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Closed Urban Blocks versus Open Housing Estate Structures: Sustainability Surveys in Brno, Czech Republic

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Abstract. A prominent place in the spatial arrangement of Czech as well as other post-socialist, Central European cities belongs to 19th century closed urban blocks and the open panel housing estates which were erected during the socialism era in the second half of 20th century. The urban characteristics of these two fundamentally diverse types of residential structures have, as we suppose, a different impact on the sustainable development of the urban area. The amount and character of local greenery, the spatial arrangement and accessibility of the courtyards, the spatial forms of the surrounding buildings and many other factors can influence the ecological stability of the area, its hygienic qualities, the intensity and way of using by various social groups, and also e.g. the prices of real estates. These and many other phenomena indicate the ecological, hygienic, social and economic sustainability of the urban area. The research methodology evaluates specific measureable indicators of sustainability within a range from 0 to 10 points where 5 points correspond to the general standard in the area, 0 points indicate degradation, and 10 points indicate the highest contribution to sustainable development. The survey results are reflected in the overall sustainability index and in the residents' satisfaction index that reflects the subjective satisfaction based on questionnaires surveys. The paper analyses the residential structures in the Central European city of Brno, Czech Republic. The case studies of the urban blocks near the city centre and of the panel housing estate Brno - Vinohrady are compared. The results imply that a considerable positive impact on the sustainable development of the area should be ascribed to the green closed urban blocks near the city centre. These urban blocks with a closed courtyard provide a quality outdoor environment with a certain level of privacy. This factor can significantly support the development of local community.

1. Introduction

An important role in the spatial structure of Czech and other post-socialist cities play two types of housing development. One of them are closed urban blocks from the 19th century and the other is an open housing estate structure from the second half of the 20th century. Both types of housing development create spatial structures made up of multi-storey buildings and variously arranged spaces between houses. Despite each type of housing development is the result of a different urban planning conception created in different periods, the principles of both conceptions are still applied nowadays. We are wondering which of these concepts is better suited to the principles of sustainable development of urbanized territory. We will focus specifically on the influence of the spaces between residential buildings on sustainability and on the satisfaction of the local community, for which we consider for research purposes the inhabitants of houses around the investigated spaces between houses. How do these spaces affect the character of the outdoor environment? Do the residents consider the spaces as



important for their quality of life? The answer to these questions can be a basic lesson not only in the conditions of the Czech Republic. The findings can also bring a new perspective on the future of the prefabricated panel housing estates, where the danger of their social decline is often discussed. Sustainable development of housing estates is often discussed [1] considering the intensity and the way of using the spaces between residential buildings

Both of the above-mentioned urban conceptions had the ambition of creating a valuable outdoor environment where people spend time in contact with other people and nature near their home. The outdoor environment immediately accessible to the inhabitants represent the spaces between the houses. The quality of the outdoor environment, which is a significant factor of the quality of life [2], can be influenced by the partial characteristics of spaces between the houses. The amount and character of local greenery, the spatial arrangement and accessibility of the spaces, the spatial forms of the surrounding buildings and many other factors can influence the ecological stability of the area, its hygienic qualities, the intensity and way of using by various social groups, and also e.g. the prices of real estates. These and many other phenomena indicate the ecological, hygienic, social and economic sustainability of the urban area. Many principles are described in professional literature. Grass surfaces and tree shades efficiently reduce the high surface temperature [3]. Urban greenery reduces the air temperature in the urban area, at least on the local scale [4]. Different forms of buildings help to mitigate the level of traffic-induced noise in the open spaces [5]. Other characteristics of open spaces may have impact on social qualities of neighbourhood. The level of noise pollution in the environment is perceived differently by various social groups, with higher sensitivity in the middle-aged people [6]. There are other factors as air pollution that have a strong influence on the health of communities and their social development [7]. The presence of greenery in public space may also influence the feeling of safety [8]. Greenery, water and quality public space can influence the price of surrounding real estate [9,10].

The aim of this study is to analyse the influence of the characteristics of spaces between the houses on selected (available) indicators of the sustainability of the area and on the satisfaction of the local community. The study examines these relationships on the example of two principally different urban structures in the city of Brno in the Czech Republic. This study builds on the results of the previous research [11], which is now focused in detail on two locations in Brno.

2. Methods and analysed areas

2.1. Methodology and data

The spaces between residential buildings are an integral part of different types of housing structures. The analysis of the relationship between the characteristics of the spaces between buildings and the indicators of sustainability and the resident' satisfaction allows to identify the advantages and disadvantages of different housing development - housing structures.

The analyse covers following urban characteristics of the spaces between residential buildings: location within the city, the quantity and character of greenery, the way of the space arrangement and accessibility, the form and high of surrounding buildings, the ownership of the spaces and surrounding buildings, etc. These characteristics can influence the ecological stability of the area, its hygienic qualities, the social and economic development and sustainability of the locality.

The contribution of spaces between buildings for sustainability is evaluated using the multi-criteria analyse, where the indicators of sustainability were used as the criteria. The selected (accessible) indicators of sustainability are grouped into four main pillars: ecology, hygiene, society and economy. Each indicator was evaluated on the scale from 0 to 10 points when the median value (5 points) referred to common standards in the area, 0 points referred to degradation of the measured indicator, and 10 points referred to the maximal contribution of the phenomenon to the sustainable development. If a given indicator could only attain unfavourable values, it was evaluated on a scale from 0 to 5 points (e.g. manifestations of vandalism). If a given indicator was not assessed or not determined in the studied area, it was assigned the neutral value of 5 points. The median values for certain indicators (diversity and number of activities, numbers of visitors, etc.) were determined on the basis of preliminary observations

in a pilot study of the area BV4 on the Brno-Vinohrady housing estate. The median values in questionnaires corresponded to a neutral perception of the given phenomenon. The median values of other hygienic and social indicators correspond with the standard level of the phenomenon in Czech Republic [11,12].

The importance of the individual indicators of sustainability was taken into account by the weightings – an index that converted the points awarded for a partial indicator or group of indicators. This weighting index was developed by dividing the overall weighting of 100 among the partial pillars of sustainability, subsequently among framework aggregated groups of indicators, and finally among partial measurable indicators. Specialists in the individual pillars of sustainability performed the allocation of weightings and the definition of indicators evaluation. The environmental pillar was divided into an ecological pillar and a hygiene pillar. Of the total weighting of 100 %, 10 % was allocated to the ecological pillar, 25 % to the hygiene pillar, 35 % to the social pillar, and 30 % to the economic pillar. The resultant value of weighted points in the sustainability pillar is equal to the sum of weighted points in the framework aggregated indicator. The resultant value of weighted points in the framework aggregated indicator is equal to the sum of the weighted points of the partial indicators. The weighted points of the partial indicators were obtained as the product of the points and weightings of these indicators divided by 10, where the number 10 represents the maximum of available points [11,12]. The table 1 presented in this paper because of its ability to be published covers just the pillars, the partial measurable indicators and the points assigned to each case study.

The following methods were used for the indicators determination (evaluation): the observation, questionnaire survey among the residents of related houses, the statistical analysis, and the analysis of real estate prices.

The observation was focused on the information about the manner and frequency of using the space, and on the occurrence of pathological phenomena which potentially influence the feeling of safety in the investigated space. The observation process included measuring of temperature, humidity and acoustic pressure (used certified, calibrated devices). The measuring was held from 12 to 15 o'clock during warm summer day. Obtained information were used to determine the hygienic indicators. They confirm the published research results [3, 4].

The important source of information is the questionnaire survey among the residents of the adjoining buildings. In total there were distributed about 1200 questionnaires, out of these 20-35% were completed for each building (building entrance) within 2-3 weeks (most case studies included about 150 distributed questionnaires). This investigation aimed at the manner of using the space, at the way the users perceived it, whether they feel safe, and last but not least at the feeling of belonging to the given locality. The questionnaire investigation served to quantify some social indicators.

Subsequently also the index of residents' satisfaction [q] was quantified. The source of data to quantify the satisfaction index [q] was also and only the questionnaire answers. The index is a proportional ratio of the total sum of the concrete points obtained from the respondents' answers to the maximal sum of available points. It expresses the level of inhabitants' satisfaction; the higher evaluation, the higher satisfaction. The index of satisfaction reflects the answers to the questions concerning e.g. frequency and purpose of the visits in the investigated space, the feeling of safety, aesthetic quality, neighbourhood relationship, feeling of home, participation in the maintenance of the space, etc. The index covers also the subjective perception of the measurable phenomenon (measured and expressed in the indicators) - noise, wind, dust and smell.

The data about the social structure of the residents were get from the 2011 census (inhabitants number, age structure, economic activity and education structure) and the 2001 census (inhabitants number for the trend comparison) performed by the Czech Statistical Office [13]. The source of information about the property prices and the rents were the statistics of the real estate agency Real Spectrum [14]. These last mentioned data were used for the indicators determination.

2.2. Analysed areas

The presented case studies are located in the city of Brno. This city with almost 400 000 inhabitants is the second largest city in the Czech Republic and represents a typical post-industrial city in the Central Europe. Two forms of residential structures in the City of Brno in the Czech Republic were selected for the analysis: closed urban blocks from the 19th century (case studies BS1-BS6), and open housing estate structures constructed under the socialism era in the 20th century (case studies BV1-BV4).

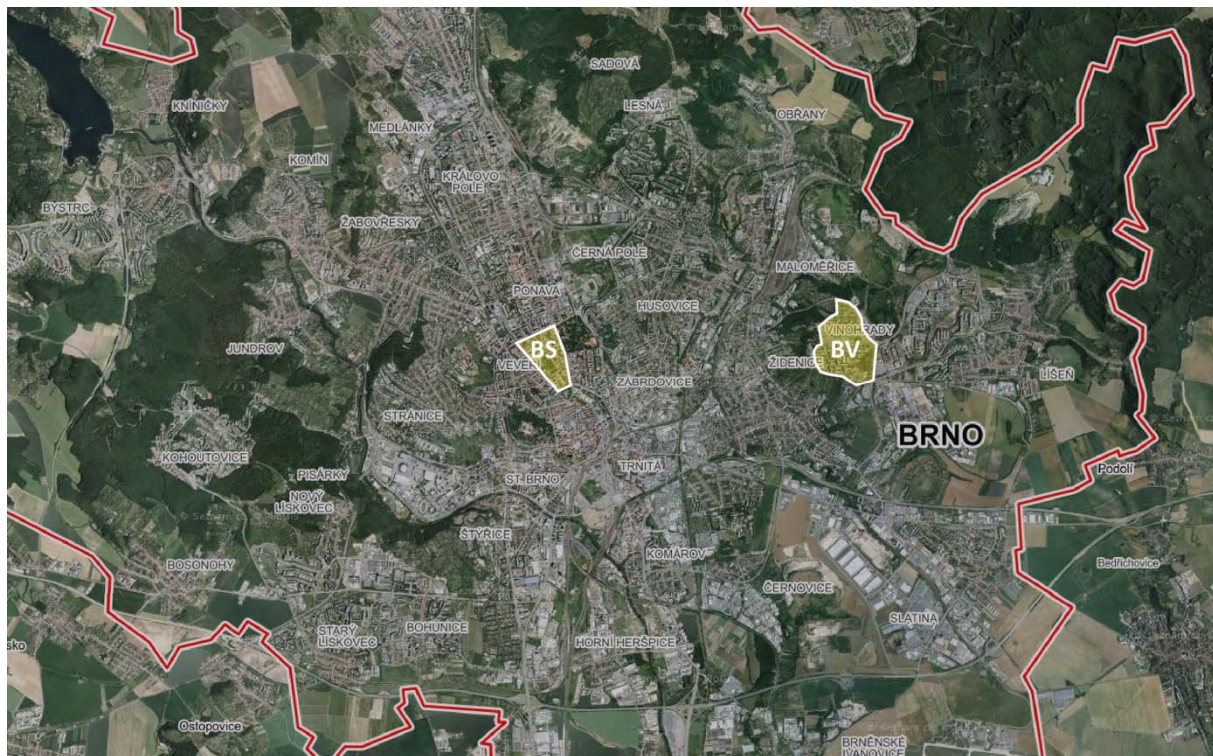


Figure 1. Position of localities with the case studies BS1-BS6 (BS) and BV1-BV4 (BV) on the Map of Brno [15]

2.2.1. The closed urban blocks in the city centre of Brno (BS1–BS6). The surveyed spaces are integral part of closed urban blocks of four- to six-floor residential buildings from the second half of 19th century which are located in the wider city centre of Brno (in Czech: Brno - střed). The research focused on six case studies in total which are labelled BS1–BS6. The spaces between residential buildings – the courtyards with a significant proportion of well-maintained low and fully-grown greenery are not, with exception of BS3, accessible to public. The BS1 courtyard is partly used by the primary and nursery school. The B6 consists of two small courtyards located approximately 300 m southeast of B1–B5; they are relatively small in comparison with the other localities; and are predominantly used as storing space of the commercial premises situated on the ground floor. All courtyards are the property of the city which maintains them. The adjoining buildings are owned by a cooperative or association of flat owners. The locality represents an attractive place of housing which is undergoing continuous renovations. The sale and rent prices of housing and commercial space in the locality are above the average within the city of Brno. While the space BS6 is an exception as the prices of housing are below the prices of BS1–BS5 and the prices of commercial space are at the same level as in BS1–BS5.

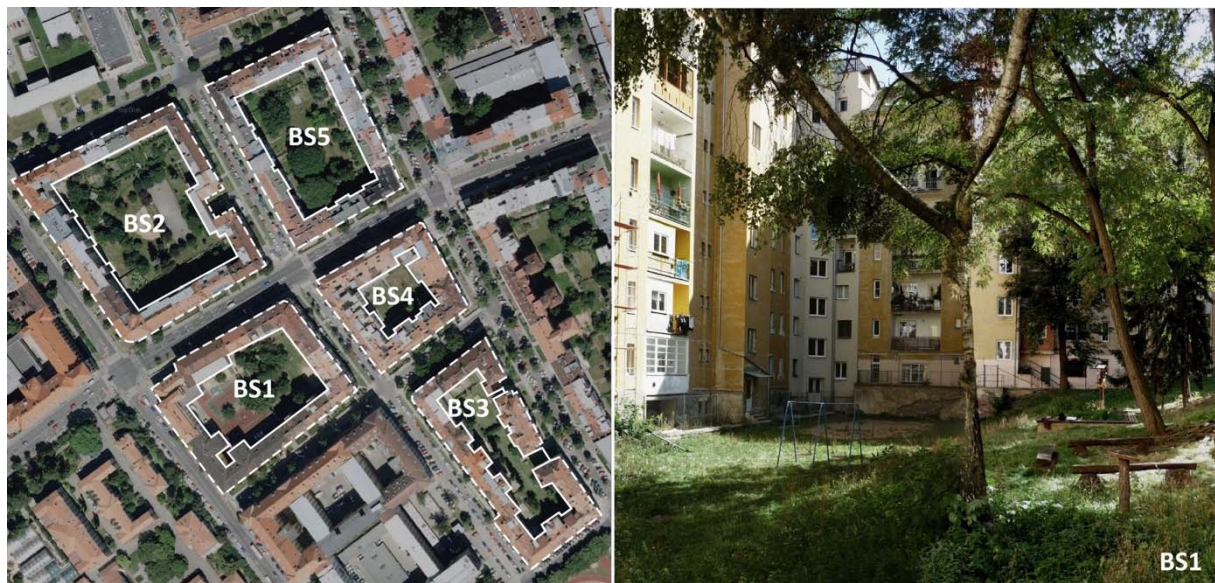


Figure 2. Map marked with the geographical borders of case studies BS1– BS5 [15]



Figure 3. Map marked with the geographical borders of the B6 case study [15]

2.2.2. The open housing estate structure in Brno-Vinohrady (BV1–BV4). The survey was performed on the open housing estate structure - the prefabricated panel housing estate Brno-Vinohrady, in the eastern part of the city. The surveyed spaces labelled BV1–BV4 are located on the plots owned by the city who maintains them. BV1 labels Pálavské náměstí [Pálava square] which is a park with a significant proportion of well-maintained low and full-grown greenery. The park is located in front of a new residential building owned by a cooperative with an underground parking space. There are shops on the street level of the building. On the north side of the park (behind the road) there is a one-story commercial building. BV2 labels a space where greenery consists of only two trees. It is the space between the above mentioned new residential building with commercial spaces on the ground floor and a two-story commercial building. BV3 labels a space with a significant amount of well-maintained low and full-grown greenery. The BV3 space surrounds a twelve-story prefabricated block of flats in private ownership. The BV4 labels the space with a significant amount of well-maintained low and full-grown

greenery. The space is surrounded by two residential buildings; in the south it is a four-story building with flats in private ownership, in the north it is an eight-story building owned by the city. The prefabricated concrete panel housing estate was completed in the socialist era in the second half of 1980s. The housing in this housing estate is considerably popular thanks to its vast services and amenities as well as affordable prices. The only significant drawback is a lack of parking spaces.



Figure 4. Map marked with the geographical borders of case studies BV1–BV4 [15]

3. Results

The research results are summarized and presented in the following Table 1. It presents a summary of the indicators and the pillars of sustainability for the analysed case studies BS1-BS6, BV1-BV4.

Table 1. Table of Sustainability Indicators.

Pillar/ Weight/ Weighted points			Points										
			Partial measurable indicator	BS1	BS2	BS3	BS4	BS5	BS6	BV1	BV2	BV3	BV4
Ecology [x] 10	1-1-1	size	4.0	6.0	3.0	4.0	5.0	0.0	7.0	0.0	6.0	5.0	1.67
	1-1-2	interaction with the surroundings - vegetation	2.0	3.0	3.0	3.0	3.0	0.0	4.0	3.0	8.0	8.0	0.83
	1-1-3	interaction with the surroundings - water	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.83
	1-1-4	shape	9.5	9.0	3.0	8.5	7.0	0.0	9.0	0.0	2.5	4.0	1.67
	1-2-1	biodiversity of desirable tree species	6.0	9.0	6.0	8.0	6.0	0.0	8.0	2.0	8.0	4.0	0.45
	1-2-2	age of desirable tree species	5.0	5.0	4.0	6.0	9.0	0.0	3.0	4.0	6.0	6.0	0.45
	1-2-3	occurrence of undesirable tree species	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	0.45
	1-2-4	occurrence of undesirable herbs	10.0	10.0	10.0	10.0	9.0	10.0	10.0	10.0	9.0	9.0	0.45
	1-2-5	desirable animals living in the wild	3.0	3.0	2.0	3.0	5.0	0.0	3.0	0.0	3.0	3.0	0.45
	1-2-6	ability to collect rainwater	5.0	5.0	4.0	4.0	4.0	0.0	4.0	0.0	4.0	4.0	0.45
Hygien e [y] 25	1-2-7	natural quality of water area	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.45
	1-2-8	naturalness of bank zones	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.45
	1-2-9	aquatic animals living in the wild	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.45
	1-2-10	density of vegetation	5.0	5.0	4.0	3.0	5.0	0.0	5.0	0.0	6.0	6.0	0.91
	2-1-1	reduction of temperature extremes	6.0	6.0	6.0	6.0	6.0	7.0	5.0	5.0	7.0	6.0	1.92
	2-2-1	reduction of humidity extremes	9.0	9.0	9.0	9.0	9.0	9.0	5.0	5.0	7.0	7.0	1.92
	2-3-1	reduction of sunburn in summer	6.5	6.5	8.5	7.5	7.0	9.0	2.0	7.0	10.0	4.0	0.96

Pillar/ Weight/ Weighted points		Partial measurable indicator	Points										Weight
			BS1	BS2	BS3	BS4	BS5	BS6	BV1	BV2	BV3	BV4	
17.45	2-3-2	reduction of insolation outside summer	2.0	2.0	2.0	2.0	4.0	0.0	4.0	1.0	4.0	4.0	0.96
14.70	2-4-1	reduction of windiness	7.5	7.5	6.0	7.5	7.5	7.5	2.5	5.0	3.0	7.5	1.92
18.25	2-5-1	dust control	9.0	9.0	7.0	9.0	9.0	8.0	5.0	1.0	6.0	7.0	1.92
15.97	2-6-1	level of acoustic pressure	7.1	7.1	5.7	7.1	7.1	7.0	5.0	4.0	5.0	6.0	1.28
14.88	2-6-2	reduction of external noise from traffic	10.0	10.0	7.9	10.0	10.0	10.0	8.0	4.0	7.5	7.5	0.64
11.29	2-6-3	noise nuisance from the neighbourhood	4.3	4.1	4.0	4.7	4.3	4.7	3.3	1.6	3.2	4.1	0.64
10.46	2-6-4	local noise nuisance	3.7	3.3	3.4	4.1	3.7	4.0	2.7	2.0	3.5	3.9	0.64
13.91	2-6-5	pleasant natural sounds	7.0	7.0	6.0	6.5	7.0	5.0	6.0	5.0	9.0	7.0	0.64
15.01	2-7-1	local smell nuisance	4.0	4.6	3.5	4.5	4.3	2.0	3.9	2.4	3.7	4.1	0.96
	2-7-2	pleasant natural smell	7.0	9.0	7.5	7.5	7.0	3.0	7.0	5.0	7.0	6.0	0.96
	2-8-1	rate of insect nuisance	4.3	4.3	3.8	4.5	4.3	4.3	2.8	3.8	3.9	4.0	1.92
	2-9-1	cleanliness of the space	5.5	9.5	5.5	9.5	5.5	3.0	5.0	5.0	5.0	7.0	3.85
	2-10-1	limitation of chemical pollutants	6.0	6.0	6.0	8.0	6.0	8.0	5.0	5.0	6.0	6.0	3.85
Society [z]	3-1-1	change in the number of residents	8.0	9.0	5.4	4.5	6.0	0.0	5.0	5.0	6.0	0.0	1.75
35	3-1-2	residents age structure given in the census	5.0	3.4	5.0	4.7	3.0	2.5	3.8	2.5	2.5	2.5	1.75
22.38	3-1-3	residents age structure in survey	10.0	8.0	9.5	4.0	4.0	0.0	8.5	1.0	7.0	5.0	1.75
21.47	3-1-4	gender diversity of the space users	9.6	5.0	8.5	4.0	8.5	5.0	3.5	7.5	5.5	10.0	1.75
22.30	3-2-1	subjective state of health	7.5	6.9	8.8	7.9	7.2	8.6	8.1	8.2	7.0	6.3	7.00
19.60	3-3-1	educational structure of residents	8.5	4.8	4.9	4.4	4.8	3.3	4.6	6.0	4.9	4.9	0.58
21.16	3-3-2	median of monthly income	7.5	6.3	7.5	6.5	7.5	5.0	7.5	7.5	7.5	7.5	0.58
16.83	3-3-3	unemployment	5.6	10.0	6.2	9.0	7.0	7.8	4.5	7.0	4.6	4.0	0.58
21.25	3-3-4	ethnic diversity	5.0	5.0	10.0	5.0	10.0	5.0	6.0	8.0	6.0	6.0	0.58
19.30	3-3-5	feeling of safety in the locality by day	4.1	4.7	4.6	4.6	4.5	4.3	4.3	2.4	3.7	3.0	0.58
19.70	3-3-6	feeling of safety in the locality by night	3.6	3.8	4.2	4.1	3.9	3.9	3.3	1.8	3.1	2.3	0.58
17.98	3-3-7	feeling of safety in the space	8.4	9.0	7.2	9.4	8.4	7.0	6.9	3.8	6.5	5.3	0.58
	3-3-8	display of vandalism	5.0	5.0	4.0	5.0	5.0	4.0	3.0	4.0	5.0	5.0	0.58
	3-3-9	traces of using drugs	5.0	5.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.58
	3-3-10	groups drinking alcohol	5.0	5.0	3.0	5.0	5.0	5.0	5.0	3.0	5.0	5.0	0.58
	3-3-11	untrustworthy strange persons	5.0	5.0	3.0	5.0	5.0	5.0	2.8	1.6	5.0	4.1	0.58
	3-3-12	“good address”	7.7	8.0	7.7	7.4	9.5	6.5	5.2	4.5	5.4	5.8	0.58
	3-4-1	diversity of activities	2.7	2.7	1.7	2.3	2.5	2.8	6.8	3.9	5.4	3.9	1.00
	3-4-2	frequency of activities	3.8	5.1	2.7	3.3	4.0	8.6	9.2	10.0	9.7	5.6	1.00
	3-4-3	maximum number of visitors	1.5	7.5	7.5	2.0	6.0	0.0	1.5	8.0	1.7	1.5	1.00
	3-4-4	average number of visitors	7.3	5.7	5.0	1.1	5.0	0.0	2.0	10.0	4.5	1.5	1.00
	3-4-5	space covers the needs	6.7	7.5	3.4	7.1	7.2	4.6	6.9	1.5	4.7	4.7	1.00
	3-4-6	perception of aesthetic quality of the space	6.5	7.6	4.3	8.0	7.2	5.0	7.3	3.4	4.2	5.4	1.00
	3-4-7	pleasant view	3.9	5.6	5.0	3.0	6.8	2.9	7.5	3.0	5.7	5.6	1.00
	3-5-1	feeling of home	7.7	7.1	6.3	6.9	6.8	5.4	5.5	4.5	5.4	5.2	1.40
	3-5-2	perception of residential mobility	6.5	4.6	7.1	6.8	5.2	6.1	8.1	8.0	6.3	8.4	1.40
	3-5-3	“longtime residency”	7.4	6.7	9.8	7.7	7.1	4.0	8.1	6.2	8.8	9.7	1.40
	3-5-4	relationship with neighbours	6.9	6.3	6.3	6.9	6.2	6.4	6.5	5.5	5.4	5.2	1.40
	3-5-5	participation in maintenance of the space	0.6	2.8	1.7	2.2	3.8	3.2	3.2	1.5	2.2	2.3	1.40
Econom y [w]	4-1-1	building plot	7.5	7.5	7.5	7.5	7.5	10.0	0.8	0.8	0.8	0.8	4.29
30	4-2-1	apartment	7.5	7.5	7.5	7.5	7.5	6.5	4.0	4.0	4.0	4.0	0.61
21.98	4-2-2	shop	10.0	10.0	10.0	10.0	10.0	10.0	7.5	9.0	5.0	5.0	0.61
21.41	4-2-3	administration	10.0	10.0	10.0	10.0	10.0	10.0	6.7	7.5	5.0	5.0	0.61
21.97	4-2-4	manufacturing and storage	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.61

Pillar/ Weight/ Weighted points		Partial measurable indicator	Points										Weight
			BS1	BS2	BS3	BS4	BS5	BS6	BV1	BV2	BV3	BV4	
22.42	4-2-5	built-in parking space	10.0	10.0	10.0	10.0	10.0	10.0	4.0	4.0	4.0	4.0	0.61
21.69	4-2-6	outdoor parking space	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	0.61
19.31	4-2-7	parking space in a separate garage	10.0	10.0	10.0	10.0	10.0	10.0	6.7	6.7	6.7	6.7	0.61
15.89	4-3-1	apartment	8.7	8.7	8.7	8.7	8.7	7.5	4.2	4.2	4.2	4.2	0.61
14.90	4-3-2	shop	10.0	10.0	10.0	10.0	10.0	10.0	8.8	9.0	2.5	2.5	0.61
16.35	4-3-3	administration	6.5	6.5	3.5	3.5	3.5	6.5	3.6	3.6	5.0	5.0	0.61
16.60	4-3-4	manufacturing and storage	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	5.0	5.0	0.61
	4-3-5	built-in parking space	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	0.61
	4-3-6	outdoor parking space	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	0.61
	4-3-7	parking space in a separate garage	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	0.61
	4-4-1	occupancy of apartments	10.0	10.0	10.0	10.0	10.0	7.0	10.0	10.0	10.0	10.0	2.14
	4-4-2	use of commercial spaces	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	2.14
	4-5-1	upkeeping costs per unit area	5.0	4.5	4.2	3.0	4.2	5.0	6.0	6.0	6.0	5.0	2.14
	4-5-2	upkeeping costs per resident	8.2	5.0	6.8	6.1	6.8	5.0	4.6	3.6	6.0	6.2	2.14
	4-6-1	tidiness and technical condition of the space	3.5	7.5	5.5	7.5	3.5	2.0	5.0	5.0	5.0	7.5	1.43
	4-6-2	tidiness and technical condition of the furnishing elements	5.5	5.5	7.5	9.5	7.5	2.0	3.0	5.0	5.0	6.0	1.43
	4-6-3	tidiness and condition of the vegetation	3.5	5.5	5.5	7.5	5.5	0.0	5.0	5.0	5.0	7.5	1.43
	4-7-1	median monthly income	5.5	4.0	5.0	5.0	5.0	3.0	5.0	5.0	6.0	5.0	4.29

The significant phenomena and relations reflected in the indicators are summarized in following commentaries.

3.1. Ecology

The closed urban blocks in the city centre (BS1-BS5), specifically the courtyards in the blocks and also the spaces between and around the residential buildings in the housing estate Brno-Vinohrady (BV1, BV3, BV4) generate good or acceptable ecological quality of the urban area. In all the mentioned cases the spaces have a significant amount of maintained greenery which includes diverse species. The spaces between buildings (case studies BV2 and BS6) serving as operational corridors do not generate good ecological quality of the area. Their weakness is the lack of natural elements. It is important to say in general, that the evaluated spaces generate ecological quality which is not generally standardized in urban areas. We can just compare the assessed qualities.

3.2. Hygiene

The most of analysed urban structures generate good hygiene qualities of the environment, only the BV1 and BV2 case studies are slightly below average. They do not reduce some hygiene phenomenon to a sufficient extent (noise, windiness, etc.) In case of the BS1-BS6 spaces it is worth mentioning the capacity of closed blocks to reduce the level of acoustic pressure and to eliminate the external traffic noise. The BV1-BV4 urban structures do not have such capacity. All of the urban structures are able to raise the humidity to a desired level. In all the case studies are present significantly pleasant natural sounds and smells (except the higher smell nuisance in BS6 and BV2). The comfort of staying in the surveyed spaces could be considered of a good level. The worst hygiene condition offers the BV2 case study (a simple pedestrian corridor). In general, the closed urban blocks provide higher level of hygiene qualities than the open housing estate structures.

3.3. Society

None of the localities is considered a socially degraded area. The summary of social indicators expressed in the sustainability pillar is above the standard in all surveyed case studies.

The number of residents in the buildings BS1 and BS2 in the wider centre of Brno is stabilized when the decrease between 2001 and 2011 was only 2 %. The other analysed residential buildings in the city centre were affected by population decline, especially the buildings in the case study BS6 with 27% inhabitant loss between 2001 and 2011. The age structure (40 years) mostly approximately corresponds with the median age in the country (except BS6); there are more seniors than children in this locality. The ratio of residents with higher than primary education is mostly slightly under the state level average (85 %) [13]. Using of the spaces is strengthened by the feeling of safety in the specific courtyards. The level of safety is enhanced by the fact that the courtyards are not open to public. According to the questionnaires, the BS1, BS2, BS4 and BS5 courtyards satisfy the residents' needs. All the residents consider the place their home. The local respondents in the wider centre of Brno have shown a unique willingness to get financially involved in the maintenance of the courtyards if they were more used by children (in BS1-BS5).

The prefabricated panel housing estate Brno-Vinohrady suffers from the decrease of residents; between 2001 and 2011 there was an average decrease approximately 7%. This number with exceptions corresponds with the standard trend in similar housing estates in Czech Republic. According to the census in the analysed buildings, the age structure shows high predominance of children under 14 years to the seniors, where the ratio is roughly 2:1 (unsustainable ratio: just the young people often leave the housing estate). The ratio of the residents of the housing estate with higher than primary education reaches the state average (85 %) [13]. The area BV1 (an original park with surrounding buildings, different from other numerous similar spaces) is perceived as an aesthetic, pleasant place that covers the resident's needs.

3.4. Economy

The closed urban blocks (BS1-BS6) generally benefit from their location in the wider city centre. They are popular in spite of the higher prices which exceed the city average [14]. The urban block BS6 is an exception as the prices of housing are below the prices of BS1–BS5 and the prices of commercial space are at the same level as in BS1–BS5.

The prices and rents of flats in prefabricated housing estate Brno-Vinohrady (BV1-BV4) are below the city average; but the prices of the outdoor parking spaces significantly exceed the city average [14] as there is a considerable lack in the locality. The living in the housing estate is desired because of its price accessibility.

The results show that the economic parameters of the analysed housing structures are significantly influenced by the characteristics of the locality as a whole, especially by its facilities, traffic accessibility and comfortability.

3.5. Overall sustainability

The following table 2 presents the overall sustainability [s] as well as the Resident's Satisfaction Index [q] (see section 3.6). The overall sustainability of the evaluated case studies [s] consists of the sum of the points in the partial pillars of ecology [x], hygiene [y], society [z] and economy [w].

Table 2 shows some basic principal results. It indicates that the most sustainable urban structures seem to be the case studies in the Brno-centre locality (BS1-BS5) with exclusion of BS6. This result is given by some facts. The closed urban blocks, especially their courtyards are, in comparison with the other case studies, slightly above the average in terms of ecology, moreover they create hygienically quality environment. The BS1-BS5 case studies are also above the average in terms of social sustainability. The resulting economical sustainability of closed urban blocks exceeds the housing estate results (BV1-BV4).

Table 2. Overall Sustainability „s“ (max. 100) and Residents' Satisfaction Index „q“ (max. 100).

	Overall Sustainability [s] $s = x + y + z + w$	Residents' Satisfaction Index [q]: $\bar{O}$ (min./max.)
BS1	65,8	69,7 (59,2/87,3)
BS2	66,4	66,4 (55,5/80,2)
BS3	63,3	62,3 (52,9/72,1)
BS4	65,8	69,6 (52,1/82,3)
BS5	64,6	68,2 (55,8/85,9)
BS6	50,6	59,9 (46,5/77,5)
BV1	54,7	66,9 (54,6/75,7)
BV2	47,4	49,0 (45,8/53,3)
BV3	55,5	58,2 (48,4/70,1)
BV4	55,0	56,5 (45,0/69,8)

The Brno-Vinohrady prefabricated housing estate (BV1-BV4) is characterized by weaker sustainability results although it does not mean that it is an unsustainable area with unclear future. The main reasons for the worse result are the following. The open housing estate urban form, especially the spaces between residential buildings provide an outdoor environment of slightly lower hygienic quality (in comparison with closed urban blocks) and the housing development – the housing structures generate lower potential for economical sustainability. The indicated social sustainability of the BV1-BV4 case studies is over the average, but as a whole below the case studies in the city centre.

3.6. Residents' Satisfaction Index

The source of data to quantify the resident's satisfaction index [q] was the questionnaire survey only. The index is a proportional ratio of the total sum of the concrete points obtained from the respondents' answers to the maximal sum of available points (the higher evaluation, the higher satisfaction). The index of satisfaction reflects the answers to the questions concerning e.g. the using of analyzed spaces, the feeling of safety, noise, wind, dust and smell, aesthetic quality, neighbourhood relationships, feeling of home, participation in maintenance of the space, etc. The Table 2 shows the overall summary of the Residents' Satisfaction Index [q] for the analysed urban structures.

The results [q] directly reflect the character of the housing development. The resident's satisfaction is strongly influenced by the environmental parameters of spaces between residential buildings. That's an important reason why the residents living in the buildings in Brno-centre locality (BS1-BS5) have expressed high level of satisfaction. Closed, calm and quiet courtyards with relatively higher humidity of air are protected from winds, dust and unwanted visitors. The courtyards offer a pleasant, very safe environment for spending the free time and meeting with other people (neighbours). The results indicate that a courtyard with insufficient dimensions and environment qualities (BS6) degrades the sustainability potential.

The housing estates whose concept is the open housing development can generate different situation. The respondents in of Brno-Vinohrady housing estate (BV1-BV4) expressed a relatively lower satisfaction. They perceive the area as being uniform and plain; the spaces between buildings do not significantly influence the quality of environment. The residents do not have an outstanding feeling of home here; they do not consider it a very good address. The spaces between and around residential buildings offer rather a uniform urban design with common environment quality. The renovated park (BV1) is an exception from the social point of view, it is a unique place with original urban design, it is a place generally accepted as a meeting point for the local community. The results also indicate that a space between buildings used just as a pedestrian corridor (BV2) just weakly supports the urban structure sustainability potential.

The results show us how many factors can influence the residents' satisfaction. The quality of outdoor environment is one of the most important factors of resident's satisfaction. It can be influenced by several parameters of the spaces between buildings, which is confirmed by some published studies, namely the influence of greenery [3, 4] and the type and height of the housing structure [5]. The next one important factor is the social quality of local community. Good relations with neighbours (higher in BS1-BS6) can be considered as determining aspect of the sustainable development of local community [16]. The sustainability of local community can influence the social development of the wider locality [17]. There is one more group of technical factors they are not included in the presented research. The indicators of occupancy rate (space per resident, number of residents per room), indicators of technical conditions of the flats, their disposition, etc. can also significantly influence the resident's satisfaction.

4. Conclusions

A total of ten case studies were explored. Two different urban structures matching two different urban planning conception were analysed in two localities in Brno, Czech Republic. Six closed urban blocks were analysed in the locality Brno-střed (BS1-BS6) and four open housing structures in the prefabricated housing estate Brno-Vinohrady (BV1-BV4). The results indicate that both conceptions may provide quality housing with some differences.

The results indicate that the closed urban blocks with their enclosed courtyards (not accessible to the public) provide the thing that the residents living in the centre of town lack most – a quiet, safe, green area (BS1-BS5). The residents perceive the courtyards as a very valuable, safe place to relax. The courtyards create an environment with a considerably higher quality than the surrounding streets. The residents (the local community) have the reason to meet in the courtyards. It seems also that the urban blocks without quality large sized inner spaces lose their residential value, and become more attractive to commercial activities (BS6).

The situation on the socialist-era prefabricated housing estates, whose basic conception is open housing development, is rather different. In the Brno-Vinohrady housing estate (BV1-BV4) with a slightly lower potential of social sustainability and lower resident's satisfaction, the spaces between buildings are uniform, featureless and they are numerous, which lowers their significance for social interaction. As the residents have suggested in the questionnaire survey, the spaces should be differentiated and suitable for particular use. An original place (like the BV1 park) gains from this reason a popularity between the local community. It is also necessary to say objectively that the interest of young families about housing in the housing estate contradicts the unfavourable prognosis. This interest is supported by affordable prices of the housing as well as good services in the locality.

Generally, it can be stated that specific urban forms (closed or open housing development) with their specific spaces between residential buildings can influence the quality of the living environment and the social relationships in the local community. The spaces between buildings represent almost the only chance to spend time in a semi-public environment which is partly protected from the street. It should be emphasised that the specific type of urban development (urban structure) - the type and height of the buildings, their spatial arrangement, and the character of the greenery can primarily influence the hygienic, privacy and safety conditions in the urban area and secondary the attractiveness of the area and the satisfaction of the local community. The overall balance of sustainability of the area and the residents' satisfaction show that the analysed urban structures have more or less succeeded in most cases to create good outdoor housing conditions.

The presented results reflect the situation in the Czech Republic, especially in the city of Brno. It should be stated that further case studies need to be analysed to validate and generalize the findings. However, even now, it is possible to try to answer the question asked in the introduction: which of the analysed urban planning conceptions better corresponds to the principles of sustainable development of the urbanized area? The results indicate that closed urban blocks are better suited to these principles, the local community that accepts higher real estate prices can be more satisfied with the outdoor (courtyard) environment and social relations. The residents of the housing estate are forced to accept some compromises.

From the perspective of the whole city, the prefabricated housing estate represents a cheaper housing option with a good, acceptable living standard. That is a good finding, because the city as a whole can be more sustainable if it offers more different, balanced housing opportunities.

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