URBAN DEVELOPMENT DECISIONS BASED ON THE ECOLOGICAL FOOTPRINT

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Abstract In the Hungarian cities, large-scale investments have recently been carried out or are being planned. Most of the investments focused the modernization and renovation of existing line sections, but there are also examples of new lines being built. Due to the increasing demands placed on rail transport (reduction of noise and vibration loads, as well as of life cycle costs), the use of embedded superstructures is gaining ground in Hungary as well. These superstructures are excellent from a technical point of view and have a lower environmental impact in terms of noise and vibration, but the cost savings and ecological footprint (EF) reductions vary between designs. The aim of our research is to explore how the social and economic sustainability development goals of rail transport infrastructure development can be achieved with the least environmental impact. The use of the EF indicator can also help corporate and policy makers to select and support the right construction technology.

Keywords: ecological footprint, urban development, construction projects, sustainability, Hungary

JEL: L7, O14, Q51

University of Maribor Press

DOI https://doi.org/10.18690/um.epf.3.2023.6
ISBN 978-961-286-736-2

1 Introduction

Kecskemét was a Hungarian market town and agricultural trading center, which became the county seat of Bács-Kiskun county after the county restructuring in the 1950s (Figure 1). Over the past 70 years, the city's economic profile has increasingly shifted towards services and industry, with an important milestone being the announcement of the Daimler-Benz car assembly plant in 2008. The factory's establishment briefly revitalized the city's development, resulting in an increase in population from 107,000 in 2001 to 112,000 in 2014 (HCSO), despite the natural decrease of around -1% typical of the city (Lechner Knolewledge Center, n.d.).

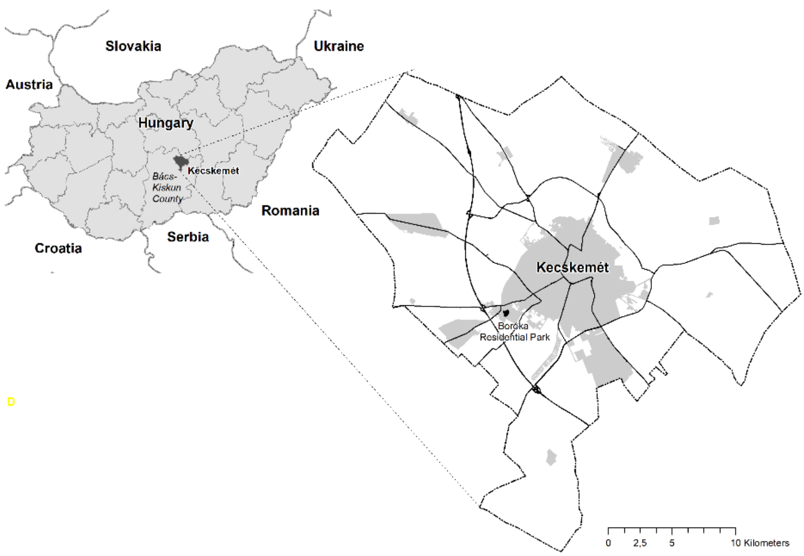

Figure 1: The geographical location of Kecskemét

Source: ArcMagyarország (2021).

In addition to the Mercedes plant, suppliers and other related service providers (logistics, facility management) also settled in the city, which overall significantly improved the city's employment (the ratio of taxpayers increased from 46.16% in 2010 to 52.03% in 2018) and unemployment (decreased from 7.26% in 2010 to 3.07% in 2018) indicators (Lechner Knowledge Center, n.d.). However, the city failed to exploit this high-prestige FDI investment fully, and over the past decade, it has not been able to diversify its economy (e.g. by developing tourism). As a result, a strong dependence on the automotive industry has developed.

The Mercedes investment positively affected housing construction in the early 2010s, when there was a significant increase in demand for rental apartments and houses. As a result, the proportion of new-built homes between 2010 and 2013 significantly exceeded the national average (0.42-0.72% compared to 0.17-0.48%). After a two-year downturn between 2014 and 2016, another upward trend started from 2017 onwards. In 2018, the proportion of new-built homes was more than twice the national average (0.92% compared to 0.4%), and in 2019 it was also significantly above (0.81% vs 0.47%) (Lechner Knowledge Center, n.d.). This is because the city is in a favorable geographical location, the capital is easily accessible from here, and there was no significant drop in property prices after the 2008 crisis due to the Mercedes investment. In fact, since 2017, the average price per square meter of residential real estate has nearly tripled (from 565 EUR/sqm to 1.507 EUR/sqm) (ingatlannet.hu).

The first residential parks appeared in Kecskemét in the second half of the 2000s. According to Hegedűs and Csatári (2012), there were five residential parks in the city in 2009, totalling 448 apartments. Over the past decade, numerous new residential parks have been created in the city, including Boróka Park, the subject of our research. The project started in 2016 and is in its second phase, with two-thirds of the planned 600 apartments already sold. The sales experience indicates that about two-thirds of buyers are investors who purchase the properties for rental purposes or in the hope of future price increases. Of the 23-hectare area owned by the investors, only 3 hectares are planned for residential real estate development, while the rest of the area will be used for commercial and green areas, as well as other services such as healthcare, in collaboration with the municipality, creating a new city center (Portfolio.hu, 2022) (Figure 1).

2 Theoretical Background

The EF is one of the best-known and most widely used complex measures of the environmental impact of consumption or production in terms of land area. It is as broad and versatile as money (Wackernagel et al., 2019a; Wackernagel et al., 2019b). Our former researches (see Szennay et al., 2021; Szigeti et al., 2021; 2023) suggest that there is a demand for an easy-to-use EF calculator, which is free, and SMEs (Small and Medium Enterprises) could reliably and without any professional expertise measure environmental impacts of their activity. Results of (Szigeti et al., 2021) showed that it is feasible to develop a standardized calculator for SMEs considering only the common elements of environmental impacts (i.e. meals, fossil fuels, electricity, etc.), while EF of material usage could be added by using sector specific satellite calculators (Szennay et al., 2021). In the case of the construction industry, such a calculator was developed and tested on Hungarian dwellings by (Szigeti et al., 2023). EF calculation of construction materials is based on the (unpriced) construction breakdown system (CBS), which is generally accepted in the Hungarian industry and consists of four steps. First, item materials are identified and converted into a common and preferred measurement (e.g., m^2, m^3, etc.). It is important, as some material types are used in more phases or in different types. Then, in the second step, materials are aggregated for the whole project. Third, measurement units are converted into more appropriate units only for calculation if needed. Finally, in the fourth step, EF is calculated using Inventory of Carbon and Energy 1.6a (Hammond & Jones, 2008) or 3.0 (Embodied Carbon Footprint Database, n.d.). For some unique items, such as windows and doors, EF is calculated in a separate analysis.

3 Methodology

The first practical test of the previous theoretical building material ecological footprint calculation (Szigeti et al., 2023) was carried out on the construction of the Boróka housing estate. Using a sample of two new build condominiums from Hungary with two and five stories and 28 and 123 apartments, respectively, (Szigeti et al., 2023) calculated a specific EF of 0.20 and 0.17 global hectares per square metres of useful floor area. The difference can be explained by the fact that the smaller condominium was built in three separate buildings with only two stories, so much more structural elements, namely structural concrete and steel, were needed. An important limitation of the calculation is that the as-built condition was considered in both cases, while mechanical (e.g., electricity, heating, water, heating, cooling, etc.), fencing, and all items not included in the CBS were excluded. In our further calculations, since we are mainly interested in orders of magnitudes here, we will use the value of 0.2 gha per square meter. The research was conducted in January and February 2023.

The first phase of development includes 59 apartments with various floor plans. The typical apartment sizes are: 33 m^2 flats, 48-54 m^2 apartments with 1.5 - 2 bedrooms, 68-78 m^2 2.5-bedroom apartments, 110 m^2 4-bedroom apartments.

The condominium was built on an undeveloped plot of land of approximately 3000 m^2 (Figure 2). According to our calculations based on the building plans, the total area of the first floor is 857.16 m^2. The second development phase includes 2x63 apartments with a variety of floor plans. The typical apartment sizes are: 25 to 30 m^2 of flats, one-and-a-half or two-bedroom apartments between 35 and 45 m^2, 50-55 m^2 living room + 2 bedrooms, 60-65 m^2 living room + 3 bedrooms. The condominium will be built on an undeveloped plot of land of approximately 6600 m^2 (Figure 2). According to our calculations based on the building plans, the total area of the first floor is 1347.2 m^2.

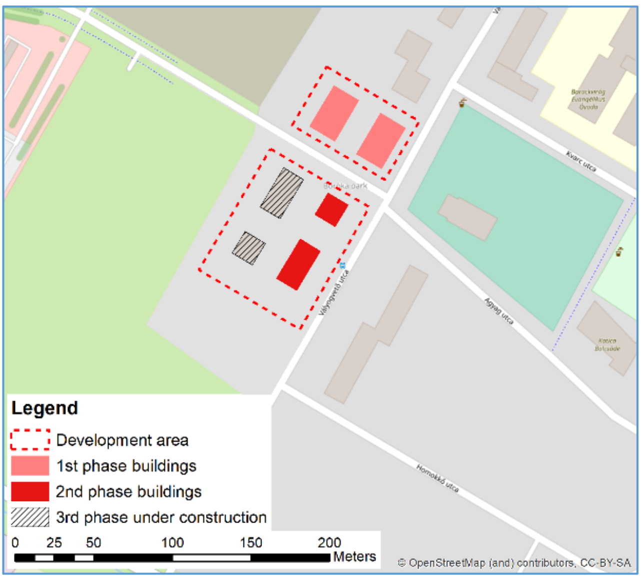

Figure 2: The Boróka Residential Park development phases

Source: OpenStreetMap

Based on the results of structural and energy audits, we estimate that the buildings have an expected lifetime of 50 years, after which they can continue to operate after the necessary interventions. In our further calculations, since we are primarily interested in orders of magnitude, we use the life expectancy of 50 years.

4 Results

The main results of our research are summarised in Table 1. Column A shows typical dwelling sizes (30, 50, 70 and 110 square meters). These are compared with hypothetical family sizes (column B). The per capita square meter values are given in column C. Column D shows the flat sizes multiplied by the ecological footprint per square meter (A*0.2 gha/ m^2). In column E, the value in column D is divided by the expected life of the dwellings (50 years). Finally, column F is the quotient of the values in columns E and B.

Table 1: Summary of our results

A floor area (m^2)	B family size (capita)	C floor area/capita (m^2)	D total footprint (gha)	E footprint/year (gha)	F footprint/year/capita (gha)
30	1	30.00	6	0.12	0.12
30	2	15.00	6	0.12	0.06
50	1	50.00	10	0.20	0.20
50	2	25.00	10	0.20	0.10
50	3	16.67	10	0.20	0.07
70	1	70.00	14	0.28	0.28
70	2	35.00	14	0.28	0.14
70	3	23.33	14	0.28	0.09
70	4	17.50	14	0.28	0.07
110	1	110.00	22	0.44	0.44
110	2	55.00	22	0.44	0.22
110	3	36.67	22	0.44	0.15
110	4	27.50	22	0.44	0.11
110	5	22.00	22	0.44	0.09

The results in Table 1 show that this value is between 0.06 gha/person and 0.44 gha/person. When interpreting the results, it is essential to note that we are only looking at the completion of the dwelling up to its structural condition, we do not include the building envelope or new appliances, and we do not consider the ecological footprint of the use. Our research includes many simplifications, we have not considered the footprint of built-up areas and energy used in construction, so our estimates only consider the part of the real environmental impact.

5 Discussion and Conclusion

According to the latest Global Footprint Network data (2022), Hungary has a per capita ecological footprint of 3.9 gha. In our research, we used the example of Boróka Park to investigate how much buying a dwelling contributes to the annual ecological footprint. At this stage of the research, it is not possible to say what the overall impact of the construction of Boróka Park will be on the footprint of the people moving there, but at around 25 square meters per capita, the ecological footprint per capita will remain at 0.1 gha per capita per year. This can be easily compensated by the more favorable energy characteristics of the new housing. It is also advisable to link public subsidies to limited dwelling sizes and larger family sizes. The resulting EF value can be used to position the homes for sale and to help consumer choice in the environmentally conscious consumer segment. This is the first application of the prior theoretical results of our research (Szigeti et al., 2023) so we do not have comparative data, which is a limitation of the interpretation of the results.

The transition to sustainable cities and the related SDG11 will be one of the biggest economic challenges in the coming years, where ecological footprinting can provide significant support in both the planning and implementation phases. The cornerstones identified in our research can provide real help in planning and decision-making.

Acknowledgment

This research was supported by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund, financed under the Tématerületi Kiválósági Program 2021 (TKP2021-NKTA) funding scheme (Project no. TKP2021-NKTA-44).

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