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Do People Like to Live in a Compact City?

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Abstract: Considerable research has been carried out to independently to estimate city sustainability, their livability as well as compactness based on their individual characteristics and features. Literature suggests that compact cities tend to be sustainable. However, little effort has been put to investigate to what extent people find a compact city to be livable. This study measures the relationship between compactness and livability based on well-established methods of measuring compactness and livability. Sixty-seven cities from developed and developing countries were selected based on Mercer and the Economist's livability ranking and their relationship between compactness and livability were evaluated. The compactness of these cities was calculated based on Visual, Roeck, Schwartzberg, Length-Width & Perimeter test methods. Finally, the correlation between livability and compactness was estimated which hinted a weak negative co-relation between them suggesting that a compact city may not be identified as a highly livable city by its dwellers.

Keywords: Livability, Sustainability, Compactness

1. INTRODUCTION

City means an urbanized area which comprises of one or more central places and the adjacent densely settled surrounding territory having a minimum of 50,000 persons (U.S. Bureau, 1995). Concentrating people and activities in urban areas confers advantages and many locate in the sprawling metropolitan periphery instead of the denser urban core (Sassen, 2001; Scott, 2001a; Castells, 1996, 2001; Mitchell, 1999; Hall, 1998). Later, the cities developed in a rapid form resulting in decline in the field of space and distance due to advancements in telecommunications and globalization (Cairncross, 2001). Thus, urbanism is the process through which cities grow.

Due to urbanization, an increasing number of people are being forced to move to cities in search of better job opportunities. This increase of population requires the improvement of public transport facilities, hospitals, water supply housing and employment opportunities. Problems like air pollution, water pollution, development of slums, destruction of forests and other nature reserves around cities for settlements and agriculture lead to increase of crime and poverty (UNEP, 2011). Proper urban planning is the key to bridging the urban divide, to make cities inclusive, environmentally friendly, economically vibrant, culturally meaningful and safe for all. It has been practiced from ancient ages to the time of the first industrial revolution. The older cities were planned in a proper way to provide solution of a problem as the king or ruler used to involve directly in the planning for different territorial and strategic purposes. However, at present, the direct involvement of the ruler of a country is decreasing due to development of planning ministry and increase of other sectorial problems. For

ensuring an efficient city planning, it is essential to follow the methods and strategies of planning that used to take upon at the older city construction's period. Many researchers have elevated history to the status of foundational planning methodology alongside quantification, survey analysis (Freestone, 2014). Besides, Planning needs continuous updating to be successful in helping to achieve urban development. Conceptualization of urban planning is still considered as a key element of development. Clearly these practices have their place in city management to control the city as a whole and to constrain its evolution (Bettencourt, 2013).

Compact city conveys the opposite concept of urban sprawl (Neuman, 2005).It sets the target to use every square meter of the land for ensuring sustainable energy, mobility, economy and living. Besides, compact city leads to efficient use of energy and transport facilities along with some important factors for a shorter and hassle free life (Alberti, 1999a). Compact development is less costly than sprawl for both operating and capital costs (Burchell and Adelaja, 1992; Burchell et al., 2002). The main principle in the compact city theory is high-density development close to or within the city core with a mixture of housing, workplaces and shops which implies densely and concentrated housing development.

Sustainability has become a part of every branches of development including city planning. According to Brundtland (1987), Sustainability can be defined as action that satisfies the requirements of the present generation without compromising the capacity of future generations to satisfy their own requirements. There are two dominant and contradictory theories about sustainable urban form: the compact city and the dispersed city. Disperse cities are the cities which are generally distributed or spread over an area. The main principle of disperse city is to build up a 'garden city' rather than to let people live in the city altogether. However, compact city can ensure more efficient land use and puts less burden on its management authorities than a disperse city due to promote and more community-oriented social patterns (Katz, 1994). Burchell et al. (2002) showed that the relation between compactness and sustainability could be negatively correlated and weakly related in limited ways.

Livability is the core component of urban form models (Satu, 2014). It has ranged from benchmarking perceptions of development levels to assigning a hardship allowance as part of expatriate relocation packages (The Economist, 2014). In 1990s, urban form models like the compact city model, new urbanism, smart growth and transit-oriented development were explored. These four models, explicitly or implicitly focus on the issues of livability. Unlike the other three models, the compact city model was advocated and developed to counteract the environmental ills of the low-rise and sprawling cities of the West with social development (Breheny, 1992; Burton, 2000; CEC, 1990; Chiu, 2008; Newman, 1992). Major attributes of compact cities include multimodal urban form, a well-defined boundary containing city growth, high density and mixed land-use patterns enabling the provision of public facilities and services within walking distance and heavy reliance on public transport (Chiu, 2008, 2012; Jenks and Dempsey, 2005; Williams, 2000). A livable city helps to balance social, economic and environmental needs, infrastructure and efficiency at the forefront of all its planning activities as poor urban planning and management can have grave results for the urban economy, the environment and society. Hence, a city is expected to be livable (World Bank, 2007).

Researches have been carried out to measure compactness using different variables. Kotharkar et al. (2014) focused on several factors related to compactness mainly on understanding the impact of urban form using transport behavior and environmental, social, and economic variables. Measuring urban form characteristics, the study concluded that Nagpur has all components of a compact city. The findings were used to assess the existing

level of city's compactness and to evaluate the appropriateness of compact development as a growth option for Nagpur. Tsai (2005) used population size, density, degree of equal distribution (Gini coefficient) and degree of clustering (Moran coefficient) to distinguish compactness from sprawl at the metropolitan level. Three indicators, the density, mixed use, and intensification, are used in urban compactness measurement. First, the density indicator includes population density, built-up density and residential density variables. The mixed use indicator consists of the availability level of elementary school services, senior high school services, junior high school services, health facilities services, the number of medical power, percentage of offices or working areas in land use and percentage of recreational or free or green spaces in land use variables. Finally, the intensification indicator covers population growth rate and migration rate variables (Barton, 2001; Neuman, 2005, 2009; Kurniadi, 2007).

The Economist and Mercer regularly conduct study and publish their ranking on city livability. The Economist 2014 assigned a livability rating on every city for over thirty qualitative and quantitative factors across five broad categories- stability, healthcare, culture and environment stability, education and infrastructure. For qualitative factors, a rating was awarded based on the judgment of in-house analysts and in-city contributors. For quantitative factors, a rating is calculated based on their relative performance of a number of external data points. The scores were then compiled and weighted to provide a score of 1–100, where 1 is considered intolerable and 100 is considered ideal. Mercer 2014 evaluates local living conditions in more than 460 cities it surveys worldwide based on Quality of a living survey using ten categories and thirty nine factors. A quality-of-living allowance is typically location-related while a mobility premium is usually independent of the host location.

The purpose of the study is to identify the underlying relationship between livability of a city and its compactness. The study has selects sixty seven cities from the six continents of the world with representatives from both developed and the developing countries and compared their compactness with their livability ranking. The specific objectives are:

- To measure the compactness of selected cities using established methods.
- Evaluate the correlation between city compactness and livability.
- Discuss the regional variations, if any.

2 METHODOLOGY

The overall methodology involves selection of cities from livability ranking, compactness measurement using different methods and then finding out the relationship between compactness and livability.

Mercer and The Economist determine the key factors like easy access to transportation, reliable electricity and drinkable water, crime rates, health statistics, sanitation standards, and expenditures on city services based on survey. Based on these factors, they perform statistical analysis & prepare the final ranking of livability.

The Economist and the Mercer consulting company annually measures "quality of living" standards, using data such as crime rates, health statistics, sanitation standards, and expenditures on city services. These are the factors based on which the cities are ranked livable or less livable. Depending on the factors, the cities are called developed and developing. In this study the ranking of developed and developing countries is used to find the relationship of compactness & livability so that it can be applied in a global context. To add different continents, The cities that are selected for analysis are identified from six zones – North America, Central and South America, Europe, Middle East and Africa, Asia and

Australia and New Zealand using livability ranking by Mercer 2014 and The Economist 2014. Visual test, Roeck test, Schwartzberg test, Length-Width test, and Perimeter test methods are used to measure the compactness of selected cities. Finally, the correlation between compactness and livability are examined using statistical software.

2.1 Livability Ranking for Cities

As discussed earlier, two of the most popular livability of city rankings are Mercer and The Economist (Section 1). In this study, ranking by Mercer 2014 (Table 1) and The Economist 2014 (Table 2) are used for analysis. Sixty seven cities are selected from six zones – North America, Central and South America, Europe, Middle East and Africa, Asia, Australia and New Zealand. Each City is represented by a city ID. For each of these six zones, the top and the bottom five cities were selected from Mercer Ranking. Further, two more groups were created with the top and the bottom ten cities based on The Economist Ranking.

Table 1: Livability Ranking for Cities (Mercer 2014)

City ID	City Name	Region/Country	Mercer Ranking	Area (Km^2)	Population
1	Vancouver	North America	5	114.97	603,502
2	Ottawa	North America	14	6500	934,243
3	Toronto	North America	15	630.21	2790000
4	Montreal	North America	23	6600	1,704,694
5	San Francisco	United States	27	3900	805,235
6	Mexico City	United States	122	1485	8,918,653
7	Detroit	United States	70	4500	713,777
8	ST Louis	United States	67	10000	319,294
9	Houston	United States	66	10300	2,099,451
10	Miami	United States	65	7300	399,457
11	Point-A-Pitre	South America	69	2.66	15992
12	San Juan	South America	72	89,651	681,055
13	Monte Video	South America	77	1840	1,305,082
14	Buenos Aires	South America	81	5200	2,890,151
15	Santiago	South America	93	641	7314.176
16	Port Au Prince	South America	221	200	1000000
17	Tegucigalpa	South America	181	1700	1,157,509
18	Cara Cas	South America	176	5400	1,943,901
19	San Sal Vador	South America	175	650	257,754
20	Managua	South America	170	700	2,205,676
21	Singapore	Asia	25	719.1	5,607,300
22	Tokyo	Asia	43	2,187.66	13,617,445
23	Kobe	Asia	47	552.23	1,536,499
24	Yokohama	Asia	49	437.38	3,732,616
25	Osaka	Asia	57	223	19600000
26	Dushanbe	Asia	209	124.6	778,500

27	Dhaka	Asia	208	306.38	14600000
28	Ashkhabad	Asia	206	440	1,031,992
29	Bishkek	Asia	204	170	937,400
30	Tashkent	Asia	202	335	2,309,600
31	Auckland	New Zealand	3	559.2	1420000
32	Sydney	Australia	10	12,367.7	5000000
33	Wellington	New Zealand	12	442	405000
34	Dubai	UAE	73	1,287.4	2,788,929
35	Abu Dhabi	UAE	78	972	1145000
36	Port Louis	Mauritius	82	46.7	149,194
37	Durban	Africa	85	226	595,061
38	Cape Town	Africa	90	400	433,688
39	Baghdad	Middle East	223	204	8,765,000
40	Bangui	Central Republic	222	67	734350
41	Brazzaville	Congo	218	263.9	1,827,000
42	Vienna	Europe	1	830	1,867,960
43	Zurich	Europe	2	88	401144
44	Munich	Europe	4	310	1,450,381
45	Dusseldorf	Europe	6	217.41	612,178
46	Frankfurt	Europe	7	248.31	732,688
47	Wroclaw	Europe	107	293	637,683
48	St Petersburg	Europe	168	1440	5,323,300
49	Albania	Europe	179	2900	2,876,591
50	Yerevan	Europe	180	223	1,060,138
51	Minsk	Europe	189	410	1,921,807
52	N’DJamena	Chad	220	100	1,092,066
53	Sana’a	Yemen Arab Republic	219	126	1,937,451

Table 2: Livability Ranking for Cities (The Economist 2014)

City ID	**City Name**	**Region/Country**	**The Economist Ranking**	**Area (Km^2)**	**Population**
1	Vancouver	Canada	3	114.97	603,502
3	Toronto	Canada	4	630.21	2790000
27	Dhaka	Bangladesh	139	306.38	14600000
31	Auckland	New Zealand	10	559.2	1420000
32	Sydney	Australia	7	12,367.7	5000000
42	Vienna	Austria	2	830	1,867,960
54	Melbourne	Australia	1	9,990.5	4,485,211
55	Adelaide	Australia	5	3,257.7	1,326,354
56	Calgary	Canada	6	6300	1,239,220
57	Helsinki	Finland	8	214.21	629,512
58	Perth	Australia	9	6,417.9	1,943,858
59	Abidjan	Cote d’Ivoire	131	2541	9000000

60	Tripoli	Libya	132	400	1,126,000
61	Douala	Cameroon	133	210	2,446,945
62	Harare	Zimbabwe	134	960	1,606,000
63	Algiers	Algeria	135	363	3,415,811
64	Karachi	Pakistan	136	3780	27,506,000
65	Lagos	Nigeria	137	6000	38000000
66	Port Moresby	PNG	138	240	410,954
67	Damascus	Syria	140	182	1711000

2.2 Data collection for measuring compactness

In this study, Measurements of are mainly based on two-dimensional geometry and the data collected from the scaled maps of the corresponding cities (Young, 2004). GIS maps and Google Maps are used for collecting the data. ArcGIS, a popular GIS tool, is used to calculate different geometric dimensions of the map, such as, area, adjusted perimeter, length, width, smallest circle that can be fitted within the city, etc. For the maps collected from Google, a popular web-based application named "Google Maps Calculator" (http://www.mapdevelopers.com) is used to calculate the aforementioned geometric dimensions.

2.3 Visual test

Visual test is to use the eye & intuition for compactness measurement. But appearances can be deceiving & intuition may fail. This is just a way to get an initial idea about the geographical shape of the cities. For this test, no formula or no calculation was done.

2.4 Roeck test

Roeck Test is performed by the equation below:

$$\text{Roeck Test Value} = \frac{\text{District Area}}{\text{Smallest Circle}} \quad (1)$$

District is defined as an administrative division of a city. The smallest circle containing the districts and the district's area are determined using the 'Google Maps Calculator'. Finally using the ratio of the district's area to that smallest circle containing the districts (equation 1), city Roeck Test values are determined. The ratio closest to 1 indicates that the particular city is the most compact. The city having the farthest value from 1, is the least compact.

2.5 Schwartzberg test

Schwartzberg test is performed by the equation below:

$$\text{Schwartzberg Test Value} = \frac{\text{length of the adjusted perimeter}}{\text{perimeter of circle with area equal to particular district}} \quad (2)$$

Adjusted perimeter of the district is constructed by connecting the straight lines on the district boundary using the 'Google Maps Calculator'. The perimeter of a circle with an area equal to the particular district was calculated using the same tool. Finally using the ratio (equation 2),

Schwartzberg test value has been found for every city. The ratio closest to 1 indicates that the particular city is the most compact. The city having the farthest value from 1, is the least compact.

2.6 Length-Width test

Length-Width test is performed by the equation below:

$$\text{Length} - \text{Width Test Value} = \frac{\text{length of rectangular enclosing particular district}}{\text{width of the rectangle}} \quad (3)$$

Using 'Google Maps Calculator', a rectangle enclosing the particular district is drawn and length & width of the rectangular are determined. Then, ratio of equation 3 is used to determine Length-Width Test Value for each city. The ratio closest to 1 indicates the most compact city. The city having the farthest value from 1 indicates the least compact city.

2.7 Perimeter test

Perimeter test is performed by the equation below:

$$\text{Perimeter of any District} = \text{Sum of District Boundaries} \quad (4)$$

Perimeters of cities and their surrounding boundaries are determined using 'Google Maps & distance Calculator'. The district entitled in a map was marked and their boundaries were denoted in the calculating tool. Finally, the tool provides the value for the district boundary. The city having the lowest perimeter value is the most compact and the city containing the highest value was the least compact.

2.8 Correlation test

Pearson product-moment correlation coefficient test method is performed to identify the relationship between liveability and compactness. In Pearson product-moment correlation, both of the variables are to be measured on an interval or ratio scale and are known as continuous variables. Correlation test formula is shown here:

$$r = \sum \frac{Z_x Z_y}{N} \quad (5)$$

Where,
r = Pearson product-moment correlation coefficient
Z_x = a z score for variable X
Z_y = a paired z score for variable Y
N= the number of pairs of X and Y scores
R, popular statistical software, is used for the study purpose to create statistical relationship of Mercer & Economist Ranking with the Test's ranking. Software analysis is to determine whether there was any relationship with the Mercer & The Economist Ranking with the Test's Ranking or not.

3. ANALYSIS AND RESULT

The results obtained following the outlined methodology are organized into three sub-sections of which 3.1-3.2 are for compactness ranking and 3.3 is for relationship between compactness and livability.
At first using equation (1), (2), (3), (4), Roeck test, Schwartzberg test, length-width test and perimeter test have been conducted to determine compactness rankings for the selected cities. Then separate statistical relationship or correlation has been built up to investigate the relationship between livability (Mercer 2014 and The Economist 2014) and compactness

3.1 Compactness Ranking for Mercer 2014

Compactness rankings have computed for fifty-three cities (represented by city id) and the values are compared with Mercer 2014 Livability ranking (Table 3). It is noticeable that, for the same city, different test methods yield different rankings. For example: the compactness rankings of Montreal City (ID: 4) using Roeck test is 1.1, whereas Schwartzberg test, length-width, test, perimeter test yield values like 0.2, 1.8 and 100 respectively.

Table 3: Test Values for Cities (Mercer)

ID	Roeck Test Value	Schwartzberg Test value	Length-width Test value	Perimeter Test Value
1	2.3	0.5	2.5	56.8
2	1.6	0.1	1.1	260.8
3	1.8	0.2	1.6	116.2
4	1.1	0.2	1.8	100.0
5	7.6	0.5	1.5	45.4
6	1.5	12.8	2.1	256.1
7	0.5	2.5	1.4	106.6
8	3.0	1.3	2.1	58.5
9	25.5	1.9	1.7	274.7
10	60.7	0.2	2.3	71.0
11	2.4	1.9	1.2	11.0
12	2.1	1.3	1.5	63.3
13	3.9	2.5	2.6	121.6
14	1.5	1.1	1.9	54.5
15	15.7	1.5	2.5	138.5
16	2.2	3.4	1.7	73.1
17	8.7	1.1	2.0	54.3
18	34.7	1.1	1.9	103.9
19	2.6	1.2	2.8	35.7
20	14.0	1.0	2.4	80.8
21	7.6	1.0	2.1	85.6
22	24.7	1.0	1.7	160.0
23	31.7	1.0	1.7	80.0
24	36.4	1.0	1.7	76.0
25	12.5	1.0	2.3	55.3

26	1.2	1.6	1.9	63.4
27	5.6	1.3	1.4	82.0
28	2.3	1.7	2.3	125.0
29	2.0	1.5	2.0	60.6
30	1.6	2.3	1.7	90.0
31	17.1	3.4	1.6	285.5
32	190.4	0.3	1.5	107.6
33	22.5	3.3	0.0	250.0
34	8.2	0.8	1.7	175.4
35	13.7	1.9	1.7	209.0
36	11.0	2.7	1.9	65.8
37	25.8	0.8	1.9	69.6
38	1.8	5.8	3.0	407.9
39	11.9	0.6	3.1	126.8
40	12.7	0.8	1.5	53.2
41	11.0	0.3	2.9	80.8
42	10.1	1.5	1.4	106.6
43	12.6	1.6	1.7	52.0
44	8.0	1.4	3.6	89.2
45	5.4	1.9	1.7	99.5
46	9.8	2.0	2.0	111.4
47	11.8	1.7	1.5	116.0
48	33.5	0.4	1.1	48.1
49	26.7	0.3	1.8	37.2
50	12.6	2.1	1.5	109.2
51	8.1	0.8	1.3	55.4
52	13.7	0.5	2.7	58.6
53	14.3	0.8	2.1	54.7

For Roeck Test, the city having value closest to 1 is more compact than others and has been ranked at the top. The city having least close value with respect to 1 has been ranked at the bottom of the list. Based on the values of Roeck test, the top five and bottom five cities of different continents are arranged sequentially and listed below:

- Top five North America Cities: Montreal (1.1), Ottawa (1.6), Toronto (1.8), Vancouver (2.3), San Francisco (7.6)
- Bottom five North America Cities: Detroit (0.5), Mexico City (1.5), ST Louis (3.0), Houston (25.5), Miami (60.7)
- Top five cities of South America: Buenos Aires (1.5), San Juan (2.1), Point-A-Pitre (2.4), Monte Video (3.9), Santiago (15.7)
- Bottom five cities of South America: Port Au Prince (2.2), San Sal Vador (2.6), Tegucigalpa (8.7), Managua (14.0), Cara Cas (34.7)
- Top five cities of Asia: Singapore (7.6), Osaka (12.5), Tokyo (24.7), Kobe (31.7), Yokohama (36.4)
- Bottom five cities of Asia: Dushanbe (1.2), Tashkent (1.6), Bishkek (2.0), Ashkhabad (2.3), Dhaka (5.6)

- Top five cities of Middle East/ Africa: Cape Town (1.8), Dubai (8.2), Abu Dhabi (13.7), Port Louis (11.0), Durban (25.8)
- Bottom five cities of Middle East: Brazzaville (11.0), Baghdad (11.9), Bangui (12.7), N'DJamena (13.7), Sana'a (14.3)
- Top five cities of Europe: Dusseldorf (5.4), Munich (8.0), Frankfurt (9.8), Vienna (10.1), Zurich (12.6)
- Bottom 5 cities of Europe: Minsk (8.1), Tbilisi (11.8), Yerevan (12.6), Tirana (26.7), Saint Petersburg (33.5)
- Top 3 cities of Australia/New Zealand: Auckland (17.1), Wellington (22.5), Sydney (190.4)

For Schwartzberg, the top five and bottom five cities of different continents are arranged in order and listed below:

- Top 5 cities of North America/USA: San Francisco (0.5), Vancouver (0.5), Montreal (0.2), Toronto (0.2), Ottawa (0.1)
- Bottom 5 cities of North America/USA: Miami (0.2), ST Louis (1.3), Houston (1.9), Detroit (2.5), Mexico City (12.8)
- Top 5 cities of South America: Buenos Aires (1.1), San Juan (1.3), Santiago (1.5), Point-A-Pitre (1.9), Monte Video (2.5)
- Bottom 5 cities of South America: Managua (1.0), Cara Cas (1.1), Tegucigalpa (1.1), San Sal Vador (1.2), Port Au Prince (3.4)
- Top 5 cities of Asia: Singapore (1.0), Tokyo (1.0), Kobe (1.0), Yokohama (1.0), Osaka (1.0)
- Bottom 5 cities of Asia: Dhaka (1.3), Bishkek (1.5), Dushanbe (1.6), Ashkhabad (1.7), Tashkent (2.3)
- Top 5 cities of Middle East: Durban (0.8), Dubai (0.8), Abu Dhabi (1.9), Port Louis (2.7), Cape Town (5.8)
- Bottom 5 cities of Middle East: Sana'a (0.8), Bangui (0.8), , Baghdad (0.6), N'DJamena (0.5), Brazzaville (0.3)
- Top 5 cities of Europe: Munich (1.4), Vienna (1.5), Zurich (1.6), Dusseldorf (1.9), Frankfurt (2.0)
- Bottom 5 cities of Europe: Tirana (0.3), Saint Petersburg (0.4), Minsk (0.8), Tbilisi (1.7), Yerevan (2.1)
- Top 3 cities of Australia/ New Zealand: Sydney (0.3), Wellington (3.3), Auckland (3.4)

For Length-Width Test, top five and bottom five cities of different continents are arranged sequentially and listed below:

- Top 5 cities of North America/USA: Ottawa (1.1), San Francisco (1.5), Toronto (1.6), Montreal (1.8), Vancouver (2.5)
- Bottom 5 cities of North America/USA: Detroit (1.4), Houston (1.7), Mexico City (2.1), ST Louis (2.1), Miami (2.3)
- Top 5 cities of South America: Point-A-Pitre (1.2), Buenos Aires (1.9), San Juan (1.5), Monte Video (2.6), Santiago (2.5)
- Bottom 5 cities of South America: Port Au Prince (1.7), Cara Cas (1.9), Tegucigalpa (2.0), Managua (2.4), San Sal Vador (2.8)
- Top 5 cities of Asia: Tokyo (1.7), Yokohama (1.7), Kobe (1.7), Singapore (2.1), Osaka (2.3)
- Bottom 5 cities of Asia: Dhaka (1.4), Tashkent (1.7), Dushanbe (1.9), Bishkek (2.0), Ashkhabad (2.3)
- Top 5 cities of Middle East: Abu Dhabi (1.7), Dubai (1.7), Durban (1.9), Port Louis

(1.9), Cape Town (3.0)

- Bottom 5 cities of Middle East: Brazzaville (2.9), Baghdad (3.1), Bangui (1.5), N'DJamena (2.7), Sana'a (2.1)
- Top 5 cities of Europe: Vienna (1.4), Frankfurt (2.0), Dusseldorf (1.7), Zurich (1.7), Munich (3.6)
- Bottom 5 cities of Europe: Saint Petersburg (1.1), Minsk (1.3), Yerevan (1.5), Tbilisi (1.5), Tirana (1.8)
- Top 3 cities of Australia/New Zealand: Sydney (1.5), Auckland (1.6), Wellington (0.0)

For Perimeter Test, the city having the lowest perimeter value is the most compact and the city with the highest value is the least compact. Based on the results of Perimeter Test, top five and bottom five cities of different continents are arranged in sequence and listed below:

- Top 5 cities of North America/USA: San Francisco (45.4), Vancouver (56.8), Montreal (100.0), Toronto (116.2), Ottawa (260.8)
- Bottom 5 cities of North America/USA: Detroit (106.6), Houston (274.7), ST Louis (58.5), Mexico City (256.1), Miami (71.0)
- Top 5 cities of South America: Point-A-Pitre (11.0), San Juan (63.3), Buenos Aires (54.5), Santiago (138.5), Monte Video (121.6)
- Bottom 5 cities of South America: Port Au Prince (73.1), Cara Cas (103.9), Tegucigalpa (54.3), Managua (80.8), San Sal Vador (35.7)
- Top 5 cities of Asia: Osaka (55.3), Yokohama (76.0), Kobe (80.0), Singapore (85.6), Tokyo (160.0)
- Bottom 5 cities of Asia: Bishkek (60.6), Dushanbe (63.4), Dhaka (82.0), Tashkent (90.0), Ashkhabad (125.0)
- Top 5 cities of middle East: Port Louis (65.8), Cape Town (407.9), Durban (69.6), Abu Dhabi (209.0), Dubai (175.4)
- Bottom 5 cities of middle east: Bangui (53.2), N'DJamena (58.6), Brazzaville (80.8), Sana'a (54.7), Baghdad (126.8)
- Top 5 cities of Europe: Vienna (106.6), Dusseldorf (99.5), Zurich (52.0), Frankfurt (111.4), Munich (89.2)
- Bottom 5 cities of Europe: Tirana (37.2), Saint Petersburg (48.1), Minsk (55.4), Yerevan (109.2), Tbilisi (116.0)
- Top 3 cities of Australia/New Zealand: Sydney (107.6), Wellington (250.0), Auckland (285.5)

3.2 Compactness Ranking for The Economist 2014

Fifty-three cities (represented by city id) have been tested for compactness ranking to compare with The Economist Livability Ranking 2014 Livabiliy ranking.

Table 4: Test Values for Cities (The Economist)

City ID	Roeck Test	Schwartzberg Test value	Length-Width Test	Perimeter Test
1	2.3	1.5	2.5	56.8
3	1.8	1.3	1.6	116.2
27	5.5	0.9	1.4	54.5
31	17.1	3.4	1.6	285.5
32	190.4	0.5	1.5	197.6
42	7.7	1.6	1.7	113.9

54	4.3	1.2	1.7	435.0
55	1.7	1.7	1.7	336.0
56	7.2	1.1	1.3	113.8
57	5.3	0.8	2.4	72.7
58	27.3	0.1	2.2	35.3
59	7.6	1.0	1.4	161.2
60	36.4	0.3	1.8	19.7
61	1.9	1.2	1.6	63.7
62	2.2	0.0	1.8	109.6
63	9.5	0.5	1.9	9.3
64	4.7	3.6	3.6	753.4
65	4.3	2.1	1.7	235.1
66	6.2	0.7	1.7	38.6
67	15.4	0.2	2.9	6.8

For Roeck Test, the top ten and bottom ten cities are arranged in sequences which are listed below:

- Top 10 compact cities of the world (Roeck Test): Adelaide (1.7), Toronto (1.8), Vancouver (2.3), Melbourne (4.3), Helsinki (5.3), Calgary (7.2), Vienna (7.7), Auckland (17.1), Perth (27.3), Sydney (190.4)
- Bottom 10 compact cities of the world (Roeck Test): Douala (1.9), Harare (2.2), Lagos (4.3), Karachi (4.7), Dhaka (5.5), Port Moresby (6.2), Abidjan (7.6), Algiers (9.5), Damascus (15.4), Tripoli (36.4)

For, Schwartzberg Test, the top ten and bottom ten cities are arranged in sequences which are listed below:

- Top 10 compact cities of the world (Schwartzberg Test): Calgary (1.1), Perth (0.1), Melbourne (1.2), Helsinki (0.8), Toronto (1.3), Vancouver (1.5), Sydney (0.5), Vienna (1.6), Adelaide (1.7), Auckland (3.4)
- Bottom 10 compact cities of the world (Schwartzberg Test): Abidjan (1.0), Dhaka (0.9), Douala (1.2), Port Moresby (0.7), Algiers (0.5), Tripoli (0.3), Damascus (0.2), Harare (0.0), Lagos (2.1), Karachi (3.6)

For Length-Width Test, the top ten and bottom ten cities are arranged in sequences which are listed below:

- Top 10 compact cities of the world (Length-Width test): Calgary (1.3), Sydney (1.5), Auckland (1.6), Toronto (1.6), Melbourne (1.7), Adelaide (1.7), Vienna (1.7), Perth (2.2), Helsinki (2.4), Vancouver (2.5)
- Bottom 10 compact cities of the world (Length-Width test): Abidjan (1.4), Dhaka (1.4), Port Moresby (1.7), Douala (1.6), Lagos (1.7), Tripoli (1.8), Harare (1.8), Algiers (1.9), Damascus (2.9), Karachi (3.6)

Perimeter Test, the top ten and bottom ten cities are arranged in sequences which are listed below:

- Top 10 compact cities of the world (Perimeter Ranking): Perth (35.3), Vancouver (56.8), Helsinki (72.7), Calgary (113.8), Vienna (113.9), Toronto (116.2), Sydney (197.6), Auckland (285.5), Adelaide (336.0), Melbourne (435.0)
- Bottom 10 compact cities of the world (Perimeter Ranking): Damascus (6.8), Algiers (9.3), Tripoli (19.7), Port Moresby (38.6), Dhaka (54.5), Douala (63.7), Harare (109.6), Abidjan (161.2), Lagos (235.1), Karachi (753.4)

3.3 Correlation between Compactness and Livability

Correlation test has been conducted (equation 5) to determine the relationship between compactness and liability rankings (Table 5&6). Software 'R' is used for the analysis.

Table 5: Statistical Relationship with Mercer Ranking

Mercer Ranking Value	**Roeck Test Value**	**Schwartzberg Test Value**	**Length Width Test Value**	**Perimeter Test Value**
1	-.06	-.09	.1	-.19

Table 6: Statistical Relationship with the Economist Ranking

The Economist Ranking Value(Top 10)	**Roeck Test Value(Top 10)**	**Schwartzberg Test Value(Top10)**	**Length Width Test Value(Top10)**	**Perimeter Test Value(Top10)**
1	0.54	0.05	-0.16	-0.26
The Economist Ranking Value(Bottom 10)	**Roeck Test Value(Bottom 10)**	**Schwartzberg Test Value(Bottom 10)**	**Length Width Test Value(Bottom 10)**	**Perimeter Test Value(Bottom 10)**
1	0.04	0.24	0.21	-.027

For Mercer Liveability Ranking, correlation values for different compactness methods- Roeck test, Schwartzberg test, length-width test, perimeter test methods- are -0.06, -0.09, 0.1, -0.19 (Table 5) respectively. Different correlation values are observed for different methods. The positive value indicates that compactness has a proportional relationship with liveability and negative value indicates opposite relationship. But relationship between compactness and liveability is not significant ($p>0.05$)

For Economist Liveability Ranking, correlation values for Roeck test, Schwartzberg test, length-width test, perimeter test methods are 0.54, 0.05, -0.16, -0.26 (Table 6) considering only top ten compact cities. The values for bottom ten cities are 0.04, 0.24, 0.21, -0.27. Again, no significant relationship is found ($p>0.05$).

Based on the overall analysis, it can be stated that, 'Compact cities are not liveable, people don't like to live in a compact city'.

4. CONCLUSIONS AND DISCUSSION

Liveability and compactness of a city depend on various factors. However, this study only considered geometric compactness. The findings of the study suggest that there is hardly any relationship between compactness of a city and liveability in terms of geometrical analysis of the city. The compactness values, however, are different for different test methods and so as the co-relation. Positive relationship between Mercer 2014 liveability and compactness is observed only in the case of Length Width Test, whereas the other three test methods suggest negative relationship. For Economist Liveability Ranking, correlation values for Roeck test, Schwartzberg test, length-width test, perimeter test methods are 0.54, 0.05, -0.16, -0.26 considering only top ten compact cities. The values for bottom ten cities are 0.04, 0.24, 0.21, -0.27. The results indicate non-existing relationship between compactness and liveability. Finally, even though no definite relationship could be established between compactness and liveability, the inference suggested by this study is that compact cities, no matter where they are located, compact cities are less likely to be liveable.

REFERENCES

Alberti, M. (1999a) Modeling the urban ecosystem: A conceptual framework. *Environment and Planning B: Planning and Design*, 26, 605–630.

Barton, A.C. (2001) Science Education in Urban Settings: Seeking New Ways of Praxis through Critical Ethnography. *Journal of Research in Science Teaching*, 38(8), 899-917. doi:10.1002/tea.1038

Breheny, M. (1992) The Compact City: An Introduction. *Built Environment*, 4, 241.

Brundtland, G.H. (1987) Our Common Future. *Oxford University Press*, Oxford.

Burchell, R., Lowenstein, G., Dophin, W. (2002) Costs of Sprawl—2000. *Transportation Research Board*, National Academy Press, Washington, DC.

Burchell, R.W., Adelaja, A.O. (1992) Impact assessment of the New Jersey Interim State Development and Redevelopment Plan. Trenton: *New Jersey Office of State Planning.*

Burton, E. (2000) Potential of the Compact City for Promoting Social Equity. *In Achieving Sustainable Urban Form*, New York, NY, USA, 19–29.

Cairncross, F. (2001) The Death of Distance: How the Communications Revolution is Changing Our Lives. Boston, MA: *Harvard Business School Press*.

Castells, M. (1996) The Rise of the Network Society (The Information Age: Economy, Society and Culture, Volume 1). Malden, MA: *Blackwell Publishers*, Inc. (556 pages, bibliography 51 pages, index 23 pages).

Castells, M. (2001) The Internet Galaxy. *Oxford University Press*, Oxford

Chiu, R.L.H. (2008) Government Intervention in Housing: Convergence and Divergence of the Asian Dragons. *Urban Policy and Research*, 26(3), 249-269. doi:10.1080/08111140802301781

Chiu, R.L.H. (2012) Urban Sustainability and the Urban Forms of China's Leading Mega Cities: Beijing, Shanghai and Guangzhou. *Urban Policy and Research*, 30(4), 359-383. doi:10.1080/08111146.2012.737578

Commission of the European Communities (1990) Green Paper on the Urban Environment. EUR 12902 EN, CEC, Brussels.

Freestone, R. (2014) Cities of tomorrow. The Planning Imagination: Peter Hall and the Study of Urban and Regional Planning, London: Routledge, 40–53.

Hall, T. (1998) Urban Geography. *Psychology Press*.

Jenks, M., Dempsey, N. (2005) Future Forms and Design for Sustainable Cities. *Architectural Press*, Oxford.

Katz, P. (1994) The New Urbanism. New York: McGraw-Hilll.

Kotharkar, R., Bahadure, P., Sarda, N. (2014) Measuring Compact Urban Form: A Case of Nagpur City, India. Sustainability, 6, 4246-4272. doi:10.3390/su6074246

Kurniadi, I. (2007) Pola Spasial Urban Compaction di Wilayah Metropolitan Bandung. Bandung*: Tugas Akhir Departemen Teknik Planologi*-ITB.

Mercer's Quality of Living Survey, 2014

Mitchell, J.P. (1999) Interbuilding and urban canyon extension solution for global positioning systems. *US Patent*: US 5990826 A.

Neuman, M. (2005) The Compact City Fallacy. *J. Plan. Educ. Res*., 25, 11-26. doi:10.1177/0739456X04270466

Neuman, M. (2009) Spatial Planning Leadership by Infrastructure: An American View. *International Planning Studies*, 14(2), 201–17. doi:10.1080/13563470903021241

Newman, K.S. (1992) Culture and structure in The Truly Disadvantaged. *City & Soc*., 6(1), 3-25. doi:10.1525/city.1992.6.1.3

Sassen, S. (2001) Global Cities and Developmentalist States: How to Derail What Could

Be an Interesting Debate: A Response to Hill and Kim. *Urban Studies*, 38(13), 2537-2540.
Satu, S. A. (2014) An examination of the livability of dense urban neighborhoods in Dhaka : the impacts of urban planning. Thesis, University of Hong Kong, Pokfulam, Hong Kong SAR. doi:10.5353/th_b5328047
Scott, A. J. (2001a) Capitalism, cities and the production of symbolic forms. *Transactions of the Institute of British Geographers*, 26, 11-23.
The Economist Intelligence Unit, Quality of Life Survey, 2014. http://www.economist.com/media/pdf/QUALITY_OF_LIFE.pdf
Tsai, Y. (2005) Quantifying Urban Form: Compactness versus Sprawl. *Urban Stud.*, 42, 141–161. doi:10.1080/0042098042000309748
U.S. Bureau of Census, Urban and Rural Definitions (1995). Available at: http://www.census.gov/population/censusdata/urdef.txt.
UNEP (2011) Decoupling natural resource use and environmental impacts from economic growth. A Report of the Working Group on Decoupling to the *International Resource Panel.*
Weber, M. (1921) Economy and Society. *Scribner and Sons*, New York.
William, D.C. (2000) Urban Sprawl: A Reference Handbook. Santa Barbara, CA: ABC-CLIO.
World Bank (2007) Livable cities : the benefits of urban environmental planning - a cities alliance study on good practices and useful tools. Washington, DC.
Young, P.H. (2004) Measuring The Compactness Of Legislative Districts.