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Measuring Livability at the Neighborhood Scale – Development of Indicators and Methods for the Comparison between Neighborhoods and Best Practice within the Chosen City

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Measuring Livability at the Neighborhood Scale – Development of Indicators and Methods for the Comparison between Neighborhoods and Best Practice within the Chosen City

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Abstract. A method that allows an assessment of the livability by comparing different neighborhoods with each other as well as with the best practice was developed in this paper. First of all, a set of 51 indicators comprising the categories of connectivity, traffic, public transportation and bicycle infrastructure, urban form, density, land use, open space coverage ratio, potential for PV, green roof and materials were defined. The values for these indicators were investigated for 36 neighborhoods in the city of Hamburg, Germany. Secondly, some neighborhoods were chosen as the most livable neighborhoods and the average of their results was used for indicating the best practice in Hamburg. This approach allows users to compare their chosen neighborhoods with the best practice of their own city. Thirdly, each absolute indicator value was transferred into a relative one, where 0 % represents the lowest found value and 100 % the highest one. Fourthly, each indicator was assigned with a character. If the smaller percentage the better, like percentage of buildings near a noisy street, this character is “S”. If the bigger percentage the better, like frequency of public travel, the character is “B”. If the closer to the best practice the better, like inhabitants per hectare, the character is “R”. Thus, the ideal neighborhood would show 0 % for character S, 100 % for B and the best practice for R. Finally, the results are presented in the radar charts in order to facilitate the comparison.

1. Introduction

Over the last decades, many sustainability assessment tools designed for different purposes, scopes, and scales have been developed. Although indicators deliver in general a good value, it is often difficult to assess how good or bad the value is and to establish a relation between the selected neighborhood and the city. There are several reasons for the existence of these obstacles. The first one is that the indicators use different units, like minutes, meters, percentages, or ratios, and are thus difficult to compare. Secondly, the ranges of the indicator value are inconsistent, hence the distance between the ideal values and the calculated value entails different information and meaning. For example, the indicator values may range from 0 % to 100 %, from 0 to an open end, from 1 to 6, etc. The inconsistency among the ranges makes it difficult to evaluate and to compare the distance between the ideal value and the calculated one, since the same distance between the ideal value and the calculated one may have different meanings for different indicators. Thirdly, the directions of comparison are inconsistent. For some indicators, the smaller the value the better. However, for some indicators, the bigger the value the better. Also, in the case where the reference value is the ideal, the



closer the calculated value to a reference one, the better it is. Fourthly, cities are not always comparable and, when a city is considered to be livable, the ideal value should be city-specific in order to make the comparison between values suitable for the context. This paper intends to propose a solution with a specific focus on these obstacles. This method makes use of the advantage that indicators generate quantitative values and is, therefore, effective for comparison.

In order to explain how the method can be used, we selected a set of indicators used to investigate the livability and focus on studying the area at the neighborhood scale, which is defined as an area of 500 m x 500 m in this paper. The neighborhood scale has increasingly been proved as an appropriate level to implement sustainability principles in urban transformation processes [1]. As we learned, sustainability is also linked to aspects like walkability and human scale, which exist among the complex interrelationships between buildings, open spaces, and transport networks, among others. The neighborhood is the necessary scale to describe the social quality of the built environment, as well as the most important one for social interactions since this is where people stay most of the time besides their apartment or building. “Within the boundaries of neighborhoods, different types of community institutions and social networks are formed, functioning as intermediaries between local individuals, and offering in principle more opportunities for active participation in collective decisions and their implementation.” [3, 4]. [Geben Sie ein Zitat aus dem Dokument oder die Zusammenfassung eines interessanten Punkts ein. Sie können das Textfeld an einer beliebigen Stelle im Dokument positionieren. Verwenden Sie die Registerkarte 'Zeichentools', wenn Sie das Format des Textfelds 'Textzitat' ändern möchten.]

2. Methodologies

2.1. STEP 1: Choosing neighborhoods and the best practices of the city

There were in total 36 neighborhoods in Hamburg sampled in order to collect the values for the 51 indicators. The values of these indicators were collected by students from a master course within one semester. All the values can be collected using open maps and online resources. This method enhances the quantitative measurement of the neighborhood. Among these 36 neighborhoods, the 11 most livable neighborhoods were selected to stand as best practices, based on the following criteria:

- i) neighborhoods with the highest rents. In Germany, the majority of apartments are rented and the rent reflects the livability. These are highly densified quarters where middle class families prefer to live.
- ii) neighborhoods that are mentioned in surveys by a remarkable majority as the most livable ones.
- iii) in Germany, they are often neighborhoods with buildings from around 1900. In Hamburg, they are supplementary near a water body.

This approach offers the advantage that the ideal values of the indicators may vary in different cities. In other words, the ideal value created by a collection of best practices, which serve as the reference for comparison, is context-dependent. When we investigate neighborhoods within a certain city, we can compare the neighborhoods with the ideal value that belongs to its own city without having to refer it to the most livable city in a different geographical and social contexts.

Table 1. Characters of the indicators based on their ideal values.

Character	Ideal value	Description	Example
B	The maximum value of the 36 neighborhoods	The bigger the better	Connectivity for pedestrians
S	The minimum value of the 36 neighborhoods	The smaller the better	Distance to the next public transport station
R	The average of the 11 most livable neighborhoods, which is also referred to as the reference value	The closer to the reference value (i.e. the average of the most livable neighborhoods), the better	Aspect ratio building height / building distance

2.2. STEP 2: Defining indicators and the ideal values

There are in total 51 indicators categorized into connectivity, traffic, public transportation and bicycle infrastructure, urban form, density, land use, open space coverage ratio, as well as the potential for PV, green roof and recycling materials. Each indicator is assigned with one of the characters B, S or R (see table 1), depending on their ideal value.

Table 2. Categories and characters of indicators. The indicators that are decisive for livability are highlighted in grey and they will be described in section 2.5. Indicators are separated by “/”, their numeration is added in column categories.

	Categories	Indicators	Character
Indicators for urban analysis	Connectivity (1 to 6)	Connectivity for pedestrian / car Cyclomatic number for pedestrians / cars	B
		Distance between intersections average for pedestrians / cars	S
	Traffic: car and truck (7 to 10)	Number of vehicles (cars and trucks) per day for main city streets / local streets Noise: proportion of buildings with L(Den) >70dB in % during the day / with L(Den) >50 dB in % during the night	S
	Traffic: public transport and bicycle rental (11 to 16)	Proportion of buildings with more than 300 m distance to the next public transport stop / the next bicycle rental station Mean distance between two public transport stops	S
		Frequency during the day / night / weekend	B
	Urban form (17 to 25)	Aspect ratio = building height / building distance at main city street / main local street / main neighborhood street	R
		Shadowing (daylight access) at main city street / main local / main neighborhood street	S
		Width of pedestrian sidewalks at main city street / main local street / main neighborhood street	B
	Open space coverage ratio (26 to 31)	Green space / water space / pedestrian zone, plaza, sport field, private space / semi-public space / public space	R
	Density (32 to 35)	District coverage ratio Population density	R
Indicators used for sustainable analysis		Building density	B
		Plot ratio	R
	Land use (36 to 45)	Single family / multifamily / hotels, accommodation / civic (government, nursery, school, youth center, hospital, etc., even if in private ownership) / religious, spiritual / commercial (=used by public like shopping malls, sport centers, restaurants, etc.) / retail / office, industry / recreational / all others	R
	PV, green roof and recycling materials (46 to 51)	Proportion of buildings with more than 300 m to the next public recycling station for different materials	S
		PV potential: percentage of suitable district area / roof area for PV / power demand of district inhabitants which could be covered by PV Modules	B
		Green roof potential: percentage of district / roof area where green roofs could be suitable	

Table 2 presents all the indicators and their corresponding characters. It is also worth noticing the difference in the indicators used in urban analysis and sustainability analysis. On the one hand, many indicators used in urban analysis have an S or B characters, which also provide a clearer and more objective direction for comparison. On the other hand, many indicators used for sustainable analysis often lack an objective ideal value. The more subjective criteria of ideal value (character R) is frequently employed for these indicators.

2.3. STEP 3: Converting original values into percentages

Each of the 51 indicators has 36 values collected from the different studied neighborhoods. The original values collected are then converted into percentages ranging from 0 % to 100 %, as presented in figure 1.

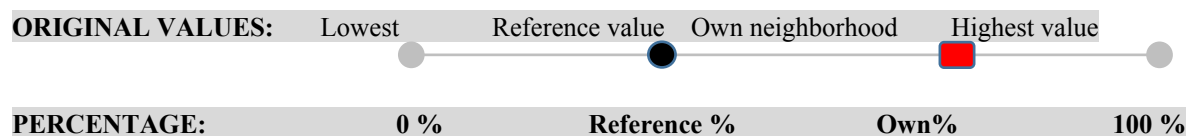


Figure 1. Converting original values into percentages.

The lowest original value among the 36 cases is converted to 0 %. The highest original value is converted to 100 %. The formula for converting the original value of the own neighborhood to the own percentage is in the following equation:

$$(Original\ Value - Minimum\ Value) / (Maximum\ value - Minimum\ value) * 100 \quad (1)$$

The average of the 11 most livable neighborhood is likewise converted into a percentage. It is used as a reference percentage when the character of the indicator is R. Also, it is used for comparison with the most livable neighborhoods for indicators where the character is B or S. The formula for converting the average of the 11 most livable neighborhoods in the reference percentage is in the following:

$$(Reference\ Value - Minimum\ Value) / (Maximum\ value - Minimum\ value) * 100 \quad (2)$$

Reference, minimum and maximum value may change and should be dynamically adapted if new neighborhoods are included in the investigation. If the values of the indicators from the newly included cases are found to be below (or above) the previous lowest (or highest) one, the lowest and highest values must be replaced by the new ones. That means that the lowest and the highest value are self-defined by the city and the investigated neighborhoods. If a new quarter is added that we regard as most livable, the reference value should be adapted.

With these formulas, the original value is converted from an absolute value into a percentage. The main advantage of this conversion is that it facilitates the comparison among indicators. With the absolute value, it is only possible to compare the results of the selected indicators for the investigated neighborhoods. However, it is not easy to compare the performance of the 51 indicators within each individual neighborhood, because the range between the lowest and the highest values differ among each indicator. By converting the original values into percentages, the range between the lowest and highest value is now equal among different indicators.

However, there is a risk with this conversion. For example, assuming that the maximum of acceptable walking distance to the next public transport station is 500 m. If the calculated value is 400 m, which is 100 m less than 500 m, the result is still within a good range. However, if the calculated value is 600 m, which is 100 m more than 500 m, it results as too far to walk to the station. Therefore, the 100 m difference from the target (500 m) does not entail the same information. Yet, this information is hidden when the value is transformed into percentages.

2.4. STEP 4: Visualizing the assessment

As mentioned in the previous section 2.2, each indicator corresponds to a character depending on its ideal value.

- The ideal percentage of character B would now be the 100 %, which is converted from the highest value of the 36 neighborhoods.
- The ideal percentage of character S would now be the 0 %, which is converted from the lowest value of the sampled neighborhoods.
- The ideal percentage of character R would now be the percentage that is converted from the reference value, which is the average value of the 11 most livable cases.

The ideal percentage is indicated with a star in figures 2, 3 and 4.

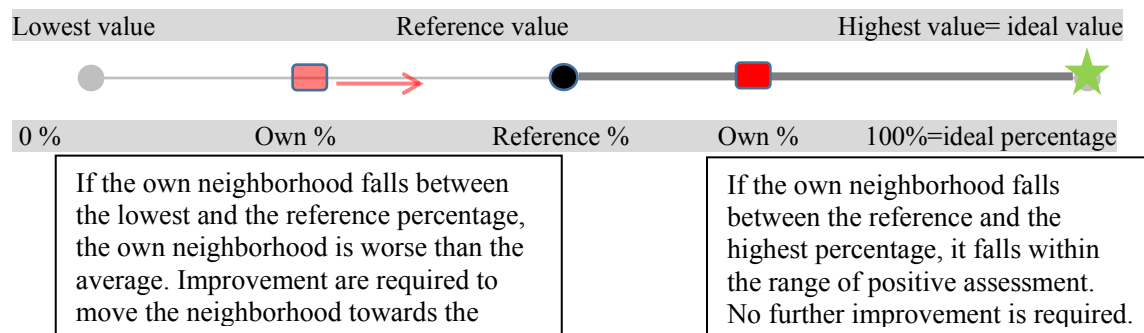


Figure 2. Indicator with character B. Highest value is converted into 100 % and used as the ideal percentages (indicated with a star). The thicker line indicates the range of positive assessment and the thinner line the range of negative one.

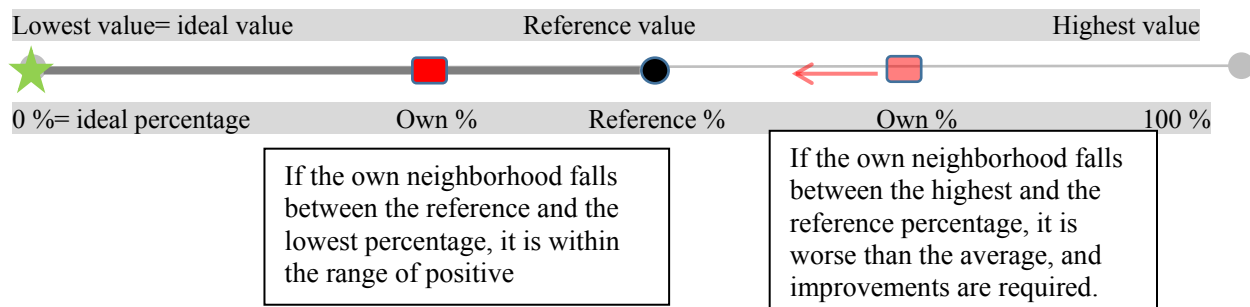


Figure 3. Indicator with character S. The lowest value is converted into 0 % and used as the ideal percentages (indicated with a star). The thicker line indicates the range of positive assessment and the thinner line indicates the range of negative assessment.

2.4.1. Assessing indicators with character B. For the indicators with character B, the ideal percentage is 100 %. If the own neighborhood falls between the reference and the ideal percentage, this means the indicator falls within the range of positive assessment and no further improvement is urgently required. However, if the percentage of the neighborhood falls between the reference percentage and 0 %, this means that the indicator falls within the range of negative assessment and further improvement towards ideal percentage should be considered in order to improve the livability. (see figure 2)

2.4.2. Assessing indicators with character S. For the indicators with character S, the ideal percentage is 0 %. If the own neighborhood falls between the reference and the ideal percentage, this means the

indicator falls within the range of positive assessment and no further improvement is urgently required. Moreover, if the value of the neighborhood falls between the reference percentage and 100 %, further improvement towards ideal percentage should be considered in order to improve the livability. (see figure 3)

2.4.3. Assessing indicators with character R. For the indicators with character R, the ideal percentage is the reference percentage, which is the average of the 11 most livable neighborhoods. Therefore, there is no ranges of positive assessments. If the own neighborhood is not on the ideal percentage, it needs to move towards it. (see figure 4)

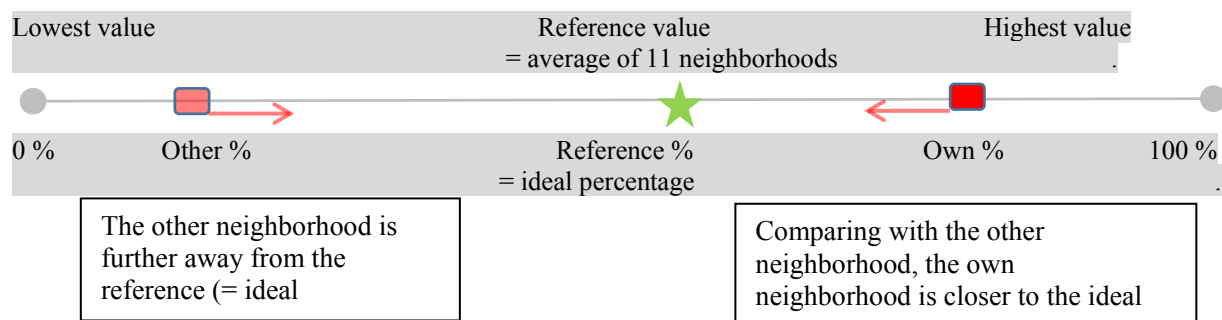


Figure 4. Indicator with character R. The average of the 11 livable neighborhoods is converted into a percentage and used as the ideal value (indicated with a star sign).

2.5. STEP 5: Standard deviation and decisive indicators for the most livable neighborhoods

In order to investigate which indicator offers more decisive measurement for a livable neighborhood, the standard deviation of the 11 livable neighborhoods was calculated. Local conditions are indirectly included because the values are from the same city. The procedure for selecting the decisive indicators is explained as follows:

- 1) For each indicator, use the percentage of the 11 livable neighborhoods converted with formula (2) and calculate their average and standard deviation.
- 2) For each indicator, divide the standard deviation by the average. The result is referred to as standard deviation range and is expressed in percentage. The formula is as follows:

$$\text{Standard deviation range} = (\text{Standard deviation} / \text{Average}) * 100 \quad (3)$$

A small standard deviation range indicates that the results of the eleven livable neighborhoods are closer to each other and the variation is smaller. It is a hint that this indicator is nearly the same in those cases and thus decisive for the quantity of livability. This makes the standard deviation range a more decisive and powerful index to describe the character of the eleven neighborhoods. On the contrary, a bigger standard deviation range indicates that the results of the eleven livable neighborhoods are more diffused. Therefore, the indicators are dispersed and thus not as decisive for livability.

- 3) Criteria for the decisive indicators: If the result from formula 3 is smaller than 50 %, the indicator is considered to be decisive.

Based on this selection criteria, 6 decisive indicators were identified, including connectivity_pedestrian, building density, population density, district coverage ratio, public space, mean distance between two public transport stops. They are highlighted in grey color in table 2.

3. Application to the case study and interpretation of the results

The results are plotted in radar charts, which facilitates the evaluation of the resulting patterns by visualizing the data. The own neighborhood can be easily compared with other neighborhoods, with the average of the 11 most livable neighborhoods and with the theoretical ideal percentage. Figure 5

illustrates the radar chart of the 6 decisive indicators in the case of the neighborhoods Billstedt and Harburg, in the city of Hamburg. In the radar chart,

- 1) The **black continuous line** represents the percentage of the own investigated neighborhood.
- 2) The **black dash line** represents the reference percentage, which is the average of the 11 most livable neighborhoods
- 3) The **grey line** represents the range of positive assessment.
- 4) The dot in **diamond shape** represents the ideal percentage, which is the highest value in the case of character B, the lowest value in the case of character S, and the reference value in the case of character R.

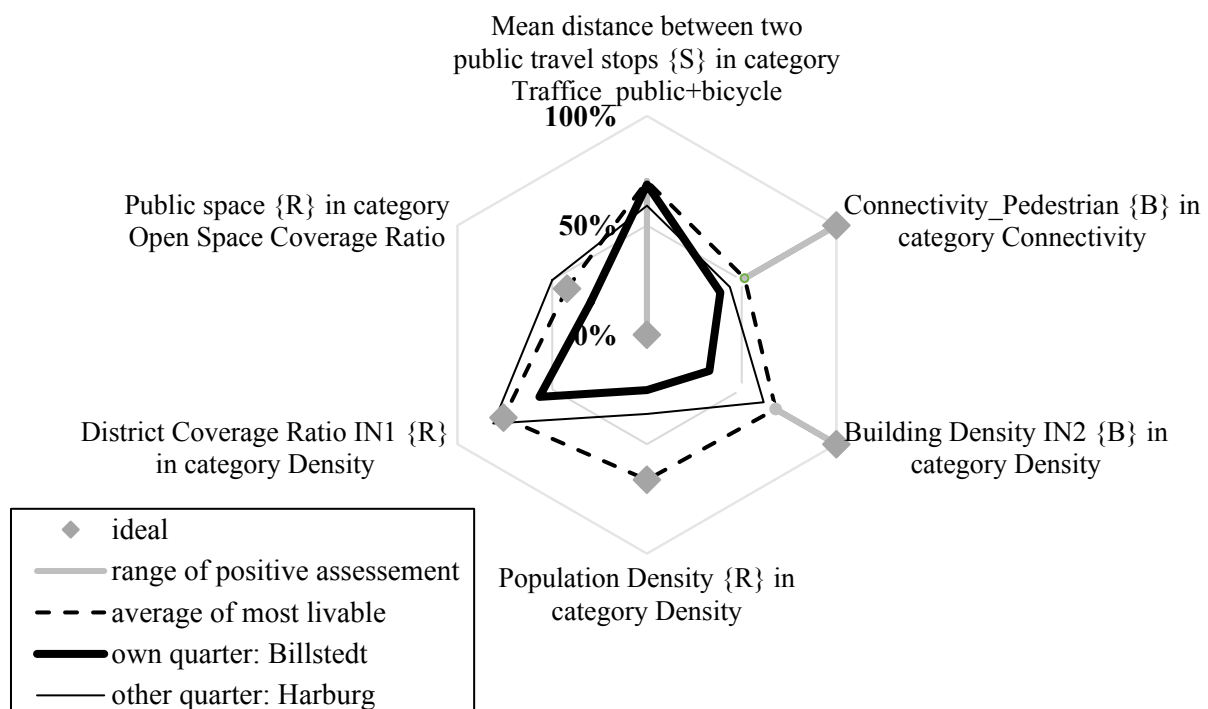


Figure 5. Comparison of the 6 decisive indicator between Billstedt and Harburg.

The results in figure 5 show that the mean distance between two public transport spots in Billstedt and Harburg are both within the range of positive assessment, with Harburg being slightly better than Billstedt. The connectivity for pedestrians in Billstedt and Harburg are both outside the range of positive assessment, indicating that further improvement is required. Proposals for the improvement interventions can be, for example, increasing the pedestrian intersection nodes, shorten the pedestrian links, and increasing the number of pedestrian links. The building density in Billstedt and Harburg are both outside of the range of positive assessment, with Billstedt's performance being much worse than Harburg. This indicates that further improvement is required. Proposals for the interventions include making use of this low-medium district coverage ratio and the unused parking spaces to create new buildings. The population density in Billstedt and Harburg is far from the ideal percentage. Since both neighborhoods are outside of the city center, this situation is reasonable. Harburg has a higher population density than Billstedt, because it is a subcenter in the south of Hamburg. Furthermore, the district coverage ratio of Harburg is very close to the ideal percentage. This forms a solid base for a sustainable neighborhood. This district coverage ratio of Billstedt is, however, smaller than the ideal value. The public space coverage ratio is very different between Billstedt and Harburg. In Harburg, the ratio is greater but still quite close to the ideal percentage, while Billstedt is the opposite. Therefore,

the required improvements would be different for the two neighborhoods. In Harburg, there is no problem with the amount of area for public space. The only problem is that a huge cemetery counts as the public space, nevertheless it is of course not plenty used for leisure activities. This prevents the increase of multifunctional use of the public space. Instead, in Billstedt, the goal is to increase the ratio of the public space. The target of an intervention could be to transform low or un-used private and semi-public spaces into functional public open spaces.

4. Conclusion: contribution of the current method. A flexible method for the “comparison”

The main purpose of this paper is to propose a method that allows the user to carry out the comparison between different neighborhoods, between the own neighborhood to the best practice and between indicators within the same neighborhood. In order to meet these purposes, we propose that the methods should have the following features:

- Translate the theoretical concepts into a quantitative measurement

The users should be able to choose the indicator that corresponds to their research interest and apply the methods proposed in this paper to create their own indicator sets. In other words, while the measurement of sustainability may vary by the theoretical definition or emphasis, the process of creating the indicator set can be the same. The methods described in this paper should be able to be employed by any theoretical concept.

- Standardize the unit of measurement to facilitate the comparison with the best practices

The quantitative measurement allows the usage of comparisons as a method to derive proposals. That is essential because the level of livability is a relative concept. Without comparing to a reference, it is difficult to depict the strengths and weaknesses of an area.

- Offer a dynamic and interactive platform that visualizes information and is user-friendly

The intended target users of this method are not only limited to the urban planners. In order to encourage the participatory planning process and a bottom-up approach, the method is intended to be used by various stakeholders and also by the lecturer for the educational purpose.

Reference

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