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Methodology and application development for monitoring quality of life in Dresden

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Abstract

The present article describes the development of a methodology and of a software for monitoring quality of life as well as the implementation and application in the Urban Planning Authority of Dresden. We will discuss quality of life indicators, approaches to modelling and multiple criteria evaluation of the quality of life in cities. Advantages of the developed method “Modified z-Transformation” are explained. This method is recommended for the practical application. A short report about the application of the developed monitoring system to Dresden will be given.

Keywords: Quality of life, Monitoring system, Modified z-Transformation, Urban Distressed Area

1. Introduction

Between 1990 and 2005, 12 urban redevelopment areas in Dresden had been identified and defined as assisted areas. These areas are distributed throughout the entire municipal area of Dresden. This instrument is intended to effectively counteract negative developments in areas of low quality of life. To detect further redevelopment areas with development potential in the course of time, to pursue existing redevelopment measures and finally to evaluate finished projects, a high scaled monitoring of urban quality of life is important. By conducting the EU-project „Improving the Quality of Life in Large Urban Distressed Areas“ (LUDA) between 2003 and 2006, the Leibniz Institute of Ecological and Regional Development (IOER) could reach first findings to the investigation of quality of life in urban distressed areas (cf. Müller et al. 2005). Dresden was one of six European cities attending the project. The method developed by LUDA should be adapted, enhanced and implemented to specific conditions in Dresden. In this context IOER and the Urban Planning Authority of Dresden developed a methodology to monitoring the quality of life, especially for the urban distressed areas and redevelopment areas (cf. Müller et al. 2009). The result of the project „Monitoring von Problem- und Stadterneuerungsgebieten“ (Monitoring of urban distressed and urban redevelopment areas) will be used to realize an integrated urban development and renewal monitoring as early-warning system in order to identify distressed areas as well as evaluate redevelopment areas. To evaluate urban quality of life, promotion needs and the success of urban development measures, a small-scale approach is pursued: The statistical wards of Dresden represent the basic spatial level of the monitoring system. An essential subtask is measuring quality of life which will be described in the next section.

2. Measuring quality of life in Dresden: indicators and spatial resolution

Quality of life is a broad term and research topic in various disciplines, for example sociology, psychology, medicine, geography, philosophy, spatial and environmental research (for the following see Müller et

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al. 2005). The variety of different disciplinary backgrounds of quality of life research reflects the complexity of this term. Each area of research tries to define quality of life from it's point of view and develops new research bases. In general, quality of life can be defined as sum of the essential elements which describe living conditions in a society and subjective well-being of each individual (cf. Korczak 1995, Pacione 2003, Schäfer 2003).

One distinguishes between objective and subjective quality of life (Bunge 1975, Korczak 1995, Diener & Suh 1997, Marans 2003). These two dimensions are intertwined closely for they are strongly related to each other. Without good objective living conditions an optimal subjective quality of life can hardly be reached. Bad social basic conditions can be positively assimilated by individual adjustment. This is called the satisfaction paradox: Under these conditions an individual is well although it should not when regarded objectively. On the other hand it is also possible that good objective living conditions do not lead to well-being. This is called dissatisfaction paradox (Korczak 1995). Objective quality of life can essentially be measured by observable indicators (mainly from statistical data as well as existing information and indicator systems). Subjective perceived quality of life can be captured by surveys.

Both objective living conditions and subjectively perceived quality of life are changing in time. Quality of life therefore has a time dimension.

Quality of life is a complex idea and has to be broken down into several thematic dimensions. For that six dimensions of quality of life are proposed (cf. Figure 1). Besides the three pillars of sustainability (environmental, economical and social) for urban quality of life, also urban structure and the supply of age-related social infrastructures play a leading role. In a further step the dimensions were structured into several sub-dimensions. Each sub-dimension is described by indicators.

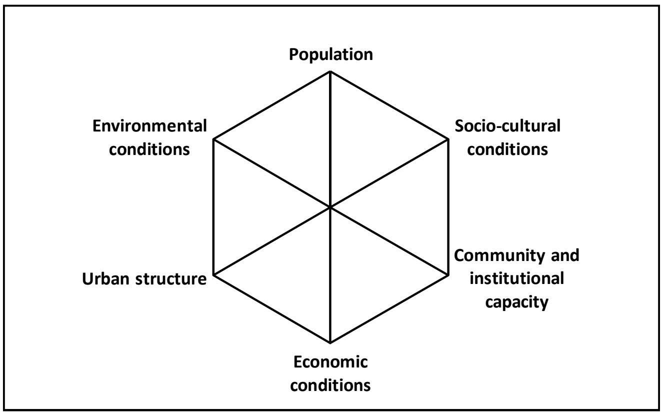

Figure 1
"Diamond" of quality of life (cf. Müller et al. 2005)

So mainly statistical data has to be taken into consideration to objective reflection of quality of life. Here data from existing information and indicator systems are best suitable. 52 objective indicators were generated for the six dimensions of quality of life (cf. Figure 1). This set of indicators consists of assessing and descriptive indicators. When assessing in the sense, the smaller or greater the indicator's value, the better the quality of life, is not reasonable, we refer to the indicator as a descriptive indicator. The 24 assessing indicators are called key indicators (cf. Figure 2).

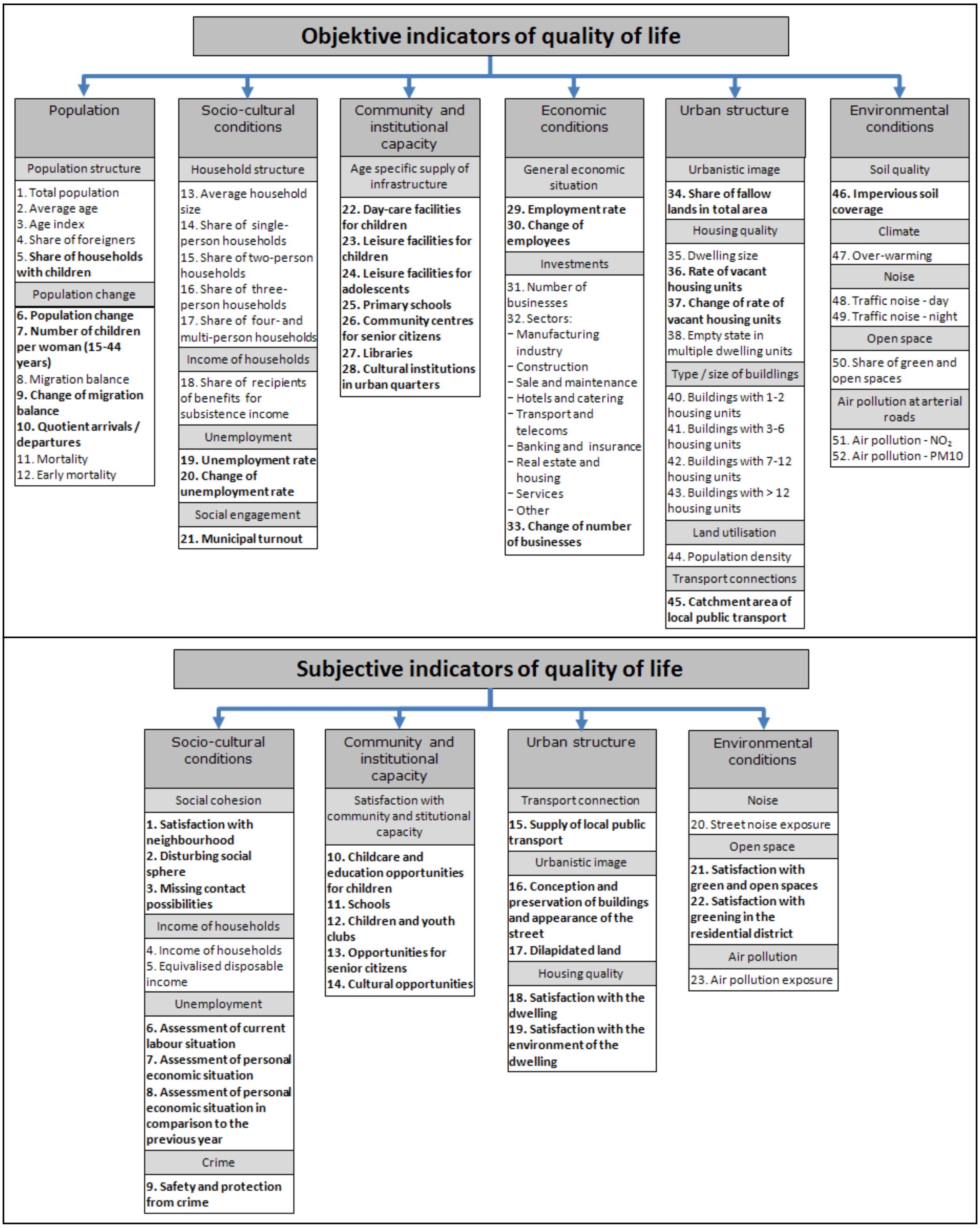

Figure 2: Overview of objective and subjective indicators; key indicators stand out in bold type

The perceived quality of life (subjective indicators) is described by data of the municipal civil survey (“Kommunale Bürgerumfrage” - KBU). Altogether 23 subjective indicators of KBU can be included (cf. Figure 2). From that, 19 indicators are assessing indicators and can be included in multivariate evaluations. A problem is the varying perception of every human-being, because all subjective indicators contain subjective opinions on given conditions.

Each modelling needs data in sufficient quantity as well as good quality, namely quantity in number of indicators and quality in spatial and time resolution, sensitivity and validity of data, as the first important feature. After the content-related component, the spatial and time aspects to examine quality of life in Dresden will be explained below.

Spatial resolution is a decisive question from the planner´s point of view. Different spatial levels (blocks, statistical wards, urban quarters, districts, cities, regions etc.) can be used to quantify quality of life. Determining of spatial borders is essential for quantifying indicators. The spatial aspect is taken into consideration by four spatial levels (cf. Figure 3). The lowest level consists of 401 statistical wards in Dresden. So the focused high spatial resolution is given. These statistical wards can be combined to 64 urban quarters and 17 districts respectively. Also single urban redevelopment areas can be examined beside these three spatial levels. Here must be pointed out, that urban redevelopment areas base on the level of 6874 statistical blocks. But they are not used in the system because of data protection and clearness. That´s why borders of urban redevelopment areas are to be re-determined.

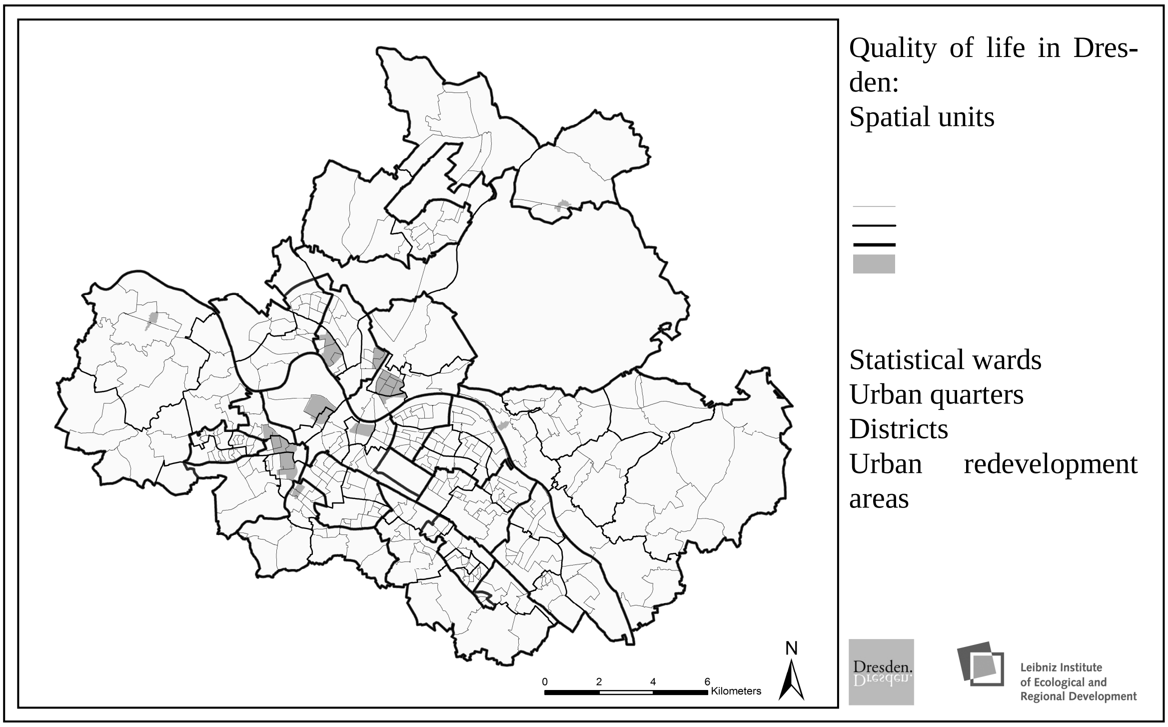

Figure 3: Spatial units and urban redevelopment areas in Dresden

Time resolution is the next important component of the monitoring system. This aspect is considered in points and periods of time. For the 24 objective key indicators data are available from 1999 to 2008, for the 19 subjective key indicators for the years 2002, 2005 and 2007.

3. Methods for multivariate evaluation of quality of life

The single indicators of quality of life have to be aggregated to an overall index to allow evaluation and comparison of spatial units regarding their quality of life and identify urban distressed areas. For this evaluation respectively aggregation use of multivariate methods is necessary. Before aggregation, regression or factor analyses for indicators have to be carried out to eliminate unwanted effects due to possibly existing correlations. Because the Urban Planning Authority of Dresden prefers evaluation by original indicators (not by factors) the factor analyses is waived. However, a regression analysis was carried out. In result one indicator has to be excluded from aggregation. Altogether there are 23 objective indicators left for aggregation.

To aggregate indicators with different dimensions, data has to be converted into non-dimensional values previously. For this purpose two methods were recommended: firstly Extreme Value Standardisation and secondly z-Transformation. In case of Extreme Value Standardisation the following formulas are used:

The smaller the indicator's value, the better the quality of life: $$z = \frac{x_{max} - x}{x_{max} - x_{min}}$$

The greater the indicator's value, the better the quality of life: $$z = \frac{x - x_{min}}{x_{max} - x_{min}}$$

Subsequently the standardized values are aggregated to an overall index by consideration of the weight:

$$I = \sum_{j=1}^{n} W_j \, z_j$$

I … Overall index with weights $W_j > 0$ and $\sum W_j = 1$

Because the number of variables is different at various points of time, the index has to be divided by the number of the applied indicators to guarantee comparability between overall indices of different points of time. For that reason, the mean of all z-values has been determined in the developed monitoring system.
The second method, the z-Transformation (cf. Müller et al. 2005) is based on standardisation of indicator values by a normal distribution with a mean of zero and a standard deviation of one. Then, all z-values of the indicators of one spatial unit were averaged and used as overall index I.
In order to clarify the differences between both methods, the transformed indicators were represented in a boxplot (Figure 4). It shows for Extreme Value Standardisation defined upper and lower limits of 1 and 0. Contrary to the z-Transformation there are no fixed limits. In the case of z-Transformation the mean always is zero. In the case of Extreme Value Standardisation great variations of the mean, however, have to be expected. The latter is justified with a partly high differentiation within the raw data. If the data set contains outliers, the result is possibly biased in the case of Extreme Value Standardisation. This would mean a wide influence on the overall index and the evaluation results for the examined spatial units. In contrast to that, outliers only have low influence on the overall index in the case of z-Transformation. For this reason, only spatial units with outliers in the data reveal dissatisfactory results at aggregation.

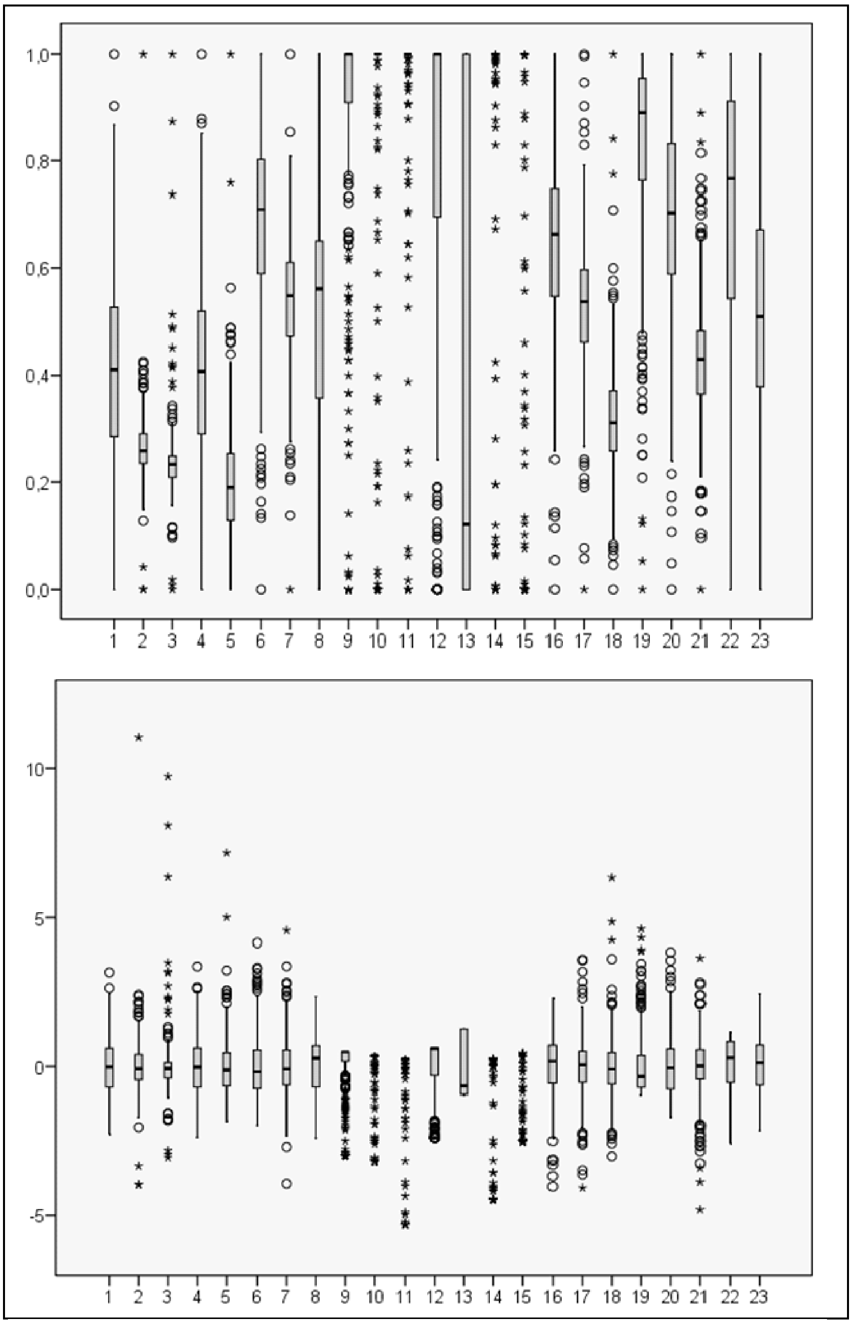

Figure 4: Boxplot for transformed variables (on top: Extreme Value Standardisation, bottom: z-Transformation)

The described differences become clearer by visualising the results in a spider chart which allows the comparative display of multi-dimensional aspects of several objects (cf. Figure 5). Figure 5 shows the comparison of population indicators at the statistical ward Luga and the entire city. In the case of Extreme Value Standardisation the minima are solely concentrated at zero. All five maxima are consistently one. This is the essential advantage of this method. But the means of the five indicators vary between zero and one. In contrast to that the mean of variables always is zero in the case of z-Transformation. Besides the above-mentioned robustness against outliers this can be seen as a further advantage. The clear disadvantage of z-Transformation is the variation of minima and maxima. In the example the z-Transformation shows a range of maxima between 3 and 11. So it is impossible to limit the value spectrum by the monitoring system.

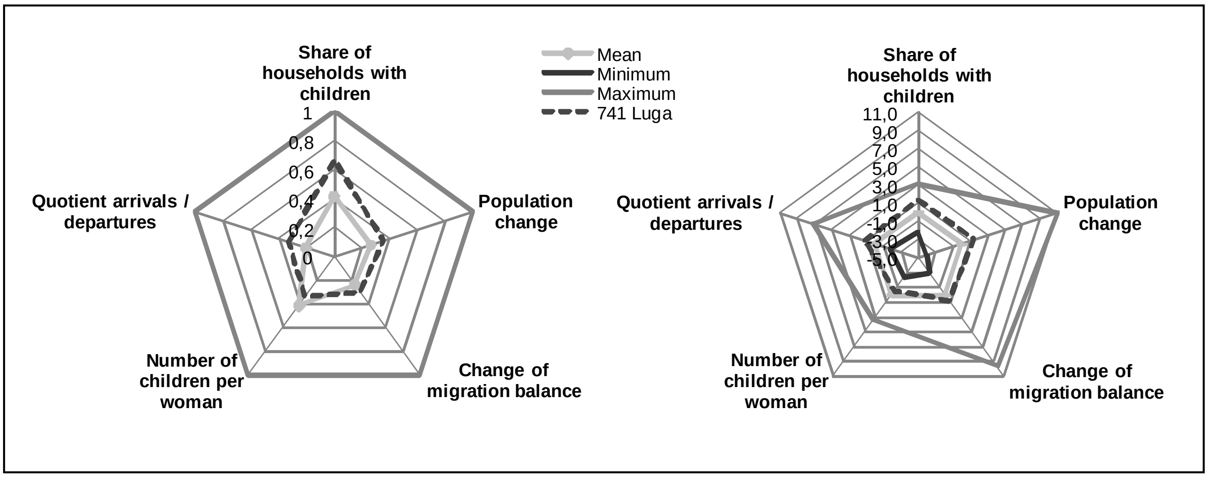

Figure 5: Presentation of results in a spider chart (on the left: Extreme Value Standardisation, on the right: z-Transformation)

As shown above both methods have advantages as well as disadvantages. The idea was to combine the benefits of both methods. So the Modified z-Transformation was developed. It limits all z-values in a similar interval:

[- triple standard variation, + triple standard variation] = [-3,+3].

It must be pointed out, that after z-Transformation standard variation σ is one (so -3σ = -3). All z-values less than -3 are determined as -3. Analogous z-values greater than 3 are reduced to 3. At large 0.3 % of the values lie outside the interval [-3, 3] and have to be defined as outliers (see Figure 6). After that the z-values are converted into points from 0 to 100 according to the following rules:

- negative triple standard variation corresponds to 0 points,
- z-value zero corresponds to 50 points,
- positive triple standard variation corresponds to 100 points and
- other z-values are interpolated and projected into the corresponding intervals [0,50] and [50,100].

Figure 7 shows an example of spider chart for Modified z-Transformation.

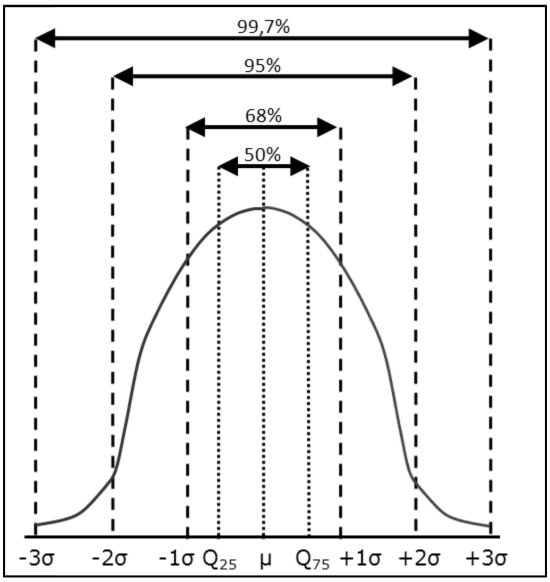

Figure 6: Frequency and selected quantile of a normal distribution

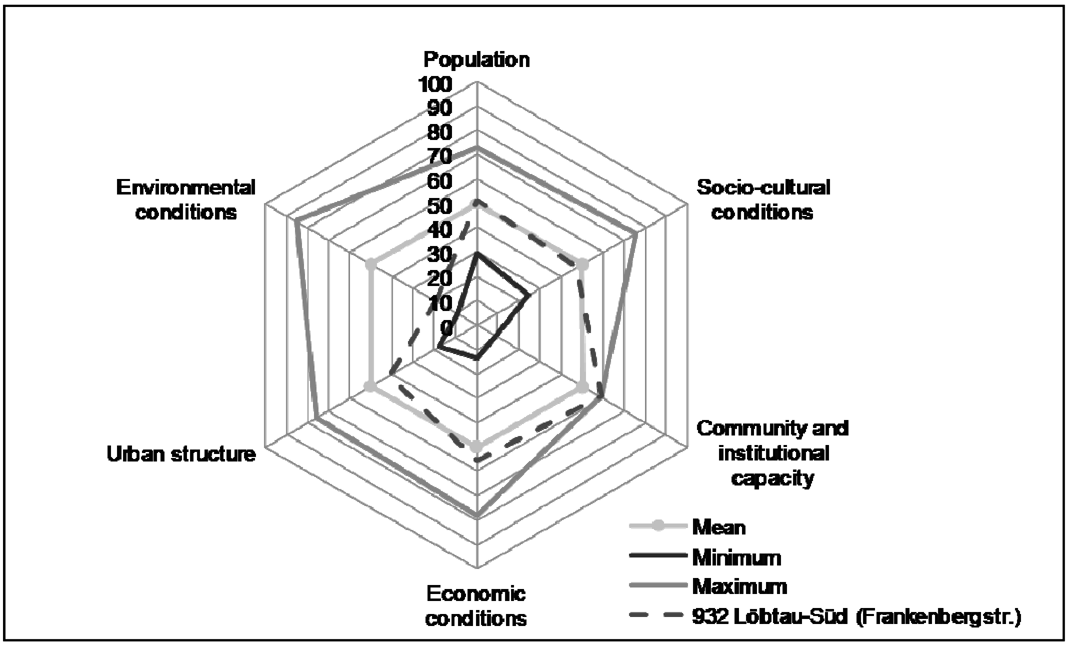

Figure 7: Spider chart for modified z-Transformation

4. Application to statistical wards of Dresden

The methods described above were tested and used to evaluate statistical wards of Dresden regarding to their quality of life. Base data consists of 23 key indicators. At first the completeness of data were checked. 355 of the 401 statistical wards could be included into further investigation. The results of Extreme Value Standardisation and z-Transformation are to be compared.

After determining the ranges of the 355 districts by using each aggregation method, the range differences between both Extreme Value Standardisation and z-Transformation results were examined. At large seven statistical wards show no range differences. Almost 22 percent have only little differences. Visualization in a chart (cf. Figure 8) shows a high correlation between the results of both methods with R = 0.95. The largest differences are located in the mid-range.

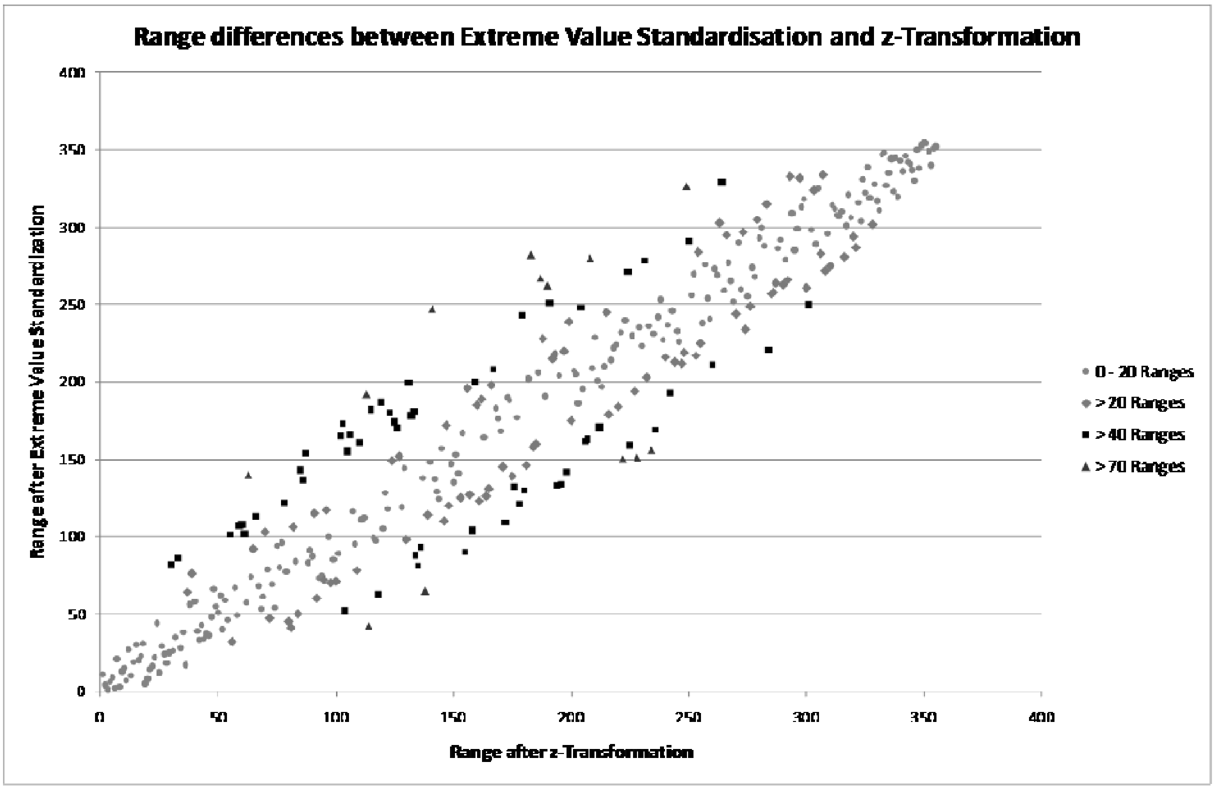

Figure 8: Correlation of ranges after Extreme Value Standardisation and z-Transformation for statistical wards

A further problem concerns the indicator's weights or rather the way of aggregation. For each dimension indicators can be aggregated to sub-indices which are to be aggregated to an overall index (dimension based aggregation) afterwards. Alternatively all indicators can be aggregated to an overall index in one step (indicator based aggregation).

Having six dimensions each dimension is weighted with 1/6. In case of equal indicator's weights within one dimension, the five indicators of the dimension population have a weight of 1/30. In comparison, soil sealing as the only indicator of the dimension environmental quality has a weight of 1/6.

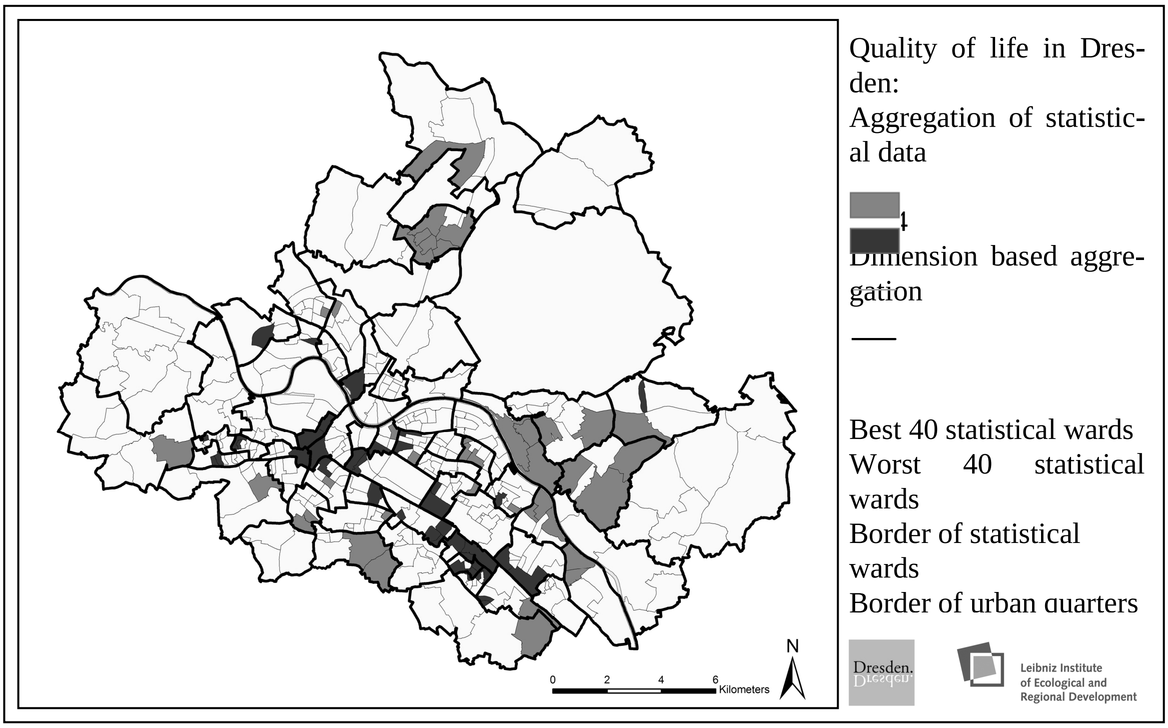

Figure 9: Spatial distribution of the best and worst 40 statistical wards by dimension based aggregation

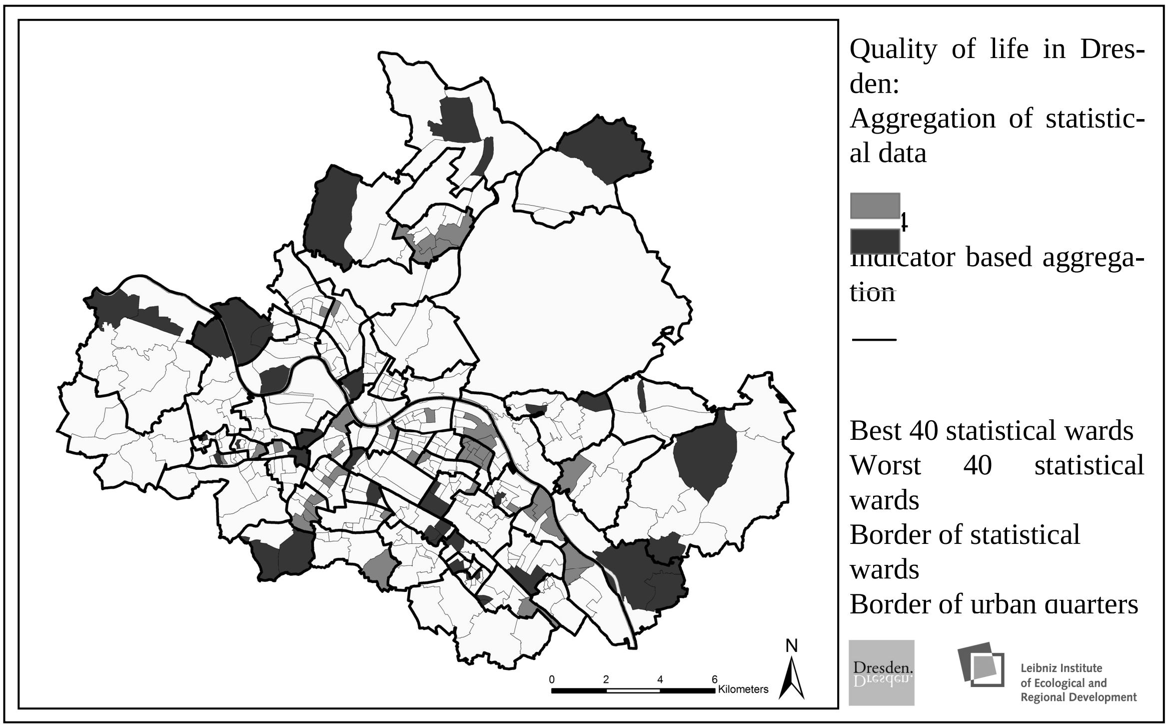

Figure 10: Spatial distribution of the best and worst 40 statistical wards by indicator based aggregation

The indicator based aggregation assumes equal weighting of all 23 key indicators. That means: All indicators have a weight of 1/23. Hence the single dimensions have the weight produced by the sum of all dimension belonging key indicator's weights.

The calculations of both weighting methods revealed that four of the 10 best statistical wards as well as four of the 10 worst ones are identical at both weighting formulations. For a better understanding the 40 best and 40 worst statistical wards are mapped (Figure 9 and Figure 10). For dimension based aggregation, a concentration of statistical wards assessed as bad is mainly found in the city centre. In contrast statistical wards assessed as better ones are lying outside the city centre (Figure 9). It has to be emphasized that extremely different qualities of life could be identified within urban quarters. Hence the monitoring system is able to identify small scaled urban distressed areas.

The indicator based aggregation shows statistical wards with bad quality of life mainly on the outskirts (Figure 10). In the city centre in contrast a mosaic of good and bad assessed areas can be detected. Because of different indicator's weighting particularly in suburban areas large range differences between results of both methods occur. In the city centre the range differences are low.

Because suburban areas hardly possess subsidizable areas, false estimations at dimension based aggregation in these areas can be disregarded. Especially calculating almost the same ranges of quality of life for city centre statistical wards have to be assessed positively.

Because of transparency and clarity of assessment steps generally the dimension based aggregation should be preferred. This method is also favored by the Urban Planning Authority of Dresden. In addition the indicator based aggregation must be tested to examine the influence of large differences with regard to the number of indicators per dimension. The Urban Planning Authority of Dresden plans to bring the number of one dimension's indicators in a line with each other in future. Dimensions with little indicators will be completed by additional indicators to have at least the same number of indicators per dimension for examination.

5. Conclusions

The generally applicable model to assess urban quality of life supports organizing quality of life researches. Differences of the results as well as advantages and disadvantages of Extreme Value Standardisation and z-Transformation could be brought out. To combine advantages of both methods the Modified z-Transformation was developed and recommended for application. Different methods of aggregation constitute two possibilities to weigh indicators. The method developed can be applied at different fields of research.

6. Literature

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