A Comprehensive Study on Smart City Compatibility of Divisional Cities in Bangladesh

Md. Nurul Wahed, Refat Kibria

Abstract—**In this paper, few indicators for smart city indexing of divisional cities of Bangladesh are introduced and data of various indicators are analyzed to rank the cities. In Bangladesh development process is not equally distributed. Some cities are getting more attention and some cities aren't getting enough. Hence the later cities are less developed then the previous cities and people from these underdeveloped cities are rushing towards the developed cities and creating various problems in the developed cities like population explosion, unemployment, crimes etc. The better the demographic situation, socio economic condition, utilization of ICT usage, quality of life, urban facilities the smarter the city is; this is the key concept.**

Index Terms—**Smart City, Urban Development, ICT Infrastructure, Standard Score.**

I. INTRODUCTION

The concept of smart city (SC) is such a concept that aims to enhance the life quality of citizen. It is getting popular and trendy day by day. However, a universally accepted definition of SC is not available and it is hard to identify common global trends. According to Business Dictionary: "A developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government. Excelling in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure [1]."

From [2], it is clear that there is no universally accepted definition of a Smart City. It means different things to different people. The conceptualization of Smart City, therefore, varies from city to city and country to country, depending on the level of development, willingness to change and reform, resources and aspirations of the city residents. A Smart City would have a different connotation in Bangladesh than, say, Europe. Even in Bangladesh, there is no one way of defining a Smart City.

Throughout this entire research an experimental approach has been followed to construct a precise framework for smart city in Bangladesh's perspective. Bangladesh is a third world country which belongs to the developing category. The current population of Bangladesh is 162,442,335 based on the latest United Nation estimates and its area is only 1, 47,

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570 km^2. The population density is 1033 per square km. The total GDP is \$205,327 which is 44Th in the world. The government of Bangladesh has made a large scale initiative to convert it to a digital one. In order to make this initiative - successful, the govt. has to pay attention on some specific factors.

In Bangladesh the development isn't distributed equally in all the regions. The capital Dhaka has become a megacity and various modern facilities are available there. As a port city, Chittagong is also very important. But not all the cities are getting enough attention. As a result, people from those underdeveloped regions are rushing towards the developed cities and affecting the development rate of those relatively developed cities by creating various problems like population explosion, unemployment, crimes, poverty etc. At this moment this country needs a highly decentralized and planned scheme to overcome all those constraints. Well, data of various indicators of seven divisional cities of our country have been analyzed and by analyzing that data some conclusions have been drawn about the smart city infrastructure (enhanced quality of life, socioeconomic development, proper utilization of ICT infrastructure).

Primary analysis has been performed on various indicators. Bangladeshi cities are still a lot behind the cities of developed countries. There are some reasons. They're: Lack of proper policy making, Lack of proper utilization of ICT infrastructure, Population explosion, Rushing population from underdeveloped places to relatively developed places, Political Instability, Lack of easy to access vital information, Lack of strong willingness for taking necessary action to build a highly effective decentralized development scheme, Lack of visionary plans, Poverty and unemployment, Lack of standard facilities for citizens, Corruption, Lack of proper education, Improper management of resources.

II. SMART CITY AND ITS APPLICATION

In [3] the authors had stated about some application areas of smart city concept. They are: Education, Public utility services, Public health care, Public safety, Business, Standard of life. They also stated that the smart city is needed for several reasons. Some of them are discussed below: (a) The world is becoming more urban. Cities and Towns are growing in size and influences. (b) Governments are decentralizing i.e. devolution of functions to lower levels of Government. (c) Cities are becoming more global. (d) Government is being reformed. (e) Technological developments and e-commerce are having a profound effect on society. (f) Increasing pressure to alternate service delivery i.e. find creative methods through which municipalities can mobilize energy capacity and resources outside the municipality for the development of the area. (g)

Increasing pressure to become service and customer oriented. (h) Increasing pressure to involve the community to the work of municipality. (i) Increasing pressure to provide all relevant information to other levels of government, communities and other stakeholders. (j) More and more functions are being devolved to local government. (k) Lack of integration between departments and directorates. (l) Increasing bureaucracy-huge reliance on manual processes and people based processes. (m) IT systems focused mainly on cost reporting not business enablement. (n) IT enabled social and economic development. (o) IT enabled Administration Service Delivery. (p) IT enabled Governance

In [4-7] the authors have stated that current cities are complex systems those are characterized by massive number of interconnected citizens, business, different modes of transport, communication networks, service and utilities, population growth and increased urbanization raise a variety of technical, social, economic and organizational problems those tend to jeopardize the economic and environmental sustainability of the cities. They have classified literature on the domains of Smart City which have two categories, (I) Hard and (II) Soft. They have identified Energy grids, Public lighting, Natural resources and water management, Waste management, Environment, Transport, Mobility, Logistics, Office and residential buildings, Healthcare, Public security as hard domains and Education and culture, social inclusion and welfare, Public administration and e-government, Economy as soft domains. They have Context variables that characterize the development trends of Smart Cities.

They belong to: Structural factors: size and demographic density, Economic development, Technology development, Environmental-friendly policies and other country-specific factors.

The context variables are: Population, Area, Demographic density, Carbon emissions per capita, GDP per capita, Unemployment rate, Country GDP per capita, Country GDP growth, Household with internet access, Country R&D expenditure and Corruption Perceptions Index (CPI).

The data analysis had two objectives. First, when the descriptive statistics were analyzed, the goal was twofold: (I) to identify the fields with the greatest diffusion of SC initiatives throughout the world; (II) to detect commonalities and differences in the patterns of SC trends across continents. The second step of the empirical study involved a more comprehensive analysis on how the contextual factors discussed in the conceptual model could influence the different dimensions of the CI. This was obtained through a regression analysis on the different layers of the CI. In order to identify higher-level factors, the coverage indices in each domain were analyzed using factor analysis at an exploratory level. The factor analysis highlighted two dimensions that confirmed the separation into hard vs. soft domains.

Overall, this study provides policy makers and city managers with useful general guidelines and suggests some practical implications. On the one hand the proposed definition offers a systemic and practical perspective of the SC notion as the CI enables a preliminary assessment to be made in order to direct the SC planning efforts towards the

appropriate application domains and initiatives. In other words, the analysis of the relationships between the CI and the selected contextual variables can help identify the main factors that enable the development of projects which could contribute towards increasing the smartness of a city.

In [8] the authors simply defined smart city innovation in terms of technology, organization, and policy as follows: Technology innovation: a mechanism to change and upgrade technological tools to improve services and create conditions where the tools can be better used, Organization innovation: a mechanism to create managerial and organizational capabilities for effective use of technological tools and conditions and Policy innovation: a mechanism to address institutional and non-technical urban problems and create conditions enabling for a smart city.

III. PROPOSED METHODOLOGIES IN BANGLADESH PERSPECTIVE

A. Identification of Indicators

As mentioned before, the research is to establish a well-defined framework for Bangladeshi cities on basis of our identified indicators. Some statistical methods for analysis purpose have been performed. The initial step in this research is the identification of indicators. A variety of factors can influence the way cities choose to develop SC initiatives. According to [9] these indicators have certain values and by inspecting these values a conclusion can be drawn about the condition of a city based on these particular indicators. Indicators define sets of values against which to measure. These raw sets of values, which are fed to systems in charge of summarizing the information, are called indicators. Indicators are identifiable and marked as possible candidates for our analysis process.

For example, literacy rate is one of the identified indicators. For analysis purpose some data had to be cleaned.

Mainly three types of indicators have been identified. They are: Fundamental indicators, ICT and communication infrastructure related indicators and facilities related indicators.

A city can be smart in various ways. If it can manage to ensure better living for its inhabitants then it can be said smart in that way. If it can ensure better ICT and communication infrastructure and can assure necessary facilities for its inhabitants then it can also be said a smart city. The fundamental indicators stated in this paper are some indicators which indicate the better demographic situation across the cities. The identified ICT and Communication infrastructure related indicators clearly indicates the situation of this infrastructure across those divisional cities of Bangladesh. The facilities related indicators indicates how much good the living quality of the citizens are across those cities, how much facilities they are getting.

Table 01 - Table of identified indicators

Fundamental Indicators	ICT and Communication Infrastructure Related Indicators	Facilities Related Indicators
Literacy Rate	Computer Usage Rate	P/H (People per Hospital)
Poverty Rate	Mobile Usage Rate	A/PG (Area Covered by per Play Ground)
Extreme poverty Rate	Internet Usage Rate	A/Park (Area Covered by per Park)
Population Density	Land phone Usage Rate	A/FBS (Area Covered by per Fire Brigade Station)
Population per Household (P/HH)	Radio Usage Rate	A/PS (Area Covered by per Police Station)
	Television Usage Rate	SGPS/GPS (Students per Govt. Primary School)
	Metaled Road per Square km	Student per Teacher in Varsity
		P/MFP (People per MBBS/FCPS Practitioner)
		Literate People per Library

B. Data collection and preparing the data sets

For analysis purpose the researchers needed to have valid data of each indicator. They collected all the data from the following data source [10]: Bangladesh Population Census 2011, Bangladesh Zila level poverty maps estimates, 2010, Bangladesh District Statistics 2011, ICT Use and Access by Individuals and Households, Bangladesh 2013 and Bangladesh Economic Census 2013. All the data sources are provided by Bangladesh Bureau of Statistics

Researchers got direct value for many of the indicators. For some indicators they had to process the data. For example they got the number of public library in each divisional city of Bangladesh. Then they performed some calculation to get the derived indicator Literate People per Library which can be written as:

$$Literate\ People\ per = Literacy\ Rate\ \frac{Population}{100\ X\ No.of\ Public\ Library}$$

They've also got the internet usage statistics of seven divisional cities. There are 16 categories in total. They are: Getting info about goods or services, Getting info from general govt. organizations, Sending or receiving emails, Posting info or instant messaging, Internet banking, Playing or downloading video games or computer games,

Downloading software, Getting info related to health or health services, Interacting with general govt. organizations, Telephoning over the internet/VoIP, Purchasing or ordering goods or services, Education or learning activities , Downloading movies, music, watching TV or video, Reading or downloading online newspapers or magazines

C. Data analysis using descriptive statistical methods

Data of various indicators of seven divisional cities of

Bangladesh has been analyzed using some descriptive statistical methods. IBM SPSS statistical tool has been used for this data analysis. The result can be seen at the appendix A. Some facts are going to be described from this descriptive analysis in Results and Discussion section.

D. Finding the Correlations among variables

Correlations among the indicators have been calculated using Pearson's Correlation Coefficient formula:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x^2)][n\sum y^2 - (\sum y^2)]}}$$

Where x, y is any two variables and n is the total number of cases. Pearson's Correlation Coefficient returns a value of between -1 and +1. A -1 means there is a strong negative correlation and +1 means that there is a strong positive correlation. The analysis will be discussed in Results and Discussion section.

E. Calculating standard scores of indicators

From [11] researchers came to know that to compare the different indicators it is necessary to standardize the values. One method to standardize is by z-transformation (see formula). This method transforms all indicator values into standardized values with an average 0 and a standard deviation 1. This method has the advantages to consider the heterogeneity within groups and maintain its metric information. Furthermore a high sensitivity towards changes is achieved.

Formula of standard score (z-score):

$$z = \frac{x_i - \mu_x}{S}$$

Where S is the standard deviation and μ_x is the mean of values. Smart City Index for each city has been calculated, for that purpose all the data have been normalized using std. score (z-score) method. After the normalization all of the positive and negative indicators are separated. For positive indicators, the higher the z-score, the better the situation is. Researchers have summed up the z-scores of each positive indicator for each city and rank them according to their summation of standard scores. For negative indicators, the lower the z-score (negative value), the better the situation is. The z-scores of negative Indicators have been summed up for each city to rank them. Relatively less important indicators (E.g. Radio Usage Rate) have been multiplied with a very small value so that they become insignificant. It should be done because all of the identified indicators are not of same weights. Suppose literacy rate is surely more important than radio usage rate.

City	Popoulation (P)	Area km^2 (A)	Density (per square km)	Litaracy Rate %	Household (HH)	P/HH	Extreme Poor %(lower poverty line)	Poor %(Uper poverty line)	Computer %	Mobile %
DHK	2.1966	1.97377	0.53068	0.92084	2.23323	-0.30127	-1.08614	-0.93611	2.18389	1.95404
CTG	0.1867	0.62862	1.07524	0.04117	0.00791	0.64467	-1.1258	-1.1937	0.01695	0.24425
SYL	-0.48576	-0.81481	0.38508	-0.1105	-0.45163	-0.43081	-0.45609	-0.7744	-0.00678	0.42423
KHU	-0.43503	-0.42451	-0.45043	0.63267	-0.37187	-0.7815	0.41282	0.6126	-0.47338	-0.79061
RAJ	-0.49251	-0.09886	-1.31444	0.51134	-0.45607	-0.49964	-0.20371	0.11405	-0.51293	-0.97059
BAR	-0.51569	-0.46469	-1.22161	0.117	-0.47688	-0.64072	1.46381	1.50104	-0.52083	-0.47565
RAN	-0.4543	-0.79952	0.99548	-2.11252	-0.4847	2.00926	0.9951	0.67652	-0.68691	-0.38567

Figure 02: A portion of data after applying standard score method.

IV. RESULT AND DISCUSSION

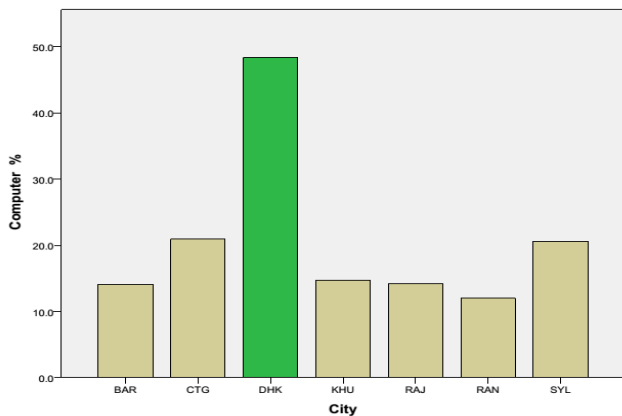### A. *Bar Charts indicating different indicators across the cities*

Figure 03: Bar chart indicating computer usage rate across seven divisional cities

It is clearly seen that, capital Dhaka has the highest Computer Usage Rate while Rangpur has the lowest.
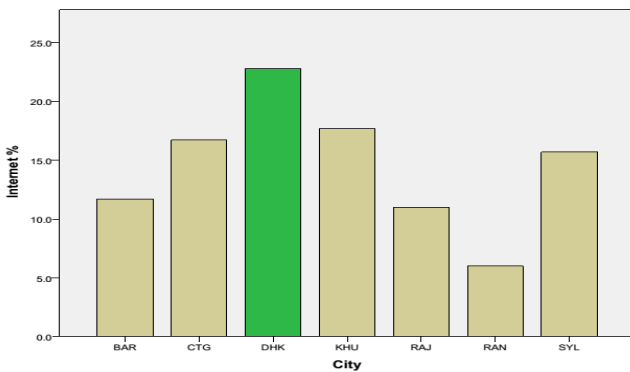

Figure 04: Bar chart indicating internet usage rate across seven divisional cities

It is clearly seen that, capital Dhaka has the highest Internet Usage Rate while Rangpur has the lowest.
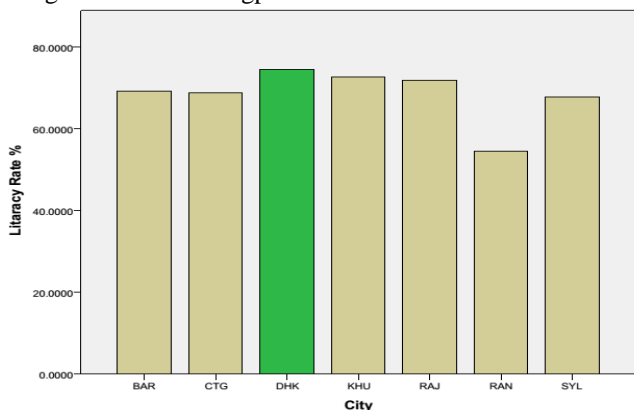

Figure 05: Bar chart indicating literacy rate across seven divisional cities

It is clearly seen that, capital Dhaka has the highest Literacy Rate while Rangpur has the lowest.

In case of all these indicators Dhaka tends to be much more advanced than any other divisional cities and cities like Barishal and Rangpur tends to be a bit underdeveloped. This is high time govt. should impose more importance on development of these underdeveloped places. If capital Dhaka gets more and more focused for urban development, there will be an imbalance. People are rushing towards Dhaka for a better life. But this extra population is creating various problems in Dhaka like environmental pollution, population explosion, unemployment, unplanned development, lack of necessary facilities like water and electricity supply. This is alarming. Development should be distributed at a more balanced form so that Dhaka doesn't have to face these problems.

B. *Scatter plot indicating mutual relationship between indicators across the cities*
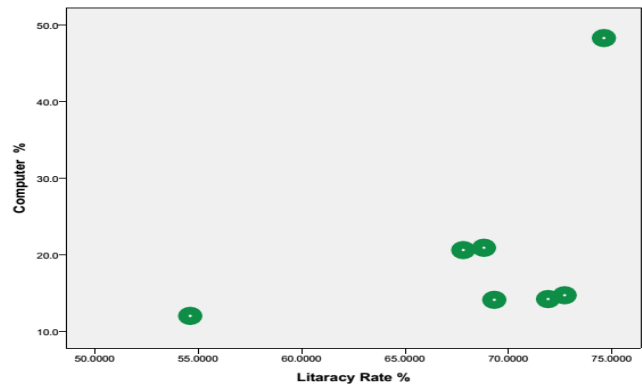

Figure 06: Scatter plot showing computer usage rate-literacy rate- relation across seven divisional cities.

From the above scatter plot it is clearly visible that literacy rate is a very important factor for computer usage rate across the divisional cities of Bangladesh. The govt. should impose sufficient importance to education all across those cities.
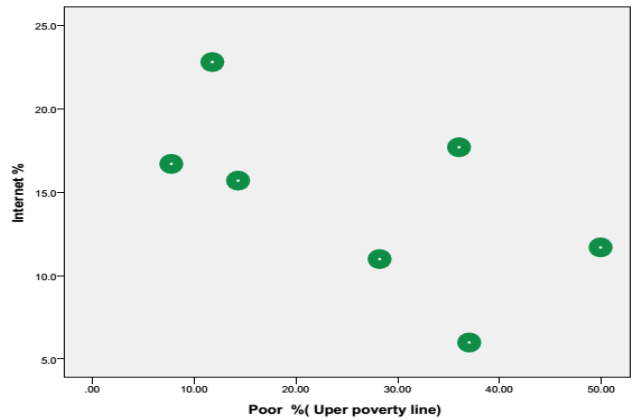

Figure 07: Scatter plot showing internet usage rate-poverty rate relation across seven divisional cities.

From the above scatter plot it is clearly visible that how poverty rate is affecting the internet usage rate across the divisional cities of Bangladesh. The govt. should keep those facts in mind.

C. *Some facts from this descriptive analysis*

Some facts are going to be described from this descriptive analysis below:

The mean of Literacy Rate is 68.53%, ranges from 54.6 (Rangpur) to 74.6 (Dhaka). Standard deviation is 6.59. As literacy rate is a positive indicator our major concern is the values which are lower than mean- standard deviation such as Rangpur has 54.6% literacy rate.

The mean of household level internet usage is 14.51%, ranges from 6% (Rangpur) to 22.8 (Dhaka). Standard deviation is 5.44. As this is a positive indicator our major concern is the values which are lower than mean- standard deviation such as Rangpur has 6% literacy rate.

The mean of A/PS (Area covered by per Police Station in km^2) is 11.00, ranges from 3 km^2 to 28 km^2 (Rangpur). As this is a negative indicator our concern is the value above mean which are Rajshahi (24), Rangpur (28).

The mean of Poverty Rate is 26.42, ranges from 7.74% (Chittagong) to 49.9% (Barishal). As this is a negative indicator our concern is the value above mean which are Khulna (36%), Rajshahi (28.2%), Barishal (49.9%) and Rangpur (37%).

D. Analyzing the correlations among different indicators

Correlations among all variables have been calculated. Some of the significant ones are going to be highlighted below:

Table 02 – Correlation between Different Indicators

Indicator 01	Indicator 02	Correlation	Comment
Literacy Rate	Population Density	-0.452	Strong Negative Relationship
Literacy Rate	Computer Usage Rate	0.473	Strong Positive Relationship
Poverty Rate	Computer Usage Rate	-0.609	Strong Negative Relationship
Poverty Rate	Mobile Usage Rate	-0.670	Strong Negative Relationship
Computer Usage Rate	Mobile Usage Rate	0.942	Very Strong Positive Relationship
Literacy Rate	Internet Usage Rate	0.780	Very Strong Positive Relationship
Computer Usage Rate	Internet Usage Rate	0.788	Very Strong Positive Relationship
Mobile Usage Rate	Internet Usage Rate	0.70	Very Strong Positive Relationship

E. Internet Usage Analysis in seven divisional cities

In section 3.2 there's a statement about 14 internet usage categories. Among them, seven categories have been identified as relatively more important and advanced. They are: Internet banking (IB), Getting info related to health or health services (IHS), Interacting with general govt. organizations (IGO), Telephoning over the internet/VoIP (TI), Purchasing or ordering goods or services (PGS), Education or learning activities (ELA), Reading or downloading online newspapers or magazines (RON). Relatively more productive internet user % in divisional cities: Dhaka – 86%, Chittagong - 71.2%, Sylhet – 84.1% Khulna – 63.6%, Rajshahi – 62.9%, Barishal–60.5% and Rangpur - 47.6%
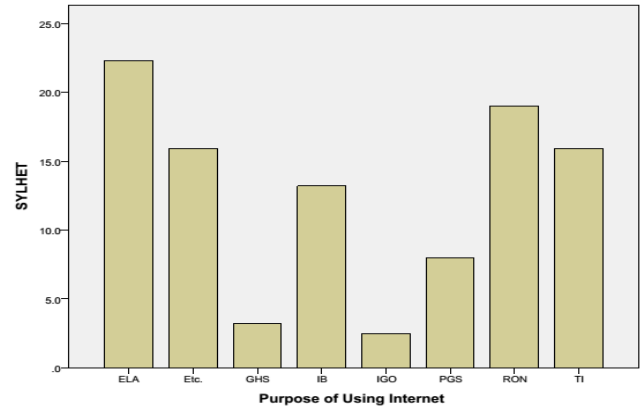

Figure 08 – Bar chart indicating internet usage categories in Sylhet city. It has the second highest percentage (After Dhaka) of productive internet usage.

F. City Ranking

The cities have been ranked in much more like a methodology described in [12]. So far 3 kinds of ranking have been done. They are based on: Ranking based on fundamental indicators, Ranking based on ICT and communication related Indicators and Ranking based on city infrastructure related indicators.

In ranking based on fundamental indicators, there are five indicators. They are population density, literacy rate, population per household, extreme poverty rate and poverty rate. Only the literacy rate is a positive indicator. For ranking summation of positive indicators – summation of negative indicators have been taken. The ranking is:

Table 03 – Fundamental indicator based city ranking

Rank	City	Score (∑positive z-score-∑negative z-scores)
1	Dhaka	2.71
2	Rajshahi	2.42
3	Sylhet	1.17
4	Khulna	0.83
5	Chittagong	0.64
6	Barishal	-0.98
7	Rangpur	-6.79

In Ranking based on ICT and communication related indicators, there are seven indicators. They are computer usage rate, mobile usage rate, internet usage rate, land phone usage rate, radio usage rate, television usage rate and metaled road per square km. All of them are positive indicators. For ranking summation of z-scores has been taken. The ranking is:

Table 04 – ICT and communication indicator based city ranking

Rank	City	Score (∑positive z-score-∑negative z-scores)
1	Dhaka	10.02
2	Sylhet	4.57
3	Chittagong	-1.31
4	Khulna	-1.38
5	Rajshahi	-3.18
6	Rangpur	-3.27
7	Barishal	-5.24

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In Ranking based on city infrastructure related indicators, there are seven indicators. They are P/H, A/PG, A/Park, A/FBS, A/PS, SGPS/GPS, Students per Teacher in Varsity, People per doctor (P/MFP), and Literate people per Library. All of them are negative indicators. For ranking summation of z-scores has been taken. The ranking is:

Table 05 – Fundamental indicator based city ranking

Rank	City	Score ($\sum$z-scores)
1	Khulna	-4.38
2	Sylhet	-2.70
3	Barishal	-2.30
4	Rangpur	-1.13
5	Dhaka	2.40
6	Chittagong	4.11
7	Rajshahi	6.16

So it is clearly visible that how the rushing people are affecting the city infrastructure scenario in capital Dhaka, as it is ranked as 5th in that particular list. This is high time govt. should decentralized the whole system. Otherwise the situation will be more deteriorating in near future.

The situation regarding ICT and Communication indicator is relatively better in Dhaka, Sylhet in Chittagong. Govt. should put more importance in Barishal and Rangpur cities. The infrastructure is worst there.

APPENDIX A

MEAN, STANDARD DEVIATION OF IDENTIFIED INDICATORS

Descriptive Statistics

	N	Mean	Std. Deviation
Density (per square km)	7	15212.57	8035.784
Litaracy Rate %	7	68.528571	6.5933589
P/HH	7	5.845424	2.0765306
Extreme Poor %(lower poverty line)	7	14.760000	11.0943634
Poor %(Uper poverty line)	7	26.4157	15.64529
Computer %	7	20.686	12.6446
Mobile %	7	95.357	2.2225
Radio %	7	20.243	4.1424
Land Phone %	7	14.929	4.4593
Television %	7	94.071	4.1955
Internet %	7	14.514	5.4429
P/H	7	15424.86	10496.285
A/PG	7	4.316484	4.1557627
A/Park	7	16.57	7.913
A/FBS	7	23.57	12.856
A/PS	7	11.00	10.456
SGPS/GPS	7	572.71	244.452
Students per Teacher(ST)	7	25.71	23.838
People per Doctor(P/MFP)	7	4058.57	2473.067
Literate People per Library ((LR*P)/100)*(1/PL)	7	365631.57	480094.702
Metalled Road (MR)(km)	7	428.114	517.3693
Valid N (listwise)	7		

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