Why People Refrain from Cycling in Indian Cities:
A Comparative Investigation

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Abstract: In comparison to many bicycle-friendly European cities, Indian cities are not popular for their bicycle-friendly environment. The absence of basic infrastructure is cited as the primary reason for such a situation. This study aims to understand this phenomenon at a micro scale by comparing two European cities, namely Amsterdam and Copenhagen and two Indian cities, Chandigarh and Noida. This research uses the ‘comparative case study’ approach to evaluate two planned Indian cities against these two successful European examples. The purpose of the study is to understand Indian people’s reluctance for cycling through a comparative spatial study. With an emphasis on cycling, the new planned cities in India supposedly provide more opportunities to cycle to its citizens. It is assumed that people choose to cycle in a city under various conditions. These conditions have been assessed by identifying suitable indicators and collecting data through a secondary survey. These indicators are grouped together in three attributes - physical, environmental and social. The collected data from each city is compared and analysed to comprehend the existing situation and draw appropriate conclusions. This study highlights many non-conventional parameters to understand people’s reluctance to cycle in the Indian cities. The research will help to understand the limitations in Indian cities through a comparative analysis of successful European cases.

1. INTRODUCTION

People have been asked why Indian cities are not bicycle-friendly, but the responses are too general. Most people share their opinions and experiences, rather than articulating the realistic facts. Recent studies cite infrastructure inadequacy and cycle ownership as the major reasons for a lack of bicycle-friendly environment sin Indian cities (Basu & Vasudevan, 2013; TERI, 2014). These rationales need a thorough investigation. This study approaches this investigation by analysing successful case studies. These cases present the success stories of bicycle-friendly cities, evolved from within extremely motor dominant societies. Each of these cases is unique and presents new perspectives. After studying these cities, important indicators that are most relevant for Indian cities have been identified. These indicators are used for a comparative analysis. The comparative analysis
helps to comprehend limitations in Indian cities and highlights possible areas of strategic interventions. Urban designers and urban planners may use these study outcomes to undertake specific strategies and overcome such limitations in Indian cities.

Globally, an unsustainable mode of transport operation has matured in cities due to the predominant focus of transit on car-users (Ensink 2009). The scenarios of Indian cities are also commensurate to the conditions of the global unsustainable transport system (Alam & Ahmed, 2013). The existing literature explains common problems like ineffective planning, absence of land use control, lack of adequate road, infrastructure bottlenecks, lack of maintenance, absence of street amenity, low comfort level and excessive motorisation for non-pedestrian friendly cities in the developing world (Oberai, Kasarda, & Parnell, 1993; Mohan & Tiwari, 1999; Pucher & Dijkstra, 2003; Pucher et al., 2005; Gakenheimer, 1999; Vasconcellos, 2001; Whitelegg & Williams, 2000; Padam & Singh, 2001). Even in Indian cities, this rampant development is extending rapidly in all directions, far beyond the city boundaries. It has greatly increased the number and length of trips for most Indians and increasingly forces them to rely on motorised transportation. This leads to a rapid growth of vehicle ownership and congested roadways. The congested roadways slow down public transit, increase operating costs, and further discourage the use of public transport. People living in cities are compelled to use cars and motorcycles to get around, especially given the unsatisfactory alternative of slow, overcrowded, unreliable, uncomfortable, and dangerous public transport services (Pucher et al., 2005).

Longer trip distances coupled with inadequate public transit systems and a rapid pace of motorisation are hampering pedestrian and cycling environments in cities. The safety of pedestrians and cyclists is compromised due to this traffic situation. However, interest in active transportation (i.e. walk and cycling) is growing within the domains of urban planning and transportation. Many cities in the world have undertaken initiatives to transform their transport systems with a combination of public transit and non-motorised transit (NMT). Alternative transportation is increasingly visualised as a solution to many environmental and congestion issues. Various criteria contribute to determining a bicycle-friendly city. These criteria can be specified as the following: a comprehensive policy and strategy, good bicycle infrastructure, shorter travel time, enhanced safety, and security. The notion of the bicycle-friendly city is emerging as one of the primary targets of sustainable urban development strategies in the twenty-first century, especially in European cities (Zayed, 2016).

People’s willingness to cycle in cities like Amsterdam and Copenhagen emerged due to some or all of the above-mentioned factors. In Amsterdam, there was mutually advantageous cooperation between property developers and the city government to oppose against the construction of large buildings and urban highways (Prujit, 2004). Copenhagen is considered as one of the most prominent bicycle-friendly cities in the world. The city replaced cars with an appropriate NMT policy. Copenhagen had to give up several car-focused modernisation projects due to the oil crisis and to prevent economic recession. Copenhagen municipality's first cycle strategy - ‘Cycle Policy 2002–2012’ - published in 2002 after mass-demonstrations for improved citywide cycling conditions (Building and Construction Administration, 2002). The cycle strategy proposed the first comprehensive vision of a bicycle city and was followed by various strategy documents such as the ‘Bicycle Track Priority Plan 2006–2016’ and the ‘Bicycle
Strategy 2011–2025’. The progress is monitored through the biannual ‘Bicycle Accounts’, assessing key performance indicators such as the accident risk (Gössling & Choi, 2015). In Copenhagen, the corresponding factors such as mild winters, traffic jams from cars during metro construction, general information and promotional campaigns facilitated the cycling environment (The City of Copenhagen, 2015). An optimum average trip length also ensures the bicycle friendliness of a city. Cycling in Canadian urban centres is low compared to many European cities, however, cycling is increasingly becoming popular in Canada (CBC, 2017). Larsen, El-Geneidy, and Yasmin (2010) and Larsen and El-Geneidy (2011) found an optimum average trip length of 2,242 meter for Canadian cities.

In India, the ‘National Urban Transport Policy 2014’ encourages and supports walking and cycling for last mile connectivity in cities (Institute of Urban Transport India, 2014). Compared to the comprehensive vision, policy and strategic plan of Copenhagen, it is a relatively small step. The examples in Indian cities are disappointing, primarily due to the weak enforcement of transport policy and its’ non-ratification by state governments.

In order to measure attributes that influence bicycle-friendliness of a city, the study compares neighbourhoods of Indian cities consisting of bicycle paths with the European cities known for their bicycle-friendly environment. Studying a neighbourhood by comparing European cities acknowledged for cycling and Indian cities will underline the necessary shortcomings of Indian cities and areas of inefficiency in implementing the NMT policy. This research proposes to investigate the following questions:

- Why do people refrain from cycling in Indian cities?
- How do Indian cities perform in bicycle friendliness, compared to bicycle-friendly European cities?

The research questions and goal of this paper will be responded to by adhering to the following objectives:

- To compare and contrast the Indian cities with respect to the relevant European cities known for their bicycle friendliness;
- To identify the major factors which encourage people to cycle in the European examples with the highest levels of bicycle friendliness;
- To recognise the probable factors that may encourage Indian people to cycle more based on the study findings.

This study is not the first to examine the problem of cycling in a city, however, the uniqueness of the study is that it aims to extend the existing understanding through spatial analytics and comparison of urban form to identify the physical, cultural and environmental reasons for Indian people’s reluctance to cycle. Traditional studies depend on travel data, questionnaire surveys and interviews with respondents. The policy and strategies based on these responses are unlikely to be successful. Many times, these traditional studies are biased and demonstrate significant statistical variations, particularly in regard to open-ended questions that focus on utilities and infrastructure availability rather accessibility and spatial analytics with different attributes. Mohan and Tiwari (1999), Pucher and Dijkstra (2003) and Pucher et al. (2005), among many others, have carried out traditional studies in Indian and European cities. The absence of relative measures to evaluate the empirical evidence limits the appropriate bicycle-friendly city policy options. The proposed ‘comparative case study’ based analysis will overcome these limitations and provide a clear understanding of the reasons and probable areas of strategic interventions. The limitation of this research is that it uses secondary data for analysing the influence of spatial proximity.
and urban form in cycling. Therefore, this research relies on availability of secondary data. It is a major limitation, particularly for Indian cities where some of the relevant data is either inaccessible or unavailable. Therefore, the probable indicators for the comparative analysis need to be carefully chosen. This study compares two European cities, namely Amsterdam and Copenhagen, with two Indian cities, Chandigarh and Noida. Basic bicycle infrastructure like cycle tracks are available in both Indian cases and yet people do not use bicycles for mobility. The comparative analysis will identify conditions beyond the basic minimum infrastructure needed in Indian cities to establish cycling as an alternative mode of travel.

The European cities are shortlisted from the recognised ‘Copenhagenize Index 2017’ that ranked European cities based on their bicycle friendliness (Copenhagenize Design Company, 2017). Amsterdam and Copenhagen rank first and third in the bicycle-friendly index respectively. India does not have a similar ranking system that grades cities based on their bicycle friendliness. Chandigarh and Noida are chosen for a comparative analysis because these two planned cities encompass modern bicycling infrastructure. Many Indian cities of similar characteristics developed organically and contain minimal to no cycling infrastructure. Even though Chandigarh and Noida are not capital cities like Amsterdam and Copenhagen, their population and cosmopolitan character are similar to that of the two European cases. Further, these two Indian cities demonstrate the post-modern and post-independence urban planning applications in India.

The next section presents the literature review. Learning from the literature review helps the research to establish its analysis methodology and relates its conclusion to referenced analogies.

2. LITERATURE REVIEW

Zhang et al. (2017) pointed out existing studies on transportation and land use interaction and stressed the lack of successful implementation of land use and transportation models including NMTs in developing countries. The smaller cities, more favourably than big cities, implement successful bicycle-friendly strategies due to their shorter trip lengths. The bigger cities focus on implementing bicycle strategies in combination with their public transportation networks. The European cities have traditionally benefitted from their smaller city sizes. The land use planning and distribution of the built form also influence the European cities’ bicycle ridership. Other factors like presence of bicycle facilities and the distance of a public transit station from neighbourhoods show a significant correlation with the volume of ridership at a bicycle station (Claude, 2014). The ideal distance of cycling varies for different trip purposes like work, shopping, and leisure. Brandenburg, Matzarakis, and Arnberger (2007) find that the probability of people using a bicycle for work when there are increased temperatures is more than for shopping or leisure purposes. Ahmed, Rose, and Jacob (2010) find that up to a certain optimum riding temperature, the bicycle ridership increases with temperature. Beyond the optimum temperature, the ridership declines. They conclude that the optimum temperature, corresponding to a maximum ridership, varies across locations, with the highest being around 28 °C. The temperature not only influences bicycle ridership but also influences the bicycle trip length.

Peiffer and Abbiss (2011) identified that cycling in heat is associated with a significant increase of core body temperature resulting in an increase
in perceived fatigue and average power output. The study considered 32°C and 40% relative humidity as the extreme condition resulting in a significant reduction of cycling. In all Indian cities, the mean ambient temperature and relative humidity are way beyond the extreme condition considered in the study. Therefore, Larsen, El-Geneidy, and Yasmin (2010) and Larsen and El-Geneidy (2011) finding on the average trip length of 2.2 km for cyclists needs reconsideration for Indian cities. In addition to the environmental parameters, trip purposes also influence the cycling trip lengths. Generally, people choose a bicycle for short trips rather than long trips like for transit to work and leisure (Wyer, 2018). The selection of the bicycle as a mode for short trips is positively related to owning a bicycle and negatively linked to owning one or more cars (Hallrdórsdóttir et al., 2011). It is important for the study to determine an optimum perimeter or average trip length to compare between different cases. Considering the health and physical ability of the commuters, environmental conditions, trip purposes, and land use categories in Indian cities, an average cycling radius of 1 km to 1.2 km is assumed. The actual trip length within this cycling perimeter is between 1.5 km to 2.0 km. Pai and Pai (2015) suggest various dimensions of the success factors of public bicycle sharing. These plausible attributes from the relevant works and literature have been studied to select the most appropriate ones that mirror the Indian situation. The existing literature classifies these attributes in five categories: safety, a well-connected network of cycleway, convenience, policies to discourage car use, and a good public transportation system integrated with bicycle facilities (Wang et al., 2014). Schwartz et al. (1999) and Meyer and Miller (2001) investigated a network of relationship attributes that influence the NMT, shown in Figure 1.

The figure above identifies various attributes like ‘link characteristics’, ‘network characteristics’, ‘supporting policies’, ‘population characteristics’, and ‘climate’.

The ‘link characteristics’ indicate parameters such as traffic volume, segregation between motorised and non-motorised transport, safety, and road surface quality. All these parameters determine the compatibility of an NMT network.

The ‘network characteristics’ suggest regional connectivity of an NMT network. It includes last mile connectivity via NMT modes that enhances network friendliness of an NMT network.

The ‘supporting policies’ signify adequate safeguard for NMT users like bicycle parking, NMT first policy, and strict legal action against traffic rule violation.
The ‘population characteristics’ refer to economic prosperity, cultural progress, awareness, and individual choices of an NMT. Preference of an NMT mode over motorised transport depends on an individual’s decision. Financial strength may result in an increased vehicle ownership and non-utilisation of NMT mode, but awareness of the benefits of NMT may reverse the situation, even in a rich neighbourhood.

The ‘climate’ denotes parameters such as heat, rainfall, snowfall, and air pollution. Extreme heat, snowfall, fog and rainy condition are obstacles to cycling. Increasingly, air pollution is also considered as a threat to any active outdoor activity like cycling.

Most studies consider six to eight diverse indicators to investigate the bicycle friendliness of a city. Fernández Heredia and Monzón de Cáceres (2010) identified that factors such as travel distance, unsafe roads, hilly landscape, physical condition of bicycle users, climate, social safety, facilities such as parking and comfort influence bicycle ridership. De Sousa, Sanches, and Ferreira (2014) considered factors such as infrastructure services, travel distance, unsafe roads, hilly landscape, climate, and cycling skill to determine their influence on perception of cycling. In the present study, ten parameters are considered according to three attributes (physical, socio-economic and cultural, and environmental). By referring to the existing literature, these attributes are adopted and a relationship developed between them. While determining the attributes and parameters, the data availability factor is also noted. The following section discusses the analysis methodology with an insight from the literature review.

3. ANALYSIS METHODOLOGY

The aim of this study is to investigate the people’s reluctance to cycling in Indian cities. The underlying objective of this paper is to identify the determining attributes through spatial analytics that may encourage people to cycle in Indian cities. This paper responds to the first objective through spatial and data analysis, and second and third objectives through discussion and interpretation of research findings. Further follow-up research is needed to validate the research findings. It is hoped that the authors may contribute further to this topic through future empirical research. Researchers who wish to further investigate the problem may discover similar findings or new results. This study recognises from the literature review that big city size, non-availability of fundamental cycling infrastructure, harsh weather, and unavailability of bicycle tracks diminish one’s desire to cycle. However, this study will investigate beyond these traditional reasonings and investigate the reasoning of non-utilisation of bicycles in Indian cities at the neighbourhood level.

To begin with, plausible attributes that encourage cycling and using other NMT modes such as walking and riding rickshaws, need to be recognised. In this study, only on cycling is focused on.

To analyse people’s reluctance to cycle in Indian cities, appropriate indicators under each attribute and its influences are needed to be identified. Availability of data is a major obstacle for this investigation. Among the five attributes, identified in Figure 1, the research considers four attributes (link characteristics, network characteristics, population characteristics, and climate/weather). Indicators that ratify these attributes are linked with each of the attributes (Figure 2). This research could only explore limited
indicators under each attribute because of the limitation of data collected through the secondary data.

The above-mentioned attributes and indicators are referred to as the physical (traffic volume, connectivity, parking, land use, density etc.), socio-economic (income and economic status), and environmental (climate/weather) attributes. The U.S. Department of Transportation emphasises the physical, environmental, and infrastructural features like the ratio of bikeways to the vehicular road, land use, built form intensity, population density, policies and (car) parking rates as important factors of a successful bicycle strategy (Goldsmith, 1992). Additionally, the parameters such as cyclist’s age, weather, road safety, cycling routes, and cycle parking facilities are regarded as important determinants for cycling. Based on the literature review and study, the following indicators have been identified for each attribute. The data is collected through a secondary survey. The data collection method, data source and rationale for considering each indicator are presented in the table below (Table 1). The data was collected during the period of January 2018 to March 2018.

Choice of quantitative determinants like land use, density, and cycling track depend entirely on the availability of data. However, it is difficult to determine qualitative data like socio-economic and cultural attributes. Increasing economic ability and spending capacity may create a car-dependent society. However, much empirical evidence indicates varying correlation between economic prosperity and the use of NMT in cities. For example, people in many Japanese and European cities use a bicycle as a preferred mode of local transit, even though these cities are socio-economically prosperous and possess a high volume of automobile ownership (Koike, 1991; Doolittle & Porter, 1994; Biernat, Buchholtz, & Bartkiewicz, 2018). It may be safely assumed that culture and behaviour contribute to a society’s desire to cycle. But it is difficult to determine a variable to represent cultural and behavioural reasoning. This research was approached by connecting socio-economic and cultural attributes with physical agility. The percentage of the male population and age structure were analysed as two dummy variables, as cycling attributes. It is assumed that a young society with a higher proportion of the male population will be culturally more responsive to cycling. The existing situation in India also suggests that bicycle users in India are predominantly captive users like lower income people, students and male members in households (Basu & Vasudevan, 2013; TERI, 2014).

The study reveals people’s accessibility to use bicycles as a preferred mode of transit. It will be beneficiary for city governments and policy
makers to address the problems of cycling in Indian cities. As mentioned earlier, data availability is a major bottleneck to conduct any research on transportation in Indian cities. This limitation was approached by carefully calibrating each dataset with the indicators. The data for each indicator is collected from various sources like the satellite maps, secondary sources, city master plan, and published literature. Thereafter, the data is tabulated and analysed to determine the significance of each indicator.

Table 1. Classification of analysis attributes, parameters and the logical reasoning for considering such parameters

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Unit</th>
<th>Data collection method/ Source</th>
<th>Logical reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Land use</td>
<td>Percent (%)</td>
<td>Spatial analysis from satellite image</td>
<td>Percentage of segregated land use and mixed land use, and its spatial distribution influence on the cycling environment.</td>
</tr>
<tr>
<td>b. Density</td>
<td>Person/sq.km.</td>
<td>(World Population Review, 2018)</td>
<td>Population density is an important parameter that affects infrastructure and service level of transit networks including cycling networks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Chandigarh Administration, 2015)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Directorate of Census Operations, 2011)</td>
<td></td>
</tr>
<tr>
<td>c. Average distance to residential land from cycle network</td>
<td>Meters (mt.)</td>
<td>Spatial analysis from satellite image</td>
<td>Proximity to cycle network is a catalyst for cycle use.</td>
</tr>
<tr>
<td>d. Average cycling track width</td>
<td>Meters (mt.)</td>
<td>Spatial analysis from satellite image</td>
<td>Wider cycle track provides safe cycling environment and encourages people to cycle.</td>
</tr>
<tr>
<td>e. Percentage of NMT friendly streets or roads</td>
<td>Percent (%)</td>
<td>Spatial analysis from satellite image</td>
<td>Dedicated NMT corridor as a percentage of gross road area is an indication of NMT friendly policy that encourage people’s participation.</td>
</tr>
</tbody>
</table>

2. Socio-economic and cultural attribute

| a. Sex ratio                                   | Ratio             | (Statistics Denmark, 2017)                                               | It is observed that males do more cycling than females, particularly in India. It might be due to physical or socio-cultural reasons. |
|                                               |                   | (Statistics Netherlands, 2014)                                            |                                                                                  |
|                                               |                   | (Central Statistics office Ministry of Statistics and Implementation, 2016) |                                                                                  |
|                                               |                   | (Directorate of Census Operations, 2011)                                 |                                                                                  |
| b. People within active NMT user age (15-50)  | Percent (%)      | The World Factbook (Central Intelligence Agency, 2017)                   | Young people are more likely to cycle than older people. Presence of youth is an encouraging indication for cycling. |
|                                               |                   |                                                                           |                                                                                  |
3. Environmental attribute

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Annual precipitation days</td>
<td>Number of days</td>
<td>Weather data</td>
</tr>
<tr>
<td>b. Number of cycle days annually</td>
<td>Number of days</td>
<td>Weather data and analysis</td>
</tr>
<tr>
<td>c. Mean maximum temperature during hottest month</td>
<td>Temperature (degrees centigrade)</td>
<td>Weather data</td>
</tr>
</tbody>
</table>

4. STUDY AREAS

Almost every citizen of Amsterdam and Copenhagen uses a bicycle for commuting. About 57% of residents in Amsterdam use a bicycle for commuting every day. In the past 20 years, bicycle use in Amsterdam has grown by more than 40%. Amsterdam contains more than 881,000 bicycles, which is four times more than the number of cars (Harms & Kansen, 2018). The people of Amsterdam cycle a total of about two million kilometres every day. By 2020, the city of Amsterdam is planning to invest around €120 million in the bicycle infrastructure. Of that, €90 million will be spent to create 38,000 new bicycle parking places (Dutch Cycling Embassy, 2018). In Copenhagen, a bicycle is accessible to 84% residents and 68% of them cycle at least once a week. 15% of the remaining people that use public transit or automobile, ride a bicycle at least once a week. 50% of the Copenhagen residents who work or study in the city use a bicycle for transit to their workplace or educational institution (Falci et al., 2016). Based on an overall study of the city’s land use plan, an area of approximately 1.2 km by 1.2 km is earmarked for a detailed investigation (Figure 3 and Figure 4). The study areas are selected based on their location near the city centre, and the availability of diverse land use characteristics.

Contrary to the European cities, people of Indian cities do not prefer to cycle (TERI, 2014). The average trip length of the Indian cities is less than 7 km. Only 15% of these trips are made on a bicycle. In the million plus cities of India, more than 60% of the total trips are vehicular trips (including public transport). A similar trend is experienced in the smaller cities, with a population range of 0.5 million – 1.0 million. In the smaller cities, trips by bicycle and vehicle are approximately 20% and 50% respectively (Fatima & Kumar, 2014; Kumar et al., 2016). Ghate (2014) studied the relationship between Indian city size and bicycle trips. He classified city size differently and found that the average trip length in medium-size cities (1 million to 3 million) is about 3.5 km, a distance ideal for cycling. However, a bicycle is not a popular mode of transit in these medium-size cities. The average trip length is less than 3 km in smaller cities with a population below 0.5 million. Despite the short trip length, the percentage of bicycle trips in these smaller cities is insignificant. In contrast, a bicycle trip as a proportion of the total trips in small and medium European cities is significantly high. Jain and Tiwari (2010) argued that the absolute number of bicycle trips is

1 Ideal weather condition signifies that there is no heavy precipitation or snowfall, and a temperature below 35°C.
increasing, but the modal share in favour of the bicycle trip is now limited to only 13%–21% in the medium (1–3 million) and the larger (3–5 million) size cities, 7%–15% in the largest cities (> 5 million), and 7%–10% in the megacities.

![Amsterdam study area base map](image1)

*Figure 3. Amsterdam study area base map (Source: Authors)*

![Copenhagen study area base map](image2)

*Figure 4. Copenhagen Study Area Base Map (Source: Authors)*

The first Indian city considered in the comparative analysis is Chandigarh. Chandigarh is one of the few planned cities in India. The Census 2011 records a population of 1.055 million in Chandigarh (MoHA, 2012). With a decadal growth rate of 40.30%, Chandigarh is one of the fastest growing cities in India (Chandigarh Administration, 2015). The city was planned with an integrated system of seven roads to ensure efficient traffic movement. Le Corbusier, who planned the city, referred to these
roads as seven ‘V’s. The city’s vertical roads stretch from the North-East to the South-West and are referred to as ‘Paths’.

The horizontal roads stretch from North-West to South-East and are referred to as ‘Margs’. They intersect at right angles, forming a gridded arterial road network for vehicular movement. The cycle tracks are largely constructed along the V3s, which extend horizontally along the city, carrying the fast-moving traffic. The second Indian city for the comparative analysis is Noida. Noida is within the National Capital Region of India. As per the Census 2011, the population of Noida is 642,381. The city aims to achieve approximately 50% green cover with integrated NMT facilities. It proposes to achieve a sprawling network of 65km of bicycle tracks, which is expected to increase to 100 km (MoHA, 2012). The proposal includes a
well-defined network of exclusive bicycle tracks linking the residential areas to major activity centres (Figure 5 and Figure 6).

5. ANALYSIS & FINDINGS

The study begins with the selection of the study areas. The basic rules for selecting an area of approximately 1.5 Sq. km are;

i. Location at the city centre or near to the city centre;
ii. Extremely harsh climatic condition in India that discourages cycling;
iii. An appropriate mix of land uses (residential, commercial, and open green space) that determine local trips by bicycle; and
iv. The existence of at least one bicycle track, or close proximity to the bicycle tracks.

![Amsterdam land use map](image)

*Figure 7. Amsterdam study area land-use map (Source: Authors)*

![Copenhagen land use map](image)

*Figure 8. Copenhagen study area land-use map (Source: Authors)*

Firstly, the land use of the study area is delineated and the percentage in each land use category is identified (Figure 7 to Figure 10). Population
density is uniform across the study area and is acquired from the city’s average population density data. The data for each indicator of an attribute is collected for each city and compared for its consistency.

The indicators of each attribute are collated in Table 2. Further, the standard score (more commonly referred to as a z-score) is calculated to identify the probability of a score occurring within the normal distribution (Table 3). The data collection period stretches from January to March 2018. It enables us to compare two scores that are from different normal distributions and draw a parallel comparison among the variables. Data on various parameters provide important insights into these four cities.
<table>
<thead>
<tr>
<th>City</th>
<th>Annual Precipitation Days</th>
<th>Number of Cycling Days Annually</th>
<th>Mean Maximum Temp. during Hottest Month (°C)</th>
<th>Land use Area (%)</th>
<th>Density (people per km²)</th>
<th>Average Distance of Each Plot from Cycle Track (in meters)</th>
<th>Average Cycling Track Width (in meters)</th>
<th>Percentage of Cyclable Streets (by length)</th>
<th>Percentage of People of Cycling Age (15-50)</th>
<th>Sex Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copenhagen</td>
<td>102</td>
<td>263</td>
<td>20.0</td>
<td>12</td>
<td>25</td>
<td>5</td>
<td>0</td>
<td>11</td>
<td>6800</td>
<td>2.9</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>132</td>
<td>235</td>
<td>21.8</td>
<td>15</td>
<td>12</td>
<td>5</td>
<td>13</td>
<td>4</td>
<td>4908</td>
<td>3.8</td>
</tr>
<tr>
<td>Chandigarh</td>
<td>70</td>
<td>295</td>
<td>39.6</td>
<td>16</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>12</td>
<td>9252</td>
<td>3.2</td>
</tr>
<tr>
<td>Noida</td>
<td>65</td>
<td>300</td>
<td>34.2</td>
<td>27</td>
<td>11</td>
<td>6</td>
<td>0</td>
<td>7</td>
<td>2463</td>
<td>2.9</td>
</tr>
<tr>
<td>Mean</td>
<td>92.3</td>
<td>272.8</td>
<td>28.9</td>
<td>17.5</td>
<td>13.5</td>
<td>5.5</td>
<td>3.2</td>
<td>8.5</td>
<td>5855.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Median</td>
<td>86</td>
<td>279</td>
<td>38.5</td>
<td>15.5</td>
<td>11.5</td>
<td>5.5</td>
<td>0</td>
<td>9</td>
<td>5854</td>
<td>3.3</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>26.9</td>
<td>26.9</td>
<td>8.25</td>
<td>8.8</td>
<td>6.1</td>
<td>5.7</td>
<td>0.5</td>
<td>5.6</td>
<td>3.2</td>
<td>2491.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>City</th>
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<th>Percentage of People of Cycling Age (15-50)</th>
<th>Sex Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copenhagen</td>
<td>0.31</td>
<td>-0.31</td>
<td>-0.93</td>
<td>-0.67</td>
<td>-0.84</td>
<td>1.42</td>
<td>-0.87</td>
<td>1.00</td>
<td>0.68</td>
<td>-0.33</td>
</tr>
<tr>
<td>Amsterdam</td>
<td>1.28</td>
<td>-1.28</td>
<td>-0.75</td>
<td>-0.96</td>
<td>-0.38</td>
<td>1.27</td>
<td>-0.19</td>
<td>1.50</td>
<td>-1.22</td>
<td>-0.33</td>
</tr>
<tr>
<td>Chandigarh</td>
<td>-0.71</td>
<td>0.71</td>
<td>1.12</td>
<td>1.21</td>
<td>-0.57</td>
<td>-0.23</td>
<td>0.87</td>
<td>0.00</td>
<td>0.95</td>
<td>1.18</td>
</tr>
<tr>
<td>Noida</td>
<td>-0.87</td>
<td>0.87</td>
<td>0.56</td>
<td>-0.99</td>
<td>1.45</td>
<td>-0.31</td>
<td>0.87</td>
<td>0.00</td>
<td>-0.41</td>
<td>-1.18</td>
</tr>
</tbody>
</table>
Further discussion on the attributes and interpretation of the results will inform the probable factors which encourage people to cycle in European cities and identification of probable factors that may encourage Indians to cycle more in Indian cities. The factors are discussed in the following three subsections.

5.1 Physical Attributes

In Amsterdam and Copenhagen, commercial land use as a percentage of the total land use is comparatively higher than in Chandigarh and Noida. A greater mix of commercial land use creates more local trips and reduces trip length compared to segregated land uses. The percentage of roads and streets is almost equal in all the four cities. The percentage of dedicated bicycle corridor in Amsterdam and Copenhagen is much higher than in Chandigarh and Noida. A study conducted in New Zealand on 2,469 cyclists revealed that the majority (88%) of people favoured bicycle lanes as an important factor for cycling, followed by bicycle paths (76%), better bicycle security (64%), reduced motor vehicle speed (55%) and bicycle-friendly public transport (38%) (Tin Tin et al., 2009). The study corroborates with the literature regarding car-oriented city planning approaches in India. In contrast to the two Indian cities, both the European cities consist of interconnected streets exclusively for bicycle use. Additionally, the average distance from each residential plot to the nearest bicycle track is comparatively shorter in Amsterdam and Copenhagen. In Chandigarh and Noida, this average distance extends well beyond 150 meters. Accessibility to a bicycle track is an important contributing factor for people’s choice to cycle. The average width of a bicycle track does not present any clear significance in this study, and a bicycle track beyond a minimum desirable width is not an influencing factor for cycling in these four cities.

It is evident that a clear focus on bicycle-friendly strategies encourages the citizens of Amsterdam and Copenhagen to cycle more. The cycling infrastructure close to the origin of potential journeys and at the destination is a key facilitator or potential barrier to encouraging cycling (Hull & O’Holleran, 2014). The cycling environment benefits from its land use distribution, dedicated bicycle corridor with greater city-wide connectivity, and easy accessibility of the bicycle corridor from individual households. As a result, the number of bicycle users and trips by bicycle is very high. Chandigarh and Noida need a comprehensive strategy supported by bicycle-oriented urban policy and physical planning to encourage its citizens to cycle more. Non-accessibility of dedicated and safe bicycle corridors (measured by average distance of bicycle track from land/ household) from individual households and non-availability of citywide bicycle networks might be the major bottleneck for cycling in Indian cities. Additional cycling infrastructure like adequate bicycle parking spaces, strict regulation to safeguard cyclists and preferential treatment to cycle in traffic may further encourage bicycle ridership in Chandigarh and Noida.

5.2 Socio-Economic and Cultural Attributes

The percentage of people within the ideal age range to cycle is higher in Amsterdam and Copenhagen. Given the demographic distribution in India, a similar (or higher) percentage of people within the ideal age range for cycling is expected in Chandigarh and Noida. However, the study finds that
the percentage of people within this age range is less in Chandigarh. The study also finds that a balanced sex ratio in Amsterdam and Copenhagen influences positively towards bicycle use. Chandigarh and Noida comprise of an extremely skewed sex ratio that might result in less use of bicycles.

The study finds that cycling in Amsterdam and Copenhagen is gender neutral, and used by everyone irrespective of social class or economic status. As a result, people from different gender, cultural and socioeconomic backgrounds enjoy cycling. In India, cycling is considered unsafe and a ‘poor man’s’ mode of transport, which also discourages the use of bicycles (TERI, 2014). Savan, Cohlmeyer, and Ledsham (2017) refer to multiple studies to identify a consistent pattern of gender differences and women’s lower participation in cycling. They conclude that the lower participation primarily attributed to the risks (actual and perceived) associated with cycling in countries with relatively poor cycling infrastructure, policies, regulations and low cycling prevalence. Chandigarh and Noida also depict similar standards of bicycle infrastructure. A gradual change of social outlook towards the use of bicycles coupled with improved infrastructure may encourage more people to use bicycles as a regular travel mode. Greater gender neutrality of bicycle users may improve the situation in India.

5.3 Environmental Attributes

The annual precipitation is well above the global average in Amsterdam and Copenhagen, and low in Chandigarh and Noida. Precipitation increases one’s hardship to cycle, but the findings suggest no major impact of precipitation on cycling in Amsterdam and Copenhagen. The pattern of precipitation may be a contributing parameter, which needs to be investigated further. For example, cycling is risky in heavy rainfall, whereas light drizzle may not affect cycling much. Compared to Amsterdam and Copenhagen, the mean maximum temperature is extremely high in both the Indian cities. Considering the high preference of cycling in Amsterdam and Copenhagen, it may be inferred that extremely high temperature is one of the predominant environmental parameters that discourages people to cycle. This is also associated with the associated health risk of performing physical activities during extreme heat.

Appropriate environmental protections along bicycle corridors (like covered bicycle paths, mist, etc.), with meticulous planning to optimise trip lengths, may encourage Indians to cycle more.

6. DISCUSSION AND CONCLUSION

This paper studies the reluctance of Indians to bicycle in cities. Existing literature suggests that traditional problems prevent the use of bicycles in Indian cities. The aim of this research was to investigate further the reasons for less cycling in Indian cities, progressing from a generalised understanding to a spatial analytics-based understanding at a neighbourhood scale. Study at the neighbourhood scale reveals the actual use of the bicycle, along with the physical and usability patterns. Many of the behavioural patterns are correlated with the physical, environmental and socio-economic attributes of a neighbourhood and its network connectivity within the city. The reviewed literature suggests the average distance travelled by a cyclist. Most of these studies are in Western cities that do not effectively reflect Indian conditions. Referring to the existing studies and the Indian context,
this research studies an approximate area of 1.5 sq. km. in four cities – two from India and two from Europe. Appropriate attributes and parameters which influence people’s decisions to use a bicycle were identified. Spatial analysis of these identified attributes and indicators further verify the main objectives of this paper.

It is inferred from this research that the pattern of rainfall or snowfall is an important factor for cycling, temperature is a strong influencing attribute, environmental comfort is required during the entire period of a bicycle trip, and comfort in segmentation or isolation does not encourage people to cycle. It may be concluded that the design of cycling streets in India needs to alter significantly. A citywide interconnected network of bicycle tracks with appropriate environmental protections allows for the desired comfort of a cyclist to cycle in a seamless cycle network. Dense trees or covered green areas are frequently used for environmental protection. In many places, covered bicycle tracks with occasional mist are used to cool down extreme summer heat in temperate and hot-dry climates. These strategies include easy accessibility to bicycle tracks, parking proximity, and cooling down facilities at workplaces and commercial centres.

It is recognised that Chandigarh and Noida encompass a high percentage of residential land use and a low percentage of commercial and mixed land use, therefore lengthening the necessary commercial and retail trips that originate from residential zones. A more diversified land use distribution within a neighbourhood increases short trips and use of the bicycle. A shorter trip for retail purposes encourages females and homemakers to cycle more, and shorter trips encourage female cyclists to cycle more in Amsterdam and Copenhagen. In addition, high density neighbourhoods deter people from cycling, and high density causes excess population that leads to more people on a bicycle corridor, possibly hampering the cycling experience and deterring people from cycling. This study also reveals the importance of a dedicated bicycle corridor. Land dedicated to roads and streets are similar in all four cities, however, dedicated bicycle tracks are more prevalent in Amsterdam and Copenhagen, facilitating cycling in these two cities. Length of the bicycle track is an overall proxy of the network, as well as accessibility of the track from each residential plot is a more important parameter than the width of a bicycle corridor. The width may vary depending on the demand and cyclist’s volume at peak hours. The Indian cities may need to improve the quantum of bicycle track and its accessibility to meet the standard of bicycle infrastructure of Amsterdam and Copenhagen and enhance possibilities of more cycling.

A higher percentage of the female population in Amsterdam and Copenhagen is an influencing factor of bicycle friendliness. It is perhaps linked with the commercial and retail trips within the neighbourhoods. In Indian cities, females are reluctant to use bicycles due to long trip length, unfit health conditions and cultural dilemmas.

This study highlights many non-conventional parameters to understand people’s reluctance to cycle in Indian cities. The study is particularly useful for understanding the limitations in Indian cities through a comparative analysis of successful European cases. Local government officials and policymakers can use this study to develop specific strategies for a citywide bicycle plan and to enhance the cycling environment in the Indian cities.
REFERENCES


Biswa, Mittal & Padmakar 129


