

POTENTIAL SURFACES OF THE CITY OF COLOMBO

L. Manawadu

Department of Geography, University of Colombo

Email: lasan@geo.cmb.ac.lk

INTRODUCTION

Potential Surface Analysis (PSA) is a method proposed by the Japanese International Cooperation Agency to identify the potential areas in a city for implementation of different social and economic activities. This method is almost similar to the Social Area Analysis (SAA), a theory and technique developed by two American Sociologists, Eshref Shevky and Wendell Bell (1955), linking changing urban social structure and residential patterns to economic development and urbanization processes. However, there were slight differences between Social Area Analysis and Potential Surface Analysis in terms of techniques proposed to analyse the data. This paper presents the procedures followed to conduct the Potential Surface Analysis as a case study of the city of Colombo, Sri Lanka and the results derived through the analysis.

STATISTICAL PROCEDURE

Similar to Social Area Analysis, Multivariate Analysis has to be used in Potential Surface Analysis to identify areas with similar characteristics which can be demarcated as separate zones or potential areas in an urban place. In this study, 53 variables Municipal wards were used for multivariate analysis and factor analysis. By using factor analysis the 53 variables were narrowed down to five factors. In this process, 11 variables were eliminated based on the results derived through the significance test. The factor solution was rotated using the Varimax method of oblique factor rotation, and no restrictions were placed on the inter-factor correlation during rotation. The Eigen value or Scree plot was examined to limit the desired number of factors. The scree plot clearly shows a steep slope at factor six which indicate that five factors are acceptable.

The five factors extracted during the analysis were essentially independent. The inter-factor correlation between factor one and two is 0.32. The correlation between the other factors does not exceed this value (Table 1). The five factors together account 65.6 per cent of the variance in the data set. The association of variables with factors shows their distinctive nature. Variables that are significantly related with factor one are not significantly related with other factors. Variables which are highly loaded to factor one, show relatively low values in relation to other factors. Therefore, they are mutually exclusive.

Table 1: Inter-factor correlation coefficients

	F1	F2	F3	F4	F5
F1	1.0000	0.3214	0.3151	-0.0142	-0.1772
F2	0.3214	1.0000	0.0660	0.0859	-0.1221
F3	0.3151	0.0660	1.0000	-0.2627	0.1362
F4	-0.0142	0.0859	-0.2627	1.00000	-0.3122
F5	-0.1772	-0.1221	0.1362	-0.3122	1.0000

INTERPRETATION OF THE FACTOR LOADINGS

The matrix of factor loadings is the basic tool of the interpretation of the results of factor analysis. Loadings greater than + 0.5 or less than – 0.5 are only used for the interpretation. Factor one has the highest Eigen value. In each of the rows the factor loadings for each of the factors are given. For each of the factors, the factor loadings of the variables are arranged in decreasing order. The relevant variables and the factor loadings for each of the factors are marked. The interpretation of the five factors are as follows:

FACTOR I: SOCIO-ECONOMIC STATUS

The first factor is an index of socio-economic status of the city. All variables which had positive high factor loadings above 0.5 are related to higher socio-economic status of the population. They are percentage of white-collar workers, percentage of professionals and technical workers, Percentage of population over 65 years, percentage of good housing, percentage of primary residential areas, percentage of sales workers, percentage of children attending schools and labour force employed (Table 2).

Table 2: Variables with high positive factor loadings to Factor one

Variable No.	Variable	Factor Loading
V28	percentage of white-collar workers	0.90147
V29	percentage of professionals and technical workers	0.89518
V03	Percentage of population over 65 years	0.89074
V44	percentage of good housing	0.81570
V48	percentage of primary residential areas	0.78622
V32	percentage of sales workers	0.64475
V47	percentage of children attending schools	0.63879
V36	labour force employed	0.62459

The negative scores on this factor have more agricultural workers, blue-colour workers etc.(Table 3).

Table 3: Variables with high negative factor loadings to Factor one

Variable No.	Variable	Factor Loading
V31	Percentage of Clerical and related workers	0.6624
V34	Percentage of agriculture and fishing workers	0.6246
V45	Percentage of upgraded housing units	0.6228
V12	Population density – 2001	0.6092
V49	Percentage of mixed residential	0.5800
V11	Population density – 1971	0.5701

Almost all the variables highly loaded to the factor one are regarded in Sociology as indicators of social status; occupation, education and better social environment.

FACTOR 2: INTENSITY OF COMMERCIAL LAND USE OF THE CITY

The variables which have a high factor loadings for factor two are quite different from those variables which had a high loadings to factor one. Those variables are land

values, occupational concentration and complexity, number of migrants, and proportion of commercial land. This factor is labeled as the intensity of commercial land use of the city (Table 4).

Table 4: Variables with high positive loadings to factor two

Variable No.	Variable	Loading
V55	Average land value	0.9011
V38	Index of concentration and complexity	0.8501
V09	Sex ratio	0.8438
V16	Migration rate	0.7973
V51	Percentage of commercial land	0.7765
V06	Mean age population	0.7049

FACTOR 3: POPULATION AND POPULATION GROWTH (SIZE FACTOR)

The third factor that emerged from the factor analysis is labeled as Population and Population growth factor. Variables positively loaded for this factor are; population (variable 1: loading 0.9012), proportion of population (variable 15: loading 0.9012), proportion of Sinhalese population (variable 16: loading 0.6089), and growth of population from 1981 to 2001 (variable 14: loading 0.6245) and growth of population from 1963 to 1971 (variable 13: loading 0, 5864).

When Berry and Horton (1970) applied Social Area Analysis to the Northeastern Illinois Metropolitan Area, they eliminated the size factor on the following ground:

“The first factor, size, was not previously identified in “Social Area Analysis:.. It proved to be a function of the inclusion of many aggregate variables in the analysis: its theoretical significance is not grate” (Berry and Horton, 1970: 321).

Following Berry and Horton, this study also excludes the size factor from further analysis.

FACTOR 4: ETHNIC SEGREGATION

The fourth factor emerged from the factor analysis is the ethnic status of the Municipal wards and here it is labeled as ethnic segregation factor of the city. All the variables related to ethnicity are highly loaded on this factor (Table 5).

Table 5: Variables with factor four and their factor loadings

Variable No.	Variable	Loading
V19	Percentage of Indian Tamil	0.88752
V18	Percentage of Ceylon Tamil	0.84508
V20	Percentage of Moor population	0.73211
V21	Percentage of Burgher population	-0.50115

Out of the six major ethnic groups of the city, only four groups are loaded for this factor because of the in-aggregated situation of other ethnic groups. Even though, there are four ethnic groups loaded to this factor, percentage of Burghers shows a negative loading because their segregation is not very significant compared with the other ethnic groups.

FACTOR 5: PRODUCTION SECTOR

Final factor appears to measure various aspect of production sector of the city. It is positively correlated with percentage of the service workers, percentage of land area belong to general industrial activities, percentage of production and related workers. The proportion of land area belong to public and semi-public is negatively correlated with this factor (Table 6).

Table 6: Variables with factor five and their factor loadings

Variable No.	Variable	Loading
V33	Percentage of service workers	0.73767
V52	Percentage of land area belong to General Industrial activities	0.71249
V35	Percentage of production and related workers	0.61429
V50	Percentage of land area belong to public and semi-public	0.50906

SPATIAL PATTERN OF THE FACTORS

To study the spatial pattern of the identified factors corresponding weights form each ward to each factor were calculated and the wards were separated into different groups according to those weights and their linear distribution.

SPATIAL PATTERN OF SOCIO-ECONOMIC CLASSES OF THE CITY

Corresponding weights related with wards and factor one show the spatial pattern of socio-economic classes of the city. They vary from 1.9391 to -1.9249. High positive values show socio-economically high class area. High negative values show areas with relatively low class social-economic status and values close to zero show lower moderate social-economic area and upper moderate social-economic area of the city. According to linear distribution of corresponding values, four socio-economic classes were identified and the wards were classified according to that as shown in Table 7.

Table 7: Socio-economic groups of the city and Municipal wards belong to each group

Socio-economic group	Municipal Ward Numbers
High class	38,39,42
Upper Middle class	07,31,35,36,37,40,41,43, 44,45
Lower Middle class	02,03,05,06,12,15,21,22,23,24,25,27,30,32,34,46,47
Low class	01,03,08,09,10,11,13,14,16,17,18,19,20,26,28,29,33

Note: Ward numbers are according to the Figure no. 01.

The spatial pattern of socio-economic classes of the city indicates that southern part of the city has a higher socio-economic status compared with the northern part of the city. Wards falling into high class socio-economic status: Bambalapitiya (ward no 38), Milagiriya (ward no 39), and Havelock Town (ward no 42) are located in the south-western part of the city, except Kuppiyawatta East (ward no 31). All the wards belonged to upper middle class socio-economic class also are situated in the southern part of the city.

Almost all wards with lower middle and low socio economic class are situated in the northern part of the city. Only two wards located in the southern edge of the city, Pamankada West (ward no 46), and Wellawatta South (ward no 47) show lower middle socio economic status. Central Business District (Fort) shows low socio-economic situation because of high concentration of low income people residing in this area.

SPATIAL PATTERN OF INTENSITY OF COMMERCIAL LAND USE

Correspondent values from the wards for this factor has a higher range than the range for socio-economic factor, from 4.8661 to – 0.8601. High range in correspondent values indicate that there is high variation in the intensity of commercial land use in the city. Highest value is loaded to Fort (Central Business District) and lowest to Kuppiyawatta (ward no 31). High values represent the high commercialized areas and low values represent the low commercialized areas. According to the linear distribution three main categories were identified (Table 8).

Table 8: Commercial groups and wards belong to each group

Commercial group	Municipal Ward Numbers
High commercialized	20,36,38
Moderate Commercialized	09,33,35,37,39,40
Low commercialized	01,02,03,04,05,06,07,08,10,11,12,13,14,15,16,17,18,19,21,22,23,24,25,26,27,28,29,30,31,32,34,41,42,43,44,45,46,47

Note: Note: Ward numbers are according to the Figure no. 01.

The wards which have a high concentration of commercial activities are Pettah (ward no 20), Kuruduwatta (ward no 36), and Bambalapitiya (ward no 38). As the CBD of the city, Pettah ward showing a highly commercialized situation is observed. The value for Pettah is around three times higher than the second highest value loaded to Kuruduwatta. A strange situation can be observed regarding the ward Kuruduwatta which has the second highest value for commercial area. This area is famous for high class residential area because all the Prime Ministers and Presidents of Sri Lanka resided in this ward. However according to this analysis, it has a high concentration of commercial activities too. This can be identified as the recent trend of the Kuruduwatta municipal ward.

Two reasons can be given for high concentration of Bambalapitiya area. First, it is located in the southern corridor of the city and the highway to south pass through this area. There is a heavy concentration of commercial activities along this road. Second, there is a few high class residential areas where people with high purchasing power in this ward.

Except Kochchikade North (ward no 09) wards which show moderate commercialization of the city are the main commercial pockets of the city. Especially, Borella North (ward no 33), Milagiriya (ward no 39), Kollupitiya (ward no 37), Borella South (ward no 35), Havelock Town (ward no 40) have developed as commercial centers of the city. Most of these wards are situated in the southern part of the city.

According to the results of the factor analysis rest of the city has very low commercial activities.

SPATIAL PATTERN OF THE ETHNIC SEGREGATION OF THE CITY

According to the values derived for this factor, the wards can be categorized into three groups; high, moderate, and low segregated areas (Table 9).

Table 9: Spatial Pattern of the Ethnic groups of the city

Commercial group	Ward Numbers
High segregated area	08,09,10,11,16,15
Moderate segregated area	39,41,43
Low segregated area	01,02,03,04,05,06,07,12,13,14,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,40,42,44,45,46,47

Note: Ward numbers are according to the Figure no. 01.

Kotahena West (ward no 08), Kochchikade North (ward no 09), and Ginthupitiya (ward no 10) are predominantly Tamil areas. Masangasvidiya (ward no 11) Maligawatta west (ward no 15) and Aluthkade East (ward no 16) are Moor dominated wards. These are exactly the areas which were identified as outliers and base segregated points compare to the average pattern of the city. Rest of the wards are not significant in the city in terms of ethnic segregation.

SPATIAL PATTERN OF THE INDUSTRIAL SECTOR OF THE CITY

The factor analysis has provided a wide range (4.2089 to -1.5259) for the values associated with wards indicating that there are certain areas with high concentration of industrial activities. The wards with high positive values have a high concentration of industrial activities while those with high negative values have very low industrial activities. Values are given in Table 10.

Table 10: Main groups of industrial activities and wards belong to each group

Industrial categories	Municipal Ward numbers
High concentration	06,13
Moderate concentration	01,02,03,04,05,07,12,14,15,16,20,22,24,25,28,29,30,38,39
Low concentration	08,09,10,11,17,18,19,21,23,26,27,31,32,33,34,35,36,37,40,41,42,43,44,45,46,47

Note: Ward numbers are according to the Figure no. 01.

The spatial pattern of industrial activities emerging from this factor clearly shows that the wards situated in northern part of the city show high and moderate concentration of industrial activities while those located in the southern part of the city have lower concentration of industrial activities.

POTENTIAL SURFACE OF THE CITY OF COLOMBO

The purpose of using factor analysis was to identify areas with similar characteristics based on a large number of variables instead of one or two variables. The procedure followed up to this point is similar to what Berry and Horton (1970) used when they applied Social Area Analysis in identify different zones in a city. The potential surface Analysis proposed by Japanese International Cooperation Agency suggested to combine Social Area Analysis, which uses a large number of variables with a suitable multivariate method, with Geographical Information Systems which allows to use map overlaying with a computer to identify surfaces with potential for various activities.

The factor analysis conducted using 55 variables eliminated certain factors because they are not relevant and the total number of variables used for identifying factors was 55. Based on these 55 variables, five factors were identified and in the proceeding sections the characteristics of those factors were identified for sub groups within those factors were presented. Though the factor analysis identified five factors, two factors (Population growth and segregation) do not seem quite relevant to identifying potential surface. Therefore, those two factors were eliminated and the other three factors; socio-economic status, Intensity of commercial land use, and industrial activities, were used to identify the potential surface through the overlaying techniques.

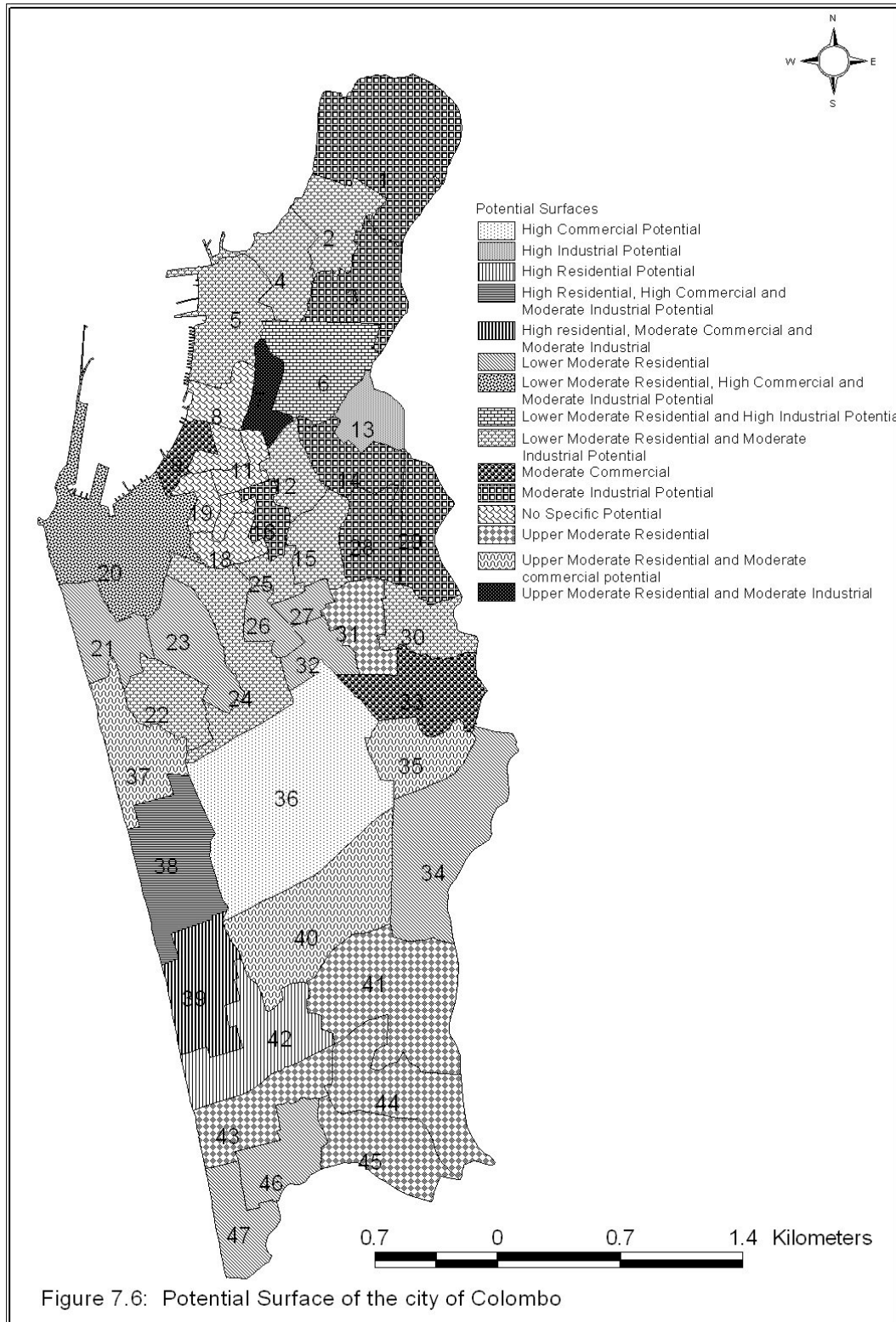
In using GIS techniques, first the map of Colombo was digitized using ArcGIS 10.1 software. Then the values generated from factor analysis for each of the wards corresponding to the three factors included for the analysis were transformed into the digital format to generate thematic maps. Then these three maps were overlaid and identified Potential Surfaces of the Colombo city (Figure 2) can be transformed to the tabular form as follows (Table 11).

Table 11: Main potentialities of Colombo city by wards

Area	Name of the ward and no	Code
High Industrial Potential	Grandpass North (13)	HI
High Residential Potential	Havelock Town (42)	HR
High Commercial Potential	Kuruduwatta (36)	HC
Moderate Industrial Potential	Mattakuliya (01) Mahawatta (03) Grandpass South (14) Aluthkade East (16) Maligawatta East (28) Dematagoda (29)	MI
Upper Moderate Residential	Kuppiyawatta East (31) Kirula (41) Wellawatta North (43) Kirulapona (44) Pamankada East (45)	UMR
Lower Moderate Residential	Koppanaveediya (21) Hunupitiya (23) Maligawatta (27) Kuppiyawatta West (32) Narahenpita (34) Wellawatta North (46) Wellawatta South (47)	LMR
Moderate Commercial	Kochhikade North (9) Borella North (33)	MC
High Residential, High Commercial and Moderate Industrial Potential	Bambalapitiya	HRHC
High residential, Moderate Commercial and Moderate Industrial	Milagiriya (39)	HRMCM
Upper Moderate Residential and Moderate commercial potential	Borella South (35), Kollupitiya (37), Thimbirigasyaya (40)	UMRMI
Upper Moderate Residential and Moderate Industrial	Kotahena East (7)	UPRMI
Lower Moderate Residential and High Industrial Potential	Bloomendhal (6)	LMRHI
Lower Moderate Residential and Moderate Industrial Potential	Modara (2) Aluthmawatha (4) Lunupokuna (5) New Bazaar (12) Maligawatta West (15) Wekanda (22) Suduwella (24) Panchikawatta (25) Wanathamulla (30)	LMRMI
Lower Moderate Residential, High Commercial and Moderate Industrial Potential	Fort (20)	LMRHCM
No Specific Potential	Kotahena West (8) Ginthupitiya (10) MasangasWeediya (11) Kochchikade South (19) Aluthkade South (17) Kehelwatta (18)	NS

NB: Note: Ward numbers are according to the Figure no. 01

Figure 01. Potentially surface of the city of Colombo



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