
WHAT INTEGRATION ADDS TO QUALITY OF LIFE

081

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Abstract

There are various indicators of quality of life, among them the well known Human Development Index (UN). The paper explores ways of including configurational dimensions in the definition of such indexes. It superimposes the integration measure of Space Syntax Theory and socioeconomic indicators mainly based in education, health and income levels, as well as the localization of jobs and the distribution of the varied residential densities in the city. It is argued that the procedure is telling as far as the relationships between the various social classes and the city are concerned. The Federal District in Brazil, i.e. the national capital Brasília, is the case-study. The city presents many peculiarities that are further illuminated by the findings of the paper. Brasília presents the lowest average density among Brazilian State Capitals. Furthermore, a study carried out among 58 cities of all continents, indicates Brasília as the second most dispersed city in the world (an attribute that is independent of average density). Brasília also concentrates immediately around its CBD more than 80% of all formal jobs in the metropolis. Finally, the rich live near the centre and the poor in the peripheral satellite nuclei, as in other cities in Brazil. Such peculiarities imply that relative localization of homes, jobs and services are more important than elsewhere in contributing to the standards of living. Here, to be (syntactically) integrated and rich, and (syntactically) segregated and poor, means a high bonus to the former and a heavy burden to the latter. Traditional socioeconomic indicators such as the Human Development Index miss important attributes that characterize the standard of living in Brasília. Analysis will be carried out in minute detail, using the census sectors as the basic spatial unit. Census sectors are geo-referenced and include the basic socioeconomic indicators that are needed. GIS tools will be used in order to correlate syntactic integration with the variables of the census sectors. We will end by "weighting" the quality of life indexes by means of configurational measures at a global level of the city, and arrive at a sociospatial quality of life indicator, that includes dimensions which are absent in current indexes of standards of living.

Introduction

Quality of life in a city depends on spatial issues of various kinds. At a local level, it depends on the quantity and quality of the daily lived spaces, from the domestic realm to buildings of local facilities such as shopping, education, and health. At a global level, it depends on the availability and proximity of jobs and services of a rather central

081-02

character. Obvious as this may be, such spatial indicators, are absent from indexes of quality of life which are commonly used worldwide. The latter usually consider income strata, employment rates, number of years spent at school, violence and mortality rates (suicides, homicides). Surely, they indicate fundamental aspects of quality of life, but the same socioeconomic indexes may behave different depending on the way spaces somehow related to them are organised in the city. For example: demographic densities could be high enough to favour shorter distances to services, or city configuration might be integrated enough to favour displacements among its parts, or distances to CBD from residential areas might favour commuting to work.

Brasilia, Brazil, in various indicators, ranks among the top “best quality” Brazilian capital cities. Studies may refer to “objective” data (e.g. income strata obtained from demographic census) or to “subjective” inquiries, in which evaluation of the people is the basis for characterising standard of living. For example, among the former, for the sake of comparison among other capitals, Brasilia is: 1) second in average per capita income level; 2) third in absolute number of rich families (a surprising attribute, for it is only the sixth in population), which explains the amount of sophisticated services that the city provides; 3) fourth in Human Development Index, as measured by the United Nations methodology. Among “subjective” inquiries, Brasilia enjoys an unchallenged first place in the prestige it has among its inhabitants: it exhibits circa five times more quality of life as compared with cities like Rio and São Paulo, evaluated by its respective inhabitants by means of the same methodology, and which rank in modest 10th and 11th places respectively.

On the other hand, various studies have been made about spatial properties of the Brazilian capital. The city does not perform as brilliantly as in general socioeconomic indicators. The main problems concern: 1) “eccentricity” of jobs in poorly integrated areas of the metropolis, increasing average distance from home to work; 2) dispersion of the overall urban tissue, with clear consequences towards an expensive and precarious public transport system; 3) low overall demographic densities, resulting in expensive urban infrastructure.

Now, clearly spatial problems interfere with the quality of life, even if this is not perceived “subjectively” by the population. A family may belong to a high income stratum, but if it lives in a segregated bit of the city, it will be penalised and will somehow be worse off than a poor family who lives quite close to the places where jobs and services concentrate (for a detailed study of the latter case see Holanda, 2006). As it is unfortunately rather typical among strictly framed disciplines, such diverse aspects (spatial x a-spatial attributes) have not been brought together so far, at least in what refers to Brasilia. This paper attempts at doing so. It experiments with weighting general socioeconomic indexes with spatial attributes, by using Space Syntax measures and other instruments akin to diverse methodologies. First, we characterize the city by spatializing socioeconomic indicators known as “inclusion/exclusion” indexes as explored by sociological literature. Second, we summarise previous spatial findings and advance new proposals in order to depict the spatial order of the city’s metropolitan structure. Finally, we propose procedures by which the two approaches may be brought together.

It is hoped that we thus arrive at a better synthesis concerning quality of life indicators, by including fundamental characteristics of the lived space of citizens. The paper will explore information from two basic sources. The first is the digital map of Brasilia metropolis, from which

the axial map has been drawn. The second is the socioeconomic data of the 2000 Demographic Census (IBGE, 2002).

Spatial Indexes

Two spatial indicators will be used here: 1) integration index, as measured by space syntax techniques; 2) distance of census sectors from CBD.

Integration index is the corner stone of space syntax theory. To calculate the index for a city, the road system is represented as a group of straight line segments, which correspond approximately to road axes. Through computer procedures we calculate the integration index of each axis, which indicates numerically their relative accessibility in relation to the whole system. That accessibility, however, is of a more topological order than geometrical order, in so far as it refers to the minimum amount of intervening lines to go through between each one of them and all others in the system. In other words, integration index reveals how easy it is to go from each street to everyone else.

As far as the integration measure is concerned, Brasilia is not exceptionally segregated among other Brazilian capitals, despite the patchwork nature of its urban tissue and the large discontinuities among its parts. Medeiros (2006) has shown how it is rather typical of Brazilian cities to be of a rather patchwork type. Among the 17 state capitals he has studied, Brasilia ranks in 10th place from the most segregated to the most integrated ones, presenting an average integration of 0.851. When compared to his data base from a sample of 164 cities all over the world, Brasilia ranks in the 77th place, again from segregation to integration, and is close to the average world integration (0.920) in Medeiros' sample.

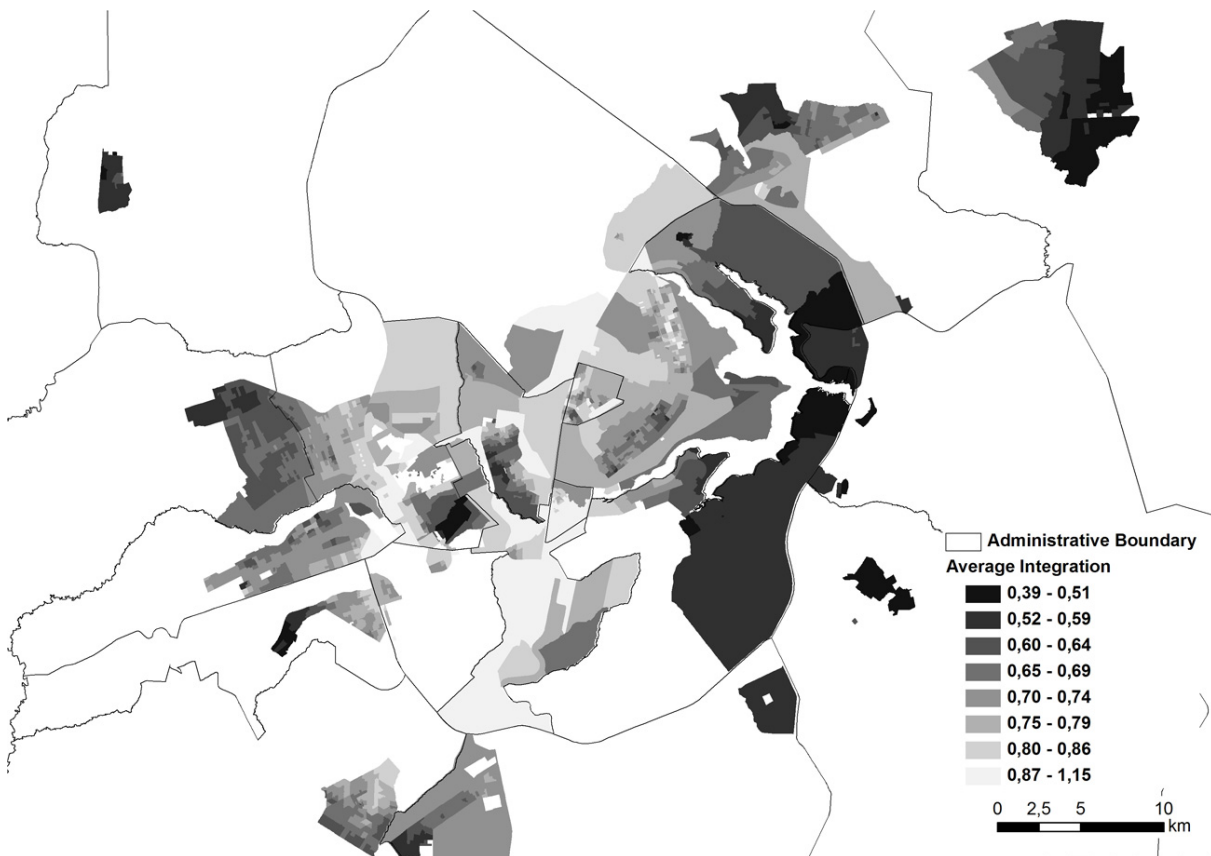
In this paper, it was possible, by means of geoprocessing techniques (using ArcGIS software), to fine-tune the integration measure of the city by census sector, and therefore be able to relate it to socioeconomic indicators which are also available in the census data. In order to calculate this integration index by census sector we have considered all axial lines which are completely inserted in each sector or which cross its borders. Their integration measure has thus been identified and the average integration by census sectors has thus been calculated. We call this Average Integration Index. Figure 1 illustrates integration by census sector.

Nevertheless, Brasilia peculiarities recommend that we use another spatial indicator, besides integration. We have shown elsewhere (Holanda, 2002) how the concentration of jobs and services is "eccentric" to the integration core of the metropolis (the set of more integrated axes of the whole system). In Brasilia – a "formal" city par excellence – high correlations do not obtain between integration and concentration of jobs and services, as the literature has reported for more "urbane" cities, that is, cities in which, among other attributes, decisions on what and where to build are more decentralised and follow the logic of "natural movement" (Hillier et al., 1993). (A detailed discussion of the dichotomy "formal"/"urbane" cities is in Holanda, 1997). In Brasilia, the logic of accessibility is therefore very much dependent also on the distance to the CBD. So, again, using geoprocessing techniques, we have calculated the distances from census areas' geometrical centres to the CBD and have included this as another analytical variable (synthetically denominated D_CBD).

The importance of including census sectors distances to the CBD also resides in the fact that there are two other important spatial attributes of the city that are not captured by syntactic integration, namely the very low average demographic density of the city and the dispersion

index. We have shown elsewhere (Hollanda, 2006) how Brasilia presents the lowest average density among Brazilian state capitals (23.30 inhabitants/hectare, compared to the average of 56.51 in./hec. and the highest, in São Paulo, of 108.83 in./hec.). Also, an index which complements this, and reveals another different and, again, peculiar dimension of the city, is its dispersion index (Hollanda, 2006). The index measures the way urban tracts are distributed in the territory, as compared to a hypothetical compact circular city of the same average density and same total area. Building upon a study by Bertauld and Malpezzi (1999), we have concluded that Brasilia is the most dispersed Brazilian capital and the second most dispersed city in the world, as compared to a sample of 57 cities in all continents. Distance to CBD is sensitive to both attributes, and this is why it is used here.

081-04 **Figure 1:**
Integration by census sector



Inclusion/Exclusion Index

In function of the space grouping of different populations, mainly related to the accessibility the income, equipment and services, we can strengthen the results gotten for the Theory of Urban Dispersion, by means of a joint analysis with the Inclusion/Exclusion Index, developed for Sposati (2000b).

This index, strictly socioeconomic, it uses census data to express the situation of the analyzed areas. First are generated the indexes calls of simple, starting from the census data, later the composed indexes are generated, starting from the simple indexes. Last the Inclusion/Exclusion Index is generated, starting from the composed indexes, as it can be seen in the Table 1.

For understanding of the distribution of the urban exclusion we used the Brazilian Demographic Census data of 2000 (IBGE, 2001) for census sector (IBGE, 2002), for being this to smallest unit of survey census made available by IBGE.

Indicators	Simple Indexes	Compose Indexes
lexi Heads of the family below the line of Poverty (without Income)	lex Precarious Condition of Survival	lex Income Autonomy of the Heads of Family
lexi Chefe of the family in the Line of Poverty (income up to 2 SM)		
lexi without Income	lex of Distribution of Income of the Heads of Family	
lexi up to 0,5 SM		
lexi 0,5 up to 1 SM		
lexi from 1 to 2 SM		
lexi from 2 to 3 SM		
lexi from 3 to 5 SM		
lexi of 5 to 10 SM		
lexi from 10 to 15 SM		
lexi from 15 to 20 SM		
lexi more than 20 SM		
lexi Heads of the family no Literate	lex of Development Education	lex Human Development
lexi Precarious Education (of 1 to 3 years of study)		
lexi from 4 to 7 years of study		
lexi from 8 to 10 years of study		
lexi from 11 to 14 years of study		
lexi more than 15 years of study		
lexi Precocious Literacy (with 5 to 9 years)	lex Education Incentive	
lexi Late Literacy (from 10 to 14 years)	lex Precarious Education	
lexi no Literate	lex Longevity	
lexi Precarious Water supply	lex Environmental Quality	lex Quality of Life
lexi Precarious Sanitary Installation (Sewer)		
lexi Precarious Treatment of the Garbage	lex Quality Home	
lexi Home Property		
lexi Habitational Density		
lexi Sanitary Comfort		
lexi Precarious House	-	
lexi Women no Literate		
lexi Concentration of Heads Women of the family		lex Equality

IEX SOCIAL EXCLUSION/INCLUSION

081-05

The data of the census sectors (IBGE, 2002) they become separated in four levels: home, instruction, people and responsible. In each level socioeconomic parameters were selected, in agreement with Ribeiro (2003) (based on Genovez, 2002), that it calculated the Inclusion/Exclusion Index (lexi), for Distrito Federal, DF.

Table 1:
Index generation

Sposati (2000a) it observes that the social exclusion in developing countries is characterized by a population that originally is to the margin of acceptable life conditions and than larger is the social inequalities the larger will be this exclusion. This exclusion implicates recognition one sweats inclusion and relative delimitation to the concept, generating subject as: what does mean exclusion? Who excluded it? Done excluding in relation to something? (Bessis, 1995; Dupas, 1999) This threshold of the concept is flexible, being susceptible to variations in the space and in the time (Kilmurray, 1995) and it depends on the perception of the groups considered as having excluded and included and of the government's positioning in relation to these. Like this, the conceptual debate presents significant importance in the production of the universe of the measures, because the conception of different models implicates different indicators structured to measure a certain phenomenon (Maxwell, 1999). In this context, to capture the multiple dimensions of the social excusion/inclusion, it puts as needs: (1) obtaining of several data, when possible, the coming of different sources; (2) the conception of different indicators that they express, spatially, the social exclusion/inclusion in the studied context; (3) the production of quantitative data linked to qualitative data, to capture the objective and subjective dimensions of the social exclusion/inclusion, and; (4) to look for the understanding of the phenomenon starting from the integration of the measures to the territory (Genovez, 2002).

For the calculation of this index they were selected parameters that express exclusion and inclusion social conditions. The value of each parameter was transformed in percentage, so that obtained the

representativeness of this in relation to the existent total value in the census sectors. This percentage value was normalized between -1 and 0, for parameters that expressed social exclusion (e.g. heads of the family without income), between 0 and +1 for parameters that expressed social inclusion (e.g. precocious education), and between -1 and +1 for parameters that expressed exclusion and social inclusion simultaneously (e.g.: longevity). For the normalization from -1 to 0 and 0 to +1, a lineal adjustment was used that it transformed absolute numbers in relative:

$$y = ax + b \Rightarrow x = \frac{(y - b)}{a} \quad (1)$$

For the calculation of the normalization from -1 to +1, was used the formula presented by Genovez (2002):

$$y = \frac{a(x + 1)}{2} + b \Rightarrow x = \left(\frac{2(y - b)}{a} \right) - 1 \quad (2)$$

where y is the observed value, in percentage, b is the minimum value found when comparing the percentages of all of the sectors, and it is the amplitude of the data, calculated as the difference between the maximum and the minimum values. This normalization turns the values adimensional, doing with whom they can be sum and compared.

After the normalization of the parameters, these were sum, generating the simple indexes, that they generated the composed indexes. In the last calculation stage the composed indexes were sum and normalized among the values from -1 to +1, from the Equation 2. This way it was obtained the Exclusion/Inclusion Social Index.

As mentioned, this index is calculated by census sectors, but their spatialization, in first analysis, can generate a group of sectors with disconnected space result, similar to a patchwork quilt. To improve the result we used methods of space interpolation, in way we obtain a surface of continuous data. Like this, we got to emphasize the space variations of the index.

Methodological Proposal

The integrated analysis of the integration and social exclusion/inclusion indexes it allows the generation of a more accurate vision of the urban reality. We know that proximity of CBD is very important to give better conditions of life. Like this, we propose the calculation of a new index, which we denominated of Urban Social-structural Quality Index (USSQI), because the calculation of the same will be based on the two indexes mentioned already and the distance to CBD.

The process of calculation of USSQI begins for the normalization of Average Integration Index and the distance. The normalization of the average integration index and of the distance it was based on a scale from 0 to 2. We calculated the average for the two parameters, and we used the value found about cut point, that it would separate the values of low integration of the values of high integration, as well as it would separate the most distant values of CBD of the closest values. This way, for the Average Index of Integration, we used the Equation 1 to normalize the values below the average between 0 and 1, for the values above the average used the Equation 3, which would normalize in a scale from 1 to 2. For the normalization of the distance, we used the equations in an inverse way, so that we were able to emphasize the close values to CBD. Like this, we used the Equation 3 to normalize the values below the average (closer of CBD) and we

used the Equation 1 to normalize the values above the average (more distant of CBD).

$$x = \left(\frac{(y - b)}{a} \right) + 1 \quad (3)$$

After the normalization of the Average Index of Integration and the distance, we sum these with the Exclusion/Inclusion Index, and we normalized the result, using the Equation 1, in a scale from 0 to 1, where as smaller the worse value the life quality and the closer of 1 better they are the life conditions.

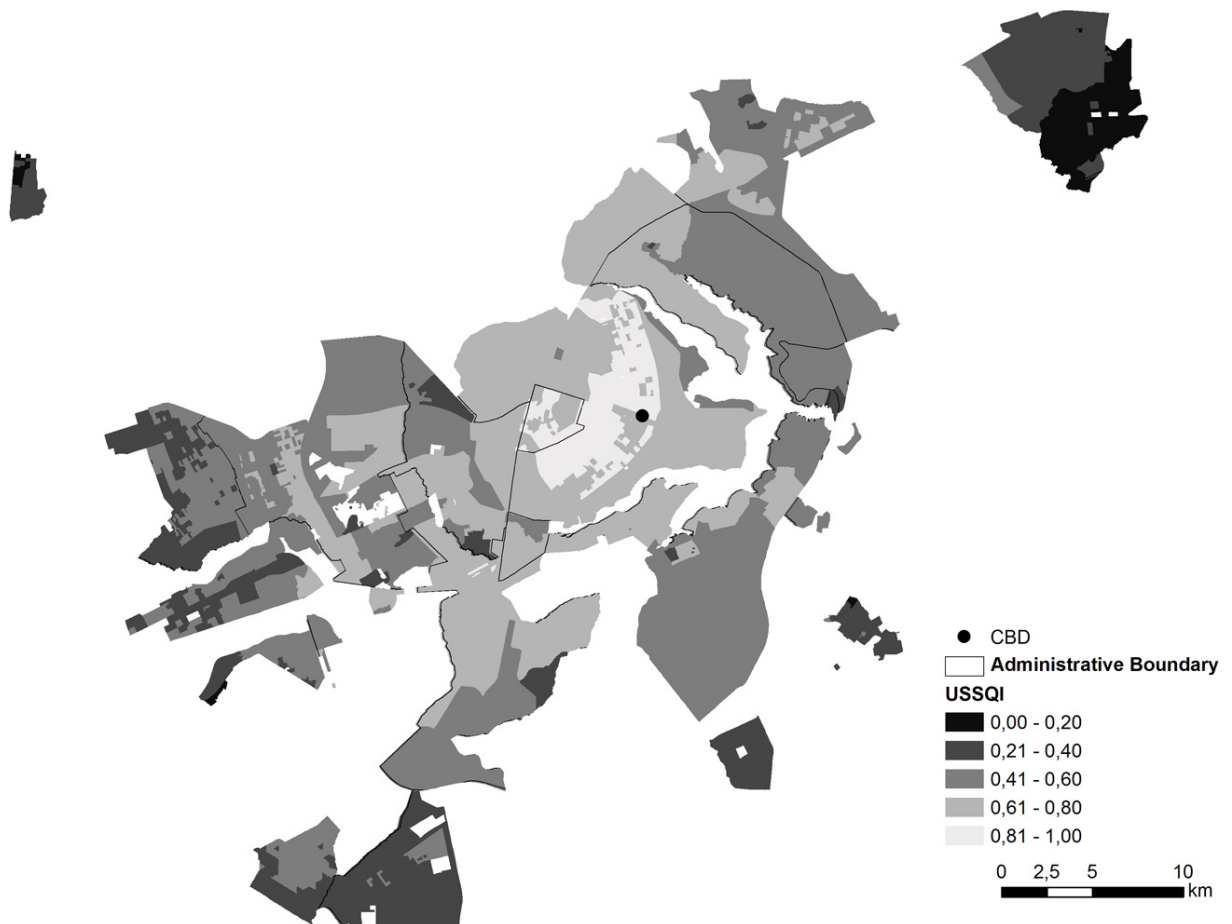
Results

081-07

The result of the calculation of USSQI can be spatially represented by the Figure 2.

The direct analysis of USSQI using the census sector is extremely difficult, because we obtain a typical pattern of patchwork quilt, once the high detail level obtained by the census sectors show small differences inside of the urban area that finally hinders the perception of patterns occurrence. Thus, a form of to avoid the patchwork quilt pattern and to obtain the grouping of the data and the generation of behaviour patterns, is through interpolation process, and in our work we used ordinary kriging.

Figure 2:
The result of the calculation of USSQI



The interpolation methods try to predict the intermediate values starting from limited groups of points, generating a surface of continuous data. Thus, this type of method tries to measure the relationship and properties of the phenomenon in study starting from their geographical position (Druck et al., 2006). The used data should have a space distribution (to regulate or irregular) and they should present a spatial correlation. The interpolation allows an analysis of

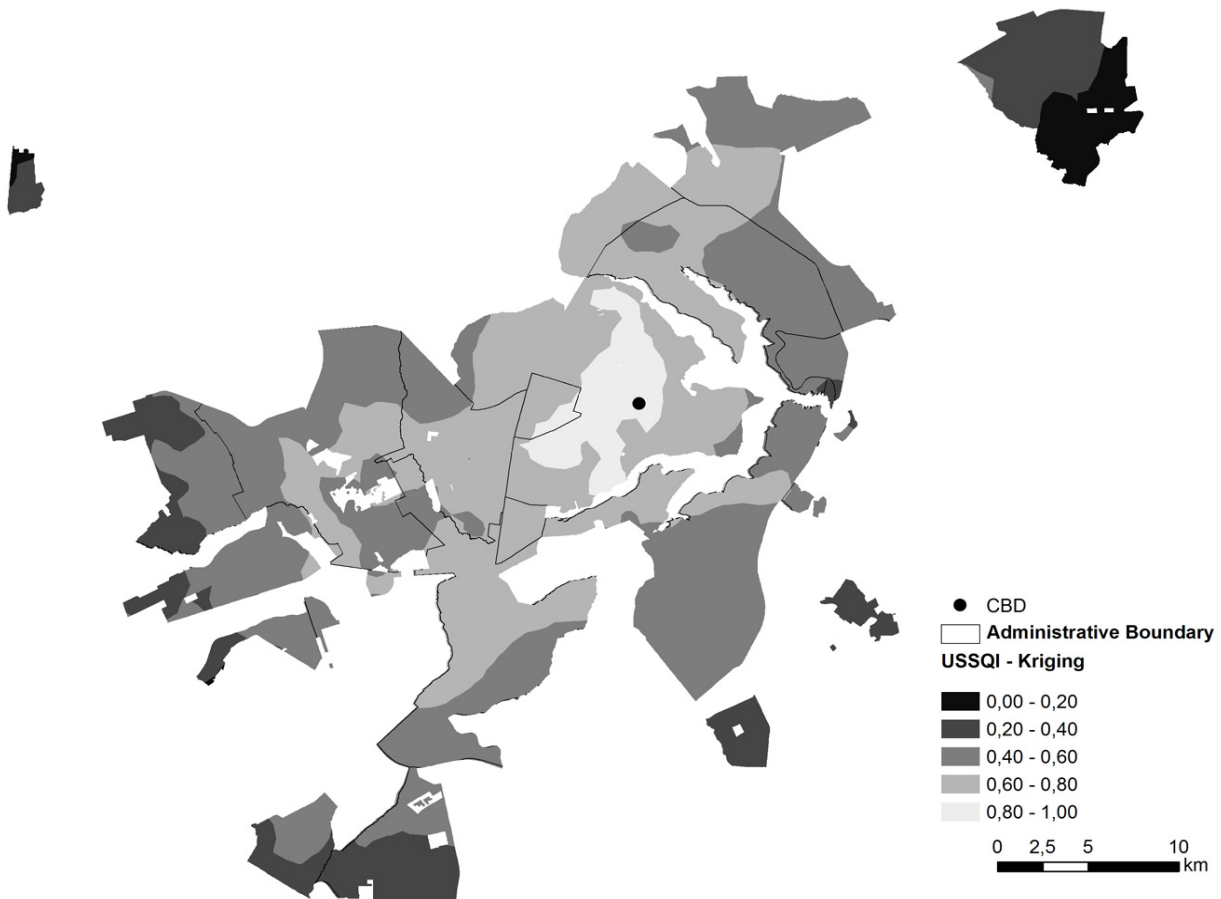
081-08

the continuity of the die, avoiding the patchwork quilt pattern, very common when we analyzed amostral data that are defined for areas of the space. Thus, we can have access to the variation patterns of the analyzed data.

The kriging can be classified as geostatistical method of local and global effect. As they explain Druck et al. (2006), each point of the surface is just esteemed starting from the interpolation of the closest samples, using a statistical stimator. Those stimators present properties of not being tendentious and of trying to minimize the inferential mistakes. Thus, this method is based on statistical models that include autocorrelation, which is the statistical relationship among the measured points. The space autocorrelation is based in the concept of space dependence, which it starting of the Tobler principles called of first law of the geography: "all of the things are similar, but closer things are more similar than distant things". Thus, the space autocorrelation is the correlation measure in the same measured variable in different places from the space. We can affirm that any phenomenon, be natural or social, they has some relationship that depends on its spatial positioning. (Druck et al., 2006)

In function of this, the kriging cannot just generate geostatistical prediction surfaces, but can also predict the certainty degree or the interpolated data accuracy. For us to use the kriging method we have, basically, that to follow a process of two steps: first, to create the variograms and covariances functions to esteem the values of spatial autocorrelation, that they depend on the autocorrelation models, adjusting the model. Second, the prediction of the ignored values should be made. Because these two different actions use the data twice: first to esteem the spatial autocorrelation and second to do the prediction. The type of chosen kriging was the ordinary, because it doesn't request the previous knowledge of the average of the values of the sample.

Figure 3:
Specialization of kriging surface for the calculated index



The semivariogram is a basic tool of support to the kriging techniques, because it allows representing, quantitatively, the variation of a regionalized phenomenon in the space. The model of used semivariogram was the spherical, where there is a progressive decrease of the spatial autocorrelation, equivalently, it occur an increment of the semivariance, even certain distance, besides which the autocorrelation is zero. This is one of the models more commonly used. The Figure 3 presents the specialization of kriging surface for the calculated index.

After the interpolation for ordinary kriging, it is clear the concentration of the largest values, which is, of the presence of better life quality, in the central area of DF, and it occur a reduction of these values as we stood back of the center. Associated the analysis of the kriging surface, we have several measures that help us to understand the behaviour of the data, such as (Kvanli et al, 1996; Andriotti, 2003):

Average - it is a measure of central tendency which indicates a central value in turn of which the data of the sample tend to concentrate.

Median - it is a physical separation of the data, in which tries to identify the central value through the ordination and separation of the amostral data in two equal groups.

Standard Deviation - it indicates the variation of the values of an amostral group in relation to the average of the sample.

Skewness - it indicates the degree of deviation of a curve in the horizontal way (Andriotti, 2003), could be positive if has the larger concentration of the values to the left of the average, or negative if has the larger concentration of values to the right of the average. Its indicates which the tendency of displacement of the data in relation to the average, median and mode, that is, of which side the data tend to concentrate.

Kurtosis - it is the degree of flattening of the curve in relation to a normal curve. It indicates as the sample of the data are distributed, that is, if has concentration close the average, or if the sample of the data are dispersed. If the value of the kurtosis goes equal to zero, then we can say that the distribution is characterized by a normal curve, these functions are called of mesokurtics; if the value is larger than zero then the distribution in subject is higher and concentrated that the normal distribution, these functions are called of leptokurtic; and, if the value is smaller than zero then the distribution function is flater than the normal distribution, being called of platikurtic. (Kvanli et al, 1996; Andriotti, 2003)

Quartil - it is a position measure that divides the sample data, orderly in ascendent order, in four equal parts. Thus, in the first quartil we have a value of the sample, and starting from him and the inferior to him, the group of data for which there are 25% of the sample. In the third quartil we have a value of the sample for which we have the concentration of 75% of the values of the group.

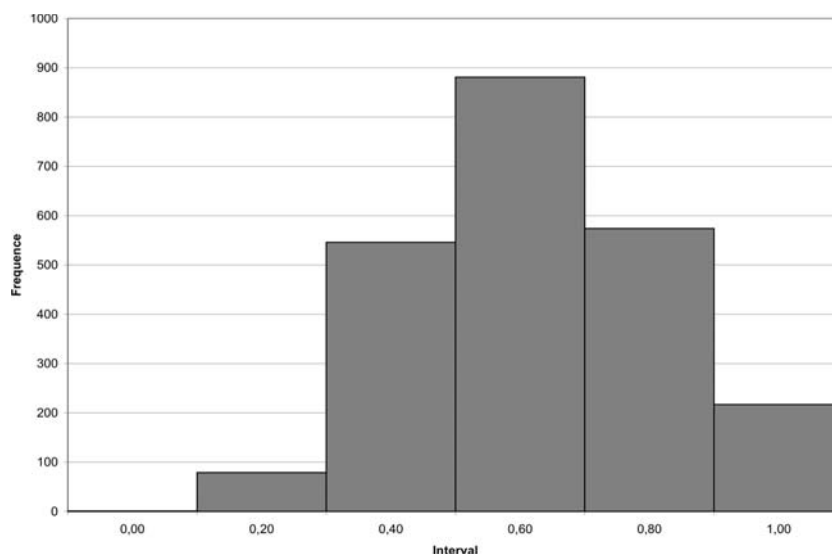
The Figure 4 presents the histogram of the index cited above.

The histogram of the USSQI (Figure 4) shows that the average of the values is 0.52. The standard deviation is of 0.18, what indicates the tendency of concentration of the values on the side of the high life quality. The value of the skewness near to zero indicates a concentration tendency of the values to the right of the graph, what shows that most of the calculated values is positive. The kurtosis value is larger than zero. Like this, the function that characterizes the distribution is leptokurtics, what reinforces the fact of the concentration of the close values to the average. The firth quartil, that represents 25% of the data, shows that just values below 0.39 are in this range.

While 75% of the data, represented by the thirth quartil, they are below 0.67. With this information we have the confirmation that the data concentrate on the positive side, what indicates that most of the areas of DF presents good life quality.

Figure 4:

Histogram of the index



081-10

Final Considerations

The process of adjustment of the social exclusion/inclusion index by means of the integration index was efficient in showing the impact of accessibility in quality of life. The analysis of the histograms shows that the two indexes present skewness to the right, indicating that there is concentration of the data on the positive side of the curve, what shows larger social inclusion and space integration.

Certain areas that presented high social inclusion, as the neighbourhoods of the Lago Sul, Brasilia and Lago Norte, with high IDHs (0.945, 0.936 and 0.933, respectively) (CODEPLAN, 2003) and that are distant on average from the CBD (7.24 km, 3.97 km and 7.71 km, respectively), have had the exclusion/inclusion value increased after the calculation of USSQI. This registers how already primileged conditions of life are benefited by good integration and small distances do CBD. Table 2 shows the correction that occurs when we calculate the USSQI.

Table 2:

Corrections after USSQI calculations

Neighbourhoods of DF	Normalized Average Integration	Average Exclusion/Inclusion	Average Distance (km)	Normalized Average Distance	Average USSQI
Brasilia	0.73	0.64	3.97	1.82	0.80
Gama	0.69	0.46	31.67	0.32	0.40
Taguatinga	0.76	0.49	19.76	0.98	0.59
Brazlândia	0.56	0.33	36.27	0.06	0.21
Ceilândia	0.62	0.35	25.46	0.66	0.40
Sobradinho	0.64	0.49	17.76	1.09	0.54
Planaltina	0.54	0.16	30.84	0.36	0.23
Paranoá	0.56	0.15	11.24	1.44	0.49
Núcleo Bandeirante	0.85	0.45	13.80	1.30	0.70
Guará	0.68	0.47	11.32	1.43	0.64
Cruzeiro	0.79	0.65	5.69	1.73	0.81
Samambaia	0.70	0.31	24.79	0.70	0.46
Santa Maria	0.65	0.28	28.79	0.48	0.36
São Sebastião	0.45	0.19	17.16	1.12	0.34
Candangolândia	0.84	0.42	9.74	1.52	0.74
Recanto das Emas	0.67	0.20	24.67	0.71	0.41
Lago Sul	0.59	0.41	7.24	1.65	0.61
Riacho Fundo	0.77	0.43	19.87	0.98	0.58
Lago Norte	0.62	0.37	7.71	1.63	0.62
Vila Planalto	0.66	0.43	3.88	1.83	0.71

More distant places like Planaltina and Brazlândia, averaging respectively 30.84 km and 36.27 km from the CBD, present the smallest IDHs of DF (0.764 and 0.761, respectively). The corrections suggest that Brazlândia gets worse when spatial aspects are concerned, and Planaltina gets slightly better. Table 2 shows that correction give emphasize the low quality of life in those places y the lowest results of USSQI. Other examples are the neighbourhoods of Cruzeiro and Vila Planalto, places which are very close to the CBD. They present average distances of 5.69 km and 3.88 km, respectively, and they present intermediate values of social exclusion/inclusion. However, the proximity with CBD makes these places increase their values of USSQI (Table 2).

In this way, the adjustment has occurred as expected. We thus obtain an index that expresses social exclusion/inclusion as well as spatial segregation/integration and the proximity of CBD, something that did not happen before: although previous works had implicitly considered segregation as a penalty to inhabitants, this was not integrated in an overall evaluation framework. On the other hand, the procedure illustrates the limitations of the traditional quality of life indicators, which do not consider the spatial insertion of people in the city.

By adjusting quality of life indicators by means of integration and distance from CBD, we have generated a new index that represents urban quality of life in a more comprehensive way. Of course, this is so far only an exploratory procedure. By empirically knowing the city we *feel* the procedure makes sense but we do not *know* so far how to prove it more thoroughly. We are now just a few steps beyond a mere *conjecture*, though one that sounds powerful. Further work is necessary to verify the consistence of hypothesis that, for example, inhabitants of Vila Planalto are indeed better off, all aspects considered, then the inhabitants of Lago Norte.

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