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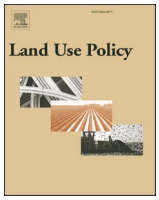

Investigating urban form, and walkability measures in the new developments. The case study of Garnizon in Gdansk

Damian Poklewski-Koziełł [a], Karolina Dudzic-Gyurkovich [a,*], Carlos Marmolejo Duarte [b,*]

[a] Faculty of Architecture, Cracow University of Technology, ul. Warszawska 24, 31-155 Cracow, Poland
[b] Centre for Land Policy and Valuations (CPSV), Barcelona's School of Architecture (ETSAB), Universitat Politècnica de Catalunya, 08028 Barcelona, Spain

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ABSTRACT

Sustainable transport choices are gaining much attention as they may support the global shift towards reducing the carbon footprint and developing more energy-efficient cities. The relation between urban form and sustainable transport has been discussed by academics and practitioners and there is a consensus that specific parameters of urban form can encourage walking and discourage car use. Following global recommendations on sustainable development, countries take steps towards strengthening pedestrian accessibility by implementing spatial characteristics of walkable neighbourhoods, but also by mobility and urban design strategies. This issue, however, is not properly recognised in countries with short experience in sustainable urban development, such as former socialist countries. In Poland no studies on walkability-related parameters of urban form have been carried out, hence the knowledge in this field is limited. This paper aims to address this gap by providing evidence of a newly built urban district located in Gdansk, Poland. We present the Polish case with three examples of new urban districts from Western Europe, that are designed as sustainable and walkable environments. The methodology is based on the descriptive case study. It includes characteristics of design parameters namely the components of the "walkability index" as well as mobility solutions and urban design guidelines. The results show the current position of Garnizon development in relation to the Western European cases with regard to the existing post-communist legacy and allow for indicating differences and possible shortcomings. Additionally, the study results can be discussed in the context of improving the quality of the housing environment in Poland through pedestrian-oriented development strategies.

1. Introduction

The growing importance of energy efficiency and the need to reduce carbon footprint by individual world economies raise questions relating to further strategies for the spatial development of cities that have the strongest impact on the natural environment and contribute significantly to climate change. Sustainable development and managing growth of urban areas constitute the primary objective of urban policy since the 1990 s and numerous concepts, models and typologies emerged among researchers as well as working professionals and decision-makers. Dispersed, scattered urban areas are associated with negative environmental, health and social outcomes such as reducing the amount of natural land, pollution, and increased travel time and transport costs (Saeidizand et al., 2021). Most of the travels, in this case, are made by individual motorised transport, which results in growing car dependency and a sedentary lifestyle.

It is agreed upon that limiting car use and strengthening pedestrian accessibility can steer urban development toward a more sustainable path. Walking as a basic human activity provides mobility in terms of reaching different destinations as well as gives possibilities for outdoor recreation and exercise without the need for specialised equipment and additional costs. As such it plays a vital role in promoting and supporting both physical and mental health and the relationship between walking and positive health outcomes is gaining more attention lately (Chen et al., 2021; Lorenzo et al., 2020; Pae and Akar, 2020). The multiple benefits of walking have been broadly acknowledged and there is agreement among experts that walking in an urban environment can be a valuable part of everyday activity (Nordh et al., 2017). Additionally, walking represents an environmentally friendly transport option and is one of the key elements of sustainable development. As walking is one of

* Corresponding authors.
E-mail addresses: damian.poklewski-koziell@pk.edu.pl (D. Poklewski-Koziełł), kdudzic-gyurkovich@pk.edu.pl (K. Dudzic-Gyurkovich), carlos.marmolejo@upc.edu (C.M. Duarte).

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the travel modes it is subject to travel choice decisions, which consist of travel route choice and travel mode choice. Both of the travel characteristics are potentially affected by the environmental conditions, however, the travel mode choice is getting significantly more attention. It is important to understand why walking is chosen over other modes of transport and what mechanisms underlie this decision, as it may provide a prerequisite for designing urban and transport policies. The existing research, suggests that the decision on the travel mode is a process that involves both internal (individual) and external (social, environmental) correlates (Abastante et al., 2021; Giles-Corti and Donovan, 2003). While studying the individual correlates gives a certain, valuable knowledge on human decisions considering walking, it does not provide the tool for shaping the urban form as walkable. It is where the external, in particular, environmental factors come into play. They can be easily tested, and a potential association between walking and built environment characteristics can be established (Lin and Moudon, 2010). Various studies have addressed this issue and numerous neighbourhood characteristics that foster or discourage walking were studied (Consoli et al., 2020; Frank et al., 2006; Hoehner et al., 2011).

In order to indicate how conducive for the utilitarian walking certain neighbourhood is a construct called "walkability" is used. It relates to pedestrian activity and the ability of the built environment to support it through its characteristics, accessibility and attractiveness (Kelly et al., 2011; Moura et al., 2017). The above definition is useful for a common understanding of the phenomenon, but it is not precise, especially concerning the parameters that should characterise the built environment. The literature review, however, does not bring a uniform, conceptual definition, on the contrary, it reveals numerous definitions formulated for the needs of specific research.

The latest definition of walkability comes from the study by M. Tobin (Tobin et al., 2022), which was devoted to discussing the term in working groups and searching for consensus. The final version of the definition focuses on promoting multiple types of physical activity, with walking being one of them, through the natural, built and social features of neighbourhoods. This study does not contribute significantly to the discussion on the walkability definition, hence it proposes the broadest understanding possible, nevertheless, it reveals that the term is still far from specific. Having said that, as we later follow the method introduced by L.D. Frank, we decided to prioritise his approach to the concept of walkability as it refers directly to urban parameters. It is conceptualised as: " the extent to which characteristics of the built environment and land use may or may not be conducive to residents in the area walking for either leisure, exercise or recreation, to access services, or to travel to work"(Leslie et al., 2007).

The majority of existing urban form and walkability research focuses on the cities of Western Europe, Northern America or Australia. Likewise, Asian cities are getting more attention lately, which is motivated by the need to understand the walkability in different urban environments and population conditions (Li et al., 2021). However, similarly to other former socialist countries of Central and Eastern Europe, Poland is still underrepresented in studies concerning important global urban trends, and walkability in particular. In consequence, the role of walkable, pedestrian-friendly environments in Poland is still not properly recognised. We share the opinion of K. Stanilov, that there is a domination of issues related to politics, economic development and social transformation in the scientific discourse, and at the same time the evolution of urban form is receiving less attention (Stanilov, 2007). Having said that, our aim in this study is to explore the possibility to implement global trends on sustainable urban development in the context of the post-socialist city and to draw attention to the regions, where the problems of the built environment and its relation with parameters and characteristics that determine walkability are studied and implemented to a lesser extent.

In light of the ongoing global discussion on limiting car traffic and creating walkable neighbourhoods, it is important to verify whether new city districts coming into being in Poland are capable to follow that trend and identify possible shortcomings. Our initial assumption was to explore and learn from the European experience what parameters and design characteristics of urban tissue are used in the construction of neighbourhoods where walking is given priority and additionally individual car traffic is limited, without compromising the residents' needs. Consequently, we would like to contribute to the existing literature on walkability in two ways. Firstly, we will offer insights from a post-socialist, developing country, where strategies for sustainable transport and urban planning are not fully established, yet it constitutes an arena of dynamic and uncontrolled urbanisation (Kowalczyk et al., 2019). Secondly, by analysing the selected Polish case in relation to other large-scale urban developments chosen as reference cases we improve the general understanding of environmental factors affecting the walkability of urban neighbourhoods. By showing "what works" and establishing the relevant case studies, the findings can be potentially useful for stakeholders and decision-makers. We believe that the Polish case can be a valuable object of investigation, as it may reveal new problems that should be discussed or solved in the process of transforming the post-socialist cities into better and more walkable ones.

Further in our study, we use a method that provides assessing the parameters of urban form associated with good walking conditions. The metrics were derived from the "Walkability Index" designed by L.D. Frank. We decided to rely on his method for two reasons: firstly, it allows us to test the urban developments at the initial stage when buildings and public spaces were still under construction and more precise parameters, concerning neighbourhood design, were not available. Secondly, it is simple, fast and possible to repeat in all the selected cases without the need for using specific software, it also allowed for easy comparison of basic parameters. To supplement the picture of each case we identified and presented additional characteristics, also commonly associated with supporting walking in urban neighbourhoods. As reference cases, which are expected to constitute a base for comparison, we chose three developments located in Austria (Seestadt), Denmark (Nordhavn), and the Netherlands (Sluisbuurt). According to the initial research, these rank among the most progressive examples of integrating smart and sustainable solutions, especially in the field of mobility (Österreicher and Treberspurg, 2019; Poklewski-Koziełł, 2018; Wang et al., 2017). This goal is to be achieved, among others, through the shaping of the urban form, therefore we found it suitable for our purpose.

This paper is organised in the following sections: (1) the literature review focuses on the relationship between urban form and active transportation modes and the socio-economical background of urban development in Poland just before and after political transformation; (2) the research methodology and case study selection are described; (3) the obtained results are presented and discussed and in the last chapter and possible future research directions are formulated.

2. Literature review

In the literature review, we summarise the research on walkability and the parameters of urban form that are commonly related to walking and walkable neighbourhoods. We also investigate different methods used to measure those parameters and select the most suitable for the purpose of the study. Subsequently, we present the socio-economical background of urban policy and urban planning in Poland and place it in the existing studies on post-socialist transformation. We also summarise the research on issues related to walkability. To obtain the best perspective possible on the selected case study, a brief insight into the actual trends in developing housing complexes in Polish cities is presented.

2.1. Urban form and walking

In the last years a substantial body of literature was devoted to the factors mediating human physical activity, as it is essential for the health and well-being of individuals and societies, however the theoretical

mechanisms that lead to the decision of undertaking activity are not obvious. Numerous theories are used to create the framework for understanding physical activity, however the majority of the approaches focus on the individuals and their intentions to engage in activity, for example, social cognitive approach or the humanistic approach (Rhodes et al., 2019). In contrast, the socioecological model explains behaviour through the environment and policy, which contributed to its popularity in urban studies (Saelens et al., 2003). According to that model, human behaviour in general is influenced by numerous levels of factors including individual, interpersonal, environmental and policy related (Bauman et al., 2012). Drawing from the socioecological theory different studies suggest that physical activity including walking may be affected, among others, by built environment characteristics such as proximity of homes and other destinations (Saelens et al., 2003) or good access to attractive open spaces (Giles-Corti et al., 2005). Consequently, urban form is perceived as a factor which can support and facilitate the choice of active modes of transport (Lin and Moudon, 2010).

There is a large body of scientific research that focuses on the relationship between urban form, walking and its multidimensional positive outcomes. Several areas can be mentioned here with physical and mental health as the most visible. First of all, Frumkin et.al (Frumkin et al., 2004) provided a comprehensive look at the complex relationship between urban planning, architecture, transportation, community design, and public health and confirmed that the way the buildings and neighbourhoods are designed can inhibit physical activity and social interaction, hence foster sedentary lifestyle.

Next, it is mentioned that different social age groups can benefit from the presence of walkable neighbourhoods. For example, F Alves et al. propose the Walkability Index for Elderly Health concerning the specific needs of senior citizens. It was mentioned to constitute a useful tool in choosing routes for daily trips. At the core of this research lies the assumption that walking is a necessary activity to stay healthy and that the urban environment can become a good place to walk (Alves et al., 2020).

Another identified benefit of the walkable environment is the potential to build social capital and a sense of community through increased interactions. The relation between walkability and social capital is well recognised in the literature. As explained by K. Leyden (Leyden, 2003) citizens living in traditional, mixed-use, pedestrian-oriented areas were more likely to meet their neighbours, and trust other people. For their part, S. French et.al (French et al., 2014) argued that a stronger sense of community is associated equally with walking and the perceived neighbourhood quality. The most recent review study confirms that the formation of social capital as an effect of walking can be associated both with land use patterns and the design of neighbourhood facilities. Especially provision of green spaces and urban furniture was found to affect social capital more than the excess density of the urban form (Morales-Flores and Marmolejo-Duarte, 2021).

Finally, implementing the principles of walkable cities has been proven to have economical value reflected in increased property values (Choi et al., 2021). Considering the problem from a wider perspective of a country and region, Gösling et.al, revealed that the costs of building, maintaining, and using motorised transport infrastructure are largely underestimated (for the territory of the European Union); therefore the departure from this form of mobility toward walking can be also justified by economic reasons (Gössling et al., 2019).

It should be noted, that in the discussion on walkability a significant contribution comes from the work of urban designers and practitioners. They suggest, that for pedestrian traffic to go smoothly, appropriate conditions should be established. J. Gehl argues that the urban form can influence and shape social behaviours that happen in spaces between buildings. According to his observations in a high-quality neighbourhood different types of activities may take place including meetings, watching other people and taking part in public life. At the same time, low quality in particular car-oriented neighbourhoods discourages walking for other than necessary purposes (Gehl, 1987). Another contribution from the field of urban design comes from J. Speck and his book "Walkable City Rules" (Speck, 2018). His definition of a walkable city refers to the results of walkability: it is a place where walking is useful, safe, comfortable and interesting. Later, he gives practical rules for organising the city space to make it walkable, thus vital, healthy and green.

In the context of the quality of the neighbourhood, or speaking generally, the quality of the urban space two important factors need to be mentioned. The first is the presence of green areas, which contribute to the health and well-being of the citizens (Kabisch et al., 2016; Le Texier et al., 2018) but also, as studied by M. Bakhshi improve the image and beauty of the city space (Bakhshi, 2015). According to the examination study by A.Russo and G. Cirella (Russo and Cirella, 2018), the recommended green space provision for European cities varies from a minimum of 9 m^2 to as generous as 50 m^2 per inhabitant. Additionally, the increase in urban development should be accompanied by a corresponding increase in the amount of natural areas (blue and green) to enable contact with nature and avoid overcrowding (Arnberger, 2012; Dudzic-Gyurkovich, 2021). The second component is the presence of public spaces. Designers and practitioners perceive them as key components of the urban fabric in terms of facilitating public life (Carmona et al., 2003). A study by S. Karuppannan and A. Sivam found that there is an increase in social interactions that can be associated with the location of the houses around open public spaces (Karuppannan and Sivam, 2011). It can be stated that in those two types of spaces: urban green areas and public spaces most of the social interactions in urban areas take place. Therefore they should be taken into consideration when discussing the walkability of the neighbourhood. We found, however, that there are no studies in which the indexes of urban green areas and public spaces are included directly in the walkability assessment.

There is agreement among the researchers as to the fact that higher residential density, shorter distances, functional diversity as well as the proximity of public transportation are important determinants of a walkable environment (Clifton et al., 2008; Ewing and Clemente, 2013; Lee and Moudon, 2006). For their part, K. Dovey and E. Pafka refer mostly to morphological properties of urban space and define three main factors which influence the level of walkability - these are density, a mix of land uses, and access (Dovey and Pafka, 2020). The importance of those three factors, i.e. density, mix and access, is not new in the discussion on the quality of neighbourhood, and can be derived from works by J. Jacobs on vital neighbourhoods and life being held on the street. In her writings, she articulated the need to design compact, multifunctional, and permeable cities (Jacobs, 1961). Today this can be related to the 15-minute city, a concept introduced lately by C. Moreno, where most of the needs can be satisfied in the close neighbourhood, which limits the need to use a car and dependability on this mode of transport (Guzman et al., 2021; Moreno et al., 2021).

From a complementary research perspective, other components of walkability are stressed. Some researchers treat density as the key concept in the description of a city's spatial structure, as it enables proximity to places and their users - residents, employees, employers and other participants of socioeconomic processes (Krehl et al., 2016). However, concerning density, there are numerous ways to approach the problem. Some definitions refer to geometry operating with site coverage, and floor area ratio (Cao et al., 2016), while others consider also population density (Clifton et al., 2008), which contributes to the number of pedestrians on the streets. The important measure combining the geometry and the population issues is the residential density index describing the number of residential units per target area, as used by L. D. Frank et al. (Frank et al., 2010).

The next key component identified in the research is the functional mix describing not only the share of different land use functions in the target area but also its spatial distribution. The importance of functional diversity is highlighted in the literature as opposed to functional zoning, and it is positively associated with the walkability of the neighbourhood (Carmona et al., 2003; Raman, 2010). Moreover, as studied by A.Wandl

and B. Hausleitner (Wandl and Hausleitner, 2021) there is a relation between functional mixing and other characteristics of walkable urban form such as permeability (the ability of the urban form to permit the movement in different directions), grain size, centrality, accessibility, and connectivity. For his part, Christian et al. (Christian et al., 2011) connected the several types and times of walking (transport, recreational, i.e., > 0, ≥ 60 or ≥ 150 min/week) with land use categories using different Land Use Mix (LUM) models. The study also demonstrated that regardless of the LUM model tested, the residents living in walkable neighbourhoods were twice more willing to walk for transport and recreational reasons.

The third issue mentioned in the research is the pedestrian permeability of the area, a concept that is mostly used in urban design and can be defined as "the extent to which a particular urban morphology is permeated by publicly accessible space" (Pafka and Dovey, 2017). The permeable area can be associated with the dense connection of the street patterns and the lack of barriers (Delso et al., 2017). Urban researchers and planners have long been interested in the relationship between the configuration of the street network and mobility (Porta et al., 2006). There is a growing amount of research on establishing the correlation between street centrality and economic or social dynamics, in particular the movement of people (Bielik et al., 2017; Hillier, 2007; Pont et al., 2019). The importance of street configuration is underlined by A. Ozbil et al. (Özbil et al., 2015), in the study of districts of Atlanta, where they state that streets act as the long-term framework within which land uses change over time, thus streets should be considered as the key determinant of walkable urban fabrics. Several studies directly link street connectivity with an increase in active transportation, specifically walking, (Berrigan et al., 2010), and provide empirical evidence for the reduction in the number and time of motorised travel (Zlatkovic et al., 2019).

Due to a growing interest in active forms of transport and walking in particular, demand for methods of evaluating parameters of the built environment that might support walking has been observed. This, in turn, has resulted in the development of numerous methods of evaluating urban form. The tools used to assess walkability are diverse and depend on the research perspective. They include spatial and geographical information systems (GIS), audits and inventories, indices, questionnaires and surveys and they can be generally divided into two categories: (1) based on objective measures of urban form that have a positive impact on walkability (Giles-Corti et al., 2005; Leslie et al., 2007; Sung and Lee, 2015) or (2) based on personal perception of environmental characteristics such as pleasantness, safety, comfort, but also good lightning, or fewer cars on the streets (Ariffin and Zahari, 2013; Fancello et al., 2020).

Since urban sprawl is strongly associated with car dependency which in turn results in reduced walkability, S. Hamidi et al. (Hamidi et al., 2015) measured the sprawl index using appropriate data on residential density, and land use mix, degree of centreing, and street accessibility. A similar set of factors was used previously by L.D. Frank et al. (Frank et al., 2010; Leslie et al., 2007) in the measurements of the walkability index. The final formula included residential density, street connectivity, and land use mix. Additionally, an interesting field of research is based on the purely mathematical analysis of spatial layouts including centrality measures of streets and open spaces, (Crucitti et al., 2006; Pereira et al., 2013; Porta et al., 2006) and embedded in the Space Syntax method (Batty, 2004; Hillier, 2007; Talavera-Garcia, 2012). The most valuable contribution of these methods lies in utilising the spatial and geographical data in the first place, which enables the evaluation of the spatial layout of the development already at the design stage.

An important contribution, in which the qualitative and quantitative measures of walkability are connected comes from the R. Talavera-Garcia. (Talavera-Garcia and Soria-Lara, 2015). Their study incorporated some measurements of the elements of urban design, such as sidewalk width, traffic speed, tree density and commercial density resulting in an integrated Q-PLOS walking index. The results of the study indicated significant differences between the two studied urban environments of Granada (Spain): traffic-oriented and local-oriented in terms of meeting the walking needs of pedestrians. Due to the required fieldwork and detailed assessment of relevant factors (number of trees, pavement width, furniture, shop windows, etc.) this method may be the most useful in estimating the quality of existing neighbourhoods and possibly opening the discussion on improvements, while in case of new developments its usefulness is limited.

Finally, walkability can depend on urban policy and space management strategies, that need to be implemented especially in the field of car parking. The presence of heavy traffic contribute to creating an unsafe environment for pedestrian and cyclists, it also lowers the aesthetics of the street which, in turn, discourages walking (Buehler et al., 2017). J. Speck, from the urban design perspective, opts for reducing the number of cars parking on the streets and sidewalks and reclaiming additional space for pedestrians, he also points to the importance of proper parking fees and shared parking strategies to effectively reduce individual car use (Speck, 2018).

The discussion on the legal framework and urban strategies is probably the most complex of all the issues regarding walkability as it varies among different countries, even in Western Europe (Halleux et al., 2012). First of all, there is a need to combine different scales: from the macroscale of country and regional planning, through the mesoscale of city planning, to the microscale of the neighbourhood or even the single plot. Additionally, multiple stakeholders and actors are involved in the processes or affected by the results. On the regional planning level, it was found important to follow strategies preventing further suburbanisation and sprawl (UN-Habitat, 2015), however, to work efficiently, these need to be passed down to institutions with executive power (Halleux et al., 2012). The city level is often perceived as the most important link in the coordination of urban development, infrastructural and mobility plans. Detailed decisions regarding land use, green space provision and public transportation in the city are made up mostly by local governments, yet this may differ depending on the country (Berisha et al., 2021).

2.2. Poland as post-communist country

To set the starting point for the discussion on walkability in Poland, the existing background should be presented. First of all, to understand the reasons for current urban dynamics in Poland and the possibility to implement global trends it is necessary to refer to the historical conditions, in particular those of the second half of the XX century. Poland is a former socialist country, which means that from the end of World War II until 1989 it was under the communist regime. To better understand the consequences, two aspects of that period need to be mentioned: firstly, the land and private estates were subject to nationalisation, and secondly planning of cities was highly centralised, carried out by the state, which was the sole provider of housing stock (Węcławowicz, 2016). When the state communism collapsed, the process of transformation toward democracy and free-market began. While the political and economical reforms took a relatively short time, the spatial changes that follow them are time-consuming due to the enduring nature of urban structures.

In the period directly following the political transformation towards democracy, the existing planning system was dismantled. Considerable competence in the field of spatial planning was granted to local governments, which can decide on the use of land and parameters of planned investments. Due to the existing construction of the legal system, investments can be carried out based on different administrative procedures. Only one of them includes the preparation of a spatial development plan (MPZP) for a bigger area (e.g. part of the city) and requires compatibility with other municipal strategies; the other can be issued for diverse scale: from one building to a large housing estate, but without compliance with other documents. Additionally, there is no legal obligation to prepare urban plans or masterplans establishing and

securing urban standards such as the presence of public spaces or functional diversity. To sum up, existing legal conditions do not provide real control over spatial development and parameters of urban structures. This system is far from perfect and has been criticised many times, for – among other issues – its susceptibility to the particular interests of private stakeholders (Hołuj, 2013; Kolipiński, 2014; Rogatka et al., 2021).

One of the effects of rapid economic transition and free-market mechanisms was the sudden emergence of business opportunities often connected with real estate or development. Return of land leases and other market mechanisms, as well as the related changes in the ownership structure, contributed to the polarisation of income in the society. (Węcławowicz, 2016). Consequently, private space has become the symbol of wealth and social status, which can be manifested in the city (Polanska, 2010), while public space is rarely planned and implemented in new developments (Mantey and Sudra, 2019).

Although all former socialist countries eventually departed from communism, towards democracy and capitalism, their paths were different and to a certain extent unique. L. Sýkora argues, that those differences have a great impact on city management and patterns of development (Sýkora and Bouzarovski, 2012). For example, in Poland the process of restitution of land ownership to their previous owners or their descendants is unique among the other post-communist countries. There is no written law regulating this specific and complex problem, which makes it highly susceptible to corruption and creates extremely unfavourable conditions for the effective management of urban development. It results in the common situation that false last will or false relatives enable taking possession of the property. In everyday discussion it is called “privatisation business” (Kusiak, 2019), however, the consequences for the spatial development of cities, such as the fragmentation of land ownership are not commonly raised.

The problems with spatial development in Poland are manifested to a great extent in the housing sector, which in the last decades reflects negative trends identified globally, namely sprawl (Różycka Czas et al., 2021), depopulation of city centres (Kazimierczak and Szafrańska, 2019) or chaotic and scattered development patterns with raise of gated communities. Currently, it is characterised by rapid growth driven exclusively by the private sector, which emerged in the 1990 s and gained considerable power (Kowalczyk et al., 2019). The location and form of new housing complexes are often dictated by economic profitability, which results in irrational spatial layouts (Mantey and Sudra, 2019). A large body of literature concentrates on the criticism of the existing state and several problems are mentioned frequently. In particular spatial dispersion, lack of services and facilities within the housing complex, poor infrastructure and fencing (Polanska, 2014; Ptak and Serafin, 2017; Wagner, 2016) are identified as the common characteristics of contemporary Polish housing developments.

Even though the transition period is technically over, we hypothesise that the communist legacy can be seen as still influencing the cities on multiple levels. First, it determines the spatial organisation and architecture of city zones and neighbourhoods built during that era, such as large mass housing estates or industrial plants. Second, it impacts the institutional and legal framework for managing land use planning and urban development. The latter is potentially more dangerous as it produces a chaotic and incoherent “quasi-system”, where the public, common and private interests are not balanced (Niedziałkowski and Beunen, 2019).

2.3. Walkability background in Poland

A noticeable trend toward reducing the use of cars has been observed in recent years, particularly in cities in Western Europe. R. Buehler et al. compared relevant data for the biggest cities in Germany, Austria, and Switzerland in terms of car-sharing trips and found a general tendency pointing to a reduced number of daily motorised trips in favour of walking and cycling (Buehler et al., 2017). The mentioned study provides an overview of policies that on the one hand discourage and make use of private cars more expensive, slower, and less convenient, and on the other hand improve the safety, quality, and feasibility of walking, cycling, and public transport. An important conclusion, crucial for the case in question, stresses the significance of integrated measures in several areas: (1) design of the urban tissue, (2) keeping long-term comprehensive transport planning concerning walking, cycling, and public transport, and finally (3) car restrictive policies, with parking management being the most important.

Unlike mentioned Western countries, in Poland, there is little experience in implementing sustainable urban development principles, also in the area of transport. According to a recent study by B. Bartosiewicz and I. Pielesiak, car dependency in Poland can be described as significant, especially when compared with Sweden, the Netherlands or Denmark. The share of daily trips made by car starts from 50% for settlements located in big cities and rises to over 70% in the case of suburbs and rural areas, which makes the car the basic travel mode (Bartosiewicz and Pielesiak, 2019). In other words, despite multiple well-recognised benefits, walking and cycling still take a further position in the hierarchy of modes of transport, even in urban areas, where access to walking and cycling infrastructure as well as to public transport is relatively good. It should be also pointed out that decades of difficult economic conditions, and an oppressive political situation, including real estate nationalisation, may have influenced personal choices on transport modes. As suggested by D. Ton et. al in the study conducted in 2019, a private car can be perceived as a symbol of prestige and therefore active transportation modes are not so willingly chosen. (Ton et al., 2019), however, this study was performed in the Netherlands and there is uncertainty as to the fact if the same factors contribute to excessive car use in Poland.

Apart from personal experiences, the institutional barriers that affect walkability may exist at the local or national level. M. Wołek, suggests that there are several ways in which the automotive industry in Poland is constantly supported. These are, among others: low parking fees, no fees for entering city centres by car, accessibility of parking spaces (along streets and on sidewalks), lack of emission-free zones, and finally investing EU funds most of all in road infrastructure, which is an additional incentive to use private cars (Wołek, 2018). As a consequence of the socio-political background of Poland, urban planners and decision-makers can be less willing to reduce the number of parking places or increase fees for entering the city than in Western countries.

The most recent research that contributed to our study comes from M. Jaśkiewicz and T. Besta (Jaśkiewicz and Besta, 2016). Within the location of Gdansk, they performed the validation of the Neighbourhood Environment Walkability Scale (NEWS) for Poland and evaluated the construct validity aspects of the adapted version. Developed in 2002 by J.F. Sallis, NEWS is used to evaluate residents’ perceptions of their environment related to physical activity, including housing density, land use mix (including proximity and accessibility indicators), street connectivity, infrastructure for walking and cycling, neighbourhood aesthetics, traffic and crime, safety and aesthetic satisfaction from the neighbourhood. In this case, the questionnaires were slightly modified with respect to local conditions and seaside location. This study results revealed, among others that the historical districts of Gdansk were assessed higher, as more walkable. In the study it was connected with the aesthetics of the historical buildings and existing greenery. New and suburban districts were rated as less friendly to pedestrians and cyclists, with less infrastructure such as services and public spaces and longer distances to amenities. In general, this study confirms the common observation that districts that are more strongly rooted in the city with better and more diverse infrastructure can be perceived by the community members as more walkable. As the spatial characteristics of neighbourhoods were presented generally, we can speculate, that the result is obtained due to the different characteristics of urban form in intra-city and suburban areas.

3. Method and materials

In this section, we will present the research method, as well as introduce the selected case studies for a more detailed analysis.

3.1. Research methodology

The general method of the case study was selected due to its usefulness at the initial stages of research when the knowledge of the problem is being constructed. Furthermore, this method allows us to concentrate on exploration and learning from the presented cases using a variety of data sources. Additionally, the case study is believed to have "the power to influence decision-making" (Le Gouais et al., 2021) in particular in the field of shaping a healthy urban environment. As a part of the case study, the walkability parameters were measured and presented (Fig. 1).

The basic principle of this research is to provide an overview of walkability-related parameters and characteristics of the selected cases with particular emphasis on the Garnizon development. Given that all the selected developments are still under construction, it was necessary to determine a method that would allow for the recognition of relevant data from maps and masterplans with minimal contribution from more precise and design-related metrics. For the same reason, the methodology that involved community engagement (surveys, questionnaires) was not suitable, as not all of the residents are settled. First of all, for the investigation of pedestrian movement to be possible at all, it is necessary to define indexes which will describe the possibility of walking in a specific built environment. Hence the urban form of the selected cases should be tested.

Knowing that there are numerous ways to measure the urban form, we decided to choose an uncomplicated method, possible to repeat in all four cases, that did not require detailed data or specific software. Therefore as a first step, we selected the objective method of assessing the basic indexes of urban form contributing to its walkability. In the next step, we reviewed additional characteristics that are commonly associated with walkable neighbourhoods, in particular, the mobility and parking strategies, as indicated by R. Buechler (Buehler et al., 2016) as well as public space and green area indexes. These two aspects allowed us to explore and better understand the diverse characteristics of the selected cases.

In this study, we started by analysing the Walkability Index (WI) established and developed by L.D. Frank (Frank et al., 2009; Leslie et al., 2007, 2005). It is intended to measure the performance of urban form in relation to walking for different purposes and assess walkability levels.

The initial formula in his study of the relationship between physical activity and the urban environment consists of three variables:

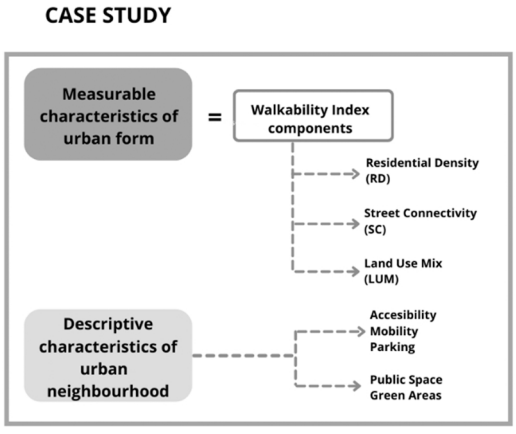

Fig. 1. Scheme of the research method.
Source: Own elaboration.

Walkability Index (WI) = (6 x Land Use Mix) + (Residential Density) + (Street Connectivity). Each of the variables is standardised, according to the formula given below, and the final walkability index is obtained by summing the three z-scores. The standardised z-score value can be calculated according to the formula:

$$z = \frac{x - \overline{x}}{S}$$

Where x is the raw score, $\overline{x}$ is the mean of the sample and S is the standard deviation of the sample.

In our study the sample consists of only 4 urban developments, therefore the usefulness of the final formula is limited, as it operates on the mean and standardised values. Additionally, it is mostly used in assessing and comparing walkability levels of different neighbourhoods in one city or municipality (Arellana et al., 2020; Lam et al., 2022; Ribeiro and Hoffimann, 2018) and no comparison utilising this method has been carried out among different geographical locations, in particular different countries. Meanwhile, the individual components (RD, SC, LUM) are a valuable source of information on the parameters of each case. Therefore, we decided to concentrate on the direct results of the particular measures (Table 1) and discuss them in our study, while the final values of the WI are presented in an annex.

Residential density (RD) was measured in compliance with the method outlined by Frank et al. (2009) as a value of the number of residential units per area unit. Street connectivity (SC) was measured as the number of pedestrian intersections per ha. We measured the last aspect of urban form, land use mix (LUM), differently, albeit maintaining the general principle of this formula, which assumed a measurement of the uniformity of distribution of functions in a target area. Firstly, in our study, the scale for calculations was the entire investigated area within its defined limits, without developing any smaller measurement scale. Secondly, we increased the number of uses from three to four. In its initial form, LUM is based on three groups of functions: housing, commercial, and office.

However, in the European context, some functions, namely: schools, kindergartens, theatres etc. are rarely purely commercial ventures. Therefore, we added one more category, namely the social function, which refers to widely understood cultural and educational functions. A similar modification of Frank's formula was made by H. Christian (Christian et al., 2011), whose studies verified the practicability of different analytical models, varying in terms of functions, in measuring their impact on different forms of activities in the urban space, resulting from transport- or leisure-related needs.

Therefore, the final formula used to calculate LUM values in our study is a variation of the initial equation.

$$LUM = -1\left(\sum_{i=1}^{n} pi \times \ln(pi)\right) \Big/ \ln(n)$$

Where pi is the proportion between the floor area covered by single land use (i) and the gross floor area, n is the number of land use functions ($n = 4$).

The general validity of the measurements (eg. final block sizes, streets and paths interconnections) was checked during the site visits.

3.1.1. Case study selection

In this study, a detailed analysis covers a new city district located in Gdansk (Poland) on the southern coast of the Baltic Sea. Together with Gdynia, Sopot, and some minor adjacent towns, forms the Tri-City metropolitan area with a current population of over 1 million. Gdansk is a historic city, founded in the Middle Ages. Due to its favourable location on the coast of the Baltic Sea and at the delta of two rivers, it was able to play a role of an important trade and shipbuilding centre and managed to hold this position until the 1920 s. During World War II the city, where such war started was destroyed to a great extent, and in subsequent years the reconstruction of the old centre took place together

Table 1
Measures of urban form.

Measure	Definition	The scale of the measurement for the target area	Equation	Data source
Residential density (RD)	Number of residential units per ha	The total area of the development	Total residential area / Average unit size / Neighbourhood size [ha]	Site development plan obtained from the municipality or provided by the developer Statistical data on the average unit size
Street connectivity (SC)	Number of intersections per ha	Total area of the development	Total number of nodal points / Neighbourhood size [ha]	Site development plan obtained from the municipality or provided by the developer
Land use mix (LUM)	Distribution of square metres of residential, commercial, office, and social development	Total area of the development	Land use mix equation presented below	Data on the area of residential, commercial, office and social functions obtained from municipalities

Source: table adapted from (Frank et al., 2005)

with the construction of new parts of the city (Matusik et al., 2020). In a period of communism and Soviet domination mostly the large prefabricated housing estates were built. The major shift in urban dynamics can be associated with the political revolution in 1989 followed by socio-economical changes. New forms of spatial development that appeared in most post-socialist cities, were also represented in Gdansk. The most visible was the increased suburbanisation and introduction of gated and single-entry communities (Korwel-Lejkowska, 2021; Polanska, 2014, 2010). In recent years urban development of Gdansk is characterised by constant growth, however similarly to other Polish cities, it is not managed through a consistent planning system.

Gdansk is a city where cycling is still of little importance. Just a slight increase in the share of travel made by combined walk and by bike has been recorded over 8 years period from 1998 to 2016, according to research published on the website of the Gdansk Municipality ("Gdansk w liczbach, ", 2021). In the discussed period, the share of travel by individual transport increased significantly, which took place at the expense of the public transport. In 2016, only 5.9% of journeys were made by bicycle, although the city is gradually expanding its bicycle infrastructure. According to another study published by the city council, in the 10 years since 2011, there has been an over threefold increase in the total length of bicycle routes (calculated as bicycle paths, bus and bicycle lanes, calmed roads and other forms of bicycle infrastructure). More or less in the same period, the motorisation rate of Gdansk continued to increase from 466 cars per 1000 inhabitants in 2009–640 cars in 2019, always being above the national average. Although the share of bicycle trips is still negligible, the total number of trips has increased by nearly 6 times compared to the reference year 1998.

The Garnizon development, which constitutes the case study, covers an area of over 23 ha and is located in the northwestern part of the city (Fig. 2). It is situated app. 5 km from the main railway station. It is characterised by a favourable location by major traffic routes: a road that runs towards the airport, and the main road of Tri-City (Grunwaldzka Avenue), which intersects all the three main cities (Gdansk, Sopot, Gdynia) and some minor towns that form the metropolitan area.

The history of land development reaches back to the early 19th century when the city became an important administrative and military centre. Since 1st April 1890, Gdansk was the headquarters of the 17th Corps of the Prussian Army (Daniluk, 2020). The development was implemented as three spatially separated barracks complexes. Over years several military structures fulfilling different functions were erected, such as canteens, stables, a manage, residential units, quarters for officers' families, a shop, gyms, a garrison club, and a casino. The construction of the barracks became an urge when in 1891 the number of stationed soldiers reached 16,000, which constituted nearly 18% of the population of Gdansk ("Portal Miasta Gdańska, ", 2021). During

Fig. 2. Location of the Garnizon development in Gdansk; a-Baltic Sea, b-city boundary, c-the Garnizon development.
Source: own elaboration based on the map available at: https://mapa.gdansk.gda.pl/.

World War II, Wehrmacht soldiers were stationed here, followed by the Red Army, and the Polish People's Army after the war.

The area subjected to the new development was covered with the local spatial development plan (MPZP named: Local Spatial Development Plan Wrzeszcz – former barracks at Słowackiego street) in 2006. A local plan (MPZP), constitutes the basic legal regulation for the new investment, however, its provisions were formulated in a general manner. It allowed for considerable freedom in terms of the design of the urban form and regulated solely the fundamental parameters of the investment, such as the development function and intensity, the maximum height, or the number of parking lots. The plan also indicated historic structures of the former barracks which were to be preserved and renovated (Fig. 3.).

This area was selected considering several criteria. Firstly, according to the study aims it has been assumed presenting the Polish case may extend the current knowledge of the walkability concept with regard to different geographical locations, and socio-economical and political backgrounds.

Secondly, we looked for large-scale development, where the parameters RD, LUM and SC can be tested. The next important issue was accessibility, in particular, the simple possibility to enter the site. Although the calculations are based on the plans and information provided by developers and municipalities, it was necessary to verify the parameters during site visits, therefore the lack of fences and gates was of key importance.

As the background for the Polish case, three districts from Western Europe were chosen and presented. The basic selection criterion was related to the principle of sustainable solutions implemented in all selected developments, in particular, the principle of pedestrian accessibility and limiting the use of a private car. This information was taken primarily from popular publications and internet sources, where all the cases serve as examples of innovative and sustainable urban development projects. The official city services confirm, that the important goal was to create diverse, accessible and pedestrian-friendly city districts (byoghavn.dk, 2022; www.amsterdam.nl, 2022; www.wien.gv.at, 2022).

The first urban complex included in the reference group is Nordhavn in Copenhagen, according to DGNB data, the only new urban district to receive the highest gold certificate awarded by the German Sustainable Building Council for sustainability and carbon neutrality (DGNB, 2022). The certification procedure was performed based on the project layout, as the district itself is not completed. According to the municipality of Copenhagen the district is designed as a "5-minute city" meaning most of the daily services and amenities can be reached within 5 min, favouring foot, bicycle and public transport. The intention was to achieve a coherent and programme-diversified urban tissue, supporting sustainable mobility choices (Dac.dk, 2022).

The second district is located in Amsterdam on the peninsula in the eastern part of the city. According to the masterplan sustainable mobility is an important issue in the overall Sluisbuurt design. The neighbourhood is designed as mostly car-free, including intelligent mobility. The urban form is declared to be diverse, accommodating and mixing several functions: housing, shopping, offices, education and healthcare (Ontwerpteam Sluisbuurt, 2019).

As the last case, the Seestad Aspern in Vienna was selected. It is a well-known urban district that comes into life incorporating the most up-to-date solutions for energy efficiency, mobility and urban innovations. It is planned as a "city of short distances", well connected with the city centre. The planned modal split assumes 40% walking and cycling, 40% public transport and only 20% of car traffic. Additionally, the urban structure is planned as diverse – accommodating housing, business, shopping and recreation, as well as social and cultural amenities. ("seestadt-aspern, ", 2022).

Other selection criteria included geographical location. The selected districts are located in Europe, within the boundary of existing cities. The distance to the historical city core varies from the app. 1.5 km (Nordhavn), 4 km (Sluisbuurt) to 5 km (Garnizon) to 8 km (Seestadt). Another important feature considered in the process of selection was the size of the districts. Initially, we aimed at comparable areas, however, the Seestadt in Vienna with a much larger target area (over 200 ha) constitutes a good example in terms of an innovative and comprehensive vision for the city district. Therefore, it was included in the final reference group. Finally, an additional, but important criterion that influenced the selection of all cases was the possibility to examine and check the basic parameters during site visits. The European location allowed us to avoid time-consuming travels during the research.

Fig. 3. Site development plan of the Garnizon development.
Source: Own elaboration based on the map available at: https://mapa.gdansk.gda.pl/ and the site development plan provided by the developer. Existing, historic structures preserved and renovated are marked in dark red, and new development is marked in bright red.

3.2. Data sources

The data used in subsequent calculations are derived in the first place from the development plans provided by the investors and the masterplans obtained from relevant municipalities, as well as they are an effect of measurements carried out in the field. In the case of the absence of necessary data and indicators, we utilised statistical data provided by competent statistical offices, and town planning offices.

For Garnizon, the estimated population (number of residents) was calculated based on the designed number of residential units and the average number of people per residential unit. According to statistical data, in 2018 in Gdansk, it was 2.64("Gdansk w liczbach, ", 2021), which gives an estimated number of residents of the estate at the level of 8127. The measurement method is a broad approximation since new developments can have a different household structure than the city average, however, no precise data on the Garnizon were available. In the case of reference developments, the target community size was calculated correspondingly (Fig. 4).

Some of the information on the function of buildings was included in the provisions of the local spatial development plan, another part of it is constituted by data provided by the investor. For buildings that have not been executed yet, quite inevitably these data demonstrate a certain degree of estimation. Nevertheless, we find it justified to study the most recent developments in order to investigate current tendencies in designing new parts of cities, as well as to recognise current management strategies.

To obtain reference values in the calculations of walkability-related parameters it was also necessary to analyse other characteristics of the urban form of the selected developments from Austria, Denmark, and the Netherlands. This study was performed following the methodology adopted for the Garnizon estate, which includes in situ observations and measurements of the urban masterplans. Concerning data sources, the first difference between the Polish and Western European cases can be spotted and it is the absence of a masterplan. The development was designed according to MPZP, a general document that is not meant to constitute a design tool. After the MPZP, the building permit is issued, based on the detailed site development plan prepared by the investor. The lack of a masterplan in the development process is generally considered a substantial weakness of the Polish planning system.

Finally, to get a broad picture of the urban environment, the amount and distribution of public places and urban green areas were also looked upon and measured. As an additional source of information, mobility strategies and urban mobility plans proved to be useful, particularly regarding pedestrians cyclists and parking space indexes. Those were taken primarily from the corresponding municipalities.

4. Results

In this section, the case studies are analysed and the results are presented. The section is organised as follows: firstly, we calculate and discuss the three main components of the walkability index: RD, SC, and LUM for the selected developments in compliance with the scheme presented in the previous section. Secondly, we describe the issues pertaining to public transportation, bicycle and private car use as well as we present amount of public space and natural (blue and green) areas.

4.1. Components of the Walkability Index

4.1.1. Residential density (RD)

Residential Density was calculated starting from the size of the total area for the entire urban project and calculating the gross floor area index. Such an index determines a relation between the floor area of all floors built above the ground level, so it allows for setting the general intensity of the development. Next, we subtracted the percentage of the share of the housing function from the obtained value. We measured the existing and planned buildings utilising the site development plans obtained from the developers, as well as the available masterplans. The data were verified during on-site visits, and no substantial differences were detected.

The visual comparison of the ground floor plans (Fig. 5.) reveals that

Fig. 4. Overview of the selected urban developments: a-Garnizon, Gdansk; b-Nordhavn; Copenhagen c-Seestadt, Vienna; d-Sluisbuurt, Amsterdam.
Source: a, c- Authors' own photo; b-Vincents productions, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons; d-https://www.amsterdam.nl/projecten/sluisbuurt.

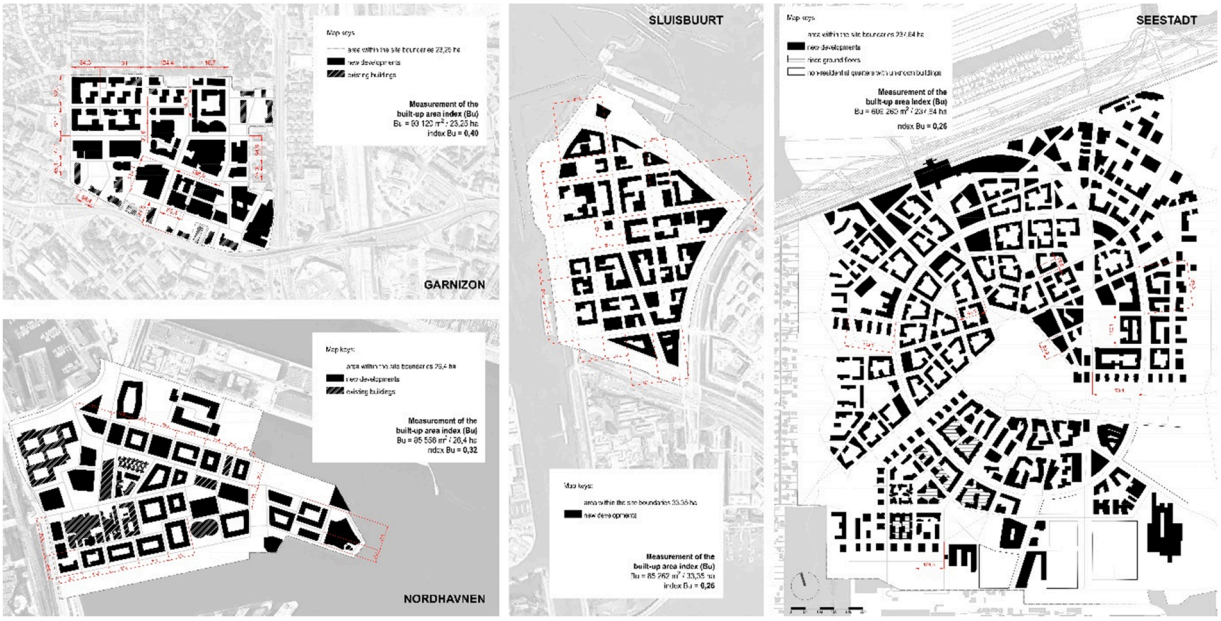

Fig. 5. The built-up area of the four selected developments.
Source: Own elaboration based on the maps, masterplans and site development plans provided by the municipalities and developers.

the Garnizon development is characterised by its relatively dense structure. In this case, it is dictated by provisions of the local spatial development plan (MPZP, 2006) which allows to cover even 90% of the total plot area with ground floor volume, which is considered an unprecedently high value. The least visually dense development is Seestadt. The central area is planned to be unbuilt and the interiors of the blocks are spacious. The built-up area index is in this case 0.26, while in Garnizon it reaches 0.4. The gross floor area index was also calculated and in the case of Garnizon it oscillates at the level of 1.63 (Table 2.) Only Sluisbuurt exceeds this value (1.65), while the lowest can be observed at Seestadt (1.02).

The high intensity of Garnizon is reflected in the number of residential units per hectare of surface area. In this case, this value is 132, which is the second highest result among the districts discussed (Table 3).

The parameter obtained for the Garnizon is high (132) – exceeded only by Sluisbuurt (165). However, in the Dutch case, such a high RD index was obtained using the domination of tall buildings, which is visible in the built-up area index and the gross floor area index. The first is one of the lowest (0.26), while the second is the highest (1.65). In the case of Garnizon, a high RD index was obtained with definite domination of medium-rise buildings (up to 9 floors), instead of tall or high-rise buildings. The result is even more surprising if we consider the existence of several heritage buildings of the former garrison, which due to their nature - dispersion and low-rise - significantly lower the density parameter of the area.

Table 2
Basic data on selected districts.

District name	1 Garnizon	2 Nordhavn	3 Seestadt	4 Sluisbuurt
Distance to the city centre (km)	5	1.5	8	4
District size (ha)	23.25	26.40	237.64	33.35
Built-up area (m2)	93,120	85,556	609,260	85,262
Gross floor area (m2)	378,607	340,800	2,425,182	550,000
Target district population	8127	4407	29,117	10,065
Total number of residential units	3078	2109	14,066	5500
Average size of the living floor area per person (m2)	29	43	43	45
Average size of a residential unit (m2)	75	90	90	82

Source: Own elaboration based on the data from masterplans, statistical offices and provided by developers.

Table 3
Values of residential density (RD) in the selected districts.

	District	Built-up area index	Gross floor area index	RD (number of residential units/ha)
1.	Garnizon	0.4	1.63	132
2.	Nordhavn	0.32	1.29	80
3.	Seestadt	0.26	1.02	59
4.	Sluisbuurt	0.26	1.65	165

Source: Own elaboration

4.1.2. Street connectivity (SC)

Calculating Street Connectivity was done by following pedestrian routes. It was assumed that the pedestrian movement takes place on the pavements of public streets as well as on hardened surfaces of squares and pedestrian paths between blocks (Fig. 6.). In the Garnizon the total amount of nodal points was determined at the level of 61 and the street connectivity (SC) equals 2.62. Similar results of SC measure were obtained in Nordhavn and Sluisbuurt, 2.58 and 2.01 respectively.

The network of pedestrian interconnections is a derivative of a compact urban grid, with block dimensions falling within the range of 33–138.5 m.

As can be seen, the street connectivity index is also relatively high – the highest amongst the developments in the comparison (Table 4). High connectivity can be explained by fine tissue granulation, as well as by opening up block interiors as public spaces. Additionally, the presence of historic detached buildings improves the street connectivity index, increasing the number of possible passageways between them. A general lack of fences around individual buildings and blocks should also be pointed out, as it increases the general number of pedestrian routes available.

4.1.3. Land use mix (LUM)

In order to determine the land use mix index, it was necessary to estimate the size and share of individual functions. For the Garnizon,

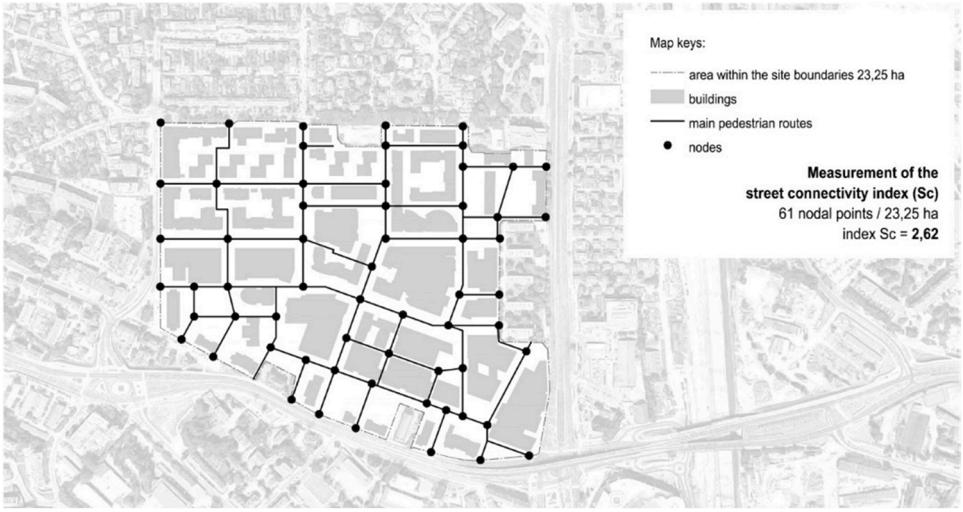

Fig. 6. Map indicating streets with sidewalks, pedestrian passages, and nodes in the Garnizon development.
Source: Own elaboration based on the map available at: https://mapa.gdansk.gda.pl/ and the site development plan provided by the developer.

Table 4
Values of Street Connectivity (SC) in the selected districts.

	District	Number of nodal points	SC (number of intersections/ha)
1.	Garnizon	61	2.62
2.	Nordhavn	68	2.58
3.	Seestadt	215	0.90
4.	Sluisbuurt	67	2.01

Source: Own elaboration

this distribution is presented in the table below (Table 5).

Residential functions constitute ca. 61% of the share in the general programme. The rest, i.e. 39% of the total area, is assigned to other uses. What is surprising in that case is a relatively small share of social functions – cultural facilities, schools and pre-schools, as well as local community clubs. They constitute only 1% of the total floor area. The lack of schools within the perimeter of the Garnizon can be explained by the fact that such facilities are located on adjacent plots within a walking distance. In other selected cases, however, the percentage of social functions in the total floor area is 4%, 7% and 10%, with the highest value belonging to the Sluisbuurt.

Despite these deficits in social functions, the land use mix can be defined as relatively high, at the level of 0.71 as compared to reference districts. The lowest index describes the land use mix in the Sluisbuurt (the Netherlands). Again, this phenomenon can be associated with the urban form of the district. It includes tall and high-rise buildings, where most of the upper floor areas are intended for residential functions. In each case the dominant, over 50% share belongs to residential, however, it varies from 52% in Seestadt to 82% in Sluisbuurt (Fig. 7.).

Table 5
Land use functions in the Garnizon development.

	Land-use functions	Gross floor area (m^2)	Percentage
1.	Residential	231,757	61%
2.	Social	4343	1%
3.	Commercial	73,834	20%
4.	Offices	68,674	18%
Total		378,607	100.00%

Source: Own elaboration

4.2. Characteristics of urban space

4.2.1. Accessibility, mobility, parking

In this section, we will provide information on the management of different types of traffic, as well as the accessibility of areas using public transport. All these aspects are of key importance when planning the modal shift from motorised to active and sustainable modes. Good quality and accessibility of public transport directly influence the reduction in the use of private cars and constitute an incentive to use more sustainable means of transport (Mugion et al., 2018).

The following table presents the basic data concerning the car ownership and modal split in metropolitan areas, where the analysed developments are located. The current position of Gdansk in comparison with Copenhagen, Vienna and Amsterdam in terms of car ownership is low. Basic statistics show that the number of private cars is increasing and in 2021 exceed 680 per 1000 inhabitants (Table 6).

4.2.1.1. Public transport. The area in question is located in the vicinity of an intersection of major roads along which public transport routes run. Numerous studies devoted to issues of pedestrian accessibility mention the distance of 400 m, representing an average of 5 min walk, as a distance we are willing to walk to reach an intended destination (El-Geneidy et al., 2014; Giles-Corti et al., 2005). Therefore, we used that distance in our study to evaluate the accessibility of stops of public transport modes: tramways and buses. They are located along surrounding streets (Fig. 8.). Nearly an entire analysed development is situated within the selected buffer zones. Additionally, a part of this area is within a walking distance from the railway station offering local connections (within the limits of Tri-City), as well as domestic and international connections. Consequently, the accessibility of public transport can be described as very good.

A comparison of selected urban developments in terms of public transport organisation reveals many similarities. In each case, the major public transportation lines run within the close vicinity, and the stops are located within the boundaries of the development. This can be associated with the intra-city location, within the existing network of public transportation. However, there are certain differences as well. The most visible is the lack of autonomous vehicles operating within the perimeter of the district. In all other districts, such solutions are already functioning or are at the stage of tests. Small autonomous buses constitute the first part of public transport – they pick up passengers from local streets, farthest from bus stops.

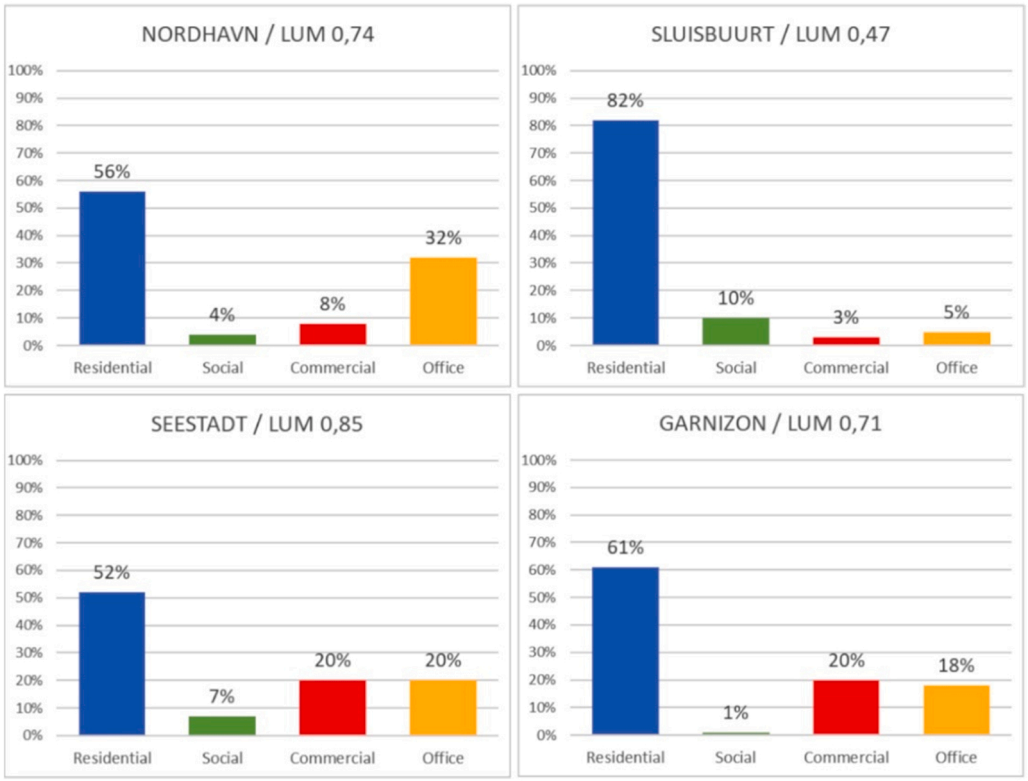

Fig. 7. LUM values and their components in the selected developments. Source: Own elaboration.

Table 6
Table depicting the car ownership rate and distribution of transport modes.

Metropolitan area	Car ownership rate per 1000 inhabitants	Modal split (%)			
		W	B	Pt	C
Copenhagen (2018)[1]	237.0	6.0	41.0	27.0	26.0
Vienna (2018)[2]	371.5	27.0	7.0	39.0	27.0
Amsterdam (2020)[1]	247.0	29.0	32.0	17.0	20.0
Gdansk (2016)[3]	572.0	20.8	5.9	32.1	41.2
Gdansk (2021)[3]	686.0	n/d	n/d	n/d	n/d

W – walking, B – bicycle, Pt – public transport, C – car. Source: own elaboration based on the (1) Deloitte report (Deloitte, 2020, 2018), (2) Vienna statistics (Vienna in Figures, 2018), (3) Gdansk statistics ("Gdansk w liczbach, ", 2021),

4.2.1.2. Private car and parking. The analysed area is located along streets that belong to three different classes: main, collective, and local, which means different technical parameters, such as width, number of lanes, speed limit, and frequency of road exits. Żołnierzy Wyklętych street (on the south side) as the main street should be designed with a limited number of exits. Here, we have as many as four, ca. 100 m apart, which is not an optimal solution in terms of traffic organisation. Nevertheless, such a situation may be justified by the need to provide access to buildings which function independently from the Garnizon development. Single exits from Żołnierzy Wyklętych avenue allow linking the aforementioned buildings to it via short extension roads. Additionally, the other streets: Grunwaldzka avenue, Szymanowskiego street, and Chrzanowskiego street have three exits each. Thus, the area is well connected on each side, which guarantees an even distribution of traffic. Exits to underground car parks have been designed in the vicinity of the outer limits of the development, hence the car traffic is taken over right after the exit from the surrounding streets. Consequently, their number circulating inner streets can be reduced. It can be considered as an application of the strategy of limiting road traffic inside the development (Table 7).

Parking space indexes are higher than in the other selected cases Denmark, the Netherlands, and Austria selected for the comparison. These indexes result directly from the provisions of the local law. The value stipulated in the local plan is 1 and 1.2 parking spaces per residential unit (MPZP, 2006). The parking needs of residents are satisfied most of all by private car park spaces located directly under the buildings. There are no solutions for a more active policy in parking management, which have been applied e.g. in Nordhavn or Seestadt, such as detached garages, a limited number of private parking spaces available, or a coordinated system of subscription fees.

4.2.1.3. Bicycles. Bike traffic within the boundaries of the Garnizon takes place along regular roads. The entire area of the district has been designed as a traffic calming zone with a speed limit of 20 km/h. Similar solutions are implemented in Amsterdam and Copenhagen, where bicycle traffic is planned to take place on streets with a speed limit (up to 30 km/h). However, in the Polish case, the local spatial development plan (MPZP) did not impose any requirements on bicycle traffic. It did not define the number of parking spaces for bikes, neither inside the building nor outside. Several important cycling lanes are running in the vicinity of the development: on the south side along the main road, Żołnierzy Wyklętych avenue, and on the east side along Grunwaldzka avenue. In the north, bicycle traffic runs along Wojska Polskiego Avenue (Fig. 7).

There is no broader strategy for supporting bicycle traffic here, there is also no local design guidance as to designing cycling lanes and parking spaces for bicycles. It is a characteristic that strongly distinguishes the Polish case from the other selected developments compared in this study. For example, in Nordhavn there is a legal obligation from the masterplan that for each 100 m^2 of a residential area at least 2.5 bicycle parking places need to be provided. Even higher values can be observed in Sluisbuurt, where the minimal number of bicycle parking places is 3

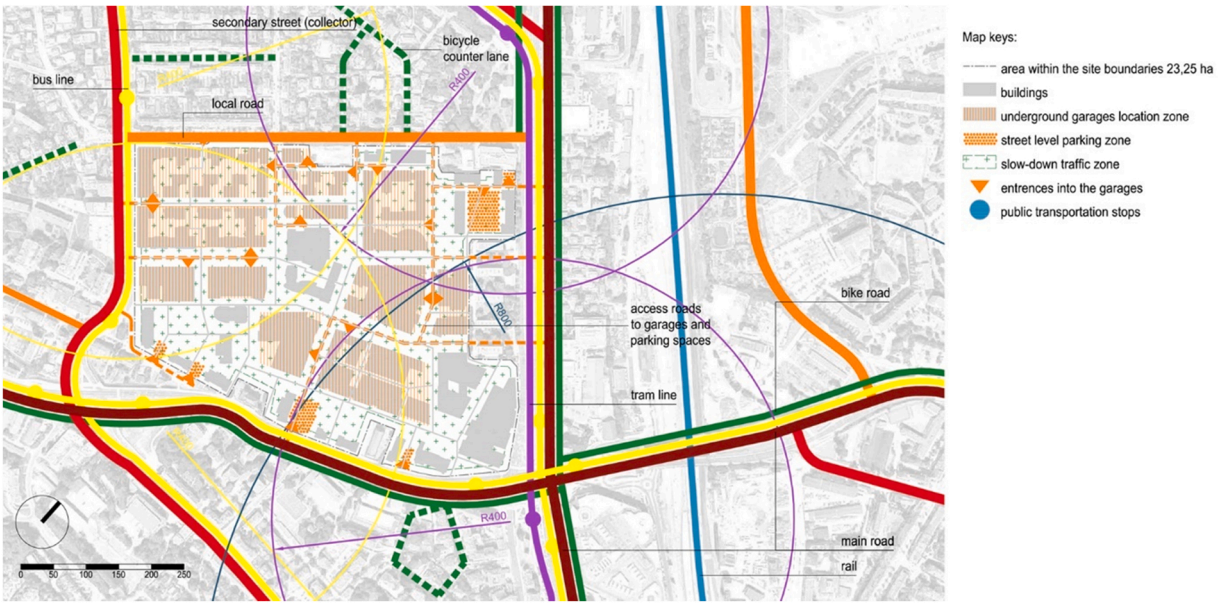

Fig. 8. Scheme of the traffic system in the Garnizon development.
Source: Own elaboration based on the map available at: https://mapa.gdansk.gda.pl/ and the site development plan provided by the developer.

Table 7
Table depicting the private car parking index.

	District	Car parking space index for residential function	Car parking space index per average flat
1.	Garnizon	n/d	1.0–1.2
2.	Nordhavn	1/200 m^2	0.45
3.	Seestadt	0.85/100 m^2	0.77
4.	Sluisbuurt	n/d	0.3

Source: own elaboration

per single apartment.

4.2.2. *Public space, green areas*

Urban green areas are important parts of the sustainable urban environment, they also play a role in supporting walking, in particular for recreational purposes. When analysing the amount of green area in Garnizon the spatial layout has to be considered. It induces both: a high residential density index and a high built-up area index. It was expected that those two measures may result in a low share of the area that can be dedicated to biologically active spaces – green and blue areas combined. In Garnizon, according to MPZP and the site development plan, it comprises merely 10.5% of the total area. Those values are exceptionally

Fig. 9. Scheme of the public spaces in the Garnizon development.
Source: Own elaboration based on the map available at: https://mapa.gdansk.gda.pl/ and the site development plan provided by the developer.

low in the group of the presented developments. In Denmark, Austria and the Netherlands percentage of the natural (blue and green) area was: 17.7%, 23.9% and 34.5% respectively.

With a low share in the total area, the index of natural space per capita is the lowest in the case of Garnizon. Currently, it is only 3 m^2 per capita (residents of the development). On the scale of the entire city, the greenery index per capita is much higher and is ca. 16.8 m^2 (Staszek, 2017), and in reference, developments vary from 10.6% (Nordhavn) to as much as 19.5% (Seestadt). The structure of natural spaces is dominated by the estate and pocket parks, and there is no natural area of supralocal significance at all (Fig. 9.). That is another difference between the Garnizon and Western European cases.

In Garnizon, hardened surfaces – public squares and pedestrian routes constitute the biggest share of the total area – over 12% (Fig. 10.). Other selected developments have significantly less hardened public spaces. It can be as low as 4.1% in Seestadt and the value the closest to Garnizon can be observed in Nordhavn (10.4%). The estimated amount per capita (resident), is the second highest result – 3.7 m^2, lower only than the result for Nordhavn.

5. Discussion, conclusions and further research

According to a popular statement by D. Banister, we are supposed to design cities so that there would be no need to have or use a car (Banister, 2008). However, the optimal design of cities and promoting walkability are influenced by many factors and there is no "one fits all" solution. It is generally agreed upon that urban patterns and transportation are strongly related and the relationship is mutual (Song et al., 2017). Therefore, parameters of urban form can influence transportation choices by creating favourable conditions for using a particular mode. Our study aimed to explore the characteristics that are related to walkability in the selected Polish housing development located in Gdansk. Additionally, we aimed at extending the knowledge on walkable neighbourhoods by providing evidence from the post-socialist country, where the processes of urban development are not properly managed and controlled. By selecting the case study method and presenting certain characteristics of Polish and Western European cases we also aimed at improving the understanding of walkability among decision-makers responsible for urban development in Poland, as they may see "what works" in other countries and learn from their experience.

The Polish case, which was our main concern was presented against the background of three urban complexes from Denmark, Austria and the Netherlands that were chosen due to their declared sustainability and walkability. Despite the different locations and different historical legacies, several similarities were visible. The first is the fact that all four neighbourhoods including Garnizon are placed on the intra-city plots and not outside of the city limits. This location has its benefits, for instance, good connections with existing public transportation, bicycle lanes and pedestrian paths. Although in Poland this decision is mostly in hands of the developers and politicians, not urban planners, it can be considered as a step towards a more rational pattern of spatial development and overcoming the negative trends associated with the post-communist transition. One of them is the uncontrolled suburbanisation visible in the Tri-City area and identified in several post-socialist countries (Nuissl and Rink, 2005). It can be bound to, among others, land privatisation and the need to fulfil housing aspirations (Korwel--Lejkowska, 2021; Sýkora and Bouzarovski, 2012).

The second similarity identified is the spatial layout. The visual comparison reveals that Garnizon has a structure based on the urban block and the same principle is visible in reference cases. It can be assumed that this layout can be beneficial for shaping the walkable urban form, as it allows for frequent interconnections of pedestrian routes and smaller distances between facilities. The study confirmed this assumption, as it demonstrated the levels of walkability-related parameters (RD, SC, LUM). Reference values were obtained from the analysis of developments from Denmark, Austria, and the Netherlands, and they can be described as comparable with Garnizon. Therefore, the performance of the urban form, in particular, the adopted layout can be perceived as good, with the potential to support pedestrian traffic within the perimeter of the complex. These conclusions relate to the findings of the study by Jaśkiewicz and Besta on walkability in Gdansk (Jaśkiewicz

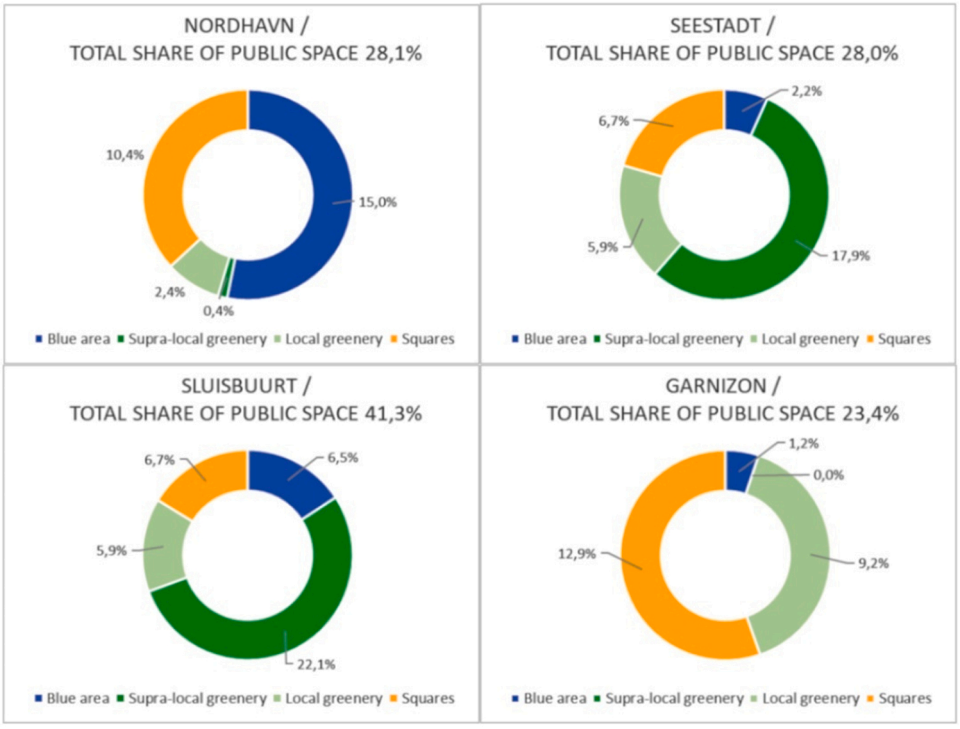

Fig. 10. Comparison of the amount and share of the types of public spaces in the selected developments.
Source: Own elaboration.

and Besta, 2016), where the relatively compact, in this case, historical districts, based on block layout were rated as walkable by survey participants.

In terms of the performance of urban form, one parameter deserves more attention: the gross floor area index. The theory of walkable cities, developed by – among others – J. Speck or K. Dovey, attaches great importance to this index. It is a parameter which is decisive first of all for accessibility and short distances, and secondly for the inflow of people who can use a specific space. In compact, intense developments, it is much easier to obtain favourable components determining the walkability index value (Dovey and Pafka, 2020). In Garnizon, efforts have been made to obtain its high compactness, which is also justified by economic reasons as it results in more floor area available for sale or lease. On the other hand, the high intensity implies that the area allocated for urban green spaces and public spaces per capita is limited (Russo and Cirella, 2018). The first visible difference between the Western European and Polish cases is related directly to the above-mentioned issue. It was identified in the field of green areas provision. In Garnizon it was significantly lower in terms of the total amount of natural (blue or green) areas and the per capita index. While the urban developments from Denmark, Austria and Netherlands can contribute to the amount of natural areas in the city, Garnizon possibly only takes advantage of already existing urban green spaces located nearby, therefore in our opinion, it can be identified as a severe shortcoming of the development.

Several differences concern the mobility regulations, in particular the parking space provision. It is significantly higher than in Western European cases, additionally, no bike parking is planned. The next visible difference is the absence of modern and sustainable transportation, such as autonomous vehicles, that are being implemented in the developments in Austria, Denmark and the Netherlands. The first problem can be fixed even within the existing legal framework through the systematic lowering of the required car parking space indices, while simultaneously including bicycle parking, however, we anticipate, that this process would experience obstacles. Denmark and the Netherlands are countries with a large share of cycling in the breakdown of transport modes, reaching the level of 40%. The motorisation level represented by the car ownership index is among the lowest in Europe. In Poland, however, this value is exceeded more than twofold. On the one hand, this phenomenon can be treated as a result of existing transport policy, which favours motorised transport and as an effect of spatial dispersion of urban structures. This makes driving a necessary but also convenient form of transport. On the other hand, such high car ownership may put pressure on the road system and demand for parking spaces. Consequently, the car is still a commonly accepted transport mode in Poland. This situation could be improved through integrated planning and mobility strategies to reduce car use as seen in Western European countries (Bartosiewicz and Pielesiak, 2019; Saeidizand et al., 2021; Wołek, 2018). However, these processes need to be planned as multi-level (national, regional and local) and long-term. For example, in Copenhagen, the shift towards walking and cycling started in the 1960 s by establishing several car-free zones, and the city is constantly working on improving walking and cycling conditions (Gehl and Koch, 2006).

Relatively high measures related to walkability and a general good evaluation of the Garnizon development can be linked also to the absence of fences that would separate the complex. The absence of fences on such a large area has improved urban form parameters, in particular, the street connectivity index (Coughenour and Bungum, 2015). It also had a positive influence on the quality and accessibility of open spaces. It is a positive phenomenon, especially considering the ongoing expansion of fenced housing estates in Poland. The global research is unanimous as to the negative impact of such structures on the neighbourhood walkability and general permeability of the area (Brade et al., 2009; Kostenwein, 2021; Sun et al., 2018). Research conducted by Coughenour and Bungum in Las Vegas investigated the pedestrian movement in different neighbourhood patterns and found that the presence of cul-de-sac streets and single-entry communities increased the pedestrian trip distances, lowered the general permeability of the area and impeded walkability in comparison to the block layout (Coughenour and Bungum, 2015). The study does not explain other issues pertaining to land ownership, fencing or pedestrian path patterns, so it is not clear if they were taken into account. In Poland, however, the land is predominantly privately owned, the fence establishes the border and does not allow strangers (not residents of this particular housing complex) to enter. Again, this discussion should be set in the context of post-socialist conditions. In 1989 and the following years Poland witnessed a critical shift towards restitution and further protection of private property. The ownership of land was passed from the state to the individuals, who are practically unfettered in their building plans. As stated by D. Polanska fencing the property "aimed at drawing physical boundaries in the city's landscape between different social groups" and it appears unlikely that this situation would change in the following years (Polanska, 2010).

The above-mentioned issues are, however, only the most visible part of the bigger problem with land use planning in Poland, which does not provide financial, legal and operational tools for implementing multidimensional urban strategies. The mechanisms for cooperation within the city units and with the private investors are virtually absent. Due to ambiguous and imprecise decisions and lack of coherence, parameters of investments often exceed rational values in terms of intensity, while green areas tend to be "sacrificed" as they cannot be sold or leased. This situation can be partially explained by the fact, that Poland in relatively recent years experienced a revolution of the land-use system and, in fact, the total dismantling of it with no effective new regulations following. The importance of integrated spatial planning was marginalised in the public debate, mostly due to the negative connotations attached to it. The planning system was perceived as a remnant of the former oppressive, totalitarian state socialism (Kolipiński, 2014). Additionally, the group of land owners and developers still benefit from the absence of local plans, as nearly every property can be subject to excessive development, and a potential source of profit. Consequently, there is no will to introduce any binding planning documents. Every land owner can execute his rights and build up his plot unless other legal regulations are not violated (Niedziałkowski and Beunen, 2019). M. Wagner concluded that Polish spatial planning law can be called "evading", as it often allows for illegal actions beneficial for particular – mostly private stakeholders (Wagner, 2016).

At the initial stage of the research, we assumed that the legal and spatial planning conditions would have an impact on the urban form of the Garnizon complex, however, it was unknown, where would it manifest itself. The analysis of the spatial layout revealed that the built-up area index and gross floor area index are the highest among all four cases and at the same time the green area index is the lowest. In light of the debate on the transformation and its multidimensional outcomes, this result can be interpreted as the manifestation of the power of private investor, who aims to maximise the return on investment. Simultaneously, the planning documents are formulated in a general and imprecise way and they do not secure the green space provision. Undoubtedly, there are certain differences in spatial planning systems in Austria, Denmark and Netherlands, yet the Polish situation can be described as unique due to a relatively new planning paradigm that was based on a combination of decentralisation and neo-liberalism as a remedy for communist central planning and nationalisation (Niedziałkowski and Beunen, 2019). This observation directly correlates with the findings of Halleux, (Halleux et al., 2012) that the history of land use and property rights is crucial and needs to be taken into account when analysing the efficiency of the planning system, in particular regarding the new threats of urban development.

As an overall result of this study, it should be concluded that the Garnizon development demonstrates certain characteristics coherent with Western European cases, while at the same time the significant shortcomings can be indicated in the fields indirectly related to spatial

planning. On the other hand, the mobility solutions place it far behind the reference districts from Western Europe. There are no comprehensive and effective legal regulations supporting walking and cycling, such as masterplan provisions or local planning coherence. The selected case reveals that it is technically possible to shape the new housing complex in such a way, that it can be compared to other sustainable and progressive urban districts. It is an important observation, that inspires optimism, however, this optimism should be cautious. The legal and institutional background is responsible for the shape of the urban environment to a great extent. Due to flaws in the Polish legal system, and spatial planning, the systematic implementation of walking-oriented solutions can be impeded and the further development path of the housing sector is difficult to predict. One of the possible scenarios is that Garnizon would remain an isolated case within the domination of low quality, car-oriented neighbourhoods.

The present study was intended as the first stage of the research on walkability in Polish conditions, which were found to be complex. Several conditions including the legal and socio-economic legacy of communism contribute to the present situation, where creating sustainable, walking-oriented neighbourhoods may face difficulties. The important value of the study lies in the fact, that it enables the discussion about walkability and provides knowledge on parameters and problems that are strongly related to shaping the city as walkable. Additionally, the case studies allow for simple and fast comparison, therefore we believe that our study can be useful for decision-makers or stakeholders in getting the awareness of possibilities of shaping the new developments and slowly changing attitudes towards walkable solutions.

Several limitations can be indicated throughout the research process. Firstly, one case from Poland was selected. According to current knowledge on urban development in Poland, it does not represent the majority of new housing complexes, as it is located within the city limits (not suburbs) and is not gated. It is an issue which calls for broadening the perspective of other districts of the city and other types of urban tissue in Poland, such as post-communist housing estates or suburban developments. We expect that for instance, the walkability variables within the gated neighbourhoods can assume different values, but this issue needs to be better recognised. Secondly, we utilised the Walkability Index only partially, not including the final calculation in our study. It was due to the fact that our sample consisted of only 4 urban districts, and in 3 of them, the urban form was carefully controlled throughout the design process. Although the results of WI did not contribute to the scope of the present study, within a bigger sample size they may provide significant information on differences in walkability levels. One of the aspects that could be not fully discussed in the paper is how the case studies are placed and integrated into the overall urban systems (cities and metropolitan areas). The position regarding the existing and planned centres and subcentres as well as existing transport connections may influence the mobility scenarios, therefore modulating the walkability outputs within the development. Such analysis could be an important contribution to the research on walkability. Although more research is necessary to get a better understanding of the factors affecting walkability in current Polish socio-economical conditions, the present study has shown that is useful to provide evidence from Poland and recognise the position of newly built development.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Annex. The calculation of the walkability index.

	District	Z-score of RD index	Z-score of SC index	6 x Z-score of LUM index	WI
1.	Nordhavn	-0.60	0.68	1.68	1.76
2.	Seestadt	-1.03	-1.41	5.89	3.45
3.	Sluisbuurt	1.16	-0.02	-8.36	-7.23
4.	Garnizon	0.48	0.74	0.79	2.02

The overall result of the calculations is the value of the walkability index for the selected four districts. In compliance with the assumptions of the original formula, the higher the index, the better conditions for walking a studied environment creates, based on the parameters of urban form solely. Against the background of the developments from Austria, Denmark, and the Netherlands, this value is relatively high. The lowest index (−7.23) was obtained for Sluisbuurt. It can be explained through the low LUM index, which is of the highest importance for the final value of the walkability index.

Some limitations are bound to the method of calculating the walkability index. The first and most important one is that all the components are standardised, which means that they are relative. In other words, the value of the index strictly depends on the parameters of the group of developments selected for comparison. In our research, the group included only four developments, three of which are characterised by the deliberate shaping of urban form according to the walkability concept. Therefore final values of the walkability index cannot be reliable for assessing the walkability of the Garnizon district. Within a different sample group, the index for the Garnizon may assume higher or lower values.

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