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Measuring Urban Sustainability through Compact City Approach: A Case Study of Lahore

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ABSTRACT

Achieving urban sustainability has become a prime goal for urban planners. However due to its subjective nature, it is complicated to integrate urban sustainability concept in planning practices. Moreover, it is advocated that measure of urban sustainability through the compact city is a vital solution for city management. However, due to dynamic nature of the city structures around the world, there exists a limited consensus on parameters and dimensions to measure urban compactness especially in the towns developed in unplanned manners. This study aims to explore different dimensions and relevant indicators to understand and measure compactness in the context of Lahore. The findings of the research reflected that the key factors for the urban sustainability in a compact city are density, transportation and landuse. Density profile in Lahore shows that new residential schemes are rapidly occupying the vacant land and consequently increasing average trip distances and urban sprawl. Besides this, landuse breakup in Lahore is highly variant because of the rapid change in its uses. Average land consumption per person in Lahore is 51 square meter which is on the lower side and would have grave consequences for public rely on car use in future. Moreover, public transport accessibility in Lahore is another problem faced by the general public. Finally, it is concluded that Lahore is a compact city to some extent with the absence of sustainability concepts due to lack of regularity authority control and haphazard development. The situation needs immediate attention of authorities otherwise use of public transportation will be decline and cars will encroach major part of ones' land consumption.

Keywords: Urban sustainability, Density, Compact city, Land consumption

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1.INTRODUCTION

The current role of urban planning in augmenting sustainable urbanization demands a shift towards innovative approaches(Hagu et al. 2006). At the International level, UN-Habitat advocating for high density urban growth for a sustainable urban planning(UN-Habitat 2014). The policymakers and practitioners believe that urban structure characterized by a zoning of different land uses, challenges urban sustainability. Spatial structure of a city can be created as a result of the influence of actions, advancement, policies and partialities during the history that can be resultant more complex and challenge (Johnson 2007). It is more complex for cities to monitor and manage the spatial growth (Bertaud 2001).

Cities must be focused on sustainable development agenda. There is a strong relationship between density, form and sustainability (Heng and Malone-Lee 2009). Urbanization is declared as result of up gradation of human refinement under the benefit of development and economic growth. Developing countries want to attract the human capital for economic aspect(Suzuki et al. 2010). Long travel distances, health, congestion and fuel emissions, inequity, pollution and degrading environment, loss of land such as agricultural and natural assets are major issues seen in developing world cities due to an impact of a physical urban form(Barrow 1995). In Pakistan, the scale of urbanization will soon effects to population lived in a city which is alarming to sustainability and standard of life. The urbanization in Pakistan will certainly impact on global sustainability as the ecological footprint.

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Moreover, it is advocated that measure of urban sustainability through the compact city is a vital solution for city management. Compact city is based on the process of intensification within city boundaries to increased residential density, centralization and mixed land uses while limiting the development beyond the city boundaries (Churchman 1999). High density, mixed land uses and intensification are three components of compacts city (Burton 2002). The urban elements or concepts such as compactness, density, ecological design, sustainable transportation, variety, passive solar design and mixed land use are used to assess the sustainability for urban forms by classification (Jabareen 2006). Scholars concentrated the concept of the compact city into three components; dense and proximate development patterns, urban areas linked by public transport, and accessibility to local services and jobs. Besides this, UN-Habitat has recommended five principles of compactness including high density (at least 15,000 inhabitants per square kilometers), mixed land-use, social mix, limited land-use specialization, and an efficient street network (UN-Habitat 2014).

The development model of the compact city is a conceivable solution for sustainable urban form. The dimensions of density, the degree of clustering, population and degree of uniform dispersal in helping of procedures to discriminate compactness from sprawl at the municipal level (Tsai 2005). The benefits of compact cities are perceived more through high density and public transit (Marcotullio 2001). High densities impel less space observed per capita with more land for agricultural and open spaces; bus and rail serve better in dense settlements with a lesser reliance on automobiles; higher densities reduce society's environmental footprint and slow the consumption of non-renewable

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resources (Ewing 2008). It can be inferred from the above literature that studying the existing urban form from compactness point of view can assist at large to understand the urban spatial structure for sustainable urban development interventions. However, due to dynamic nature of the city structures around the world, there exists a limited consensus on parameters and dimensions to measure urban compactness especially in the towns developed in unplanned manners. This study aims to explore different dimensions and relevant indicators to understand and measure compactness in the context of Lahore. Lahore is selected for the case study due to its rapid growth. The creation of new towns, slums and squatter settlement has been seen with the absence of the long term planning & management in Lahore. The result would be helpful to practitioners, policymakers, town planners and administrators, etc. for effective outcome and output.

2.METHODOLOGY

The mixed research method was used in the present study which involves qualitative and quantitative techniques for data collection and analysis, thus allowing triangulation of data. The assessment of urban form of Lahore was carried out through the evaluation of master plan 2021 of Lahore district prepared by Lahore Development Authority. This exercise helped us to calculate the proportions of various land uses in Lahore district. Subsequently, a review of the literature was carried out to identify the set of indicators to determine the urban form characteristic about compactness.

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Table-1: Priority Analysis

HIGHEST TO LOWER PRIORITY

LOWER TO HIGHEST PRIORITY

Density	Gross Pop. Density	Land Use Split up	Average Density	Average Land Consumption Per Person	
Transportation Network	Average Trip Length	Road Network Density	Walkability Index	Congestion Index	Mode Share
Density Distribution/Dispersion	Density Profile	Population by Distance to Centers of Gravity or CBD			Density Gradient
Accessibility	Public Transport Accessibility			Service Accessibility	
Mixed Use Land Consumption	Land use Split up	Ratio of Residential to Non-Residential Use		Ratio of Built-up to Open Area	
Shapes	Dispersion Index				

A set of indicators used in a similar study of Nagpur, India were adopted to check the urban sustainability through compactness (Kotharkar et al. 2014). A total of 18 indicators were framed to assess the urban sustainability. A priority analysis was carried out to check the appropriateness of these indicators in the local context. For this purpose, 76 experts from related fields including professional town planners (50), engineering and architecture (8) and economic and social science (18) were interviewed (Table 1). Resultantly, a comprehensive framework of indicators to assess the urban sustainability through compact city approach was developed (Table 2).

Density and its spatial distribution is a fundamental element of urban form which is extensively used for sprawl assessment and to define the compactness of urban form (Knaap et al. 2005). Likewise, through density profile, the relationship between population and area can be explained over the years. Three different forms of density were used in the study to better understand the overall density pattern in Lahore namely (i) gross population density (ii) average town density and (iii) density profile (Table 2).

For analysis, Census population of 1998 and estimated population of Lahore 2015 by the Bureau of Statistics Punjab (Government of Punjab 2015) were used.

Table2: Framework regarding Urban Form Characteristics and Indicators

Urban Form Characteristics	Indicators	Calculation Formula
Density	• Gross population density • Average Town density • Density profile	$Gross\ Population\ Density = \frac{\text{Estimated Population}}{\text{Area}}$ $Average\ Town\ Density = \frac{\text{Town Population}}{\text{Area}}$
Transportation & Accessibility	• Average trip length • Road network density • Public transport accessibility	$Road\ Network\ Density = \frac{Road\ Length\ (meters)}{Population}$
Mixed Use Land Consumption	• Land use split up • Average land consumption per person • Ratio of residential to non-residential use • Ratio of built up to open area	$Ratio\ of\ Res.to\ Non-Res. = \frac{\text{Residential Area}}{Non-Residential\ Area}$ $Avg.Land\ Cons.\ Per\ Person = \frac{\text{Town Population}}{Average\ Land\ Consumption\ Area\ (Sq.m)}$ $Ratio\ of\ Built-up\ to\ Open\ Area = \frac{Built-up\ Area}{Open\ Area}$

Similarly, transportation and accessibility have enduring social, economic and environmental impacts on urban sustainability (Haghshenas and Vaziri 2012). Accessibility or proximately of a service, place, or anticipated activity may be described as how efficiently with less time and travel distance a person can reach or avail the service or facility. It is dependent on the land use planning of the city. Accessibility in terms of distance was measured in the present study.

2.1. Data Collection

Data regarding density, land consumption, the ratio of residential to non residential area, the ratio of built-up area to open area, landuse split up and road network density was collected from Punjab Development Statistics (Government of Punjab 2015). Similarly

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Master Plan of Lahore, Punjab Land use Classification, Reclassification and Redevelopment rules were obtained from the Lahore Development Authority, The Urban Unit Lahore, Town Municipal Administration and City District Government Lahore. On the other hand, the field survey was conducted to get the trip length and public transport accessibility from the user in Lahore. A total 60 respondents were interviewed. Convince sampling technique was used to interview the respondents face to face.

3. RESULTS AND DISCUSSION

3.1. Population Density of Lahore

Density and its spatial distribution is a basic unit of urban form which is extensively used for sprawl assessment (Knaap et al. 2005, Navarro and Ortuño 2011). A decrease in density value over time is measured a warning of urban sprawl and density distribution delineates the compactness. Density refers to determine the direction towards city development & growth. However, its distribution can vary in various parts of a city. The transit oriented and mixed land use development can be reached through the high density localities (Bulkeley and Betsill 2005). Moreover, incremental density in a sustainable manner would ensure the wellbeing and optimum utilization of the natural and manmade resources. The urban development lies on higher density can be illustrated of the globalized statute of urban space, urban form and urban syntax (Lau et al. 2000). However higher density is deemed to generate some issues such as lack of privacy, isolation, tensions, lack of communication and breakdown of identity but helpful to handle the rapid growth of urban population and scarcity of land and environmental issues (Zhang 2000).

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The city of Lahore has been divided into nine towns for administration purposes reflected in table 3. Great disparities have been observed regarding density in peripheral and inner towns of Lahore. This is mainly because of the concentration of the long term economic activities in inner towns of Lahore such as in Data Ganj Buksh Town, Samanabad Town, Shalamar Town and Gulberg Town.

Table 3: Average Density in Lahore

Sr. No.	Town	Population 2015 Estimated	Area (square kilometers)	Average Density (Persons per square kilometers)
1	Aziz Bhatti Town	623,000	91	6,846
2	Data Ganj Buksh Town	1,070,000	35	30,571
3	Gulberg Town	859,000	34	25,619
4	Allama Iqbal Town	853,000	475	1,796
5	Nishtar Town	1,104,000	532	2,075
6	Ravi Town	1,749,000	64	27,422
7	Samanabad Town	1,086,000	37	29,495
8	Shalimar Town	585,000	16	37,332
9	Wagha Town	724,000	447	1,621
10	Cantonment	892,000	70	12,674
Total		**9,545,000**	**1,800**	**-**

According to the Punjab government population estimates in 2015, the Gross Population Density of Lahore is around 5300 persons per square kilometre. This shows low compactness as the value of gross population density in Lahore is very low compared to the UN high density value of 15,000 persons per square kilometres (UN-Habitat 2014). A

proportion of agriculture and vacant land in housing schemes in the Allama Iqbal Town, Nishtar Town and Wagha Town are the major reasons behind this low density in Lahore. Besides the weak enforcement of public departments in this regard, the land mafia have played an active role in extravagating the situation by speculating the land for the price hike. The Shalimar Town contains the highest value of average density which is 37,332 inhabitants per square kilometers with the Population of 585,000 and area of 16 square kilometers. Secondly, Data Ganj Buksh Town has average density 30,571 persons per square kilometers with the population of 1,070,000 and area of 35 square kilometers. Shalimar Town and Data Ganj Buksh Town represented the highest density among the other towns of Lahore because these towns contain Lahore's oldest settlements such as Wall city, Urdu Bazar, Shah Alam Market, Anarkali, Mughalpura, Bhagwanpura and famous Lahore Railway Station. Almost all of areas in these towns are unplanned and the majority of the settlements have been developed illegally. A vast majority of these settlements contains mixed development and haphazard trend of development except the few areas. Rest of the towns have low density. On average value of these towns is 17,545 inhabitants per square kilometres which show a compactness in Lahore as per UN-Habitat standards. Further, in Lahore, based on 1998 and 2015 population, the average difference in density from 1998 to 2015 is 5,917 (Figure 1). The difference between the average density of 1998 and 2015 is rapid because of the massive migration of inhabitants from the other small and medium size cities which implies the overload on municipal and infrastructure services in the Lahore. Therefore, the city needs the proper census which helps the calculation and decision making of the different projects.

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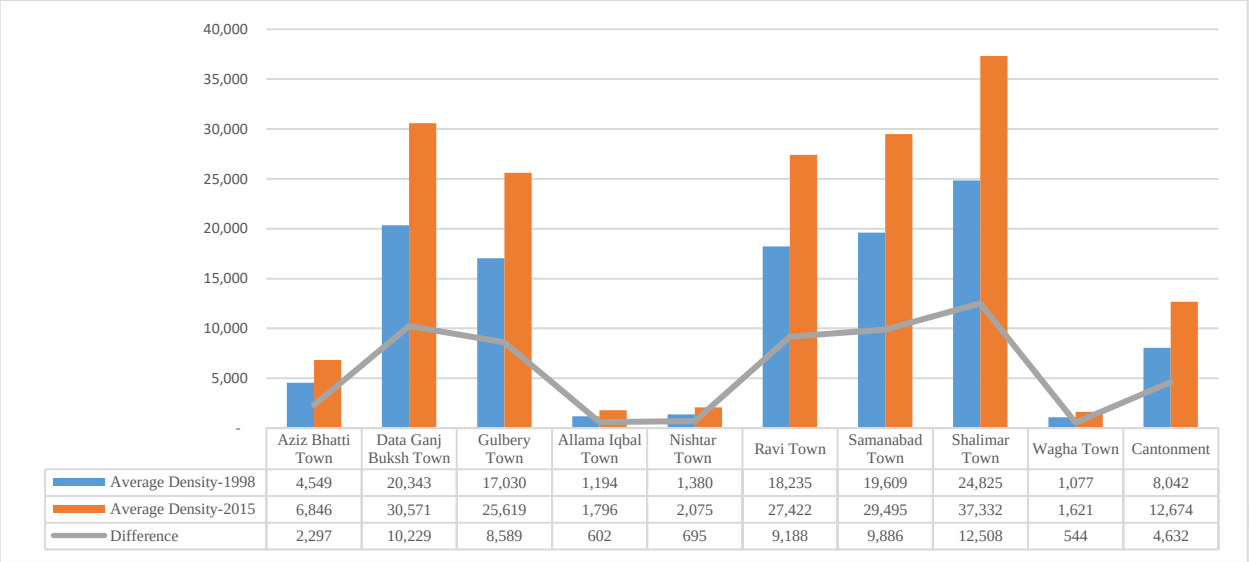

	Aziz Bhatti Town	Data Ganj Buksh Town	Gulbery Town	Allama Iqbal Town	Nishtar Town	Ravi Town	Samanabad Town	Shalimar Town	Wagha Town	Cantonment
Average Density-1998	4,549	20,343	17,030	1,194	1,380	18,235	19,609	24,825	1,077	8,042
Average Density-2015	6,846	30,571	25,619	1,796	2,075	27,422	29,495	37,332	1,621	12,674
Difference	2,297	10,229	8,589	602	695	9,188	9,886	12,508	544	4,632

Figure 1: Density Profile in Lahore

3.2. Land Use Split up

Landuse, average land consumption per person, ratio of residential to non-residential and ratio of built-up to open area were essential elements for assessment of urban forms for their sustainability (Jabareen 2006). Landuse distribution tells the categorical analysis for the spatial use and sprawl of city (Galster et al. 2001). Average land consumption per person used for measurement of urbanized land and density in the urban area (Fulton et al. 2001). Ratio of residential to non-residential and ratio of built up to open area used for analysis of trend relationship (Ewing 2008) and development pattern (Song and Knaap 2004). In Lahore, a different types of land uses is defined at the broad level (Figure 2). The total area of Lahore district is split up in agriculture area comprising of 48% of the total area, the barren land means vacated or abandoned parcel of land which contains 25% of the total area and residentiary means residential, local commercial, education and health compromising of 21% of the total area. The dilemma of landuse policies and planning lies with the absence of environmental and social aspects which are turning towards the problematic in city management. It depicts the weak relationship between the landuse and transportation system in the city. Thus only direct intervention can resolve the environmental and social issues associated with existing transport and land use pattern/distribution (Giuliano 1995). Internationally, the growth of built up area has led

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a significant role in decreasing the agriculture, green area, orchards and gardens which can be overcome by appropriate regulations and policy for the urban growth and expansion (Mosammam et al. 2017).

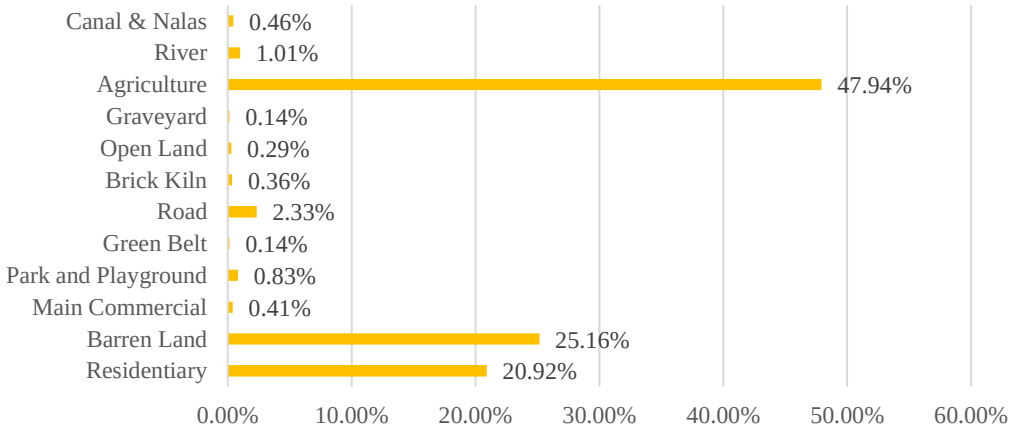

Figure 2: Land use distribution in Lahore

On the contrary, it has been noted that allocation of parks and playgrounds is very low which is essential for quality of life and sustainability. This is mainly because the competent authority of government has low priority or give less attention toward the active and passive recreation facility. In Lahore, the average value of "ratio of built up area to open area" is 4.35 which illustrates the built up area in Lahore is four times more than the open area because of the massive development projects such as multi-storey plazas, the development of number of new housing schemes and construction of roads in the Lahore.

It also noted that most of the land in Lahore district is falling in the barren land which means the land is suitable and develop for housing purpose but still vacant due to unforeseen reasons. The real estate agents and land mafia play a significant role in higher the price of land. The residentiary area is two times more than the other landuse in Lahore. Shalimar town has the highest value of 5.1 which means the residentiary area is five times

more than the other landuse in this town. Wagha Town has the least value of 0.06 which reflected the low residentiary area in the town. It has been seen that on the average level, residential area is twice to the nonresidential area in Lahore because the private land mafia interested toward the development of land in the form of housing schemes.

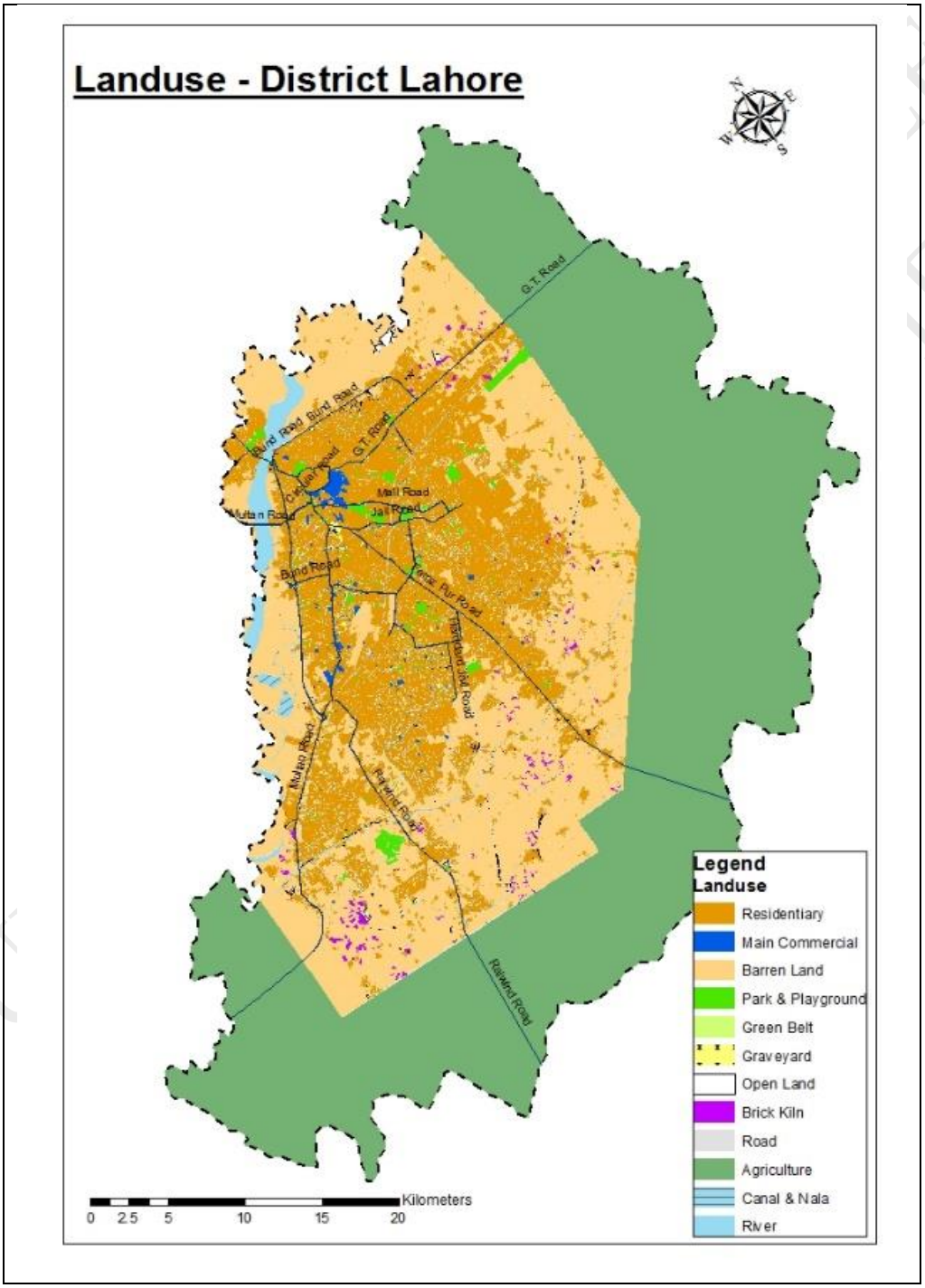

Figure 3: Land use split up - Lahore

3.3. Average Land Consumption per Person

In lack of ideal figures for land consumption, benchmarks may be absolute by associating space consumption by other uses, in this case land uses and land for car requirement is compared.

Total land consumption of Lahore is 455 square kilometers out of 1800 square kilometers. It means that there is only 25% of the total land in Lahore is consumable and rest of the land is not directly beneficial to the inhabitants of Lahore. Allama Iqbal town has the highest value because of new housing scheme development in this town i.e. LDA Avenue-I, Jubilee Town and Bahria Town.

On the other hand, the average land consumption per persons is 51square meters which means one person consumes 51 square meters of the consumable land on average in Lahore. The value of land consumption is quite low compared to Belin and New York with average land consumption per person value of 279 and 249 respectively (Bertaud 2001). When average land consumption is compared with minimum land area required for a car to manoeuvre which is 40 square meters, the results show that a car consumes nearly 80% of the land of a person which means that car is encroaching personal spaces in Lahore. Similar practises have been observed in Moscow and Shanghai cities which have the low average land consumption of personal land figuring 59 and 33 square meters respectively(Bertaud 2001). The results implicate that public relies on the car as a mode of transport will increase and use of public transport will decline as did observe in Moscow and Shanghai cities in the past.

3.4. Road Network Density

Public transport facilities often result in the increase in density along their routes. Therefore, we would expect a smaller trip length along the primary road network. Road Network Density is an important indicator of Transportation Network. Urban expansion

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and road network density are very closing related. Studies have concluded that road network is the primary driving force of urban expansion. In our study, we have conducted road network density has a strong association with level of development and socioeconomic characteristics. It is therefore can be concluded that high road network density has reflected high development patterns. Road network density in Lahore is 0.82 meter per person while the value for Nagpur is 0.21 meter per person, 0.8 meters per person, Sydney is 1.2 meter per person and Denver is 1.7 meters per person (Kotharkar et al. 2014). Public transport accessibility in Lahore is 1.55 kilometers while the value must be 0.4 to 0.5 kilometers (Wisma et al. 2010). Likewise, the result of average trip length in Lahore is 42.32 kilometers per day while the value for New York and Chicago are 30.42 kilometers and 21.73 kilometers respectively. The value for Lahore must be reduced for the achievement of sustainability. The public transport is the very cheapest mode for travelling, especially for the third world country like Pakistan. In Lahore, average distance (kilometers) to reach the nearest bus/stop by residents is 1.55 kilometers. However, most of the respondents said that public transportation routes are not directly linked to their destinations or important nodes. They further reported lack of planning and management in traffic and parking issues.

4. Sustainability Matrix

Sustainability is a subjective term and to read it, a scale was developed based on expert opinion of leading town planners working in Lahore Development Authority and City District Government Lahore after comparing the results of the Lahore with standards and results of the major cities of the world (Table 4). Resultantly a sustainability matrix was developed indicating whether a subject characteristic accessed poses some degree of sustainability in the city. Rationally, Lahore contains the compact city, but the absence of sustainability in it.

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Table 4: Sustainability Matrix

Indicator	Lahore Result	Standard	Scale of Sustainability (Expert Opinion)			
			Vibrant	Good	Normal	Poor
Gross Population Density	5300 inhabitants per square kilometers	15,000 inhabitants per square kilometers (UN-Habitat 2014)			✓	
Average Town Density	17,545 inhabitants per square kilometers	15,000 inhabitants per square kilometers (UN-Habitat 2014)	✓			
Land Use Split up	The value is much difference				✓	
Avg. land consumption per person	51 square meters	40 Square meters (Bertaud 2001)			✓	
Ratio of residential to non-residential area	1.99 times	50 % or 1 time (Ministry of Housing and Works 1986)		✓		
Ratio of built-up to open area	4.35 times	75% built up area or 3 times (Ministry of Housing and Works 1986)			✓	
Avg. Trip length	42.32 kilometers	New York 30.42 kilometers, Chicago – 21.73 kilometers. (Cortright 2010)				✓
Road network density	0.82 meter per person				✓	
Public transport accessibility	1.55 kilometers	0.4 to 0.5 kilometers (Wisma et al. 2010)			✓	

As discussed earlier, the major key factors for the urban sustainability in compact city approach are density, transportation and landuse sector. The findings of results describe gross population density in Lahore is 5303 inhabitants per square kilometers and Average town density in Lahore is 17,545 inhabitants per square kilometers while the density of

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Delhi is 12,591 inhabitants per square kilometers and Nagpur is 562 inhabitants per square kilometers (Kotharkar et al. 2014). It depicts that density in Lahore can increase sustainably. Density profile in Lahore shows that new residential towns rapidly occupy the vacant land for the living having better living facilities. However, such development is increasing average trip distances and urban sprawl. Further parks and playgrounds are becoming rare in Lahore. In this connection, urban planners of Lahore Development Authority believe that if we need to provide better living facilities within city limits then it would help to accomplish the goal of the urban sustainability through compact city approach.

Landuse breakup in Lahore is very variant because of the rapid change in its uses. It must be accordance with some standards and plan of the city. The average value of the ratio of residential to non-residential is around 2 times which means the residential area is twice the time to another landuse area. The average value of the ratio of built-up area to open area is 4.35 which means the built-up area is 4 times more the open area. Average land consumption per person in Lahore is 51 square meter which is on the lower side and had grave consequences for public rely on car use in future in Lahore when we see this situation from the average trip length in Lahore which is 42.32 kilometers per day. As stated above, this value is on the higher side as compared to major cities of the world. Moreover, higher public transport accessibility in Lahore is another problem facing by the general public. The situation needs immediate attention of authorities otherwise use of public transportation will be decline and cars will encroach major part of ones' land consumption. The below diagram depicts the scale of sustainability in Lahore. Inner side lines represent the resilient relationship and outside lines present a weak sustainability in Lahore.

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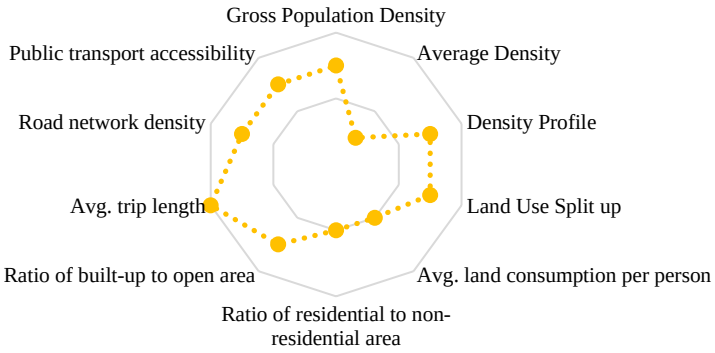

Figure 4: Scale of Sustainability of Lahore

Overall Lahore is partially compact city to some extent with absent the concept of sustainability due to haphazard & uncontrolled growth, new housing on the vulnerable site, lack of planning and prioritisation of the projects, outskirts of the city shown less growth and development (Figure 4). It needs a proper consolidation of policy, programs and plans to the achievement of urban sustainability.

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