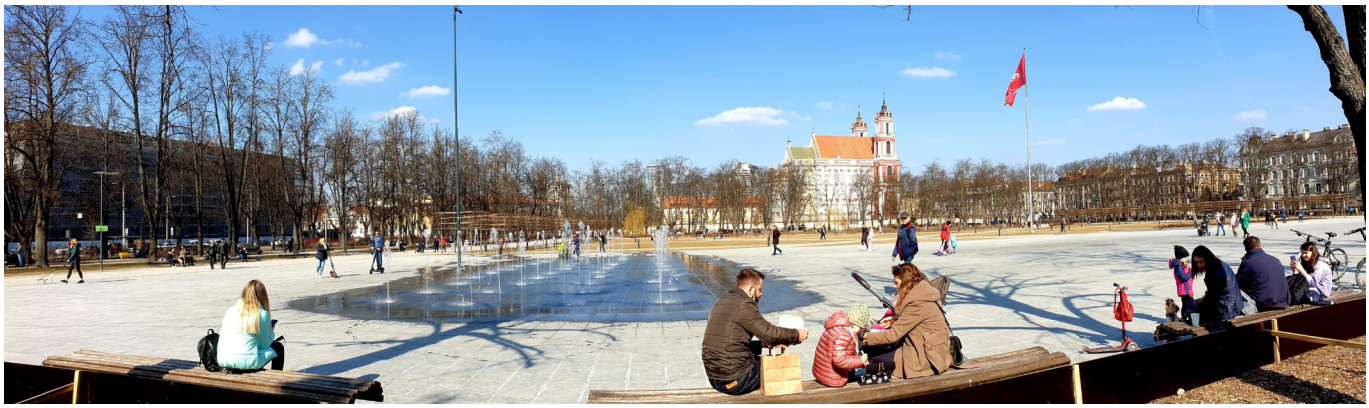

Figure 7. Vilnius Lukiškės Square
(Source: A. Mačikūnaitė)

Figure 8. Klaipėda Revival Square
(Source: A. Mačikūnaitė)

to the spaciousness feature, chose elements of small architecture (58%, n=19) or dominant objects/buildings (49%, n=16).

In Klaipėda Revival Square, which was given the worst scores by the respondents, people distinguished the features of spaciousness (64%, n=21) and dominant objects/buildings (58%, n=19). Poles valued the abundance of greenery in the public space and spaciousness as the most important features that determined the attractiveness of Klaipėda Revival Square (Figure 8).

The evaluation of recreational squares in central city areas showed that Vilnius Cathedral Square was rated as the most attractive square (average rating of 8.96 points). The rating of Kaunas Independence Square was slightly lower, but also very high (8.23), and Klaipėda Theater Square was given the lowest score – 7.23. The results showed that Vilnius Cathedral Square was rated highest by Ukrainians (9.67), but the ratings of other national minorities were also quite high. Evaluating Kaunas Independence Square, the highest ratings for its public space were given by the group with no indicated nationality (9.50), and the overall average was reduced by the Belarusian minority, which gave a rating of below 7 points. Klaipeda Theatre Square, rated lowest by the national minorities, was assessed approximately – with averages ranging from 6.80 to 7.55.

According to the respondents, the attractiveness of Vilnius Cathedral Square is equally determined by spaciousness and dominant objects/buildings (85%, n=28) (Figure 9), but, only the Poles and Ukrainians agreed that these features had the greatest influence on public space.

The choice of features that determined the attractiveness of Kaunas Independence Square was slightly different from Vilnius Cathedral Square, since for most of the respondents, spaciousness was only the third most important feature, after dominant objects/buildings (79%, n=26) and small architectural elements (64%, n=21).

In the worst rated Klaipėda Theater Square, the respondents, as with Kaunas Independence Square, distinguished the properties of dominant objects/buildings (73%, n=24) and small architectural elements as being preferable (58%, n=19).

The assessment of parks showed that again Vilnius was the first choice – Bernardines Garden was rated as the most attractive park – with an overall rating of 8.84 points. The ratings for Klaipėda Dane Embankment and Kaunas Peace Park were lower – 7.43 and 7.03 points respectively, while Kaunas Santaka Park, according to all of the citizens from different cultures who participated in the survey, was the worst – 6.87 points. The results of the assessment of the attractiveness of parks to each national minority showed that Vilnius Bernardines Garden was assessed most favourably by citizens who did not indicate their nationality (9.50) and Poles (9.40). In the case of Kaunas Santaka Park, the highest ratings for this public space were given by the mixed nationality group (8.18), but it remained the least favoured due to the low overall ratings given by Ukrainians

Figure 9. Vilnius Cathedral Square
(Source: A. Mačikūnaitė)

Figure 10. Kaunas Santaka Park
(Source: A. Mačikūnaitė)

and Belarusians (5.67 and 4.67). Kaunas Peace Park was given by the highest scores by the mixed nationality group (7.91), and Klaipėda Danė embankment was highest rated by Russians (8.89).

According to the respondents, the attractiveness of Vilnius Bernardines Garden is determined by its abundance of trees/greenery (85%, n=28), spaciousness (79%, n=26) and natural aspects, such as the possibility of sitting on the grass (58%, n=19), water visibility/accessibility (46%, n=15). The results showed that for Russians and Ukrainians, along with spaciousness, elements of small architecture were also important.

The choice of features that determined the attractiveness of Kaunas Santaka Park was the same as for Vilnius Bernardines Garden: the abundance of trees/greenery (82%, n=27) and spaciousness (70%, n=23), but Kaunas Santaka Park was rated as being least attractive (Figure 10). The distribution of these characteristics also dominated in the choices of each ethnic group.

According to the respondents, Kaunas Peace Park was characterized by an abundance of trees/greenery (79%, n=26), spaciousness (55%, n=18), dominant objects/buildings (52%, n=17), and small architectural elements (49%, n=16). This trend was also reflected in the different ethnic groups' choices.

The citizens of different cultures who participated in the survey distinguished five characteristics that determine the attractiveness of Klaipėda Danė: spaciousness and small architectural elements (67%, n=22), visibility/accessibility of water bodies (61%, n=20), trees/greenery and artistic/sculptural accents (55%, n=18). All of these characteristics were also reflected in the individual choices of each national minority.

Attractiveness level of existing public spaces in the central areas of major Lithuanian cities according to expert evaluation in situ

The assessments of the attractiveness of public spaces for citizens from different cultures were compared with expert evaluations in situ. A table for monitoring and evaluating the spaces was created using the morphological/structural and harmony-related evaluation parameters proposed by Salingaros. Every indicator was rated on a scale from 0 to 2 (the total sum of the category cannot exceed 10). Further, a comparative analysis of the evaluation results was performed.

The expert evaluation results for morphological/structural and harmony-related parameters for all of the public spaces were obtained by observing and evaluating existing space in situ. The expert evaluation and respondents' opinions had similarities: the morphological characteristics of most public spaces were reflected in both the scores and the attractiveness of the features chosen by the respondents. The highest percentage of respondents (70%, n=23) chose spaciousness as the most attractive feature of Vilnius Town Hall Square, which also has the highest 2-point expert rating. The majority of respondents chose the abundance of trees/greenery and spaciousness, at Vilnius Lukiškės Square as being most attractive, which according to the research in situ corresponds to the highest 2-point ratings (the morphological spatial parameter and harmony criteria of the public connection between the public space and the contextual environment). Analysis of the recreational squares in the central city areas, showed that the spaciousness of both Kaunas and Klaipėda squares was assessed rather poorly (Kaunas Independence Square – 0.5 points; Klaipėda Theater Square – 1 point), which corresponded with the assessment of the respondents.

The same can be said about the morphological/structural parameter of spatial arrangement. In the evaluation of central historical city squares, the highest points were given to Kaunas and Klaipėda Town Hall Squares (1.5 – Kaunas Town Hall Square; 2.0 – Klaipėda Town Hall Square), for which the respondents chose the features determining the spatial arrangement (dominant objects/buildings, small architectural elements, artistic/sculptural accents). This parameter exactly matches the assessment of squares important for statehood: both Kaunas and Klaipėda squares were given with 2 points, as were the dominant features assessed by the respondents (small architectural elements and dominant objects/buildings). The morphological parameter of completeness for recreational squares in central city areas had differences just for Vilnius Cathedral Square, which was given only 0.5 points, because the public space is quite empty and there are very few elements of small architecture. The features of dominant objects/buildings and small architectural elements perfectly reflected the parameter of completeness for public spaces in both Kaunas and Klaipėda (Kaunas Independence Square – 2 points; Klaipėda Theater Square – 1.5 points).

Contrasting evaluations were given only in the case of parks: the respondents paid more attention to harmony-related parameters than to morphological ones – natural elements were selected as features that determined attractiveness.

Analysis of the attractiveness of public spaces in terms of harmony, showed that the most important parameter was emotion, which was the highest in Vilnius Town Hall Square, Kaunas Unity Square, Kaunas Independence Square, Klaipėda Theatre Square and Kaunas Santaka Park (2.0 points), because these public spaces are surrounded with activities that allow us to feel the possibility of comfort in them, and communicate with other people. With regard to the central historical city squares, it can be stated that Kaunas City Hall Square has quite a high rating for emotion (1.5 points), but the possibilities of comfort are somehow overshadowed by the outdoor cafes located on the perimeter of the square, which in the warm season invite you to sit in them, not in the square itself by offering a view of the dominant – Kaunas City Hall. The emotion of Klaipeda Town Hall Square does not fully meet the social needs in terms of establishing relationships with other people, and it provides a minimum possibility of comfort (0.5 points). In terms of emotion and central recreational squares, it can be affirmed that Kaunas Independence and Klaipėda Theatre squares are valued slightly higher than Vilnius Cathedral Square, but only due to the greater possibility of comfort (the number of small architectural elements).

For the harmony parameter in terms of connection with the surroundings, it can be stated that the highest scores were for the central historical city squares (Vilnius and Kaunas City Hall squares), because of the connection with the surrounding cafes and shops. The squares important for statehood, were given poor assessments of their connection with nature, because only Vilnius Lukiškės Square has a densely planted area of trees, which frames the square. The connection of Kaunas Unity Square with the environment is more based on a functional connection between the buildings because the public space itself is different from the others – it contrasts with the surrounding environment (estimated at 0.5 points). Meanwhile, Klaipėda Revival Square has no functional or natural connection with the environment (other buildings and surrounding spaces) – it acts as an independent recreational and transit zone. Kaunas Independence Square has the highest score (2.0) for the natural connectivity of recreational squares in central city areas, because there are a lot of trees around the small architectural elements. The connection between parks and the environment is obvious, for example, Kaunas Santaka Park has connectivity with its surroundings in the architectural and natural sense, as it connects with the public space of Kaunas Castle to the east and meets the confluence of two rivers to the west.

Central historical squares are usually located in front of a significant city building – the Town Hall, but passing the Danė river embankment, you may not even pay attention to the small, open Klaipeda Town Hall Square, which seems to have no clear, defined functional purpose. It was therefore rated with the lowest (0.5) score for perception. For squares important for statehood, it can be stated that the function of Vilnius Lukiškės Square corresponds best to its situation in the city (Vilnius Lukiškės Square was given 2 points; Kaunas Unity and Klaipėda Revival Squares were given 1 point). Although Lukiškės Square (as well as Klaipėda Revival Square) is mostly used for a transit, it also has recreational purpose. The flags raised on the masts represent the importance of this public space for statehood, while Klaipėda public space does not fully reflect this. In contrast, Kaunas Unity Square is a modern artistic and multifunctional square, offering various activities, and raising positivity. Its importance for statehood is difficult to understand because there is no functional connection with past, historical events, and there are different perceptual visual and functional barriers created by the last renovation of the square that prevent the perception of all historical layers and meanings of the place (1 point). Vilnius Cathedral and Klaipėda Theater squares are recreational public spaces in central city areas used for major city celebrations, gatherings, events and fairs. It can be stated that Kaunas Santaka and Peace parks have the best correlations of functions. Kaunas Santaka Park has a one thousand-seat amphitheatre on the right slope of Nemunas River, in which events and gatherings are sometimes organized and there is an outdoor café. Kaunas Peace Park is the site of the former Kaunas cemetery, which has recreational areas suitable for everyone, regardless of nationality. There are existing religious buildings in the Peace Park, such as: The Mosque and Cathedral of our Lady, which serves and maintains its function for different ethnic communities.

Direct/physical contact in most of the central historical squares is very high, because buildings surrounding these public spaces provide an opportunity to smell/touch/see and hear the surrounding phenomena. The possibility of direct/physical contact for the squares important for statehood is the lowest in Klaipėda Revival Square (Vilnius Lukiškės Square – 1 point; Kaunas Unity Square – 2 points; Klaipėda Revival Square – 0.5 points), because visual, tactile, and audible senses are raised more by a natural than man-made environment (derived from the environment surrounding the public space). For the perceptual/visual and audible aspects in central recreational squares, the highest score for direct/physical contact is in Kaunas Independence and Klaipėda Theater squares (1.5 points), while in Vilnius Cathedral Square it is just 1 point. This is because Kaunas and Klaipėda have outdoor cafes that closely surround the space, making it possible to feel/hear or smell the environment. Meanwhile in Vilnius Cathedral Square the perceptual/visual and audible aspects are distributed over a wide space. Kaunas Peace Park got the lowest result for direct/physical contact (1.0), because all the territory is calmer and lacking main pedestrian alleys with a high possibility of perceptual/visual and audible diversity.

Based on the attractiveness level according to Salingaros (multiplying the sum of evaluation points belonging to morphological/structural parameters by the sum of the harmony evaluation scores) and taking into account the respondents' assessments, we obtained the following results for the central historical squares and squares important for the statehood: Vilnius Town Hall Square, according to the Salingaros method, was given **67.5** from 100 points by experts, and **7.93** from 10 points (overall average assessment of respondents); Kaunas Town Hall Square – **63.0**/100 and **8.06**/10; Klaipėda Town Hall Square was least attractive with **24.0**/100 and **7.00**/10 points respectively. Vilnius Lukiškės Square was given **64.0**/100 and **7.09**/10; Kaunas Unity Square – **52.5**/100 and **6.57**/10; Klaipėda Revival Square - **34.0**/100 and **5.34**/10.

Comparing the attractiveness level according to Salingaros and the evaluation of respondents, we can see differences only in the recreational squares in central city areas and parks. For example, Vilnius Cathedral Square was assessed as more attractive by the respondents (**8.96**/10), but the Salingaros evaluation in situ showed a lower result (**56.25**/100). The opposite is true for the situation with Kaunas Independence Square: where the Salingaros evaluation showed a higher result for attractiveness (**71.25**/100), the citizens of different nationalities gave a lower assessment of the public space (**8.23**/10) in comparison with Vilnius Cathedral Square (**8.96**/10). The Salingaros evaluation for attractiveness coincided with the evaluation of respondents only for Klaipėda Theater Square: the Salingaros evaluation gave **55.25**/100 and the respondents **7.23**/10.

A high score was given to Kaunas Santaka Park during the evaluation in situ (**85.00**/100), but the respondents gave it a poor evaluation (**6.87**/10). In the case of Vilnius Bernardines Garden and Klaipėda Danė embankment, the trend of attractiveness assessment coincided: the highest ratings were given to Vilnius Bernardines Garden (**90.00**/100 and **8.84**/10); Danė embankment was given **80.75**/100 and

7.43/10 (average evaluation by respondents). Kaunas Peace Park was evaluated the worst according to the Salingaros method (**52.00**/100) but raised up by the average of the respondents' evaluation (**7.03**/10).

Summarizing the results of the analysis of typologically similar public spaces in major Lithuanian cities and the research in situ, it can be stated that the dominant spaciousness parameter for some typological groups of public spaces led to small differences between evaluation by the respondents and the research in situ in selecting the most attractive public space. More attention given to the morphological/structural spaciousness parameter could have slightly reduced people's ability to take certain harmony-related parameters more seriously, but due to the dependence of the parameter score in most cases, higher scores for morphological/structural or harmony assessment parameters still resulted in a higher average of the respondents' assessment.

CONCLUSIONS

The sociological survey in the first part of the research confirmed the importance of environmental psychology models (natural, physical and social and behavioural environments) for determining the needs of people from different cultures. After conducting a stimulatory-comparative sociological survey for various ethnic groups, the most attractive public spaces were identified for each typological group, and the characteristics that determined their attractiveness were clarified.

The most attractive central historical public city space is Kaunas Town Hall Square, the attractiveness of which was determined by the features of dominant objects and small architectural elements. In the assessment of the attractiveness of squares important for statehood, Vilnius Lukiškės Square took the highest position, since it is characterized by the abundance of greenery and spaciousness, and the importance of the space for statehood is clearly emphasized, for example, with flags raised on poles. The expert assessment of the attractiveness of recreational squares in the central city areas differs from the evaluation of non-experts. Vilnius Cathedral Square was rated better by the respondents due to the features of dominant objects/ buildings and artistic/sculptural accents in the public space, while Kaunas Independence Square, which was rated lower by respondents, was assessed in situ as attractive due to its close connection with surrounding urban spaces and clear pedestrian flows. Vilnius Bernardines Garden was undoubtedly the most attractive Lithuanian city centre park, with high evaluation scores determined by the abundance of trees/ greenery, spaciousness, small architectural elements, and natural aspects, such as the ability to sit on grass, visibility/accessibility of water bodies.

Based on the opinion of people from different ethnic groups, the needs of different people in relation to public spaces in major Lithuanian cities have been identified and the possibilities for their spatial expression have been assessed. For example, for individual citizens of various nationalities (Roma, Latvians, Georgians, Armenians, Indians, Turks, Czechs, Pakistanis, Swedes, Italians, Brazilians), the possibility of exploring the surrounding environment is important encompassing the tactile, visual, and audible aspects of the social environment. Also, a passive public space and artistic/sculptural accents are more acceptable for them. A possible spatial solution for meeting such needs could be a museum-type public space, representing the greenery of different cultures and emphasizing the importance of natural public spaces in the urban context.

For Polish people, emotions and initiation of contact in public space are important, and for Jewish citizens in public space it is very important to have the possibility of establishing relationships with other people and having functional areas for communication and gatherings. An example of how these needs have been met in spatial design solutions could be the Afghan Cultural Market Public Space in Melbourne, Australia, a project which emphasizes the importance of integrating different ethnic groups into society by fostering the gatherings of diverse communities in public spaces.

The perception and diversity of public space are important for Russian citizens, and symbolism for Ukrainians. Combining the needs of both nations, the multicultural Superkilen Park project in the centre of Norrebro, Denmark can be highlighted, the spatial realization of which perfectly meets international standards in today's multicultural society, and it gives a physical expression to the cultural, semantic, and functional symbols of different cultures.

Summarizing the research, it can be stated that the opinion of people with different cultural backgrounds in the context of the natural, physical and social and behavioural environment showed the importance of their different needs in public space, and the principle of harmony between humans and the environment was highlighted by the semantic, aesthetic and functional codes of different cultures manifested in the main morphological and harmony-related features of public spaces, such as spaciousness, small architectural elements, dominant objects/buildings, abundance of trees/ greenery.

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SPATIAL CHARACTERISTICS OF CONTEMPORARY PREFABRICATED MODULAR DORMITORY CELLS

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Prefabricated modular architecture brings diversified opportunities for sustainable university student accommodation. Modern and modular construction systems offer affordable and comfortable housing to students. The housing units form the core construction units of the dormitories. They are made from recycled shipping containers or prefabricated modular blocks that share common characteristics. The accommodation sections of modular dormitories are characterised by efficient sorting of prefabricated cells along horizontal communications. The paper analyses characteristic case studies and defines the predominant floor plan types of modular student accommodation cells. The difference in the layout and operational solutions also results from the specifics of the supporting structures. The aim is to categorise the prevailing floor types of modular accommodation cells and to define the spatial standard of student rooms while maintaining the right measure in the relationship: efficiency – invention – user comfort. Attractive interiors can increase the value of college houses. The basis of such projects is to have well-organised floor plans, which are clear and functional, even with regard to their visual effects.

***Key words*: modular architecture, university dormitories, accommodation unit, student room.**

INTRODUCTION

University dormitories are evolving parallelly with the general trends affecting educational facilities. As for broader developments, globalisation has also had an impact on these trends by promoting competitiveness between schools and at the same time changing students' views about campuses and their facilities. University students currently live in a dynamic, ever-changing environment that is influenced by rapid technological developments. "Globalization and the rapid spread of the Internet have had a great impact upon the structure of Generation Z, a generation growing with indispensable computers and technological breakthroughs" (Szydło *et al*., 2021, p. 5). The current young and energetic generation, influenced by a lifestyle subordinate to the digital age, has established relationships through social networks. Technological innovations minimise the need for community spaces that provide social interaction.

The term "modular unit" means that a building consists of separate parts or units that can be connected to each other (Wehmeier, 2005). Modularity is thus associated with catenation and buildability. Throughout the history of architecture, the term modular has referred mainly to prefabricated mobile and temporary buildings. The term module is distinguished from modular in architecture, and it was already present in the time of Vitruvius, derived from the Greek term "embater" and Latin term "modulus" which both mean a scale. The module is a relative unit of scale derived directly from construction, according to which the proportions of a building are determined. Concurrently, historically the module was an absolute and fixed unit of length, used to determine the dimensions of buildings. However, the term "modular unit" does not mean a building designed in standard dimensional modules; instead, it represents the prefabrication of a volumetric building unit. According to Knaack *et al.* (2012), modules are three-dimensional independent units or partially complete parts, which when stacked or joined together form the body of a modular building. The modular unit is a complete volumetric form of prefabrication. Lawson (2014) characterises

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modular buildings analogously: as "cell-type" structures which consist of identical spatial units that are suitable for transport. Furthermore, he fundamentally distinguishes modular constructions from planar and hybrid elements. Thus, a modular cell is a "three-dimensional or volumetric unit that is assembled in a factory and delivered to a construction site as the main structural element of a building" (Lawson, 2014, p. 1).

PIONEERS OF PREFABRICATED MODULAR ARCHITECTURE FOR ACCOMMODATION FACILITIES

The typology of capsule accommodation has been characteristic of modern architectural trends prevalent since the 1960s, influenced by remarkable projects by Archigram (an English group of architects) and Japanese Metabolists. The referential examples of Archigram show off its enthusiasm for the possibilities offered by new technologies. "Waren Chalk from Archigram began using the term capsule in 1964 – for prefabricated mass-produced housing units called Capsule Homes" (Šenk, 2018, p. 3). The architectural designs of Archigram were inspired by industrial production, science-fiction literature, and cybernetics. The avant-garde design of the student home by Peter Cook "Car Body/Pressed Metal Cabin" provided the possible replacement of worn-out modules/cells with new, technically improved units. It consisted of clusters of residential student "capsules" attached to central vertical service cores. "Thus, this architecture has become 'consumerist' like cars or other consumer goods, and the city is constantly renewing itself – through cyber control" (Haas, 1978, p. 456). According to Sadler (2005), Cook's design was literally a copy of the automotive design.

Cedric Price was also extremely beneficial to the English experimental architecture and design of the 1960s. Compared to the Smithsons, who designed the well-known modular cells "The house of the Future", he was more cautious in his designs and appeared almost technocratic in his concepts. In addition to his well-known project "Fun Palace", his design "Potteries Thinkbelt" from 1964 is inspiring for modular typologies. It uses technological systems to create a cybernetic structure of residential capsules, which can also be used to revitalise abandoned industrial areas (Ayres, 2012). Potteries Thinkbelt also includes a cyber control system for territory, transport options, education systems and an alternative education system for 20,000 students. Functioning as a mobile university that moves along a railway line (Malinowska and Lebek, 2017), it consists of mobile or fixed educational units and four basic types of mobile student suites that are to be considered as architectural pioneers of student modular living cells (Figure 1).

The prefabricated modular architecture of the past has inspired architects and designers around the world with its many features. Its structures are portable, prefabricated, demountable, dynamic and adaptable. The primary skeleton of the living cell of a modular dormitory is a container or a modular block. At the same time, these modular blocks make it possible to maintain the mobility of the structure and support flexibility in the architecture. According to Friedman (2016, p. 5), "Flexibility can involve macro

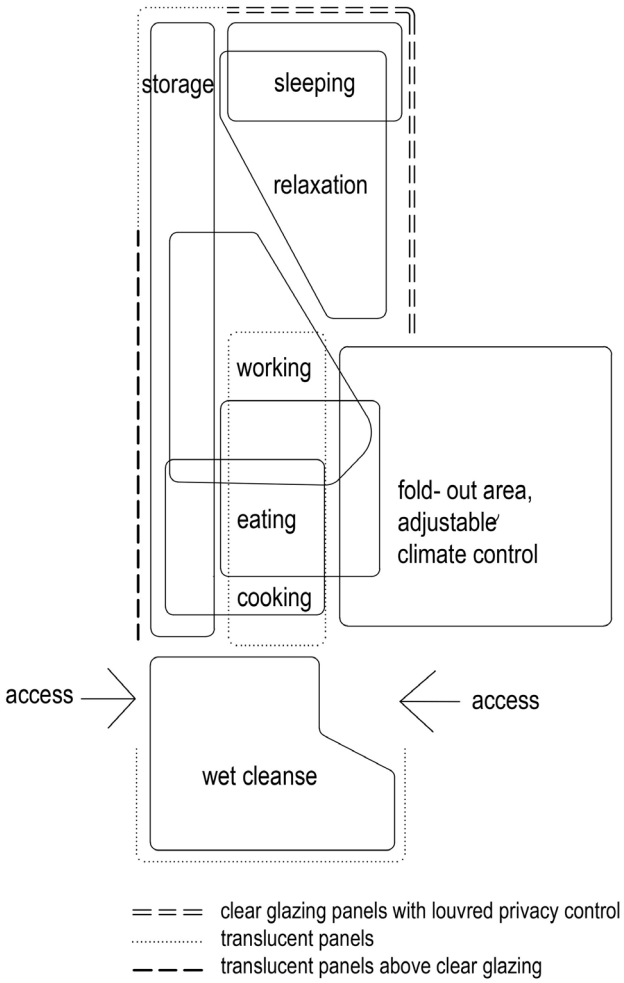

Figure 1. Potteries Thinkbelt: an ideological scheme of overlapping functions in the small space of a habitable unit. Floor plan of student accommodation cells
(Source: Lobsinger, 2000)

changes that affect the entire building, including adding or removing space or changing the function of the building." It can therefore also contribute to changes in spaces and their layout. The prototypes of modular dormitories are alternative designs of accommodation facilities, the basic characteristic of which is the search for a minimum area suitable for individual accommodation. In the field of architecture, we refer to this as microarchitecture. Volume reduction in the optimal architectural design does not automatically mean the deterioration of quality. The active part of the space is distinct from the passive part if the student lives in one room only (Kotradyova, 2015). If the space considered is undersized compared to a spatial standard, then it is not possible to insert new functional zones between the barrier zones and construction filters (doors, walls, etc.). Consequently, miniaturisation increases the demands on the shell/packaging of the accommodation unit as well as on the organisation of the interior.

Professor Richard Horden, inspired by the Japanese Metabolists' ideas, proposed a series of projects, which may also be referred to as examples of microarchitecture. In collaboration with John Höpfner Architekten, he began mass production of a project called the Micro-compact home,

which has been inhabited by students in Munich since 2005 (Krämer, 2006). The Micro-compact home is still popular among students since it is significantly cheaper than the other dormitories in the area. The cost effectiveness of the utilities and use of a smaller area have reduced the monthly rent for the student dormitories, which according to Herzan (2010) is approximately EUR 125. The aim was to design an affordable, mobile residential building with a high-quality design and construction. This low-energy concept of mobile housing for one to two people is inspired by the scale of Japanese traditional spaces for tea drinking ceremonies – the so-called Chashitsu (Bradbury and Powers, 2009). It allows real testing of a comfortable accommodation prototype in a minimal area. The Micro-compact home occupies an area of 7m^2, the internal volume of which is 266 x 266 x 266 cm (Leydecker, 2013). The interior clear height is 1.89m and the interior volume 18.6m^3 (Kronenburg, 2008). The utility and dimensions of the space are also related to the multifunctionality and dynamics of the furniture and one cannot help but notice that a certain new architectural edge is derived from the notion that such area is simply not suitable for the purposes of long-term accommodation (e.g., the entire academic year). Rather, it is suitable as an alternative form of accommodation for short stays (possibly as a hotel-type facility). The above claim is also supported by research by the Technical University in Munich and NASA Space Center in Houston (Horden, 1999).

The excessive multifunctionality of the furniture and spaces can be burdensome (Haines and Mitchell, 2014) for the accommodated student. He or she is forced to rearrange furniture elements and adapt the space required for an activity for a certain period of time. Above all, when discussing this issue, it ought to be remembered that the legislative requirements for the minimum size of student rooms result mainly from medical requirements (Ministerstvo zdravotníctva SR, 277/2008), which also address the impact of confined spaces on the human psyche (Slobodian, 2012). It is a difficult task to answer the question of whether sustained residency in a minimal area can be the cause of extreme psychological stress for a student. Collaborative research carried out by the Technical University of Munich and the NASA Space Center in Houston confirms the importance of distinguishing between study space and rest areas in a confined space (Horden, 1999). Ideally, these amphoteric activities do not take place in the same area in the room. Living space in a minimal area must be optimized as well as possible with regard to usefulness but also to the mental well-being of the user. The characteristics of the interior design, such as suitable colours and touch-friendly materials, increase the comfort for users. Those characteristics are as important as the principle of easy handling and integration of technical equipment into a room. According to Kotradyova *et al*. (2019) the relation between the material used and human physiology is very dependent and, for example, the brain is under less stress in an environment with wooden materials. The contribution made by accommodation prototypes in the form of microarchitecture for the development of dormitories should not primarily be the reduction of space, but rather the variability of equipment and the resulting multifunctionality of areas.

TYPICAL SPATIAL STANDARD OF PREFABRICATED MODULAR DORMITORY CELLS

According to interpretive dictionaries, the term "standard" represents an achieved, common level, as well as a stable form (Šalingová-Ivanová and Maníková, 1990). In the first place, however, the standard should be a well-designed environment that suits the individuality of the user, which contributes to achieving maximum performance and satisfaction, with a minimal health burden. In the legislation of European countries, the minimum area parameters for student rooms differ significantly. In Germany, a single student room requires a minimum area of 12m^2 (Mutius and Nussberger, 1994). In the United Kingdom, the minimum area of a single room is only 6.5m^2. In the case of a double room, the minimum area requirement of 10.2m^2 is significantly underestimated. A common single room size in Great Britain and the United States of America occupies 10m^2, a double does not exceed 18m^2 (Adler, 2007).

The real average of the spatial characteristics of a student accommodation cell on a European scale can be defined on the basis of analysing case studies of conventional (non-modular) dormitories. Research (Vráblová and Majcher, 2013) has shown that in conventional dormitories, the ratio of the space forming a typical accommodation cell is currently predominantly 63:37, where the higher value represents the student's living space and the lower value the area for accessories (hygiene, kitchenette, etc.). The width of a single student room is most often in the range of 2.75 - 4.25 m; the average value is 3.4m. The depth of the whole cell is on average 6.85m. The total area of the student cell (room and accessories in total) is on average 23m^2 (Vráblová, 2009). However, the dimensions of modular accommodation units are subordinated to the carrying capacity of the means of transport, as well as the dimensional standard of the transport type.

With the aim to create a platform for a theoretical model of a modular student housing unit that would be effective in economical, energy and disposition-operational terms, 35 modular dormitories (corridor or courtyard balcony type) in European countries were researched by our team from 2019 to 2021. This included: a review of project documentation and photographic materials; a survey of published expert studies; and site visits to the dormitories to assess the level of user satisfaction. The individual disposition schemes of the housing units were analysed, as well as whole floors in the selected dormitories, and the material and construction solutions. The individual case studies were reviewed and assessed in sequences, and categorised according to an Ishikawa graph. This paper focuses on assessing one category from the Ishikawa diagram: the disposition-layout schemes of the student housing units.

Two predominant floor plan types of modular student accommodation cells emerged from the case-study analysis. The difference between them stems from the specifics of the supporting structure used, e.g., for modular cells made from an existing shipping container, a second type of floor plan arrangement is typical.

Table 1. A comparison of the modular dormitories analysed (35 case studies). Abbreviations: PK – prefabricated kitchenette, PB – prefabricated bathroom, SK – standard kitchenette mounted on the construction site, SB – standard bathroom mounted on the construction site; LC – in the centre of the student cell layout; ES – entrance side of the student cell layout

HALL OF RESIDENCE_ CITY architect (Units) Average room area	**Majority room types**	**Layout features**	**Construction and material**	**Psychological and social aspects**
SPACEBOX_UTRECHT Mart de Jong (300) 17m^2	single rooms (+ apartments)	PK (1400 x 500 mm) + PB; position: ES	galvanized steel columns; composite panels	lack of space for social interaction
DUWO_DELFT Mecanoo Architecten (186) 21m^2	single rooms (+possibility of 2nd person lodging)	PK + PB, standardised furniture; position: ES	steel frame; concrete floors; wooden wall frames; renewable materials	separation of common areas only to the ground floor level
ZUIDERZEEWEG_ AMSTERDAM Fact Architect (335) 30m^2	single rooms	PK + PB; position: LC	steel frame; wood-based panels; renewable materials	natural material in the interior - a positive effect on the psyche
HABIT CAMPUS DE SANT CUGAT_ BARCELONA H Arquitectes (57) 56m^2	single rooms	PK + PB; position: ES; rooms without furniture	prefabricated concrete modules covered with galvanized steel	high degree of personalization of the room - including wall and ceiling surfaces
GRØNNEVIKSØREN_ BERGEN 3RW Arkitekter AS (704) 16.5m^2	single rooms (+apartments)	PK + PB; position: ES; rooms without furniture	steel frames and concrete slabs	personalization of the room environment; access balconies: social interaction
WOODIE_HAMBURG Sauerbruch Hutton Architekten (371) 19m^2	single rooms	PK + PB; position: ES, built-in cabinets and beds	wooden prefabricated modules	interior: natural (wooden) material - a positive effect on the psyche
KEETWONEN_ AMSTERDAM TempoHousing (1000) 26.75m^2	single rooms	PK + PB; position: LC	new steel containers (non-recycled)	rooms divided into functional zones
QUBIC_AMSTERDAM HVDN architekten (715) 24m^2	single rooms (+ 72 apartments)	PK + PB; position: ES	former shipping containers; plastic prefabricated panels facade	social activation: groups of rooms with shared terraces
CITÉ A DOCKS_LE HAVRE Cattani Architects (100) 24m^2	single rooms	PK + PB; position: LC; wooden furniture	former shipping containers with independent supporting steel frame structure	social activation: shared balconies
FRANKIE & JOHNNY_ BERLIN Holzer Kobler Architekturen (417) 26m^2	single rooms (+ apartments)	PK + PB; position: LC; standardised furniture	former shipping containers 40´; mineral wool + vacuum insulation	wide access balconies and terraces supporting social interaction
SMALLVILLE_SION DMD Modular (42) 18m^2, 28m^2, 35m^2	single rooms	60%: PB position: LC; PK position: ES; 40%: PB position: ES; custom-made furniture	steel frame; wood-based panels; renewable materials (interior: wooden surfaces)	rooms divided to functional zones; natural material in the interior - a positive effect on the psyche
MANRESA CAMPUS_ BARCELONA Xavier Tragant (75) 46m^2	single rooms	PK + PB; position: ES; without furniture	prefabricated concrete modules covered with galvanized steel	high degree of personalization of the room - including wall and ceiling surfaces
DYSON STUDENT VILLAGE_ MALMESBURY WilkinsonEyre (78) 30.24m^2	double rooms	PB position: ES; integrated built-in storage furniture and tables	cross-laminate timber (CLT) construction; the external aluminium cladding, sedum-covered roofs; 92% natural materials	timber in the interior - natural living environment; central social and learning hub, shared kitchen;

CAMPUS MELATEN_ AACHEN SzturArchitekten (285) 26m², 29m² (10%)	single rooms (+ apartments)	PK position: ES; PB position: LC;	recycling of 288 existing mobile residential modules; metallic facade	courtyard and exterior connecting bridges: a space for social interaction
MOLLWITZSTRASSE_ BERLIN n|vier architekten (86) 19m²	single rooms (+ apartments)	PK + PB position: ES; standardised furniture	modular wooden frame construction + wood-based filling panels	shared kitchens, interior social spaces, neutral colour of the interior - a positive effect on the psyche
FREIBURG IM BREISGAU Weissenrieder architekten (147) 14m²	double rooms	shared kitchen + bathroom for the whole floor	wooden prefabricated modules, visible wooden wall surfaces in the rooms	natural material in the interior - a positive effect on the psyche
MIKROWOHNUNGEN_ HEILBRONN Joos Keller (23) 17.5/35m²	single rooms (+ apartments)	PK + PB position: ES;	wooden prefabricated modules, visible wooden wall surfaces in the rooms	rooms divided into functional zones; social activation: shared exterior gallery
LUTTERTERRASSE_ GÖTTINGEN LIMA Architekten (265) 18m²	single rooms	PK + PB position: ES;	wooden prefabricated modules, visible wooden wall surfaces in the rooms	natural material in the interior - a positive effect on the psyche
MODULBAU_ BRAUNSCHWEIG IWB inngenieure (75) 19m²	single rooms (+ apartments)	PK + PB position: ES;	new steel prefabricated modules; facade of HPL prefabricated panels	lack of space for social interaction
STUDENT HOUSING MODULE_REIMS XCube-Engineer Prefabrication (131) 27m²	double rooms	PK + PB position: ES;	former shipping containers, walls finishing: mineral wool + composite panels	lack of space for social interaction; excessive colour of interior surfaces - negative effect on the psyche
STUDENT HOUSING MODULE_HEIDELBERG XCube-Engineer Prefabrication (265) 27m²	single rooms (1-, 2-, 3-room cells)	PK + PB position: ES; standardised furniture	wooden frame construction + plasterboards	lack of space for social interaction
MODULAR CHECKERBOARD_PAU 2A Design, Davis Authenac (214) 17.5m²	single rooms (+ 2 apartments)	PK position: LC; PB position: ES; integrated built-in furniture; kitchenette: in the night zone	prefabricated concrete modular units	lack of space for social interaction; personalization: floors and ceiling without surface treatment
STUDENT ACCOMMODATION_ GHOTENBURG Nova Deko Modular (162) 26.5m²	single rooms	PK position: ES; PB position: LC; standardised furniture	former shipping containers, sheet metal panels facade	social activation: shared enclosed balconies and exterior atrium
CAMPUS_KOBLENZ Ternes Architekten BDA (37) 28m²/19.2m²	single rooms	PK position: ES; PB position: LC; integrated built-in + standardised furniture	steel frame construction, composite panels + thermal insulation	high degree of personalization of the room; shared roof terrace
CAMPUS_WAGENINGEN Te Kiefte Architecten (312) 21m²	single rooms	PK+PB position: ES; integrated built-in furniture	steel frame construction, aluminum and wooden facade cladding	courtyard and exterior access balconies: a space for social interaction
STUDENT VILLAGE_ AMSTERDAM Studio Selva (358) 18m²	single rooms	PK+PB position: ES; integrated built-in furniture + standardised furniture	wooden frame construction + wood-based filling panels	several courtyards: a communicative space for interaction
U2 CAMPUS APARTMENTS_ NORDVEJ Concept Living A/S (312) 26m²	apartments	PK position: LC; PB position: LC; standardised furniture	steel frames and metal panels cladding	high degree of personalization of the room; courtyard and access balconies: a space for interaction

STORKOWER STRASSE_BERLIN ARUP (129) 16m^2	single rooms (apartments)	PK+PB position: ES; integrated built-in furniture	timber load-bearing walls and columns; reinforced concrete floor slabs	natural material in the interior - a positive effect on the psyche
PARADIES_ KONSTANZ Lutz + Roos Architekten (134) 20m^2	single rooms (1-, 2- room cells)	PK+PB position: ES; separate hallway; integrated built-in furniture	timber load-bearing walls and columns; reinforced concrete floor slabs	participatory planning (cooperation with students), + prototype of a modular cell
THE FIZZ SPARTAAN_ AMSTERDAM Studioninedots (361) 27,5m^2	single rooms	PB position: ES; SK position: ES; standardised furniture	reinforced concrete floor slabs and wall parts; + wood-based filling panels	social activation: shared terrace; café and relaxation spaces
Campus Montilivi_ GIRONA Xavier Tragant (70) 47m^2	single rooms (55%); apartments	PK+PB position: ES; standardised furniture	prefabricated concrete modules covered with galvanized steel	social activation: gym, TV room, lounge bar, shared kitchens
KOAS SEMINAARIMÄKI_ JYVÄSKYLÄ Verstas Architects (103) 27m^2	single rooms (91%); apartments	PB position: ES; PK position: LC; standardised furniture	cross-laminate timber (CLT) construction; facades: fire-retardant wooden cladding	social activation: clubroom, shared kitchens
KERAMUS_ UTRECHT Jillis Kinkel (232) 21m^2	single rooms (+ apartments)	PK + PB position: ES; standardised furniture	steel frame construction, reinforced concrete floor slabs; facades: ceramics cladding	social activation: shared roof terraces; separation of common areas only to the ground floor level
KATZENSPRUNG_ VAALS MH1 Architecten, Studio Job (461) 21m^2	single rooms (+ apartments)	PK + PB position: ES; standardised furniture	steel frame construction, reinforced concrete floor slabs; facades: perforated fiber cement boards,	high degree of personalization of the room; interactive exterior space between buildings
POP-UP DORMS_WIEN F2 Architekten (86) 12m^2	single rooms	shared kitchen + bathroom for group of units	wooden frame construction + wood - based filling panels	natural material in the interior - a positive effect on the psyche; common atrium without direct light - negative effect on the psyche

The most common type of floor plan is specific to the utilitarian composition of two spaces: the student room and the bathroom. The rooms are mostly single. Area-minimized sanitary facilities are part of the accommodation cells, and in the room itself, near the entrance, there is an integrated kitchenette. In many cases, in some areas of the accommodation section, there are several accommodation cells consisting of a group of two, three or four student rooms with a common living room and kitchen – similar to apartment hotel accommodation for more people.

The average area of the usable space of the whole accommodation cell ranges from 17m^2 to 56m^2, and the predominant area is 20-25m^2, which is a standard compatible with the accommodation cells of conventional university homes. The standard room width is approximately 3m (a width greater than 3.30 is exceptional due to the complexity of transportation). The disadvantage in many of the case studies is that the rooms are accessed directly from the exterior, in addition to the reduced possibility of social interaction in the room due to the non-division of the space into private and "semi-private" zones (entry is directly into the bedroom) (Figure 2).

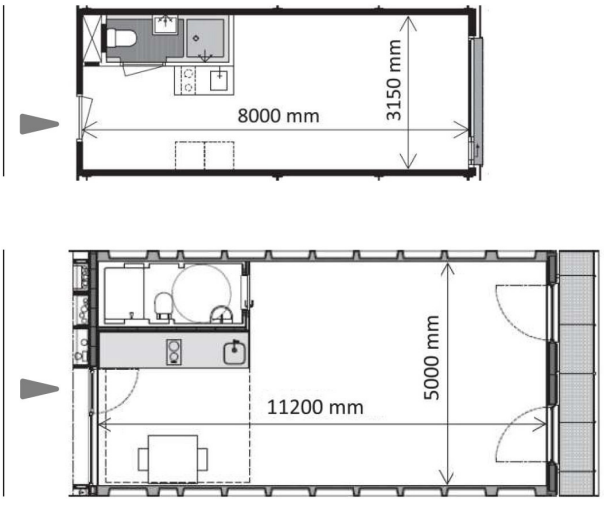

Figure 2. The first-floor plan type of modular student accommodation cells: characteristic layout-operational scheme of the spaces. Modular dormitory accommodation units: DUWO in Delft (architectural association Mecanoo) and the modular dormitory of the Catalan Technical University of Barcelona, H Arquitectes (Source: Friedman, 2016; Goula, 2013)

From the construction point of view, prefabricated modular units produced by joining large-format wooden panels are most numerous in this floor plan, using wood or steel as the frame supporting structure of the modules. According to Kotradyova *et al*. (2019):

> "Wood with its natural and emotional impact through visual, tactile, and olfactory interaction also has positive objective properties of the healthy microclimate, such as great contact comfort, improvement of room acoustics, the regulation of air humidity in a space, reduction of VOC (volatile organic compound) and emissions." (Kotradyova *et al*., 2019, p. 2)

For modular units in taller buildings (usually 5-8 storeys), a load-bearing system consisting of a combination of steel frame structures and reinforced concrete slabs is the usual choice. Another possibility is to use plastic and composite materials (mostly polyester resins and glass fibres), which are very lightweight, and easy to shape and maintain.

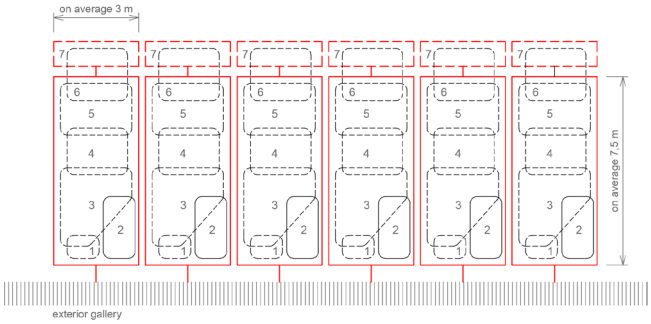

Figure 3. Theoretical model A1: modular student dormitory cell composition in the scheme of the accommodation section of the first type of floor plans. Legend: 1 – entrance zone, 2 - sanitation, 3 – cooking, eating, 4 – sleeping, relax, 5 – learning, working, 6 – relaxation, 7 – balcony
(Source: Authors)

A typical arrangement for the second most common type of floor plan is one in which the accommodation cell is divided into two smaller living spaces oriented towards the opposite facades of the building. In the middle of the floor plan is an integrated bathroom between them. The kitchenette and dining area, which forms a small living room, is separated from the bedroom on the other side. The layout is thus divided into a private zone and a "semi-private" day zone – which is also used for meetings of smaller group of students. The entrance to the cell is via the kitchenette and dining area. A long and narrow floor plan is typical for the given modular blocks. The entrance area with a kitchenette also serves as an acoustic and hygienic filter for the living space, symbolically replacing the vestibule. An indisputable advantage of this concept is the direct contact between the interior and the shared exterior, i.e., the contact between the living area of the living cell and the interactive space of the common horizontal communication. The scheme supports contact between students directly in the room – in its "living area", while the bedroom remains the private territory of the occupant (Figure 4).

The typical narrow accommodation cells occupy an area of 25 - 30m^2 on average, which represents a minimal increase

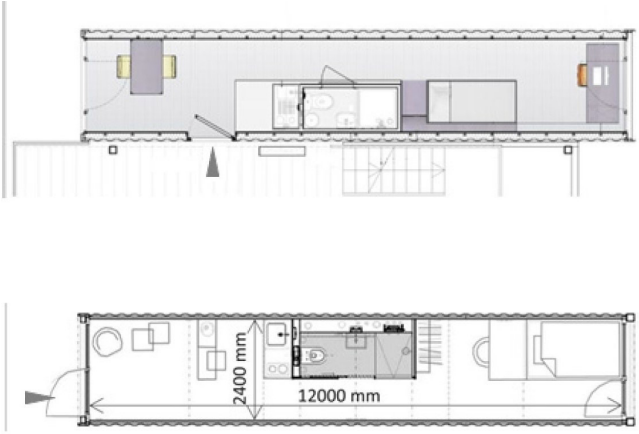

Figure 4. Characteristic narrow longitudinal floor plans of the second group of accommodation cells. Modular accommodation cells as building units of student residences Cité a docks in Le Havre (Cattani Architects) and Frankie & Johny in Berlin (Holzer Kobler Architekturen)
(Source: Holzer Kobler Architekturen, 2016; Authors, 2021)

in the dimensions compared to the first type of floor plan. Though the perceived space seems more generous in the first type of floor plan, it neither allows the structuring of the room into zones nor preserves privacy in the night zone of the room. A typical dimension of this floor plan is the atypical proportion of the area: a very narrow clear width of the room, which is on average 2300mm in the case-study buildings (Figure 4). This proportion results mainly from the size types of the shipping containers used for conversion into modular student accommodation cells that are characteristic of the floor plan of the second type. The standardisation of the dimensions of ISO containers also affects their use in the modular building structure. In particular, 5 standard container lengths are used worldwide: 6.1m, 12.2m, 13.7m, 14.6m and 16.2m. The so-called "40-ft" container – with a length of 12.2m, is the most widely used size type in shipping (ECS European Containers, 2020).

15% of the floor plans from the case studies with a narrow longitudinal floor plan of the second type are modular

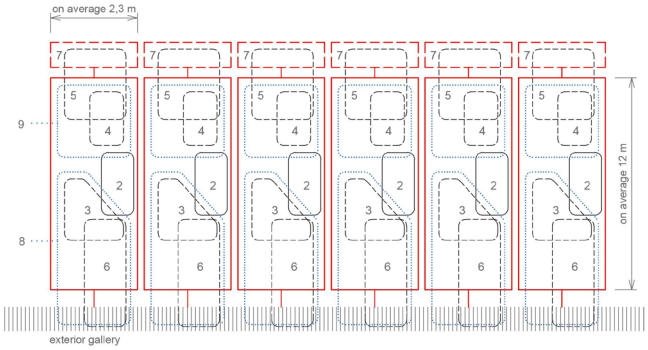

Figure 5. Theoretical model A2: modular student living cell compositions of the accommodation section of the second type of floor plan. Entrance zone lacks a solution for its functions – user enters directly into the living room equipped with a dining corner. Legend: (1- entrance zone - not available here), 2 - sanitation, 3 – cooking, eating, 4 – sleeping, relaxing, 5 – learning, working, 6 – relaxing, 7 – balcony, 8 – day zone, 9 – night zone
(Source: Authors)

dormitories composed of prefabricated cells, often designed from easily recyclable materials. An inspiring example is the Zuiderzeeweg student residence in Amsterdam (Bellini *et al*., 2015), where the basic supporting structure of a modular cell is a steel frame structure, and the walls are filled with wood-based panels (Figure 5).

The spatial and surface maximum of the student modular cells in the case studies are subject to road transport requirements, to ensure the collision-free transport of prefabricated cells. For example, in the Slovak Republic according to Government Regulation no. 349/2009 Coll. the width of the vehicle with the load must not exceed 2.55m and the maximum permissible length of the vehicles is 12m (for truck sets with a semi-trailer 16.50 m). The height must not exceed 4.05m (Vláda Slovenskej republiky, 349/2009). The given dimensional limits must also be taken into account in the design and subsequent implementation of a modular student dormitory. Moreover, this is true even in exceptional circumstances, for example if the production is carried out in the vicinity of the building plot, as the sustainability of the modular architecture has to be considered, and thus it is appropriate to support its possible mobility in the future. It follows that the maximum usable area of a modular cell (after thermal insulation of the inner space of the construction) does not exceed 30m^2. (The maximum allowed length of the truck, including the driver's trailer and cabin, is 16.5m – therefore the container should not exceed a maximum length of 12m to be able to load it onto the trailer).

Based on the above-mentioned minimum requirements for student accommodation and at the same time the limit parameters for transportation in European countries, it is possible to determine which size types of transport containers are suitable for conversion to a modular student accommodation cell. The most suitable space for conversion is a 40′ container, with internal dimensions of 2.352 x 12.032 x 2.385m, and a total external volume of 67.5m^3 (ECS European Containers, 2020). The 40′ container meets the minimum requirements for student accommodation facilities – the height of the interior space is more than 2.38 m, including a reserve for insulation and interior finishes. The external dimension does not exceed a width of 2.55m or the maximum specified length subject to road transport.

DISCUSSION

In the design and implementation of these student residences, the architects' desire to maintain intimacy in the living cells while supporting the community life of the students can be seen. The observer cannot help but notice that the focus is placed on the creation of common areas for study, dining and relaxation. In fact, an additional analysis would have to struggle with the question of what would be the ideal ratio of the private zone intended only for individual use to the common areas. According to a study by Hendershott *et al*. (2015), which dealt with the evaluation of the quality of student housing, students were less satisfied with university housing than with their academic or social life. They highlighted insufficient spatial dimensions and lack of privacy as serious problems. Preservation of privacy is also mentioned as one of the priorities of Twale and Damron (1991), who described a student residence as satisfactory only if it offers a quiet environment structured for smaller groups of residents, providing privacy and appropriate room sizes.

The quality of the interior design of the student room has a great influence on the general satisfaction of the residents with regard to their university home and whether they give positive feedback. The student accommodation cell is the main determinant of satisfaction with the accommodation facility. Tailor-made progressively integrated interiors in buildings such as the Horden "micro-compact home" or the prefabricated Woodie dormitory cells cannot be fully adapted to a student's requirements. Despite the general positive response of the professional public to their design, there is a risk of a negative impact on the students' psyche. According to Thomsen and Eikemo (2010) young people need to develop and express their own identity, and living environments without opportunities for personalisation can have a negative impact on housing satisfaction. There are many possible reasons for this, for example, they do not feel comfortable in the interior, the placement of furniture does not suit them or the design restricts them. A suitable solution is the flexibility of the interior: its adaptability to the user's current activity, which has the disadvantage of increasing the cost of construction.

Student dissatisfaction with their accommodation can stem from the insufficient manner in which the issue of privacy and intimacy is dealt with, in contrast to the encouragement of social interaction provided by the designs. This is because the designs promote the development of relationships between the residents living together, without considering whether this is something they truly desire. Indeed, many of the problems that students report arise in response to forced social activity and the absence of opportunities to spend time alone. Students responded negatively with regard to the lack of space where they could spend time doing activities such as learning or just resting. "The dormitory rooms are supposed to provide students with required physical conditions and also spaces for spare time activities" (Kilicaslan, 2013, p. 451). This implies inadequacy of the design of double and multi-bed student rooms, which do not provide intimacy and privacy to the individual. However, the solution is not only the design of accommodation sections with single rooms, but also the use of apartment-type accommodation, where roommates can perform activities with the added benefit of privacy.

In the case studies, as well as other implementations of modular student dormitories, accommodation in single rooms is clearly preferred (Table 1). The problem of creating various smaller groups of students is solved here by connecting the modular units, so that 2-4 single rooms have a common living room with a kitchenette, and form a student accommodation cell. In the case of student dormitories that possess exclusively single rooms of adequate size, it is possible to reduce social spaces to a minimum. Students meet friends directly in their rooms, which are actively connected with balconies or courtyards

where they can socialise (Figure 6). The operational solution for accommodation cells with the second type of floor plans supports the preservation of intimacy and privacy of the individual, and at the same time it offers another area for meeting friends. As for the concept of accommodation cells with only one compact space in a room, there is no boundary between the perception of privacy and common social areas. According to a study by Kobue *et al*. (2017), students prefer single rooms that provide a feeling of privacy, a fast internet connection and flexible furnishing. The interest in single rooms stems from the fact that most students have never shared a bedroom, and many do not even have experience with a common bathroom (Rickes, 2009).

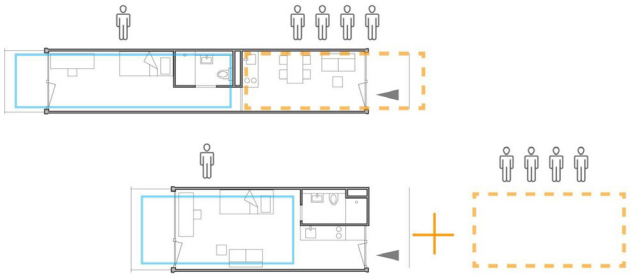

Figure 6. An operational solution for accommodation cells of the second (container) and first type (with only one compact space) – the perception of privacy.
(Source: Authors)

The interior of modular student cells is mostly furnished with flexible, easy-to-maintain furniture. A complex bathroom block, as well as a kitchenette, are integrated into the overall structure directly in the factory. In regards to conventional dormitories, the ratio of the students' living space to the area covered by accessories (hygiene, kitchenette, etc.) is 63:37 (Vráblová and Majcher, 2013). This is in contrast to the ratio found in the case studies for modular dormitories, in which the living space area is 83% of the entire unit. The furniture and finishes are implemented in various ways, one being a comprehensively furnished interior designed accordingly to previously taken measurements, as an integrated part of a prefabricated cell. Another option is to furnish the cell with standard furniture after mounting it at the construction site. In some case studies, the accommodation cell is not furnished, neither are the wall surfaces treated (in such cases students furnish the room themselves according to their own ideas). The advantage of a fully integrated interior is a higher quality of processing and a lower price, which is a consequence of the nature of mass production. The disadvantage is the impossibility of rearranging furniture according to the students' wishes. The extent of the degree of interior prefabrication depends on the capacity of the university home and the volume of the planned investment (as well as possible regional specifics).

Integrated built-in furniture tends to take up less space, which allows for better usability of smaller rooms. The resulting minimised living cell area reduces the costs of construction and especially the building operation, despite the integration of more demanding interior features. These buildings are then competitive with traditional buildings. However, built-in furniture requires more demanding and precise planning. The disadvantage of integrated built-in furniture is the inability to move it – to individualize the student room. One solution would be flexible furniture (rotating, sliding, folding pieces), which would make it possible to adapt the room for operation during the day and night.

The characteristic modular prefabricated student room has a large window opposite the main entrance over the entire area of the front facade. The large glazing of the windows provides space with plenty of daylight for typical long narrow spaces. The entrance to the rooms is either from an enclosed corridor or directly from the exterior gallery. Although the absent vestibule filter brings heat losses in the winter, it helps to ventilate the rooms in the summer. The accommodation sections of modular student residences are characterised by efficient sorting of prefabricated cells along a horizontal communication – most often in the form of an exterior gallery. The cells are oriented (in the more effective cases) by their shorter walls to a common communication and the windows are mounted on the front-facing facades or on both front walls. The composition of accommodation cells with a floor plan divided into two smaller living areas (long narrow floor plans of cells) does not allow a layout scheme of the three tracts: accommodation cell – communication – accommodation cell, because there would not be sufficient daylight in one part of the cell. The solution is to offset the opposite row of cells, creating a common courtyard that also supports the social interaction of students (Table 2). The suitability of the choice of floor plan for the accommodation section results from the characteristics of the parcel and the number of students accommodated. However, it cannot be stated that the typological form consisting of shorter modules (the first type of floor plan) is more effective, as the requirements for the creation of common spaces are increased and the room does not consist of an intimate and a social zone. Architectural design brings a number of variants of grouping modular residential student units into a functional unit, but it is important to find the right measure in the relationship between efficiency – invention – user comfort.

Table 2. The relationship between the functional division of the modular dormitory accommodation section and the manner in which they are used (35 case studies)

	space /use	individual use (1, 2 persons)	group use (up to 4 people)	common use
private zone	room	100 %		
	entrance hall	33 %	67 %	
	bathroom	92 %	8 %	
daily use zone	separate toilet	7 %	33 %	
	kitchenette	65 %	25 %	
	kitchen with dining	28 %	38 %	4 %
leisure activities zone	dayroom			
	study room			
	clubroom			4 %
	sport spaces			32 %
auxiliary equipment zone	laundry room			58 %
	sanitary facilities			5 %
	technical facilities			2 %

CONCLUSION

The concept of modular architecture in the general typology of university dormitories is a new understanding of spatial solutions for student rooms, resulting from the prefabrication of three-dimensional compositional spaces/cells. The architectural design of modular accommodation units is subject not only to conventional legislative requirements, but also to the standard of various transport modes. The disadvantage of the initial volume limitation of the prefabricated cell becomes a benefit in the sustainability of university campuses. The dormitory buildings are easily dismantled, transportable, and can be adapted. The main characteristic of modular student housing is its high degree of prefabrication. For the characteristic forms of modular units that are comprehensively prefabricated or modified from transport containers, a specific organisation of the interior space is necessary. In contrast to conservative (non-modular) university dormitories, a modular scheme creates a new floorplan of a residential student cell: a longitudinal floor plan with sanitary zone in the middle of the layout. The dual space of the longitudinal single room meets the current demands for progressive and socially valuable accommodation for university students. A secondary effect of a divided floor plan is its convertibility in the event of a change in the building's function in the future: a divided space with a two-sided orientation of living spaces brings more efficient use (for example in the form of lower standard apartments). The aim of the correct design is to have user-friendly, ecologically and economically efficient modular accommodation cells designed according to universal design requirements as the basic compositional unit of the dormitory.

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MAPPING URBAN DESIGN LITERATURE: A NETWORK-BASED APPROACH

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The aim of this paper was to analyze and connect the existing literature on urban design. The use of mapping methodologies from a network-based approach made it possible to chronologically identify the most relevant authors from a literature review on urban design and their contributions, establishing points of theoretical connection. The main result of this analysis was the construction of three proposed approaches: i) an environmental and ecological approach, including for example research about the third landscape, the healthy city or ecosystemic urbanism; ii) a technological approach with Industry 4.0 and iii) a participatory and gender perspective approach.

***Key words*: urban design, network analysis, ecology, gender, industry 4.0.**

INTRODUCTION

The importance of urban design can be seen in the continuous contributions that have been made to it in recent decades. Social, ecological, and technological evolutions and environmental problems are related to the factors that define the design of the built environment, involving both new interventions and the rehabilitation and regeneration of the existing built environment. Analyses related to previous theories on urban design enable the transmission of ideas and exchange of knowledge that advances the design of cities.

The main theoretical and urban design assumptions of the 20th century include the principles of the garden city and the industrial city as examples of the "top down approach" to planning, the Athens charter, "progressive urbanism" and "modernist planning" (Choay, 1965) and a participatory and advocacy planning approach from the 1960s. Theories and practices framed between the tuberculosis pandemic in the early twentieth-century and the two world wars led to the search for alternatives through the principles of rationalism or the Modern Movement in architecture and urban design developed around the world (Colomina, 2019). These principles were adopted by urban planners for the reconstruction of Europe after the Second World War. This movement also fostered the advance of theory and the development of associated congresses for debate through the "Congrès International d'Architecture Moderne" (1928-1959) and the subsequent split and spontaneous creation of Team X (1961-1981) with "The Doorn Manifesto".

Urban population movements in the last fifty years frame urban design approaches. As seen in Figure 1, there have been transitions from lower population levels in urban settings in 1960 to higher levels in 2019, such as in Gabon, Oman and Saudi Arabia. Other countries have made a reverse transition from high levels in 1960 to low levels in 2019, e.g., in Austria and Egypt. Still other countries that had high population levels in 1960 remained constant in 2019, e.g., Australia, Argentina, Belgium, Denmark, and others. According to UN Goal 11 (UN, 2015), which refers to "making cities more inclusive, safe, resilient and sustainable", and considering the gradual shift in residence of the human population from rural to urban areas, since 2007, more than half of the world's population lives in cities, and this is expected to increase to 68% by 2050. Urban design is pertinent in relationship with migration but it also includes agriculture robotization and the climate crisis, bearing in mind how rural, remote, desert and wilderness territories make up 98% of the earth's surface (Koolhaas and AMO, 2020). However, cities and metropolitan areas also account for about 70% of global carbon emissions, and they use more than 60% of resources. Moreover, rapid urbanization is most devastating in informal settlements and slums

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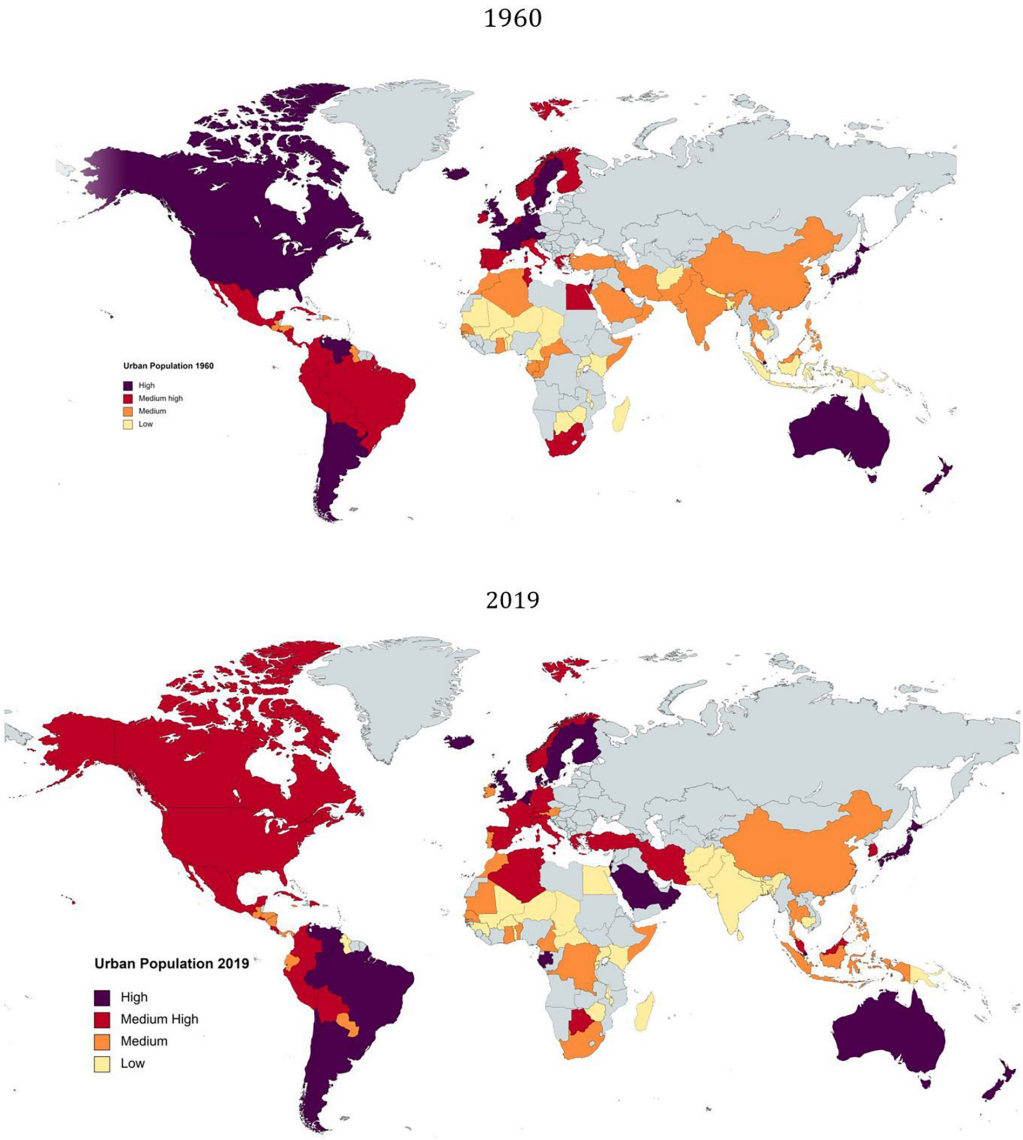

Figure 1. Percentage of urban populations in 1960 and 2019
(Source: World Bank data 1960-2019 and authors' own elaboration)

globally. Furthermore, in many cities, air pollution has become an unavoidable health hazard for both human and natural ecosystems (Figure 1).

Additionally, UN goal 5 (UN, 2015) to "achieve gender equality and empower all women and girls" is crucial in urban design. Women and girls continue to be subjected to harmful practices that profoundly affect their lives. They are too often denied decision-making power and participation. There are also insufficient laws and policies in the frameworks and spheres of public life that protect their rights. These objectives drive the need to cooperate in the collaborative, multidisciplinary and multicultural design of both rural and urban built environments from a gender-based perspective.

The aim of this paper is to analyze and connect existing literature on urban design and to make new contributions to the field. Attention is paid to making associations between authors, years and concepts, in order to shed some light on the complexity of this discipline. The methodological proposal to achieve the objective is based on network analysis or mapping methodology. This proposal has been used in different disciplines such as biology, economics, urban planning and architecture. The research carried out in this paper could be oriented as a pedagogical tool for students and researchers in the fields of architecture and urban planning and for people with an interest in these disciplines.

The paper is organized as follows: the methodology is presented in the next section. After that, the section deals with the review of the literature on urban design, in particular proposals by Ellin (1999), Cuthbert (2007b) and Foroughmand Araabi (2014, 2016, 2017). In the case of the latter two authors, theoretical connections are made between both. Then, a new contribution is made, based on three approaches to theories associated with the literature. In doing so, special attention is paid to multidisciplinarity in this field, which is an important requirement for different knowledge and key concepts that need to be considered.

Finally, the penultimate section enounces the results and discussion and final section presents the main conclusions.

METHODOLOGY

According to Fortunato and Hric (2016) the science of network analysis is a modern discipline that has a wide range of uses, for example, in natural, social, computer and engineering sciences, as well as in the built environment (Hillier and Hanson, 1984) and politics. Basically, networks are made up of edges that connect vertices or nodes. The formation of communities (network clustering) and their structure within the network, as well as the representativeness and importance of the actors (unit of analysis) are usually the objectives pursued. The centrality measures used are based on the researchers' decisions and the literature, and they allow the connections to be interpreted. Network analysis is a powerful visual tool, which provides information about relationships in complex systems. Its basic interpretation is as follows: starting from a subgraph C of a graph G, the number of nodes and edges are "n" and "m" for G, and "nc" and "mc" for C. The adjacency matrix of G is A, and its elements "A_{ij}" are equal to 1 if nodes i and j are neighbours, otherwise they have the value 0. The type of structure is assumed; for more detail, see Fortunato and Hric (2016).

Returning to the chosen centrality measures, the following measures were chosen: degree centrality, betweenness centrality, and modularity class. The degree *d* measure reported on the connection and representativeness of a node with respect to other nodes. The calculation of the degree value is shown in equation 1

$$d_i = \sum_{j \neq i} A_{ij} \qquad [1]$$

where d_i is the degree node *i* and A_{ij} is the adjacency matrix. The betweenness centrality measure is the number of times a node acts as a bridge on the shortest path between two other nodes. The calculation of the Betweenness B(v) is shown in equation 2

$$B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}} \qquad [2]$$

where σ_{st} is the total amount of shortest paths from node *s* to node *t* and $\sigma_{st}(v)$ is the quantity of those paths that pass through *v*.

According to Newman (2006) there are different ways of defining the concept of modularity. In this sense, modularity Mc is defined as the section of edges that fall within two groups (e.g., group 1 or 2), minus the probable sum of edges within groups 1 and 2 for a random graph with the same node degree dispersal as the given network. The calculation of the modularity class is shown in equation 3

$$Mc = \frac{1}{2m} \sum_{vw} \left[A_{vw} - \frac{k_v k_w}{2m}\right] \frac{s_v\, s_w + 1}{2} \qquad [3]$$

where v and w are the nodes with node degrees k_v, k_w and membership s_v and s_w respectively from a random network. A_{vw} is the adjacency matrix of nodes v and w. Finally, m is the total number of stubs in the network.

The free software Gephi was used because of its visual power (Force Atlas visualization algorithms were used for network definition and Louvain for modularity optimization). In relation to the concept of modularity, community is considered to be the empirically discovered relationships between the different elements of the network, according to Scott (1991). The structure of the databases was carried out by forming columns relating authors to years, authors to each other, and authors to the chosen topic. Subsequently, the choice of adjacency matrix format and the adjustment parameters in Gephi allowed the visualization and interpretation of each analysis network.

LITERATURE REVIEW

The information gathering process follows the phases mentioned by Larrán and Andrades (2017):

- search for relevant studies in urban design using urban design, urban development, social space, and spatial representations as some of the key words;
- screening of studies by analyzing their titles, abstracts and full texts;
- extracting information, by means of in-depth analysis of the papers, in order to control the quality; and
- forming different databases (authors, years, concepts), according to the selection of works identified.

Two analyses of previous literature reviews of great depth and temporal breadth were considered. The first is by Ellin (1999), perhaps one of the most extensive existing reviews, together with those of the urban design reader (Larice and Macdonald, 2012) and the city reader (LeGates and Stout, 2020) included in Figure 4. Attention was paid to the list of authors and their chronology, then those by Cuthbert (2007b) and Foroughmand Araabi (2016). In this case, the typologies proposed by these authors were compared.

Ellin (1999)

As a preliminary step, Figure 2 shows the word cloud that identifies the importance of the authors (left-hand side) and years (right-hand side) in the review carried out by Ellin (1999). In relation to the authors, Alexander, Lefebvre,

Figure 2. Word cloud authors and years Ellin (1999) review (Source: Ellin (1999) and authors' own elaboration)

and Jencks are the most represented, with six contributions followed by Lynch with five and Rossi with four. The years, 1969, 1965 or 1964 are the most represented (Figure 2).

Table 1 and Figure 3 show a network analysis which, firstly, confirms what has already been presented in Figure 2, and secondly, allows the nodes (authors and years) to be connected. In terms of the degree measure, which provides information about the importance of the nodes in the network, the brown and green nodes show the authors and years respectively. In relation to the authors, Alexander and Lefebvre have been present in the literature on urban design for many years. In particular, Alexander's research is related to 1964, 1965, 1975, 1977, 1979 and 1987 and Lefebvre's philosophy is show in 1967, 1968, 1970, 1972, 1974 and 1991, which implies that they have a relevant representativeness, as the edge connections show.

In addition to Figure 3, Table 1 provides information on the values of the metrics used by the Gephi software, which enables further analysis (Table 1).

Table 1. Values of network centrality measures from Ellin's (1999) literature review
(Source: own elaboration based on Ellin 1999)

Authors	Degree	Betweenness	Closeness
Alexander	**6**	**1162.91**	**0.247**
Lefebvre	**6**	**856.99**	0.238
Jencks	**5**	526.19	0.235
Lynch	**5**	**821.01**	0.213
Rossi	**4**	450.21	**0.252**
Mumford	**3**	285.59	0.194
Rudofsky	**3**	447.80	0.218
Venturi and Scott Brown	**3**	426.81	**0.244**
Bookchin	**2**	99.04	0.223
Boyer	**2**	152.00	0.133
Goodman	**2**	77.00	0.186
Halprin	**2**	225.00	0.182
Koolhaas and AMO	**2**	6.00	0.625
Krier	**2**	365.00	0.175
Newman	**2**	168.17	0.189
Rapoport	**2**	143.17	0.206
Stern	**2**	383.13	0.207

The degree value (Table 1) corroborates the representativeness mentioned above. The measure betweenness centrality (Table 1) refers to the importance of the extent to which a link node between other nodes in the network is relevant. This allows the connection/disconnection of other nodes in the network. Lefebvre, Lynch and especially Alexander have the highest values.

The closeness centrality measure is based on the idea that nodes with a short distance can propagate information quickly through the network. The highest values relate to Rossi, Alexander Ishikawa and Silverstein, Venturi and Scott Brown.

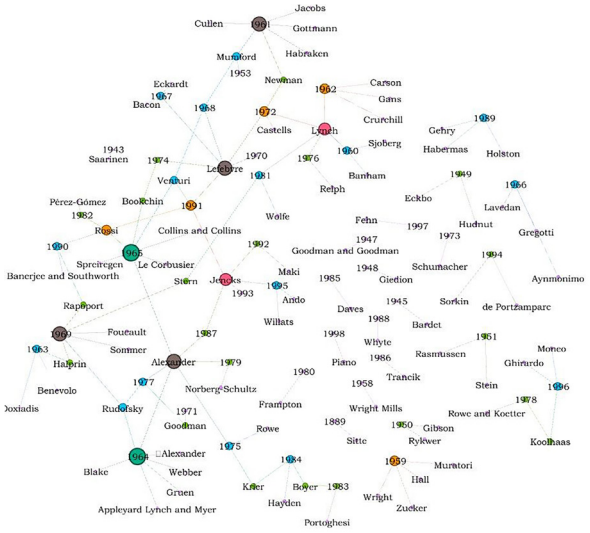

Figure 3. Network from Ellin's (1999) literature review
(Source: Ellin (1999) and own elaboration)

Proposals by Cuthbert (2007b) and Foroughmand Araabi (2014, 2016, 2017)

Figure 4 shows the network analysis, authors, year and research topic collected jointly by Cuthbert (2007b) and Foroughmand Araabi (2014, 2016, 2017). Cuthbert's (2007b) review and analysis are based on 40 selected contributions over the last 50 years of urban design. Foroughmand Araabi (2016) mentions the main contributions addressed by some universities in the USA, United Kingdom and Australia, and also, by those that these universities use in common. The metric called "modularity class" is used in this network to provide information about the structure of the network in modules or groups/clusters. These clusters with high modularity imply that they have dense connections between nodes of different modules. The limits of modularity are compromised when detecting small communities or clusters.

There are 27 communities or clusters. Cluster#1 with magenta nodes is the one with the highest modularity, as shown in Table 2, referring only to the authors' nodes. It is followed by cluster#2 in green, cluster#3 in blue, and cluster#4 in brown. Figure 5 is a detail of the mentioned clusters. As can be seen, cluster #1 is made up of Gehl's contributions with the research "Life between Buildings" and "Cities for People" published in 2010 and 1971, whose thematic denomination would be "social". Cluster #2 can be framed within "vernacular and critical regionalism" studies. Cluster #3 can be identified with "mathematical and compositional analysis". Finally, cluster #4 can be outlined with "perception of the urban environment". Clusters #1 and #4 can be grouped within "humanising urban space", while clusters #2 and #3 are framed within "searching and generation of patterns" (Figure 5).

In addition, Table 2 reports the measures of Degree, Betweenness and Closeness in relation to the overall network in Figure 4. Gehl, Alexander and Lynch's highest BC or Kostof, Halprin and Rudofsky's highest CC are analogous to how the network was previously analyzed in Ellin's 1999

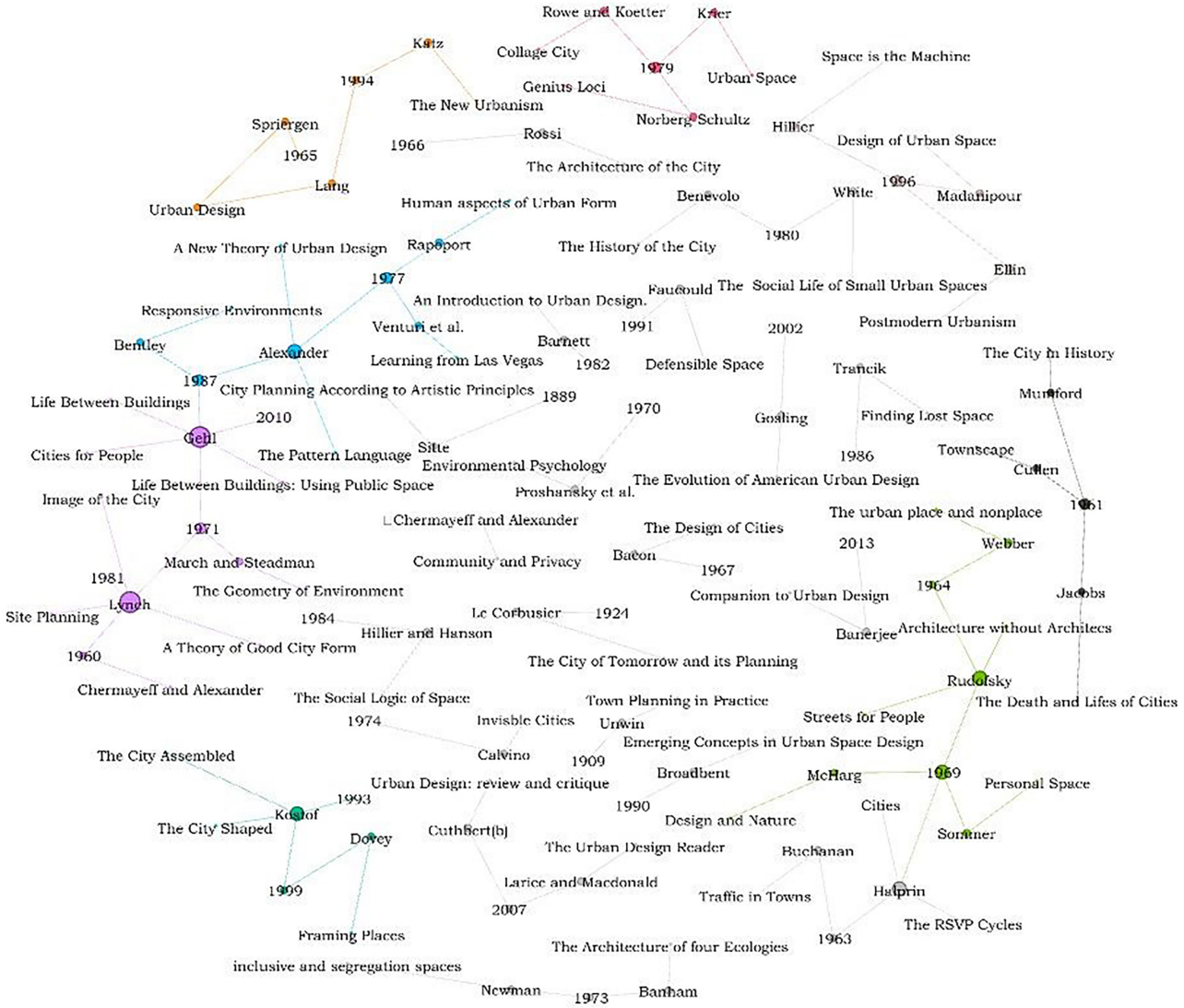

Figure 4. Network, of authors, year and research topic collected jointly by Cuthbert (2007b) and Foroughmand Araabi (2014, 2016, 2017) (Source: adapted from Cuthbert (2007), Foroughmand Araabi (2016) and the authors' own elaboration)

Table 2. Values of the network centrality measures from Cuthbert (2007), Foroughmand Araabi (2016) literature review (Source: adapted from Cuthbert (2007), Foroughmand Araabi (2016) and own elaboration)

Authors	Degree	Betweenness	Closeness	Modularity Class
Lynch	6	128.0	0.297	16
Gehl	6	200.0	0.378	16
Halprin	4	62.0	0.410	5
Rudofsky	4	62.0	0.312	4
Alexander	4	137.0	0.666	12
Kostof	4	12.0	0.5	14
Mumford	2	5.0	0.5	1
Jacobs	2	5.0	0.5	1
Cullen	2	5.0	0.5	1
Buchanan	2	15.0	0.253	5
Weber	2	15.0	0.253	4
Spriergen	2	5.0	0.375	2
Bacon	2	8.0	0.461	2
Sommer	2	1.0	1.0	3
Prohansky *et al.*	2	15.0	0.571	4

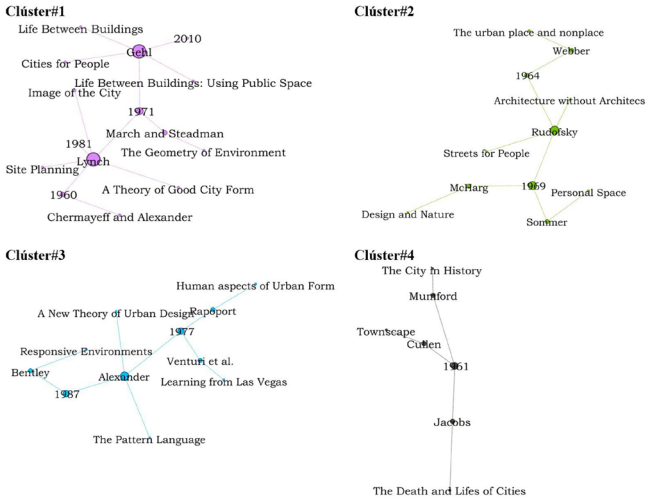

Figure 5. Example of four clusters of authors, year and research topic collected jointly by Cuthbert (2007b) and Foroughmand Araabi (2014, 2016, 2017) (Source: adapted from Cuthbert (2007), Foroughmand Araabi (2016) and authors' own elaboration)

analysis, thus informing us on the representativeness and information propagation in the network (Table 2).

Cuthbert (2007b) and Foroughmand Araabi (2016) conducted qualitative analyses, to classify the contributions made by the authors in their respective reviews. Cuthbert (2007b) made three distinctions:

- "Collage City", Rowe and Koetter (1979); "Concepts of Urban Design", Gosling and Maitland (1984); "Finding Lost Space-Theories of Urban Design", Trancik (1986); and "Emerging Concepts in Urban Space Design", Broadbent (1990);
- "A Theory of Good City Form", Lynch (1981); "Urban Space", Krier (1979); "The Social Logic of Space", Hillier and Hanson (1984); "A New Theory of Urban Design", Alexander (1987); and
- the influence of practice on urban design theories, in two blocks, Sustainability and New Urbanism with a certain paradigm tendency that seems to overshadow other approaches.

Foroughmand Araabi (2016, pp. 13-14) classifies literature into three types:

- Type I: Theories of composition of mass and space: "Artistic Principles", Sitte (2013); "Space Syntax", Hillier and Hanson (1984); "Theories about visual aspects of public spaces", Trancik (1986); "Townscape", Cullen (2012); "Theories of the image of the city", Lynch (1960); "The Death and Life of Great American Cities", Jacobs (1984); "Theories to evoke social interaction", White (1980); "The Social Life Of Small Urban Spaces", "Life Between Buildings", Gehl (2011); "Theories to enhance identity, studying history and the meaning of cities", Krier (1993);"The City Shaped", Kostof (1999); and "Collage City", Rowe and Koetter (1978);
- Type II: Theories about the object of urban design with a comprehensive view of what urban design objects are about (descriptive emphasis): "Good City Form", Lynch (1981); "Public Places and urban Spaces", Carmona *et al*., (2003); and theories about how to improve the object of urban design (prescriptive emphasis): "Responsive Environments", Bentley *et al*. (1987); and
- Type III: Theories about the knowledge of urban design. Theorising urban design knowledge from the perspective of other disciplines: "Design of Urban Space", Madanipour (1996) and "Place-shaping Continuum", Carmona (2014).

The classification made by these two authors has points in common. Figure 6 illustrates the methodology proposed in this paper.

For example, Lynch (1981); Hillier and Hanson (1984), Trancik (1986), Krier (1993) and Rowe and Koetter (1978) are part of the common theoretical framework of both literature reviews, while the unconnected external nodes are the individualized theoretical contributions of each author.

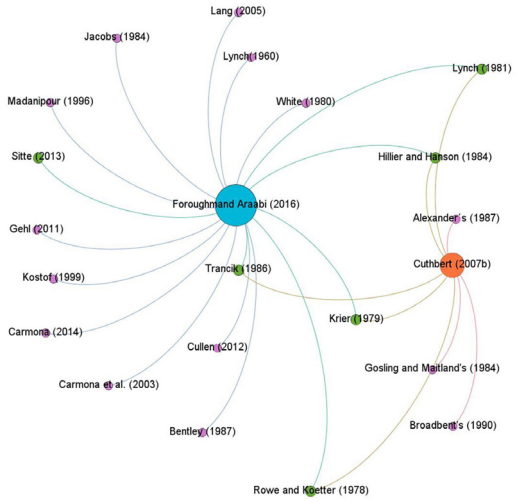

Figure 6. Conceptual (Dis)connections of Cuthbert (2007), Foroughmand Araabi (2016).
(Source: adapted from Cuthbert (2007), Foroughmand Araabi (2016) and own elaboration)

SOME ANALYTICAL CONTRIBUTIONS TO URBAN DESIGN

The literature review carried out in the preceding sections allows us to continue with new developments and to analyze the contributions in the field of urban design. To this end, three approaches were established with regard to the Sustainable Development Goals (UN, 2015) in order to outline guidelines for urban design in the future. These goals relate directly to architectural and urban design in an integral way and consider all its facets, starting from the available resources and energies, and including the actors involved in the interdisciplinary design process. Figure 7 shows the connections between Cuthbert (2007), Foroughmand Araabi (2016), and De Jorge-Huertas and De Jorge-Moreno (2021). The connections with the reviews analyzed were established based on the authors that connect them (green and blue nodes). The authors represented by the external

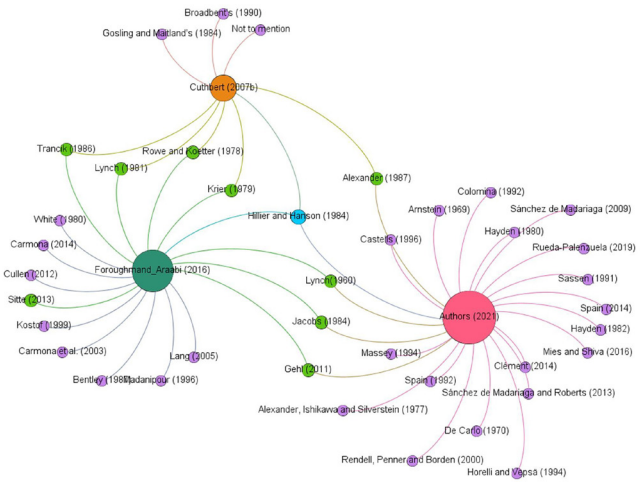

Figure 7. Conceptual (Dis)connections from Cuthbert (2007), Foroughmand Araabi (2016) and De Jorge-Huertas and De Jorge-Moreno (2021)
(Source: adapted from Cuthbert (2007), Foroughmand Araabi (2016) and authors' own elaboration)

radio centric mauve nodes refer to the individual theoretical contributions (Figure 7).

The following theoretical approaches are explained: (i) environmental and ecological approach, (ii) technological approach and Industry 4.0, and (iii) participatory and gender-based approach. The three of them are shown in Figure 8.

Environmental and ecological approach

This approach is centered on theories around the natural and anthropized environment, and it focuses on the relation with the environment and its ecosystems or the relationship with animals, plants and landscape ecology in urban design. In this regard, we can consider several visions and utopias: from ancient Babylon with its hanging gardens, Ebenezer Howard's garden cities, Arturo Soria y Mata's linear landscaped city or Frederick Law Olmsted's urban parks, Frank Lloyd Wright's Broadacre City of 1934, agrarian urbanism and ecological urbanism, the "agropolis" or "agrarianism", the agricultural city in the context of Japanese metabolism with Kisho Kurokawa in the 1960s and "Agronica" by Andrea Branzi's group in 1995. These previous case studies and other works already built have resulted in some guidelines in relation to urban and architectural design in synergy with nature. Additionally, recent research on "the third landscape" (Clément, 2014) advocates taking care of the environment without pesticides. It is relevant to take the landscape into account in the design of the built environment and to do so through "ecosystemic" urbanism (Rueda-Palenzuela, 2019), e.g. the "superilles" in Barcelona. In addition, this approach should make visible ecofeminist theories, valuing the role that women play in putting forward ideas related to ecological destruction and industrial catastrophes (Mies and Shiva, 2016). One of these ecofeminist ideas could be enabling teleworking to reconcile work and family life, and reclaiming abandoned villages and rural places. Furthermore, this approach also focuses on promoting organic materials with lower emissions, such as wood, and the future transparent wood, or materials and construction systems with lower energy and economic expenditure, by reducing the time and type of transport required for the materialization of urban designs.

Technological approach and Industry 4.0

Alternatively, in other layers of urban design, there is a new technology-based approach based on artificial intelligence, digitalization and virtual and biological worlds superimposed on the built environment (Industry 4.0). Authors such as Hillier and Hanson (1984) could be considered pioneers in the application of graph theory to the discipline of architecture, an approach focused on dialogue with systems through "Space Syntax". Consideration should also be given to the link between urban design and new intangible information and communication networks (Castells, 1996) or the technologies of global cities (Sassen, 1991). "Global cities" need networks that required large refrigerated servers for their subsistence. In fact, in the last two decades entire "cities" have been designed for machines with the advent of the worldwide computer network that uses the telephone line to transmit information. Complete cities have been designed with cooling towers and data centres located in Prineville, Iowa, Douglas and Lenoir (USA), in Saint-Ghislain (Belgium), in the former Stora Enso paper mill in Hamina (Finland) converted into a data centre and in Luleå (Sweden). Entirely new typologies of architecture and urban design have been brought about by a 21st century phenomenon. The "Internet-network" as a decentralized set of interconnected communication networks, with its pros and cons, is already a planning and design tool for the built environment in the digital age. Moreover, it has been assimilated as a "path" by society, from its designers to the users themselves. The map, now virtual, is on a micro-device connected to the internet through the Global Positioning System (GPS). In this sense, entire cities have also been developed linked to large technology companies such as Google in California. These new phenomena could be understood as a Fordist reinterpretation of the industrial cities designed ad hoc to control workers in the 20th century. In today's information age this model tends to be repeated with intangible and delocalized industry.

Participatory and gender-based approach

The participation-based urban design approach began in the late 1960s. However, it has been a re-emerging and recurring interdisciplinary theme since 1980, including its gender-based perspective, as Daphne Spain (1992) points out. On the one hand, authors such as Lynch (1960), Alexander *et al.* (1977) and Alexander (1987) provide a generative design through a system of patterns for the production of the urban form in what could be considered a "pro-participatory" approach influenced by the systems and hierarchies of mathematics and biology.

On the other hand, authors such as Hayden (1980, 1982), Jacobs (1984), Colomina (1992), Massey (1994), Horelli and Vepsä (1994), Rendell *et al.* (2000), Gehl (2011),

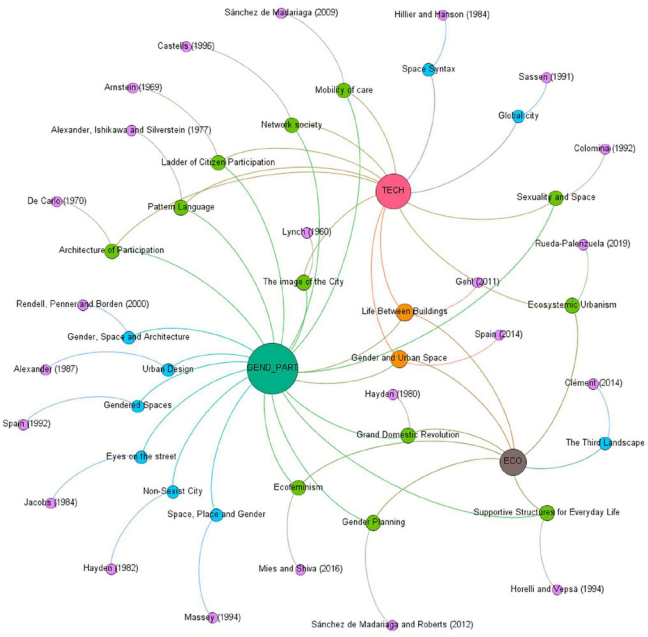

Figure 8. Approaches i) environmental and ecological (brown node), ii) technological and Industry 4.0 (magenta node) and iii) participatory and from a gender perspective (green node).
(Source: Authors, 2021)

Sánchez de Madariaga and Roberts (2013), and Spain (2014) have created a solid research framework in relation to urban design and participatory planning from a gender perspective, studying the safety and humanization of spaces at any scale from architecture, landscape to urban planning, and, proposing the deconstruction of patriarchal distribution of space. These studies analyze factors and agents of change for urban design such as the critique of the "man-made" environment, the "chain of tasks" and the "mobility of care" (Sánchez de Madariaga, 2009), spaces and their different needs associated with gender, the relationship between LGBT communities and creative cities, the creation of health and self-help clinics, queer sites, feminist bookshops and domestic violence shelters, the development of public facilities with free choice participation of citizens (Arnstein, 1969) and "the public of architecture" (De Carlo, 1970), also promoting the need for pedestrianised urban spaces, reducing the need for car use and promoting the triangle "services - work and home" with proximity (Figure 8).

RESULTS AND DISCUSSION

This work has analyzed and connected the existing literature on urban design. Special attention has been paid to previous studies by Ellin (1999), Cuthbert (2007b), Foroughmand Araabi (2016) and others. Points of theoretical connection between themes and their references were established, and then some contributions to urban design analysis were proposed. In this sense, if urban design is getting close the 2030 Sustainable Development Goals, perhaps the approaches previously addressed in this paper can be considered. Regarding the first approach, related to the environment and ecology, urban design should decarbonize the energy system of the built environment completely by 2050. This entails taking into account the design of landscape ecology in urban planning, increasing shared public and alternative transport, promoting a circular economy through self-sufficiency and non-energy dependence, creating urban farms with Km.0 products and seedbeds in the city, recycling and reusing materials, energy and waste, and improving acoustic and air quality. In relation to the second approach, urban design could tend towards becoming interdependent with new technologies and digitalization from applications, in order to calculate and forecast pollution or waiting times and provide thermo-atmospheric sensors personalized to each individual's health. It could provide the possibility for citizens to go beyond being consumers or passive recipients. Citizens could be creators with virtual realities and wearable devices or through connected 3D printing. Regarding the third approach, both safety in urban space, a sense of local and global belonging and identity in urban places, as well as the deconstruction of the "tyranny of gendered spaces" are increasingly inescapable factors, and urban design can help to foster more equitable spaces through urban design for the work-life balance and care, compactness, livability and accessibility of the city by prioritizing the different users in the city.

CONCLUSIONS

The aim of this work has been to map and investigate the existing literature on urban design. The use of mapping methodologies from a network-based approach has allowed us to chronologically identify the most relevant authors from a literature review on urban design and their contributions, establishing points of theoretical connection between them. The main result of this study is the construction of three possible approaches: i) environmental and ecological, including for example research about the third landscape, the healthy city or "ecosystemic" urbanism; ii) technological and Industry 4.0 and iii) participatory and from a gender perspective.

Possible extensions could be related to specific case studies or pivotal cases based on the approaches and theories analyzed by mapping. Another extension could involve the simultaneity of approaches creating new contributions, e.g., an urban design approach oriented towards and specializing in ecological dialogue from a gender perspective could be a new approach to research, which could generate contemporary theories, policies and practices.

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