Public Disclosure Authorized

Chittagong
Strategic Urban Transport Master Plan
(P155253)

Strategic Urban Transport Master Plan
24 November, 2018

Prepared by:

empowering people
e.Gen Consultants Ltd., Bangladesh
in association with
integrated transport planning
Integrated Transport Planning Ltd,
United Kingdom

Prepared for:

THE WORLD BANK

Table of Contents

List of Tables

List of Figures

Table of Acronyms and Abbreviations

BBS	Bangladesh Bureau of Statistics
BRT	Bus Rapid Transit
BRRL	Bangladesh Road Research Laboratory
BRTA	Bangladesh Road Transit Authority
CCC	Chittagong City Corporation
CDA	Chittagong Development Authority
CEPZ	Chittagong Export Processing Zone
CMP	Chittagong Metropolitan Police
LOS	Level of service
LRT	Light Rail Transit
NMT	Non-motorised transport
OD	Origin-destination
OICA	International Organisation of Motor Vehicle Manufacturers
PCU	Passenger car unit
PPHPD	Passengers per hour per direction
PPP	Purchasing power parity
PT	Public transport
PTA	Public transport authority
PV	Present value
SUTMP	Strategic urban transport master plan
UN	United Nations
VCR	Volume capacity ratio

1. Introduction

This Strategic Urban Master Plan (SUTMP) presents a plan for improving mobility in Chittagong between the years 2019 and 2030. The vision is to develop;

> *"A transport system that provides integrated public transport with walking and cycling provision in a safe, accessible, efficient and environmentally friendly manner for the people of Chittagong."*

The recommendations focus on improving the provision of public transport, pedestrian facilities and improving the flow of vehicles at junctions. The recommendations are scheduled into three implementation time-periods:

- Short term: 2019 - 2022
- Medium term: 2023 – 2025
- Long term: 2026 – 2030

Implementation of the SUTMP will increase access to jobs and services, reduce transport costs, reduce GHG emissions and reduce local air pollution and improve mobility for women.

1.1 Study area

The study area of the SUTMP is the city boundary identified in Figure 1-1. This area contains the vast majority of the continuous urban area of the city. While the population of towns and villages in neighbouring districts is significant, these locations are considered as sperate to Chittagong city. All of the projects and measures presented in the SUTMP are located within the city boundary, however the development of these projects and measures is sensitive to the growth in transport demand to these neighbouring districts in the future.

Figure 1-1: Chittagong city wards and city boundary

1.2 Reports produced

This SUTMP (D5) is supported by the following documents:

- D1: Inception Report
- D2: Review of existing data, documents and plans
- D3: Investment options
- D4A: Traffic survey and demand analysis: Section A, data report
- D4B: Traffic survey and demand analysis: Section B, model report
- D6A: Corridor improvements pre-feasibility study
- D6B: Road scheme improvements pre-feasibility study
- D7: Bus restructuring and institutional assessment

1.3 Data collection

A data collection exercise was undertaken to develop an evidence base for the SUTMP and construct a transport model used to help identify interventions, inform their design and appraisal.

The surveys undertaken are listed in Table 1-1 alongside a high-level description of the data collection methods and sample size achieved. The surveys were conducted in April, May and June 2017. A detailed description of the methodologies used and the survey results can be found in *D2: Review of existing data, documents and plans.*

Table 1-1: List of traffic and urban transport surveys

Survey	Contents	Collection methods	Location	Sample frequency	Sample periods	Sample size achieved
Road network inventory	Physical features and barriers to traffic flow	Enumerator Observation	70.5 kilometres	N/A	N/A	N/A
Traffic counts	Classified traffic volume counts	Video recording	21 locations	3 Days	AM/PM Peak	N/A
Vehicle intercept OD survey	Travel patterns, OD matrix	Enumerator interviews	15 locations	3 Days	AM/PM Peak	13,085 vehicles, 19,445 passengers
Travel time and speed survey	Travel speeds and bottlenecks	GPS data recorder	7 corridors and 9 travel modes	3 Days	AM/PM Peak	N/A

Survey	Contents	Collection methods	Location	Sample frequency	Sample periods	Sample size achieved
PT boarding and alighting survey	Quantity and location of passenger ridership	Enumerator observation	27 routes covering bus, human hauler and tempo	3 Days	AM/PM Peak	30,837 boarding's and alighting's
PT frequency and occupancy survey	Service frequency and occupancy	Enumerator observation	20 locations	3 Days	AM/PM Peak	N/A
Household interview survey	Travel patterns, OD matrix, socio-economic indicators	Enumerator interviews	1,000 households	N/A	N/A	1,034 households, 5,007 people, 2,697 trips
Traveller & women travellers survey	Travel characteristics, opinions on travel and travel choices	Enumerator interviews	20 locations	3 Days	AM/PM Peak	2,016 for traveller survey, 614 for women travellers' survey
Freight queueing survey	Queue length on freight routes by the time of day	GPS data recorder	5 Freight routes	1 Day per route	17:30 to 22:00	N/A
Bottleneck survey	Location and cause of junction and link-based congestion	Enumerator observation	All major routes	Single or multiple observations per site	Between 9:00 and 18:00	N/A

1.4 Layout of this document

Following this introductory chapter, the report is structured as follows:

- Chapter 2 describes the current urban structure of Chittagong and expected changes in the future
- Chapter 3 describes the current supply of transport provision
- Chapter 4 describes the current demand for transport in the city
- Chapter 5 forecasts the changes to transport demand in the future
- Chapter 6 presents the transport schemes that are currently being implemented or are committed. The SUTMP assumes that these will be delivered.
- Chapter 7 identified the main problems with transport provision in the city
- Chapter 8 describes the future transport problems if a do-minimum scenario is followed

- Chapter 9 presents the vision and objectives for the SUTMP as developed through stakeholder engagement
- Chapter 10 presents and discusses options for improving transport in Chittagong
- Chapter 11 presents the actions recommended to be implemented in the short term
- Chapter 12 presents the actions recommended to be implemented in the medium term
- Chapter 13 presents the actions recommended to be implemented in the long-term
- Chapter 14 presents the organisational structure for implementation
- Chapter 15 identifies how the estimated cost of the actions have been established
- Chapter 16 presents the modeling impact of the SUTMP on traffic levels and the emission of air pollutants
- Chapter 17 contains an economic appraisal of the SUTMP

2. Urban development

2.1 Urban structure

Figure 2-1 and Figure 2-2 present the urban area of Chittagong in 1995 and 2017 respectively. The study area for the SUTMP is the Chittagong City boundary, this is identified by the black outline in Figure 2-1 and by the yellow area in Figure 2-2.

The population within this boundary has grown considerably from 360,000 in 1960[1] to 2.9 million in 2017[2]. The urban area has begun to spill over into adjacent districts – notably linear development along the Dhaka Highway to the north-east. Nearby towns have also grown considerably in size including Fateabad and Hathazari in the north, Quaish and Burischar in the north-east, and a variety of villages located on the southern side of the Karnaphuli River in the districts of Boalkhali and Anwara. The population of the wider metro area, which includes these satellite towns stands at 4.8 million.

Between 2011 and 2017 the population of the Chittagong grew by 2.2% per annum[1]. This growth has been fuelled by rural-urban migration and natural population rise. The urban extent of Chittagong has grown as well as densified. Comparing Figure 2-1 and Figure 2-2 shows how the city has grown between 1995 and 2017. From 1991 to 2011 average household size has decreased[4], this adds additional pressure for new residential areas.

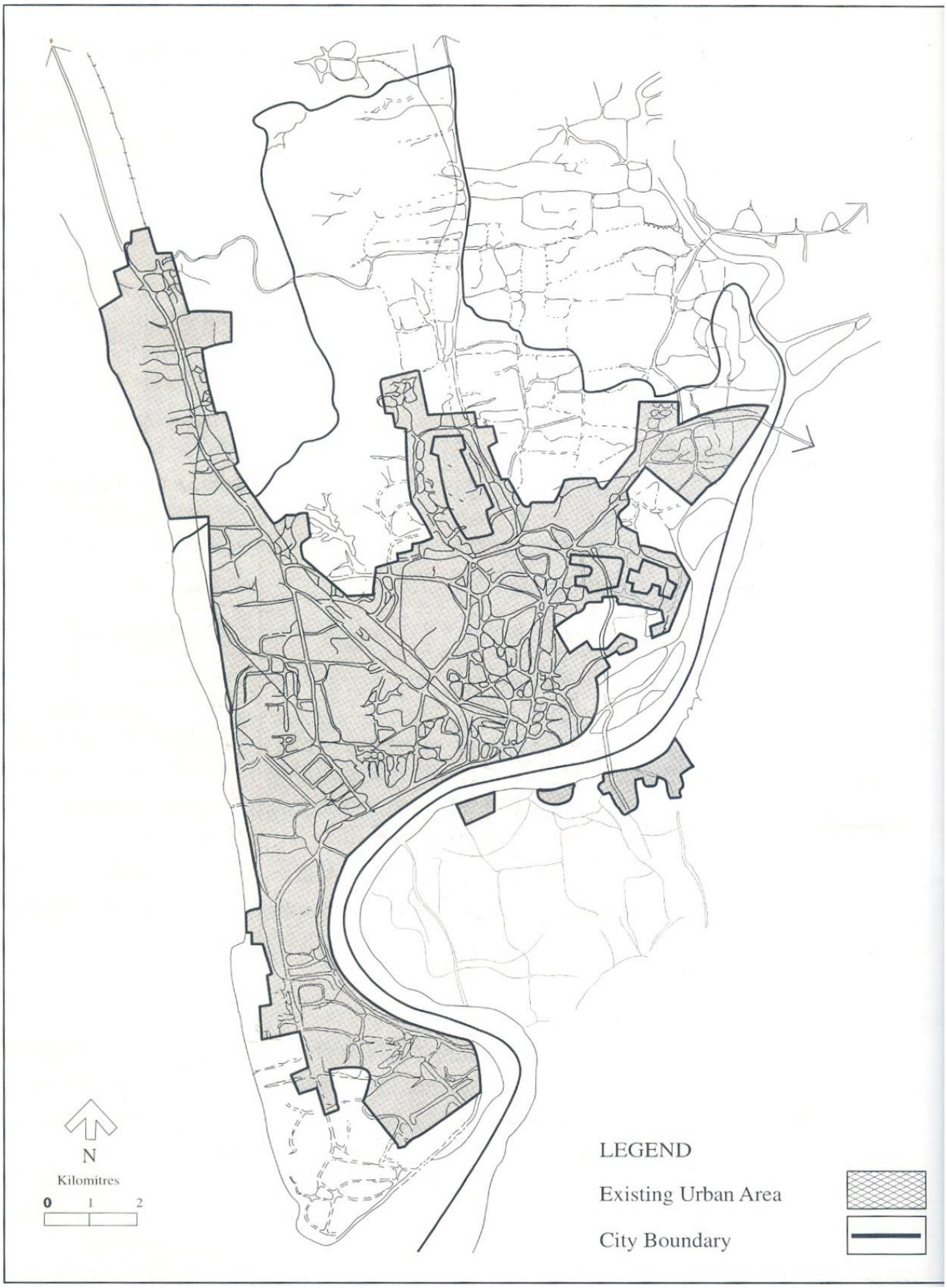
The growth of Chittagong is constrained by natural barriers; the Bay of Bengal to the west, the Karnaphuli River to the south and east, and hilly terrain to the north. Potential flooding prevents significant coastal or riverside development. This constraint has contributed to Chittagong growing denser. Figure 2-3 presents population density by ward, the city-wide average is 17,000 people per sq-km. However, densities can exceed 46,000 people per sq-km in central districts such as Kotwali and Double Mooring.

Recent population growth has focused on the peripheral areas of the city including the districts of Patenga, Pahartali, Bayazid Bostami and Chandgaon, these areas grew by 4.0% to 5.1% per annum over the past 5 years. While the central areas of Kotwali, Khulshi, and Halishahar only grew by 1.2 to 1.9%[3] over the same time period.

---

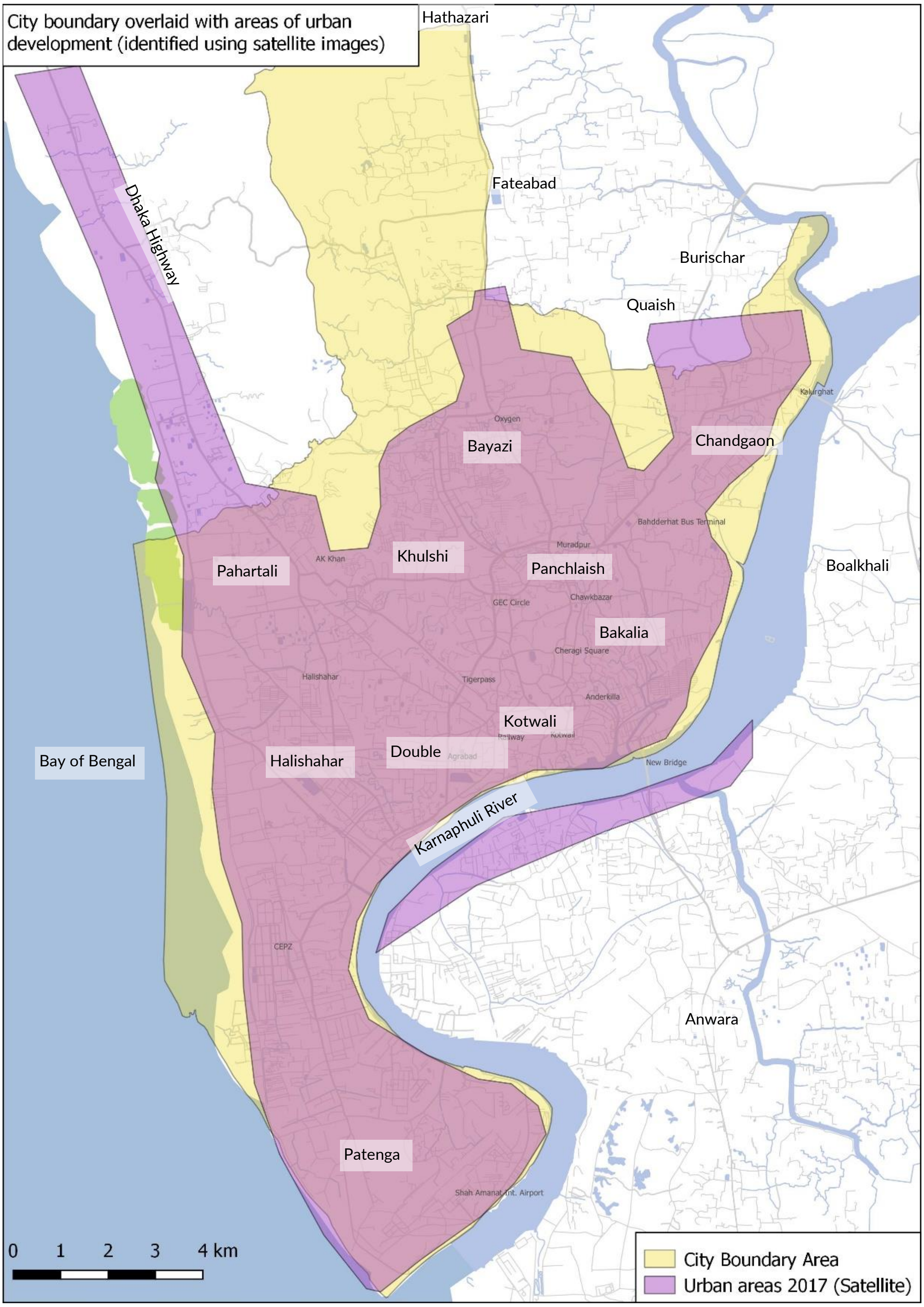
[1] UN Population Division 2014. *World Urbanisation Prospectus.* https://esa.un.org/unpd/wup/CD-ROM/
[2] eGen 2017. *Chittagong SUTMP: Traffic Survey & Demand Analysis: Section B, Model Report*, Table 3-1
[3] Bangladesh Bureau of Statistics

Figure 2-1: Urban extent of Chittagong in 1995



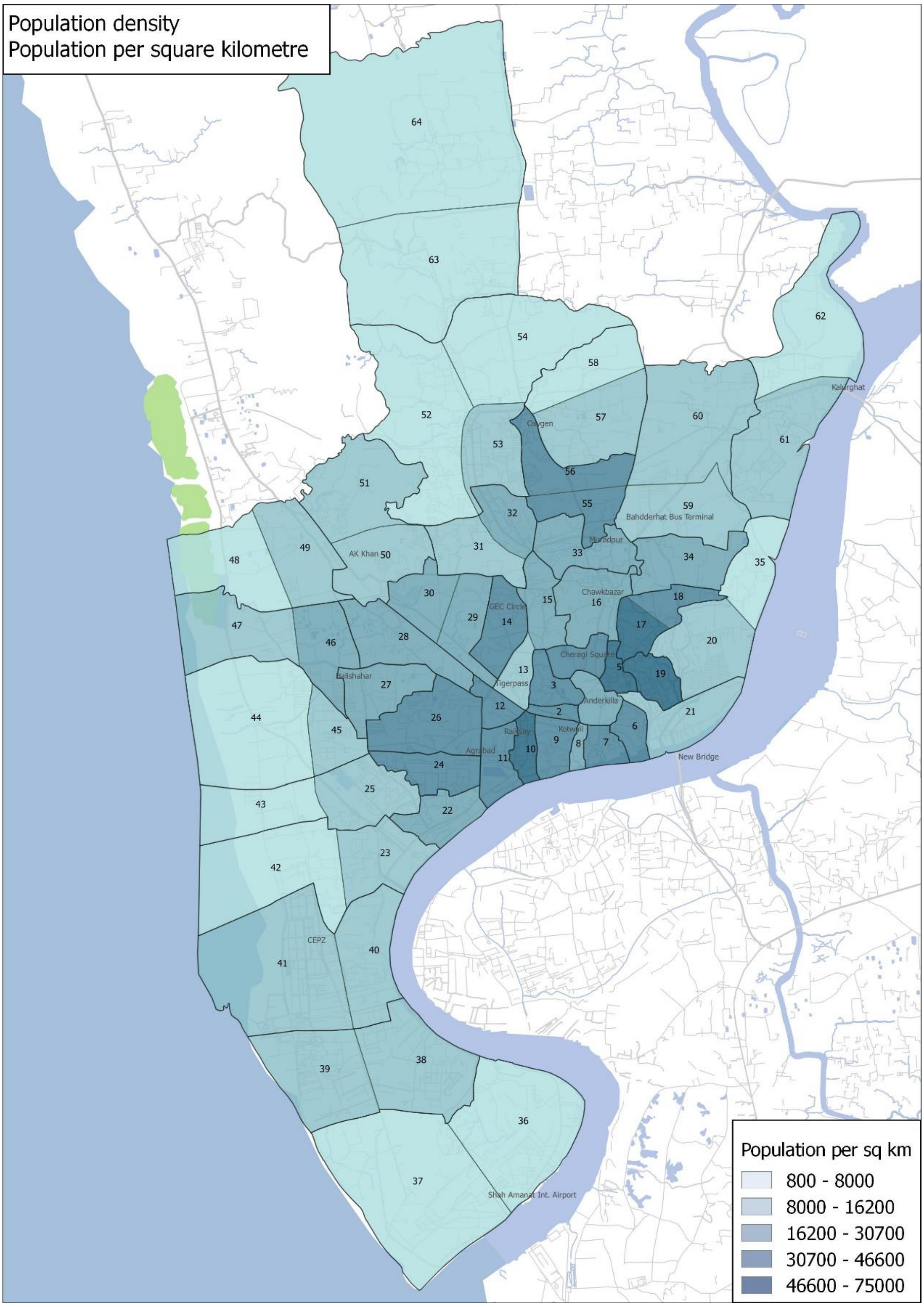
Source: CDA Urban Development Plan 1995 – 2nd Edition (published 2008)

Figure 2-2: Urban extent of Chittagong in 2017



Source: Consultants estimate based on Google Earth imagery

Figure 2-3: Population density of Chittagong in 2017



Source: Bangladesh Bureau of Statistics, 2011. Population from census factored up to 2017.

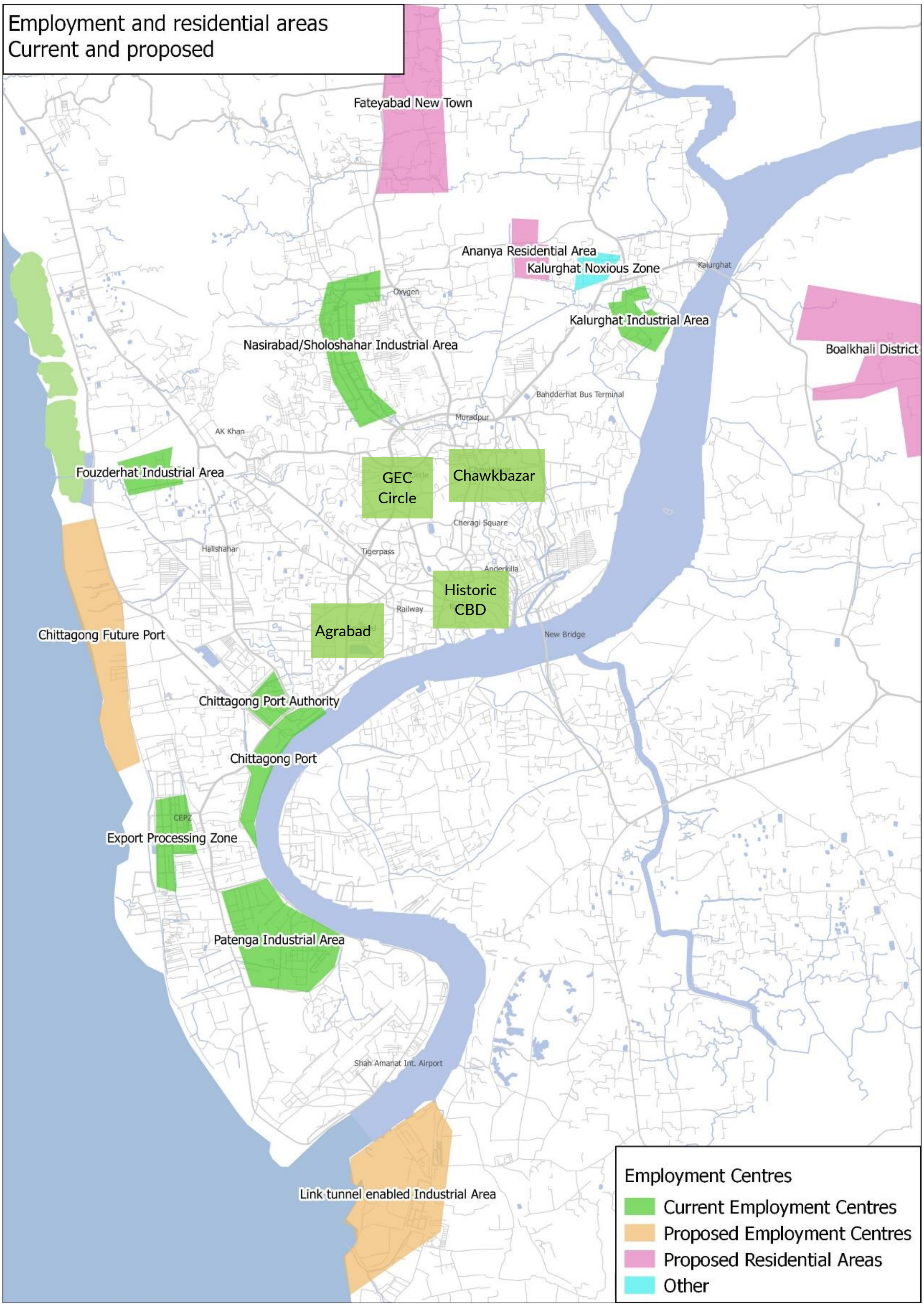
2.2 Employment

The main employment areas in Chittagong are plotted in Figure 2-4. Roughly 34% of Chittagong's population are employed in industry, with 64% in services. Slow travel times and uncoordinated development has encouraged Chittagong to develop into a multi-centric city. Four commercial centres have established themselves; the historical CBD (around Kotwali), Chawkbazar, Agrabad and GEC Circle. The major industrial areas are located in more peripheral areas, away from the centre of the city.

Consequently, many of the major employment sites are hard to access. Some workers have to travel across the city to access employment in factories located around the outskirts. The largest employment area of this kind is the Chittagong Export Processing Zone (CEPZ) which employs around 200,000 people. It is located to the south-west of the city centre off M.A. Aziz Road. Some of the industries located in the CEPZ run their own dedicated bus services to bring employees into work.

The Port, and ancillary logistic and warehousing services are also a major employer in the city. These sites are also located in the south of the city.

Figure 2-4: Location of key employment sites



2.3 Future growth

Based on UN growth forecasts, we predict the population of Chittagong City to increase from 2.9 million today to 4.1 million by 2030 (see Table 2-1). The annual population growth rate is expected to increase from 2.2% (as experienced in the last 6 years) to 2.9% by 2025, before dropping back down to 2.5%.

Table 2-1: Predicted population change for Chittagong City 2011-2030

Year	Annual growth rate	Population Projection
2011	2.2%	2,600,000
2017	2.6%	2,900,000
2020	2.9%	3,200,000
2022	2.9%	3,400,000
2025	2.5%	3,700,000
2027	2.5%	3,800,000
2030	2.5%	4,100,000

Source: UN Population Division 2014, World Urbanisation Prospectus, https://esa.un.org/unpd/wup/CD-ROM/

The population of neighboring districts are also forecast to increase. Chowdhury (2014) [4] identifies a number of potential growth areas that lay outside of the Chittagong City boundary, including developments to the north and east of the City as well as south of the Karnaphuli River (Figure 2-5). Even though these developments are located outside of the City boundary, the SUTMP should be responsive to an increase in trips to these locations. Therefore, the impact of these new developments on transport demand in the City has been included in the modeling exercise.

CDA has already identified development land for a number of these sites - for example, Fateabad and Anonnya are to host new residential developments of around 3,000 units, including commercial and other uses such as a hospital.

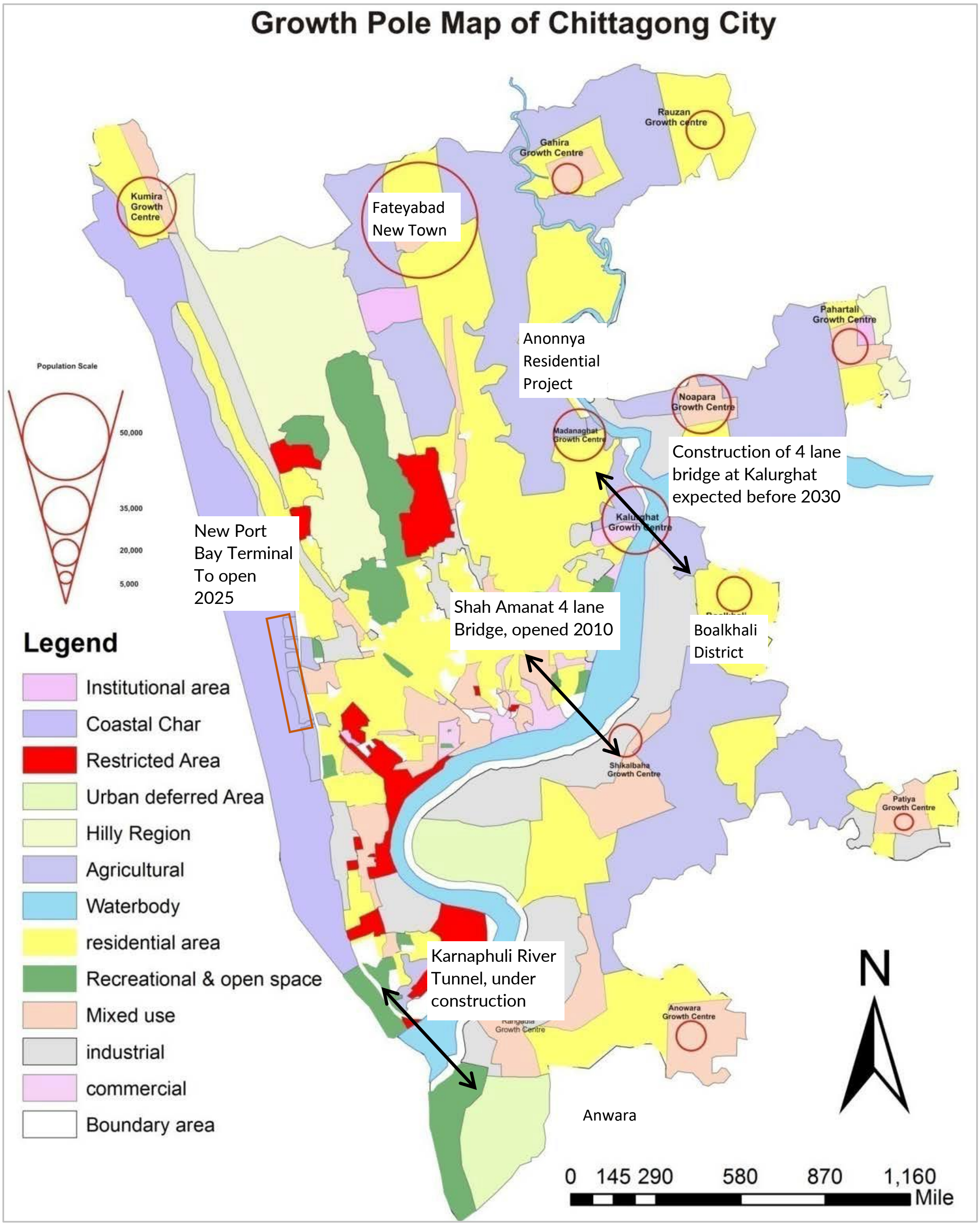
[4] Chowdhury, P. A., (2014), *Future Growth Trend & Potential Residential Area Identification of a City: A Case Study of Chittagong.* Current Urban Studies 2, 168-177 :

New and improved transport connections over the Karnaphuli River are expected to encourage development on the southern side of the river and increase travel demand across the river. These new connections include the completion of the Karnaphuli tunnel at the mouth of the river (by 2025) and the expected construction of a 4-lane bridge at Kalurghat (by 2030) to replace the existing single lane bridge.

Tied to the development of the Karnaphuli tunnel, significant industrial development is expected in Anwara district, on the south side of the river. Development of the new Port Bay terminal on the western coastal edge of the city is also expected to significantly alter the demand for work trips and truck movements in Chittagong.

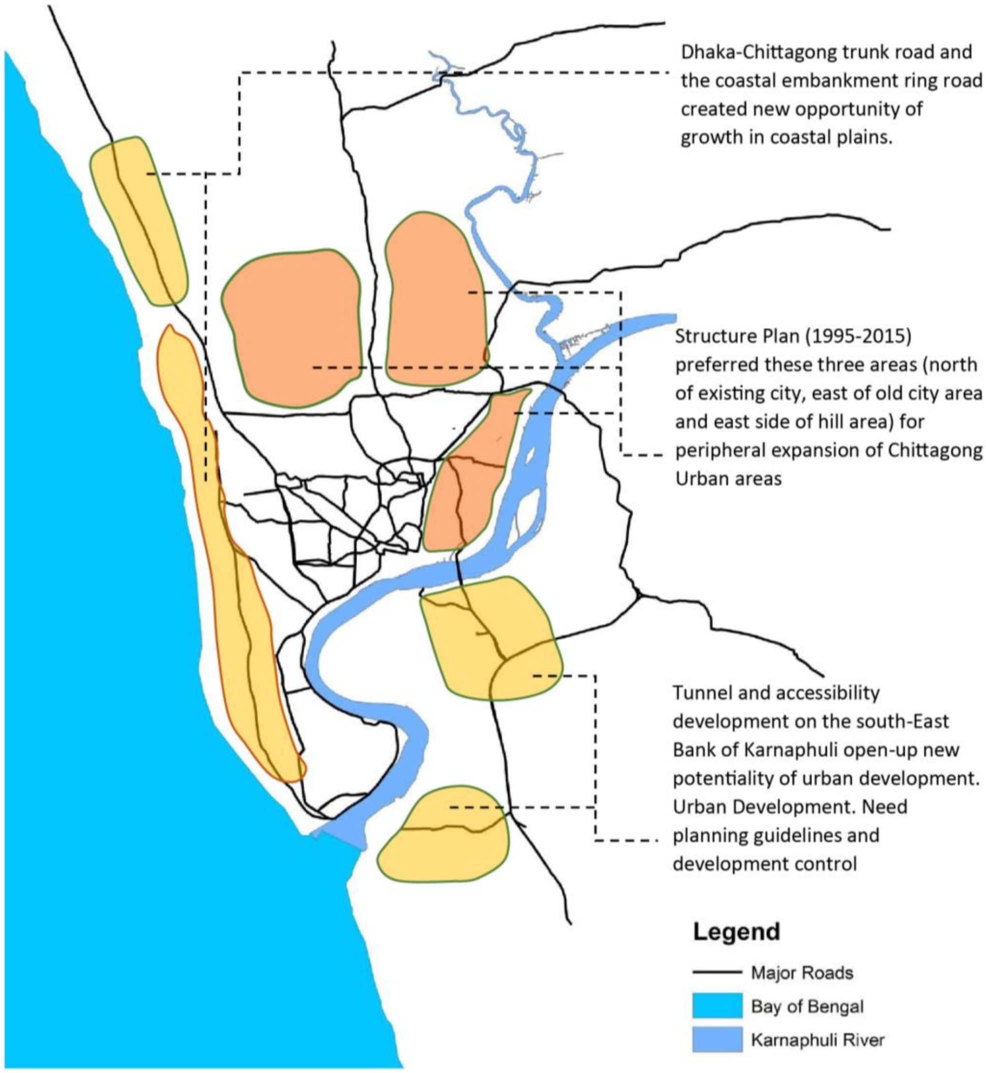
Mahmud (2018) identifies opportunities for land use changes to support the future development of Chittagong Port. Figure 2-6 identify new growth areas in the west of the city along the Bay of Bengal where the new Bay port terminal is to be built. Developments here could include industrial and logistic facilities that support the port and vice versa.

Figure 2-5: Potential future growth areas around Chittagong



Source: Chowdhury, P. A., (2014), *Future Growth Trend & Potential Residential Area Identification of a City: A Case Study of Chittagong.* Current Urban Studies 2, 168-177

Figure 2-6: Growth potential areas as per structure plan and reality



Source: Akter Madhmud. (2018) *A background study on land use analysis for CSUTM*

2.4 Population characteristics

A household survey was conducted across Chittagong as part of this study. The average household size was found to be 4.8, with 1.6 household members earning an income through formal or informal work. The Bangladesh Bureau of Statistics (BBS) *Household Income and Expenditure Survey 2016*[5] reports Chittagong Division to have the second highest household size in the country following Sylhet.

Corresponding to Bangladesh being classified by the World Bank as a lower-middle income country, poverty levels in Chittagong are high, but BBS report that they are improving. The average daily household income is BDT 1,700 or USD 56 PPP, this represents high levels of poverty, but it is better than the national average (BDT 800), and better than the average for urban areas (BDT 1,100)[5].

The spread of households by daily income is presented in Figure 2-7. The World Bank defines extreme poverty as USD 1.90 PPP. This equates to a daily household income of BDT 650. The household survey therefore found just over 8% of the Chittagong population live in extreme poverty. This corresponds with the estimate produced by the Bangladesh Bureau of Statistics (2016)[5] which found 9% of the population of Chittagong to live in extreme poverty.

Figure 2-7: Income distribution in Chittagong

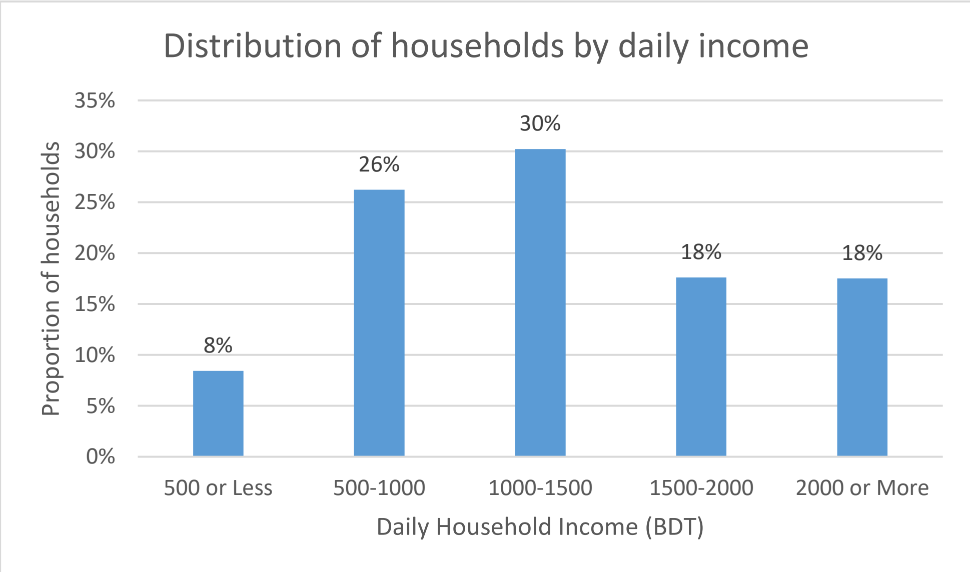


Figure 2-8 identifies locations in Chittagong where the highest levels of poverty tend to occur. In general, poorer households are located in more peripheral locations, especially to the north and west of city including:

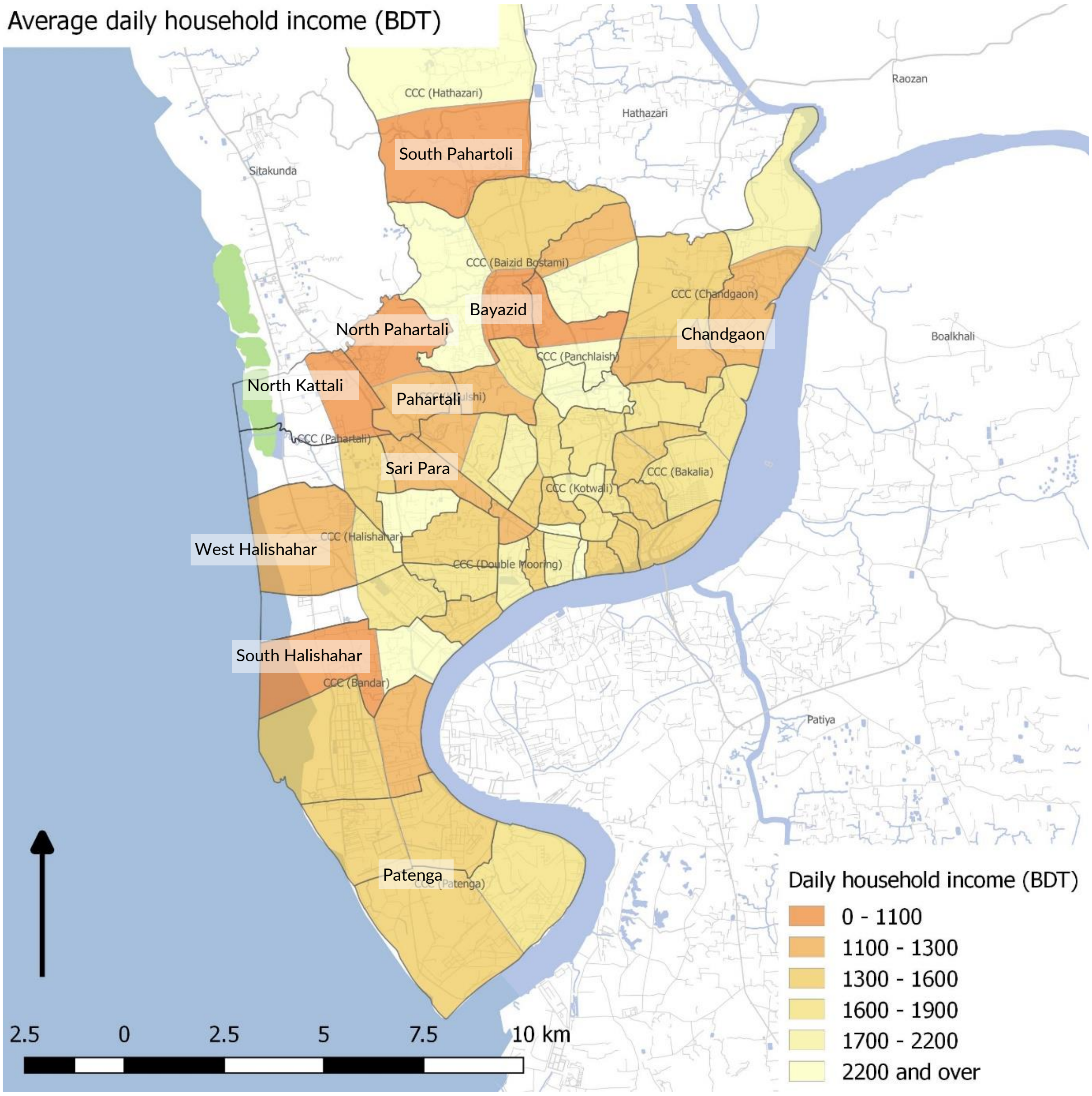
- In the north, South Pahartali, and Bayazid located along the Hathazari Road
- A cluster of poverty in the north-west around North Pahartali, North Kattali, Pahartoli and Sari Para
- The west of the city near to the Bay of Bengal in west Halishahar and South Halishahar
- Persistent levels of poverty are also found in the north-east in Chandgaon, and across Patenga in the south.

[5] Bangladesh Bureau of Statistics 2016. *Preliminary Report on Household Income and Expenditure Survey 2016*

In line with low incomes, the ownership of private vehicles is extremely low. Data from BRTA derives a motorisation rate of 9.9 cars per 1,000 in Chittagong. The household interview survey found only 6% of households have access to a car, and 7% have access to a motorcycle. This is extremely low when compared internationally. For context, the International Road Federation[6] and the OICA[7] place Bangladesh as a whole in the bottom five countries in the world for vehicle ownership.

[6] International Road Federation http://worldroadstatistics.org/
[7] OICA vehicles in use http://www.oica.net/category/vehicles-in-use/

Figure 2-8: Geographic distribution of average household income



3. Current Transport Supply

3.1 Transport modes

Data from BRTA show the private transport modes in Chittagong consist of:

- Car - 30,000 registered vehicles
- Motorcycles - 75,000 registered vehicles
- Trucks - 9,200 registered vehicles

Public Transport (PT) caters for half of all passenger trips in Chittagong. There are six PT modes in Chittagong, their roles are presented in Table 3-1. The most important of these modes are the bus, tempo and human-hauler which operate along fixed routes licenced by BRTA.

Rickshaws and CNGs (auto-rickshaws) are plentiful across the city. They provide taxi services across the city. Often these rides are shared, sometimes between family and friends, but also with strangers. Their roles are also described in Table 3-1.

Table 3-1: Key transport modes in Chittagong

Service type	Mode	Seating capacity	Functional role	Number of routes	Number of vehicles
City Route	Urban bus 	30 - 40	The backbone of the public transit network. Focused on CDA avenue. Slow speed	11	1,300
	Human Hauler 	14 - 20	Duplicates bus routes, faster and relatively comfortable	16	2,700
	Tempo 	10 - 12	Duplicates Bus routes. Faster, but not as comfortable	18	1,700

Work transport	Worker bus 	30 - 40	Exclusive transport, typically for factory workers	N.A.	140
Long-distance Route	Inter-district bus 	50 - 60	Links to surrounding towns and cities across Bangladesh	19	1,100
	Rail 		Links to surrounding districts. Mostly longer distance trips	N.A.	
Rickshaw-type	CNG 	4 - 6	Medium distance private trips, high fare	N.A.	25,000
	Rickshaw 	2 - 3	Short distance trips, low fare	N.A.	Up to 150,000

3.2 Road network

The layout of the road network is presented in Figure 3-1, and the number of lanes in Figure 3-2. There are five broad features of the road network which are presented in Table 3-2.

Figure 3-1: Layout of the road network

Figure 3-2: Number of lanes of the road network

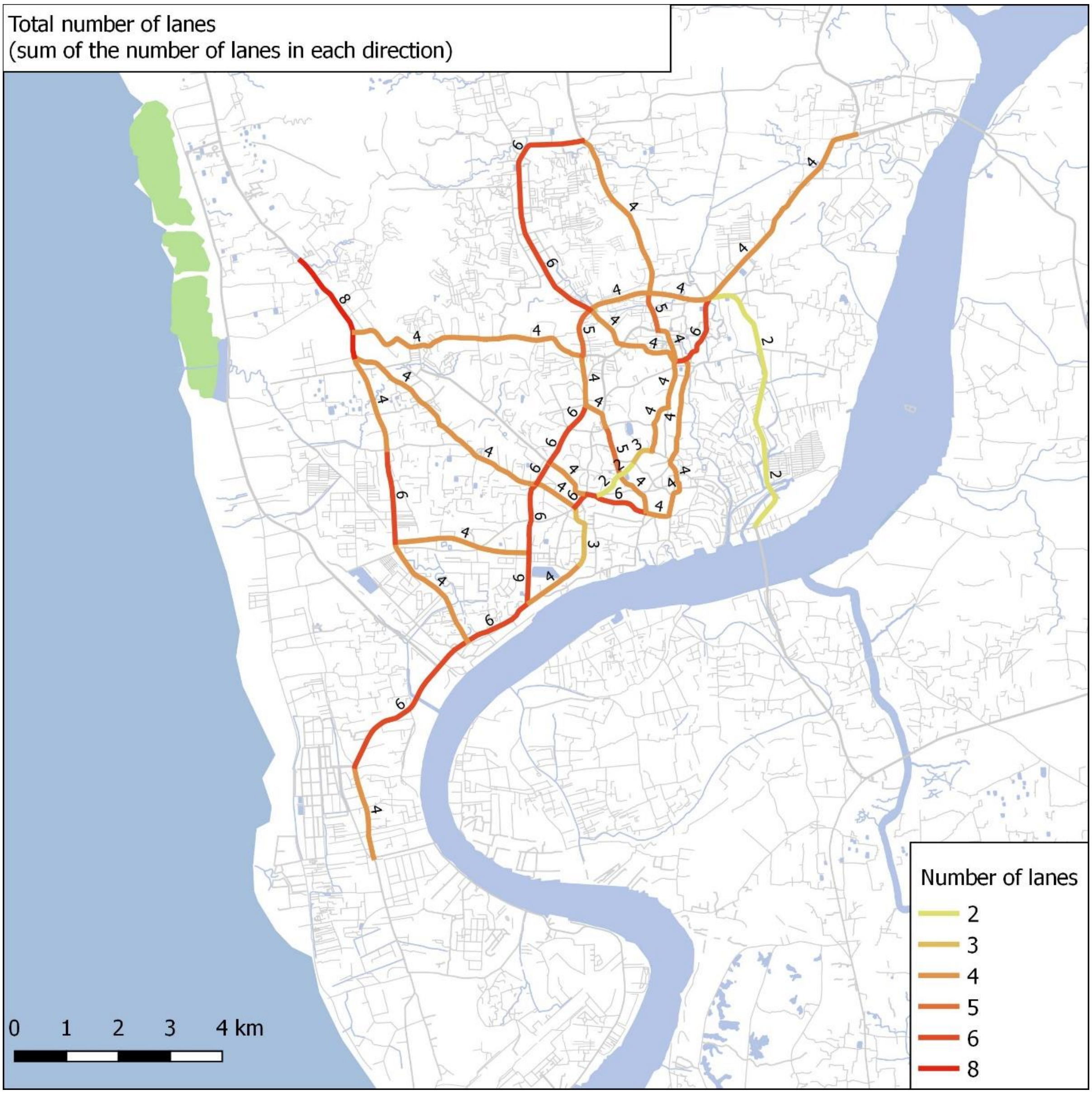


Table 3-2: Main features of the road network

The road from the airport to Kalurghat forms a 'spine' through the city. This spine includes M.A. Aziz Rd, Mooring Rd, Sheikh Mujib Rd, CDA Avenue and Arakan Rd. The road is a dual carriageway throughout and features a 4km elevated highway along CDA Ave.	 Sheikh Mujib Rd at Dewanhat	 CDA Avenue at GEC Circle
The historic areas of the city are located 'inside' this spine, south and east of CDA Avenue. The roads in this area are typically narrow.	 Nabab Siraj Ud Daula Rd, north of Anderkilla	 College Rd at Chawkbazar

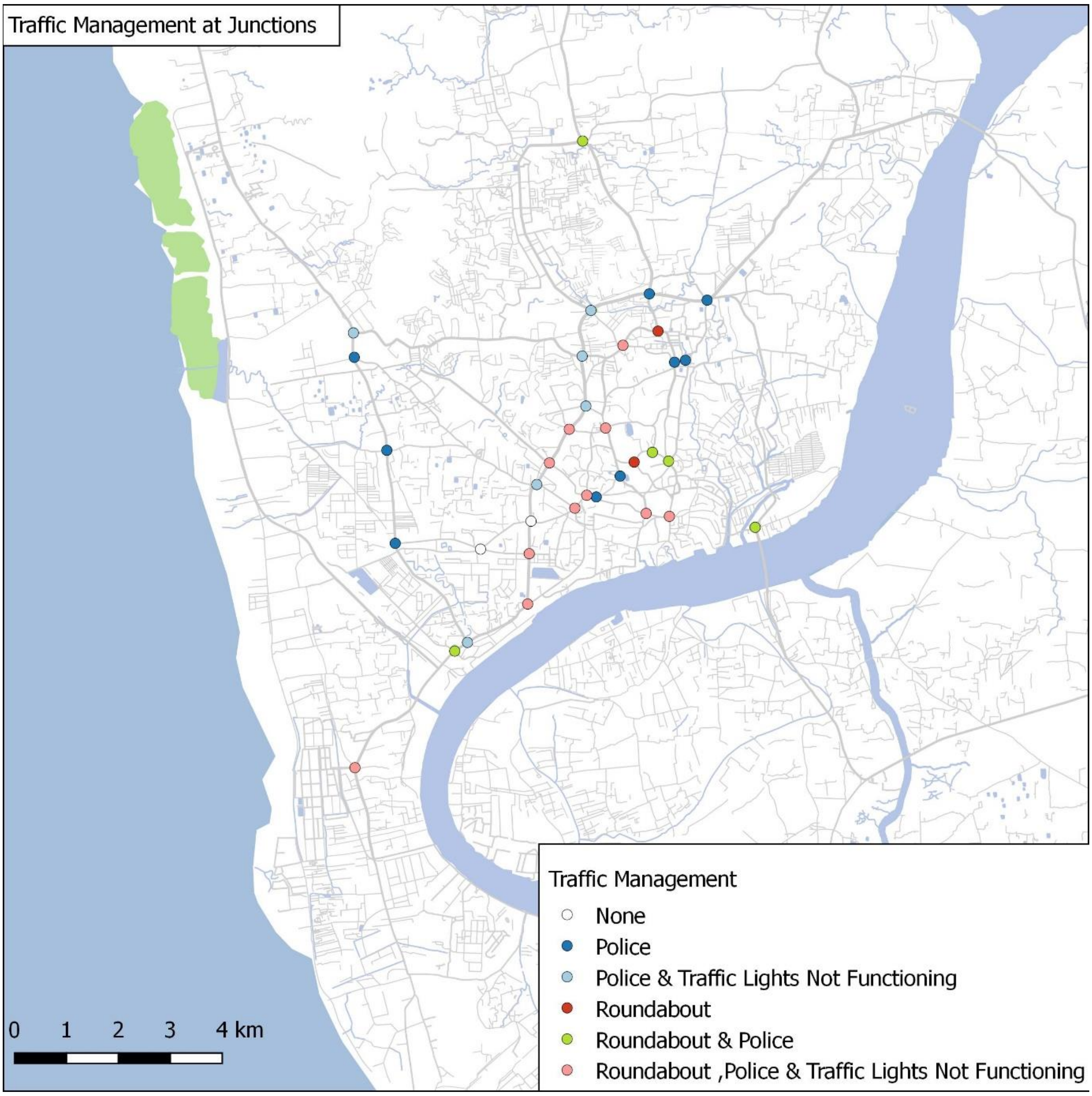
Major trunk roads exist 'outside' of the spine, north and west of CDA Ave. Two trunk roads provide connections to the Dhaka Highway these are Port Connecting Road and Zakir Hossain Road. Supported by the Dhaka Trunk Road which is narrower but provides a direct connection to the historic centre. The Hathazari Road provides the primary connection to the north, but this road is currently narrow, within the city it is supported by Bayazid Bostami Rd.	 Port Connecting Rd north of Boropole  Zakhir Hossain Rd at Khulshi
In between the trunk roads and secondary roads are numerous small streets that permeate residential and industrial areas. Many of these roads are too narrow for cars and buses, but they can be accessed by rickshaws, motorcycles, CNGs and some by tempo.	 Between Nabab Siraj Ud Daula Rd and College Rd
There are two bridges over the Karnaphuli River crossings; a single lane bridge at Kalurghat, and a modern 4-lane bridge located near to the city centre named Shah Amanat Bridge, often known as 'New Bridge'. This opened in 2010.	 Kalurghat Bridge  Shah Amanat Bridge (New Bridge)

Most main roads within Chittagong are of a reasonable width, with at least 2 lanes in each direction. The exception is the A.G. Road (N1) between Bahaddarhat and Shaheed Boshiruzzaman Sq (New Bridge). The pavement quality of a number of main roads is poor. This will act to reduce travel speeds and increase emissions.

3.2.1 Junctions

A critical part of the highway infrastructure are the junctions. All surveyed junctions had no signage or markings. The majority of junctions were controlled by the police with no traffic lights functioning at any location (Figure 3-3).

Figure 3-3: Traffic management at junctions



3.3 PT network

3.3.1 Rail

The rail network is presented in Figure 3-4. There is a single urban rail service that connects Chittagong University to the city, but this service is infrequent and plays a minimal role in urban transport. The primary long distance services connect to Dhaka and Sylhet[8]. There are a total of 16 inter-city services per day.

Figure 3-4: Rail network

[8] Bangladesh Railway, http://railway.portal.gov.bd/site/page/b4daad0c-381b-4d3f-8612-d28207e58724

3.3.2 Bus, human-hauler and tempo routes

The surveys of the bus, human-hauler and tempo routes were conducted to identify their frequency and capacity and onboard surveys were conducted to identify the patronage of each route and their speed.

Maps of the PT routes are presented in Figure 3-5, Figure 3-6 and Figure 3-7. For bus and human-haulers there is a concentration of routes along the ‘spine’ of CDA Avenue and M.A. Aziz Road as well as a ‘spur’ along Station Road to access New Market. There are also a number of human-hauler routes on Port Connecting Rd. The location of the tempo routes is more varied because they are smaller in size and can operate on narrower streets.

Generally, bus, human-hauler and tempo routes tend to stick to the main roads; they rarely permeate the large housing or industrial estates, probably due to the narrow streets in these areas. Instead, passengers have to either walk or take a rickshaw for a long distance to access the PT network.

Figure 3-5: Route plan of the bus services

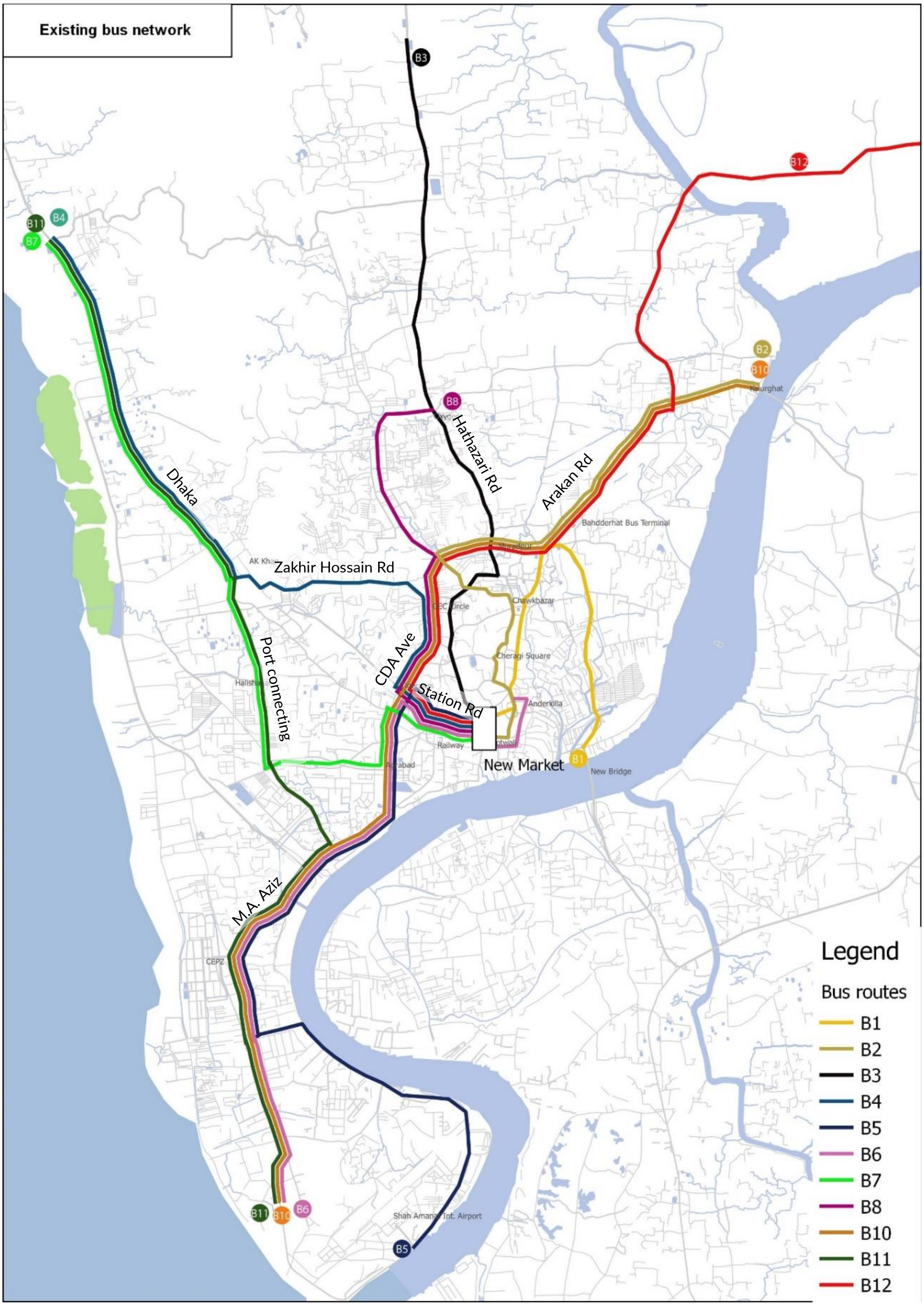


Figure 3-6: Route plan of the human-hauler services

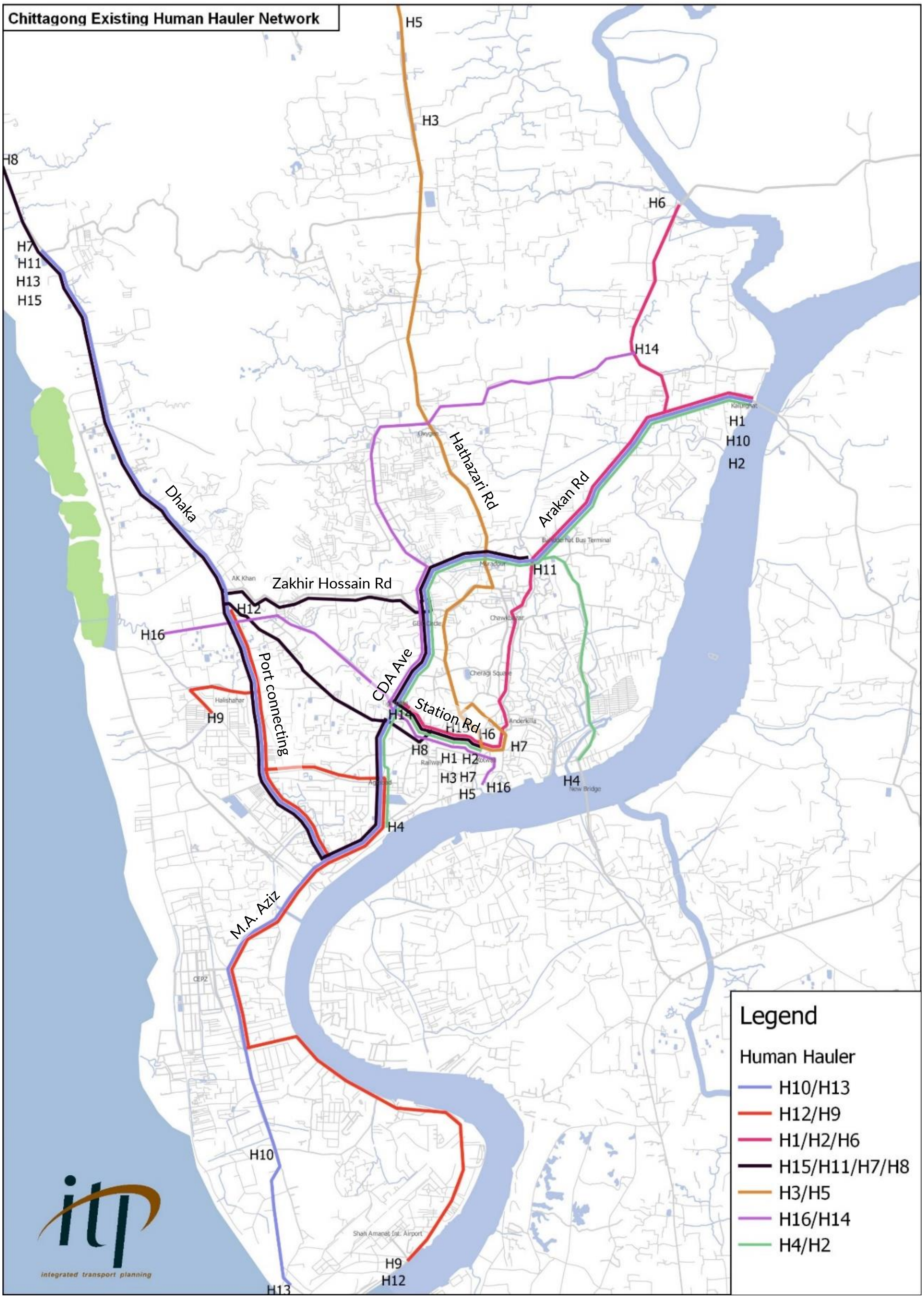


Figure 3-7: Route plan of the tempo services

3.3.3 Level of service and fare

Table 3-3 presents a summary of the typical level of service provided by PT routes of each mode. The frequency of services running on each route is typically quite high. For example, the average frequency for a bus route is 31 buses per hour (approximately one bus every two minutes). However, these buses are not likely to be equally spread out.

Table 3-3 shows that buses have the lowest average operating speeds of the PT modes at 10.3Kph while the nimbler human-hauler and tempos operate at between 12 and 13Kph. For comparison, the table includes the speed of CNG and rickshaw services. While the speed of Rickshaws and CNGs is lower, or comparable, with PT services, they offer point-to-point services which will offer a shorter travel time for many trips.

Table 3-3: Summary of PT level of service by mode

Mode	Number of routes	Average route distance (one-way, Kms)	Average peak frequency for a route (buses per hour)	Average operating speed (PM-peak*) (Kph)
Bus	11	17.8	31	10.3
Human-Hauler	16	18.1	18	12.7
Tempo	18	13.0	25	12.5
Rickshaw type				
CNG				11.7
Rickshaw				8.2

Nb. In-vehicle GPS surveys has shown traffic speeds to be slowest in the afternoon

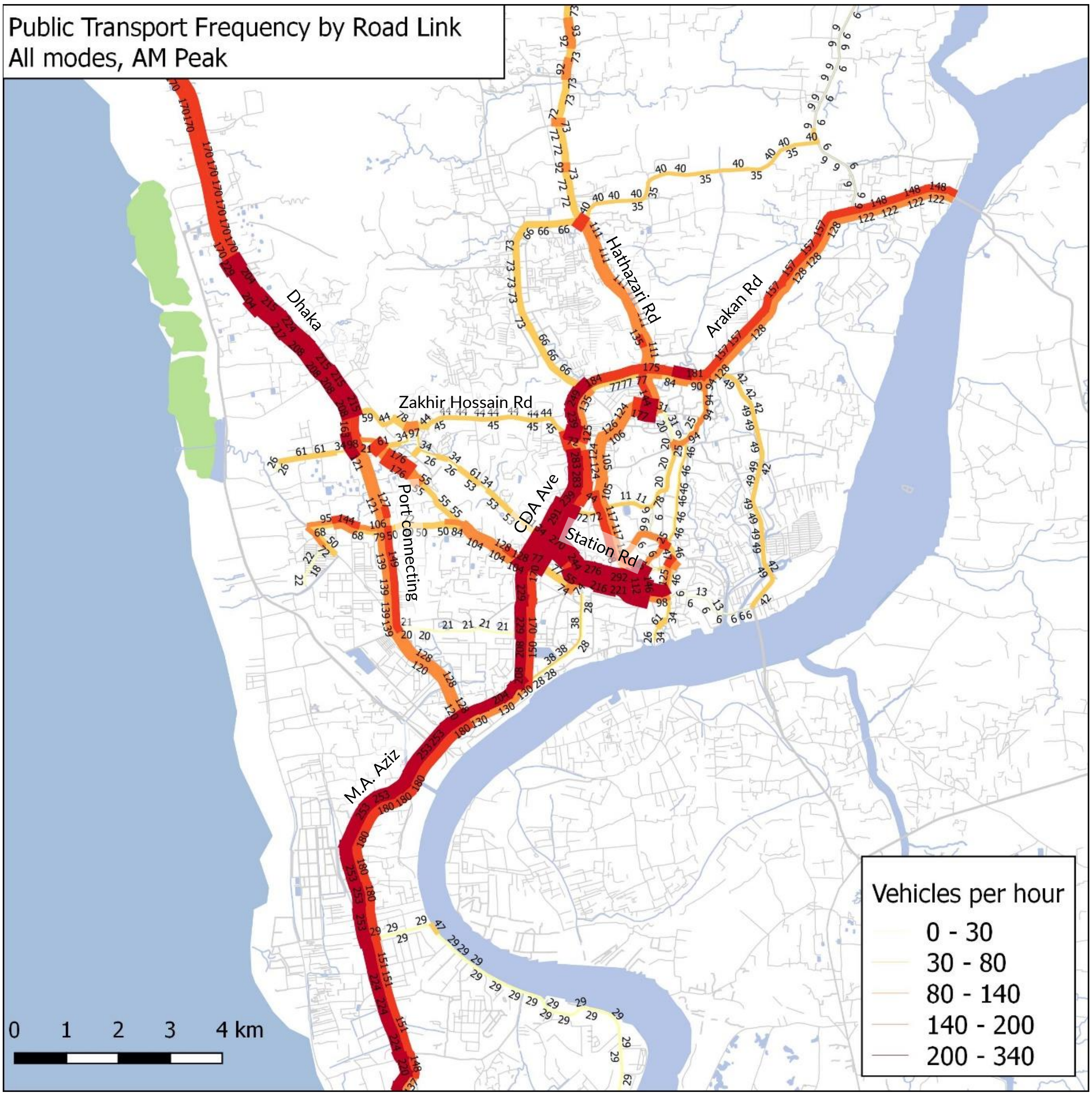
PT fares are distance based, Table 3-4 presents the fare table for the PT modes as well as Rickshaw and CNG for comparison.

Table 3-4: Fare table for bus, human-hauler and tempo

Vehicle Type	Base Fare (BDT)	Distance Included in Base Fare (Kms)	Fare per additional Km (BDT)
Tempo	6	3	1.6
Human Hauler	5	3	1.6
Mini-Bus	5	3	1.6
Rickshaw	No Fixed Rate		
CNG	40	2	12

To illustrate the intensity of PT services in Chittagong, the combined hourly frequency is presented in Figure 3-8. Again, this highlights the concentration of PT services on the ‘spine’ of CDA Ave and M.A. Aziz Rd as well as the ‘spur’ of Station Road to New Market. On these roads combined frequencies of between 250 and 300 vehicles per hour are observed, which corresponds to a PT vehicle passing every 12 to 15 seconds on average

Figure 3-8: Combined frequency of all PT services (bus, human-hauler and tempo)



3.3.4 PT terminals

Two types of bus services operate in Chittagong; inter-district and city-buses. City-buses serve the city of Chittagong, whilst inter-district buses provide transport to surrounding districts and other cities in Bangladesh.

There are currently 10 inter-district bus terminals located across Chittagong including the city centre locations (see Figure 3-10). Although these are referred to as ‘terminals’ they do not consist of buildings or even ground markings – they are mainly free parking areas for idling inter-district buses.

Figure 3-9: Kadamtali inter-district bus terminal

Source: eGEN, 1/11/2016

There are 7 locations across the city where city-buses terminate; at these locations the terminal facilities are minimal. Presently the vehicles tend to park up on the roadside, and there are not terminal buildings. Combined with the above, this means that the current operation of both city-bus and inter-district terminals cause significant congestion on the road network.

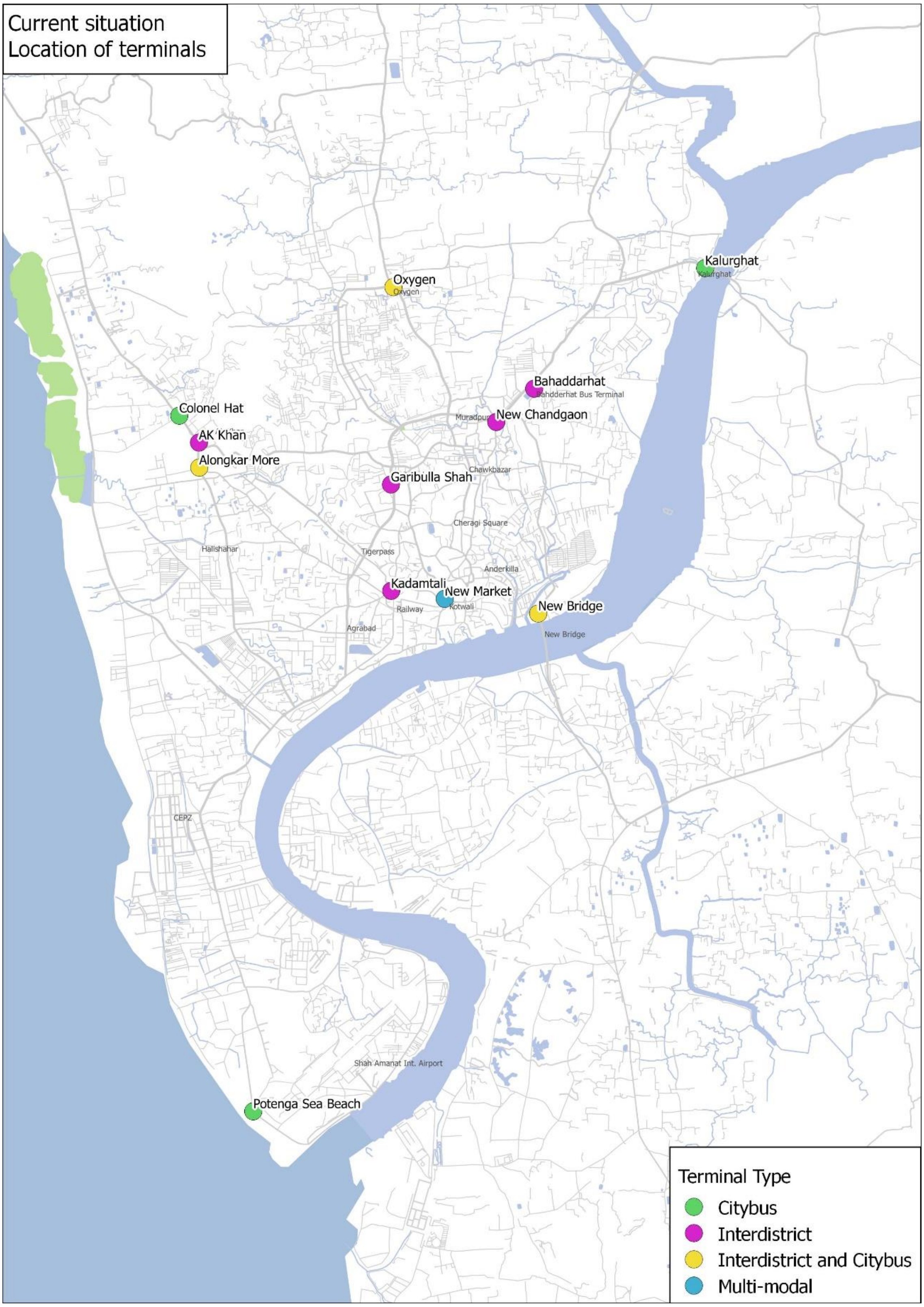
At present, inter-district buses are limited in using the city centre between 10am and 10pm. Access to these buses outside of those times is therefore provided by low-capacity public transport including tempos and human haulers (as well as rickshaws and CNGs).

Table 3-5 lists the terminals, the main destinations served and the number of inter-district services per day. The location of the terminals is shown in Figure 3-10.

Table 3-5: Characteristics of current public transport terminals

Type	Name	Main destinations	Daily no. of inter-district bus services	Peak hour frequency of departing city-bus services
City-bus	New Market	Local city-bus services	0	157
	Kalurghat	Local city-bus services	0	110
	Patenga Sea Beach	Local city-bus services	0	190
	Colonel Hat	Local city-bus services	0	50
Inter-district	New Chandgaon	Rangamati and Bandarban	291	0
	Bahaddarhat	Bandarban, Rangamati, Banshkhali, Kaptai	413	0
	Garibulla Shah (GEC)	Mainly towards Dhaka	227	0
	AK Khan	Dhaka	299	0
	Station Rd	All Over Bangladesh and Chittagong	231	0
	Kadamtali/Shuvopur	Noahkhali and Comilla	172	0
	Cinema Palace	Cox's Bazar and Teknaf	21	0
Inter-district and city bus	Oxygen (Rangamati-Hathazari Bus Station)	Local, Raujan, Rangamati, Khagrachori, Najirhat	240	12
	New Bridge (Shaheed Boshiruzzaman Sq)	Local, Anowara, Lohagara and Potia	525	63
	Alongkar Mor	Local, Dhaka, southern and northern Bangladesh	670	30
Total			**3,089**	**612**

Figure 3-10: Location of PT terminals



4. Current Travel Demand

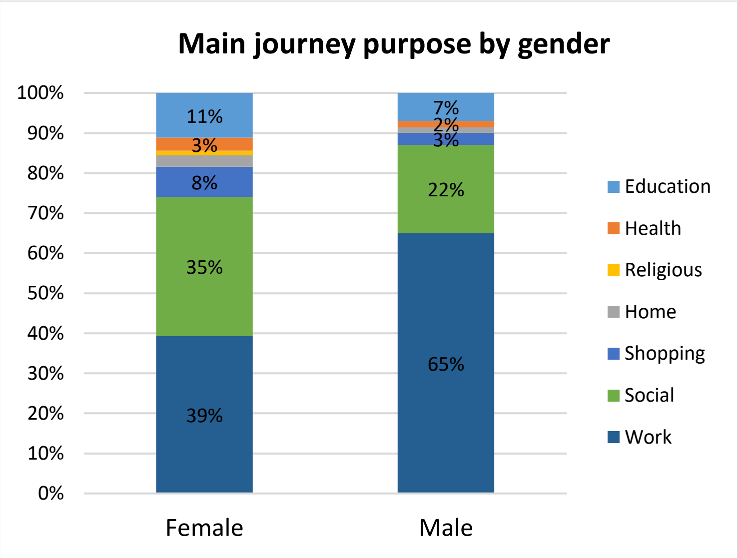
4.1 Trip rate and trip purpose

Analysis of the household interview survey has identified the average weekday trip rate of 2.3 per person, which includes all walking and other NMT trips. This is a trip rate is similar to other Asian countries[9]. Combing the trip rate with a population of 2.9 million derives the number of **total daily trips of 6.7 million** performed within the city on a typical weekday.

Figure 4-1 presents the share of trip purpose for male and female travelers. This data comes from the traveler interview surveys, the survey was conducted largely with adults, so education trips are under-reported. Overall work is the most common travel purpose, although there is a large disparity between men and women.

A large number of social trips performed by women will include caring for dependent children or the elderly - 14% of trips taken by women were traveling either with children or elderly dependents, as reported by the women's traveler survey. Compared to men, women have a wider range of trip purposes and travel to a wider range of destinations.

Figure 4-1: Purpose share of trips by gender



[9] Trip rates for other Asian cities presented in JICA (2014) HOURTANS Ho Chi Minh City Master Plan. Ha Noi: 2.6, Manila: 2.2, Kuala Lumpur: 2.5, Bangkok: 2.3, Chendu: 2.6, Tokyo: 2.3.

4.2 Mode share

4.2.1 Mode share of passenger trips

The mode share of all passenger trips has been calculated from the household interview survey and calibrated using the transport model. Figure 4-2 shows that the PT modes of bus, human-hauler and tempo, account for 43% of trips. Walking accounts for 25% of all trips, and CNG and rickshaw carry 22% of trips. As for private transport, cars account for 7% of trips and motorcycles 3%. Many of the car based trips are official or business trips.

Figure 4-2: Mode split of all passenger trips

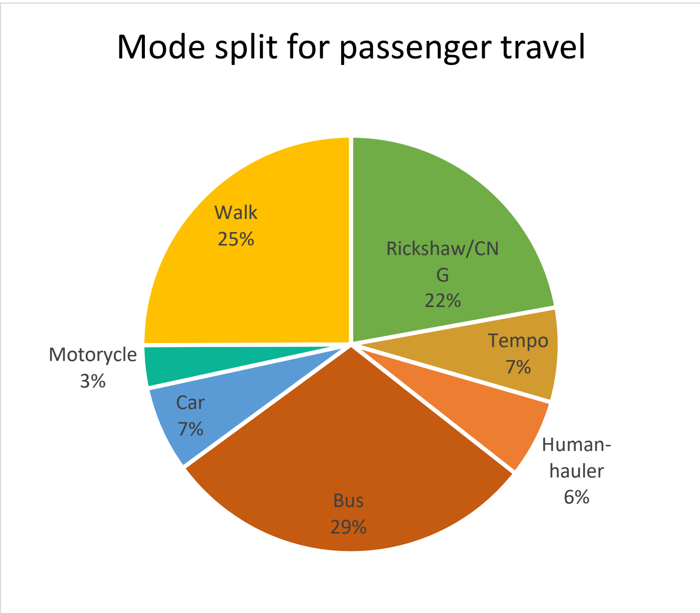
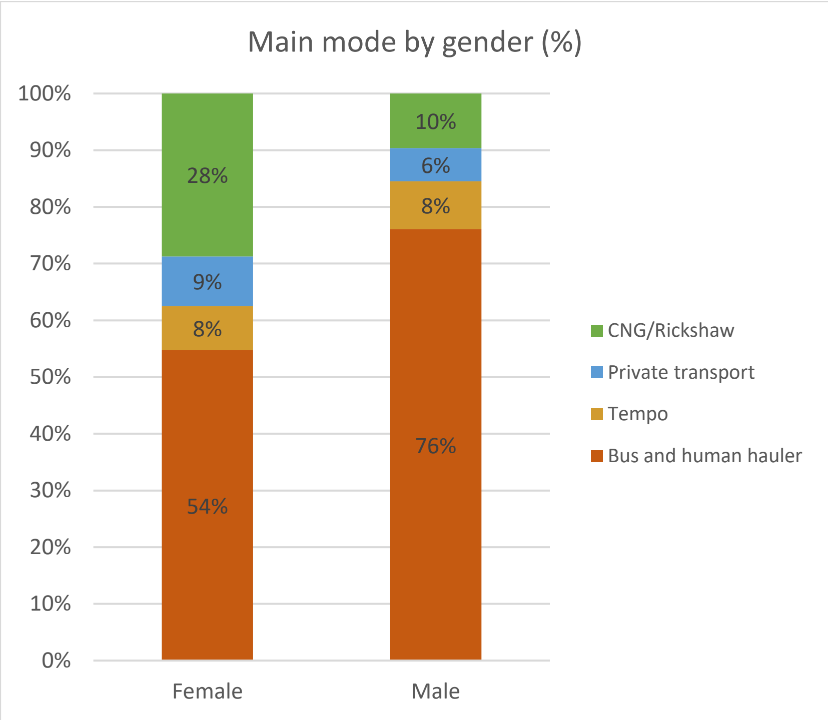


Figure 4-5 presents the aggregated mode split for each gender, as captured by the on-street traveler interview survey and women traveler survey. Women are much more likely to use CNGs or rickshaws and are less likely to use the bus or human-hauler. ITP's technical note which accompanies this study titled 'Women's access to public transport in Bangladesh' identifies three main reasons why women do not use public transport as much as men. 1) women often face harassment when they use public transport, 2) women often travel with dependents such as young or elderly who are not suited to public transport, and 3) the trips women undertake are often complicated or encompass a larger range of destinations for which public transport routes do not necessarily best serve (the wider range of trip purposes is explicit in Figure 4-1).

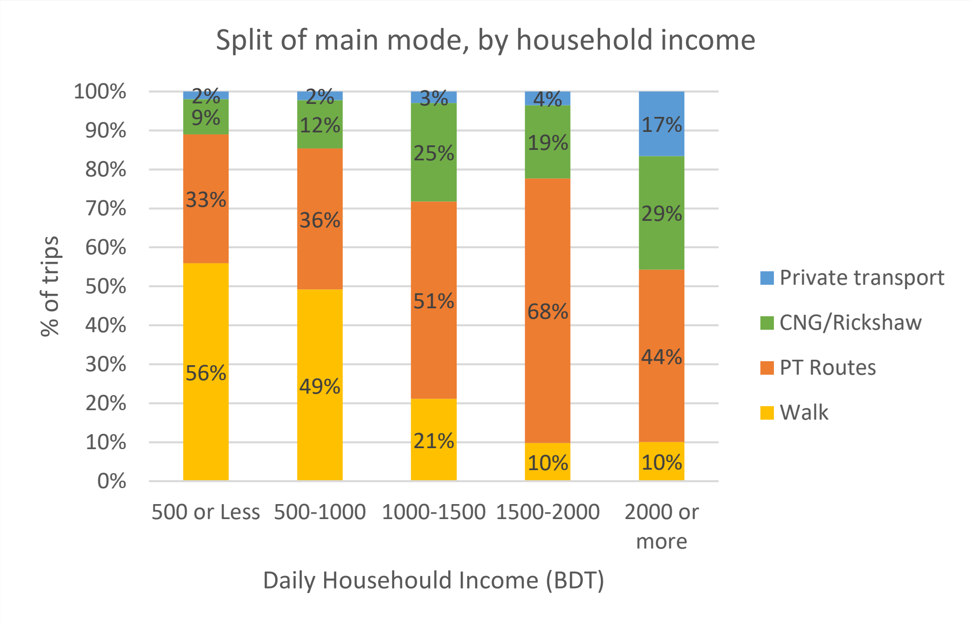
Figure 4-3: Modal share by gender (excludes walk)



Note: excludes walking because the sampling methodology did not pick up walking trips

Figure 4-4 presents the main mode of trips for different income groups. It shows that walking is the most common mode for households earning less than 100 BDT, after this earning point walking reduces considerably, while the use of PT and CNG increase. It is likely that the use of these modes is required to access better-paid jobs. PT use increases with income, except for the top income group (2000 BDT and over) who instead start to use private transport instead of PT.

Figure 4-4: How mode split varies by household income



4.2.2 Mode share of vehicle movements

Traffic counts and vehicle occupancy surveys were conducted at 21 sites located on main roads in the Chittagong. The two pie charts below (Figure 4-5) present the mode share observed on these main roads. The mode share is expressed in terms of the number of passengers carried by each vehicle type (left-hand chart) and in terms of the amount of road space the vehicles take up as measured by PCU (right-hand chart). PCU values refer to Passenger Car Units - the PCU values used are presented in Table 4-1.

This data shows that PT is very popular, as bus, human-hauler and tempo together carry 70% of all passengers, most of whom are carried by bus.

Although the majority of passengers are carried by PT, these three modes only take up a combined 30% of the road space. In contract private transport (cars and motorcycles) use 29% of road space, but only carry 13% of passengers. This highlights the inefficient use of road space which contributes to congestion and slow travel speeds. Bus, the mode that carries nearly half of all numbers of passengers, uses only 17% of road space.

Figure 4-5: Mode share and share of road space on main roads

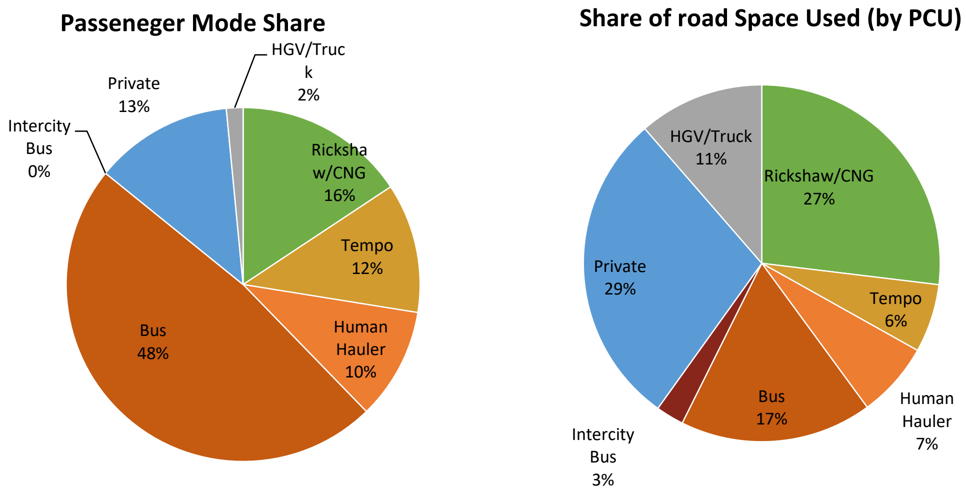


Table 4-1: Passenger Car Units (PCUs)

Vehicle	PCU value	Vehicle	PCU value
Rickshaw	0.4	Car	1
CNG	0.7	Commercial Van	1.5
Tempo	1	Rigid Trucks	1.5
Human Hauler	1.5	Articulated Trucks	2.5
Local Bus	2	Tanker	2.5
Inter-district Bus (Coach)	2	Manual Van	1
Motorcycle	0.5		

Source: The Indian Road Congress (IRC), 1994, and DHUTS Dhaka Urban Transport Study

4.3 Daily profile of traffic

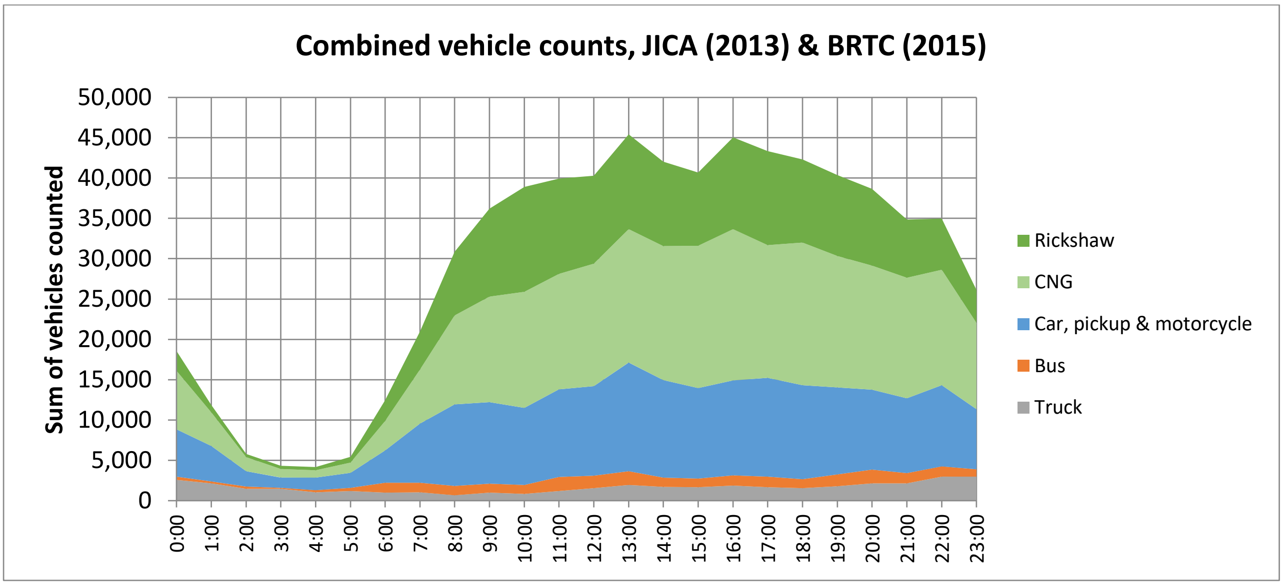
The profile of traffic flow through the day is presented in Figure 4-6. This shows count data from two studies: “Elevated Expressway from Lalkhanbazar to Hazrat Shah Amanat International Airport” conducted by BRTC in 2015 and counts conducted by JICA at four locations in 2013.

The figure shows that traffic volumes in Chittagong build throughout the day, until falling after the mid-afternoon. This represents a smooth bell-curve shape, without a demarked AM or PM peak period.

CNG vehicle movements form the main component of the bell-shaped curve of daily traffic volume at these sites. The high number of CNGs are observed independently in both the JICA and BRTC counts. Car and rickshaw also make up a substantial portion of the traffic, and these profiles tend to be flatter through the day.

It should be noted that the graph shows the profile of vehicles through the day, but not passengers whose movements may exhibit a peaked daily profile.

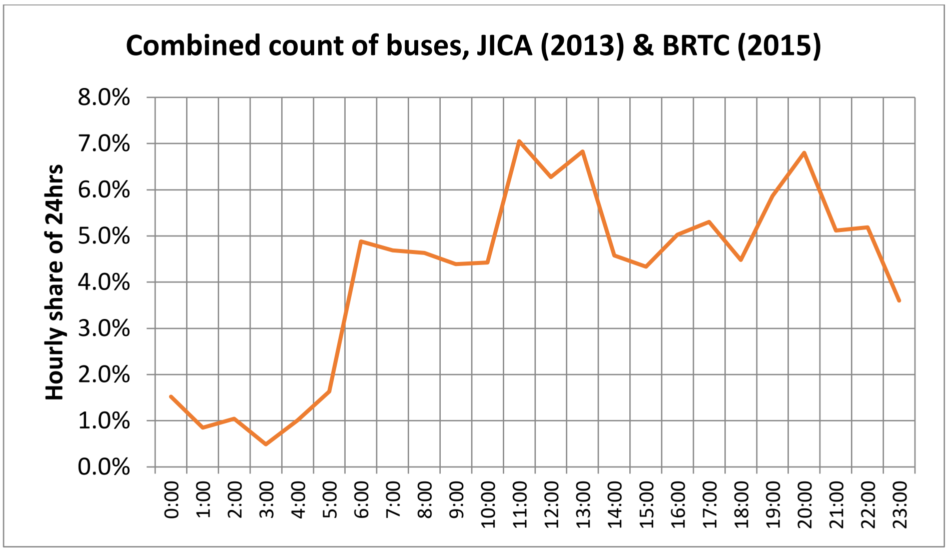
Figure 4-6: Daily profile of traffic volume by mode



Buses are shown to make up a relatively small proportion of the total traffic volume (Figure 4-6), however we know from the household interview survey that a plurality of trips are made by bus (shown in Figure 4-2). Figure 4-7 isolates the bus counts, as observed by JICA (2013) and BTRC (2015). This shows small AM and PM peaks between 11am-1pm and 7-9pm.

The pattern of travel in Chittagong does not exhibit an AM/PM peaked profile familiar in western countries of 7 to 9am and 5pm to 7pm. The international standard of a 9 to 5 day does not necessarily dominate in Chittagong, therefore trips are conducted over a larger range in times. As a result, this suppresses the peak and generally moves it by about 2 hours later in the day.

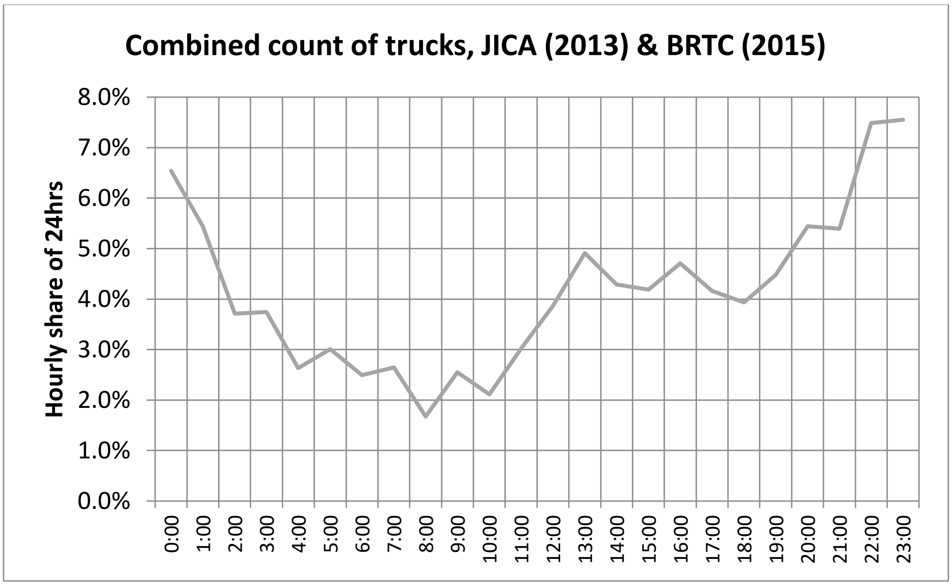
Figure 4-7: Daily profile of bus traffic volume



Trucks do not comprise a large proportion of the traffic at the JICA (2013) and BRTC (2015) count locations (Figure 4-6). However, isolating the truck counts from these studies shows a dipped pattern of truck movements (Figure 4-8), with a plurality of trucks moving at night, about 6% per hour from 8pm-2am, and the fewest truck moments occurring between the hours of 4 and 12am. It is to be welcomed that more trucks try to move at night, so they don't contribute to congestion during the day.

Trucks are not allowed to ply the city roads between 7am and 8pm except for Port Link Rd, Port Connecting Road and Agrabad Access Road.

Figure 4-8: Daily profile of truck traffic volume



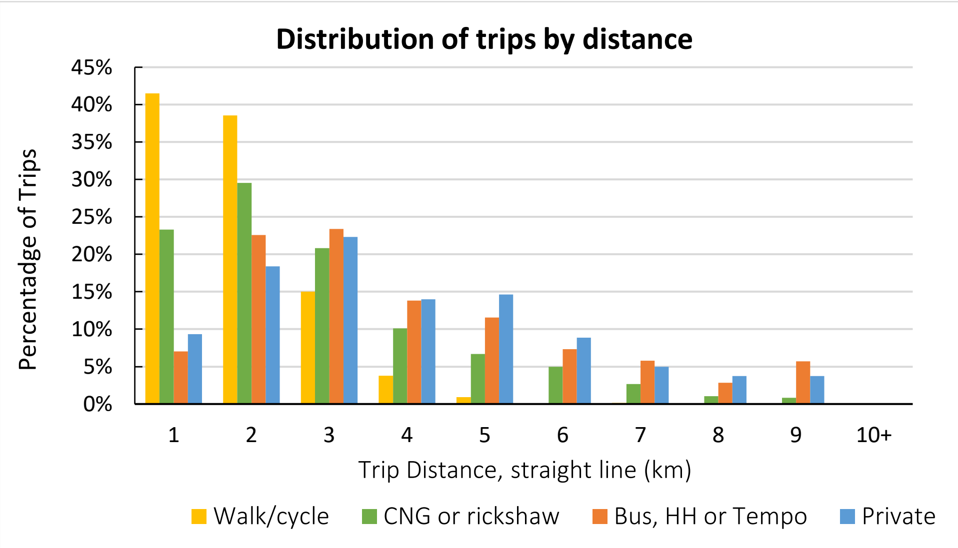
4.4 Trip length

The spatial pattern of trips performed in Chittagong has been derived from the household interview survey and vehicle intercept survey as well as the trip purpose and mode used. Both of these surveys asked respondents to detail the origin and destination locations for the trips they make. Origin-destination data is frequently referred to as 'OD' data.

Figure 4-9 presents the distribution of trip lengths for chained trips, disaggregated by the main mode. The average trip length by mode is listed in Table 4-2.

As expected walking trips are the shortest at 1.3km on average and trips conducted by private modes (mostly car and motorcycle) are the longest at 3.0km. In comparison globally, trips conducted in Chittagong tend to be short. Average trip length in Cebu (Philippines) is 4.8km[10], Ho-Chi-Minh-City (Vietnam) 7.5km[11] and Nairobi (Kenya) 11.4km[12]. The short trip length may reflect the compact and dense nature of the city as well as the poor levels of accessibility across the city, as detailed in section 7.1.3.

Figure 4-9: Distribution of trips by straight line distance



Source: eGen 2017 household interview survey and vehicle intercept survey

[10] ITP, 2012. Cebu BRT FS
[11] ITP 2014, Ho-Chi-Minh-City BRT FS
[12] ITP 2017, Nairobi line 1 BRT FS

Table 4-2: Average trip length, by the main mode

Mode	Average trip length, straight line (km)
PT	3.6
CNG or rickshaw	1.8
Private	3.0
Walk/cycle	1.3
All Trips	**2.6**

4.5 Spatial pattern of travel demand

The OD data has been coded into the 64 zones created from Chittagong ward boundaries. To visualise the movements being made in Chittagong the OD data has been presented in a series of maps with desire lines between each zone, see Figure 4-10 to Figure 4-15. OD matrices have been developed for each of the five modal groups which feed into the transport model, these are:

- PT: bus, human-hauler and tempo
- CNG and rickshaw
- Car and motorcycle
- Walk/cycle
- Truck

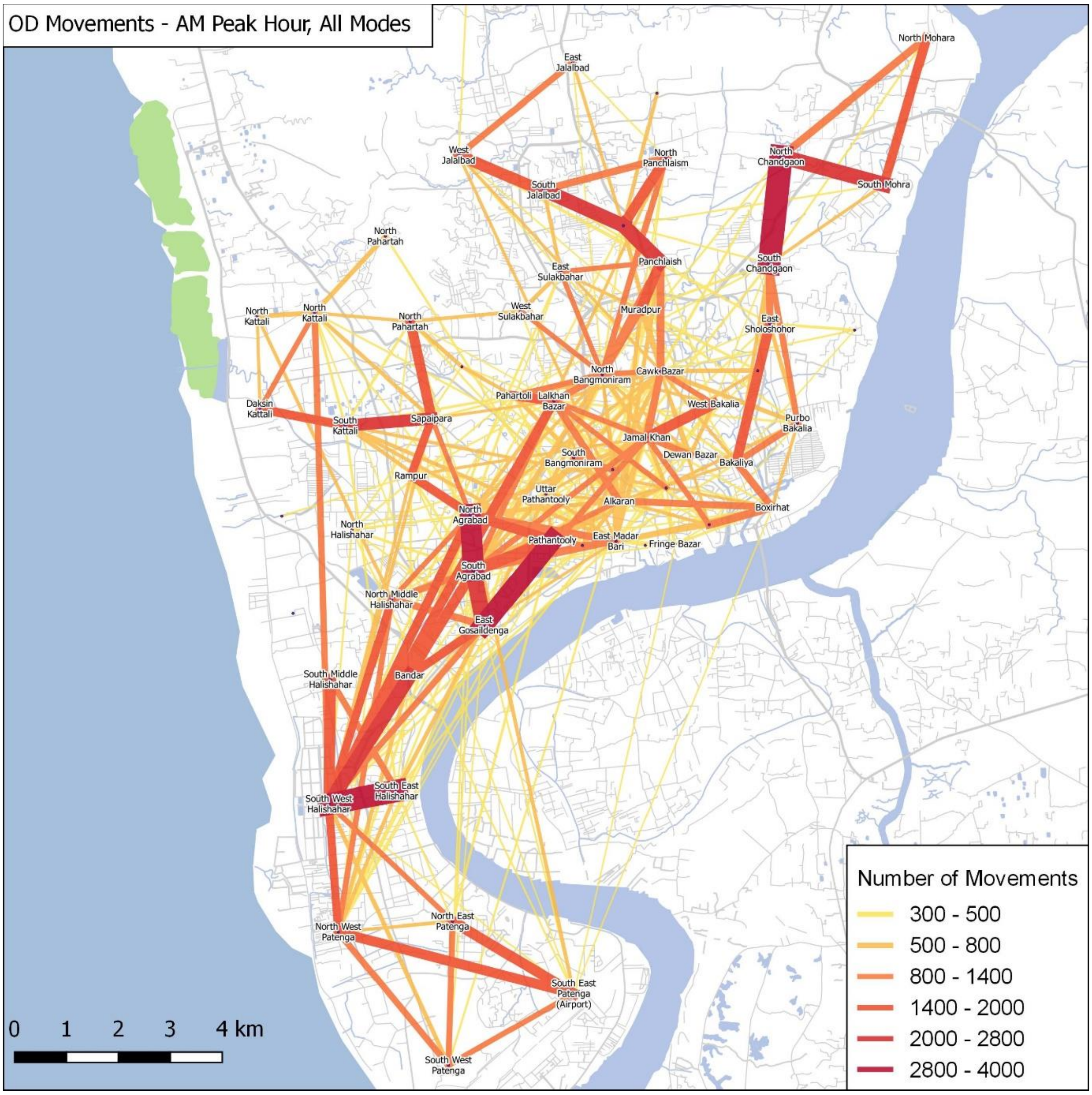
Figure 4-10 shows the AM peak hour movements for all modes. This data indicates that the movement in Chittagong is polycentric rather than monocentric. Popular movements are found in all areas of the city as opposed to a pull towards a single city centre.

There is a cluster of popular movements towards the south-west Halishahar area where the CEPZ is located. This shows that this economic zone is one of the key trip attractors in Chittagong.

Other areas of high trip attraction include core include North Bangmoniram which is where GEC bus stop is located, Jamal Khan, Chawkbazar, and Khulshi. In addition, significant movements occur in more peripherals areas of the city such as between North and South Chandgaon, movements in

Halishahar, movements in Jalalabad and Panchlaish. There is also a concentration of movements in the Agrabad and Gosaildenga area.

Figure 4-10: OD movements in AM peak - all modes



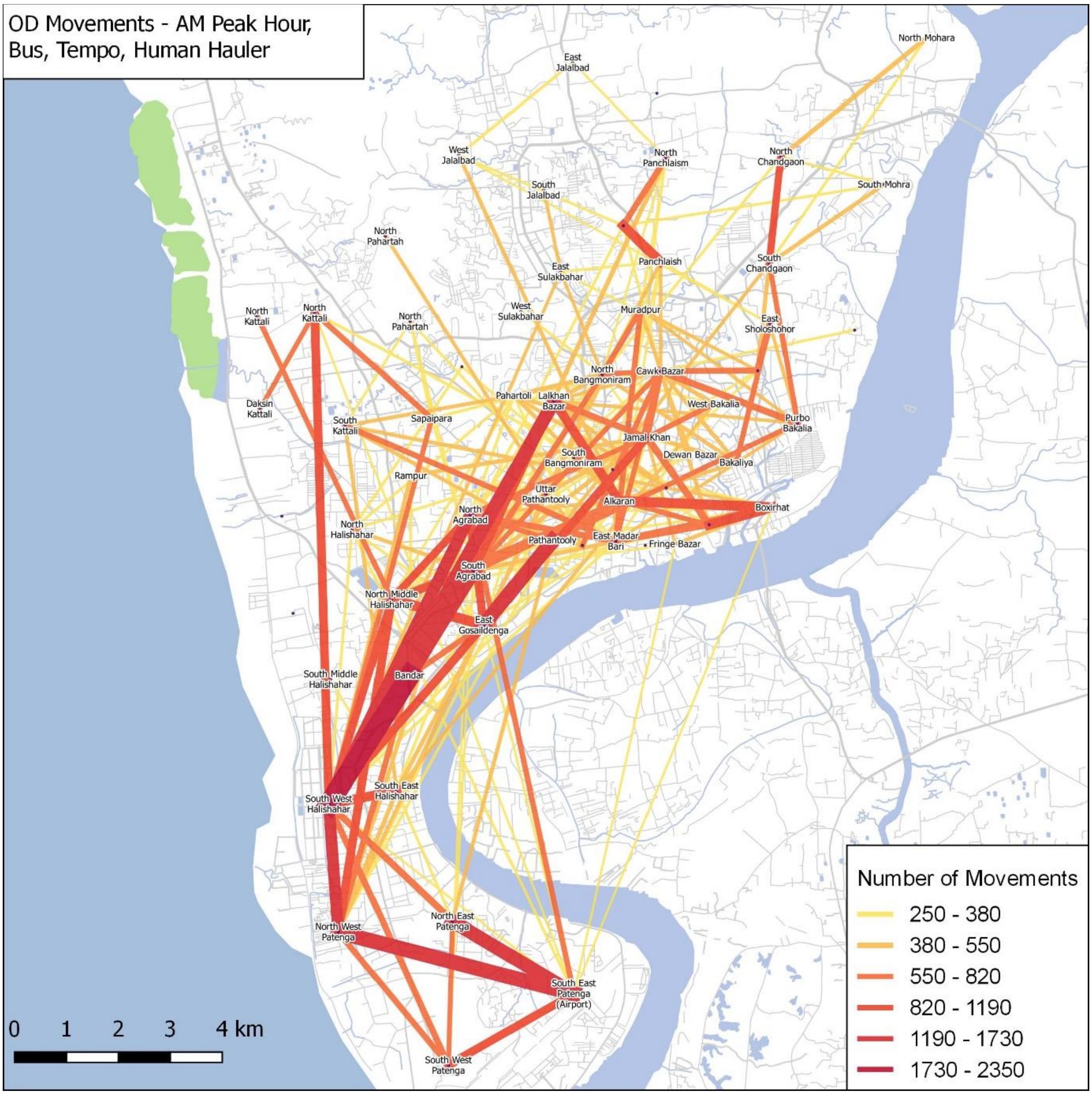
Factored up from the vehicle intercept survey (19,445 trips), the household interview (2,697 trips) and traveller interview (2,016 trips)

4.5.1 Public transport

Geographically, Figure 4-11 highlights the importance of public transport in serving the CEPZ in South West Halishahar (CEPZ). The strongest of these movements occur between south-west

Halishahar and areas located along the corridor between CDA Avenue and CEPZ. The city centre areas of Alkaran, East Madar Bari and Pathantooly are also popular destinations with movements of high volume from all parts of Chittagong.

Figure 4-11: OD movements in AM peak - PT: bus, human-hauler, tempo



Factored up from the household survey (1,268 trips) and traveller interview (1,611 trips)

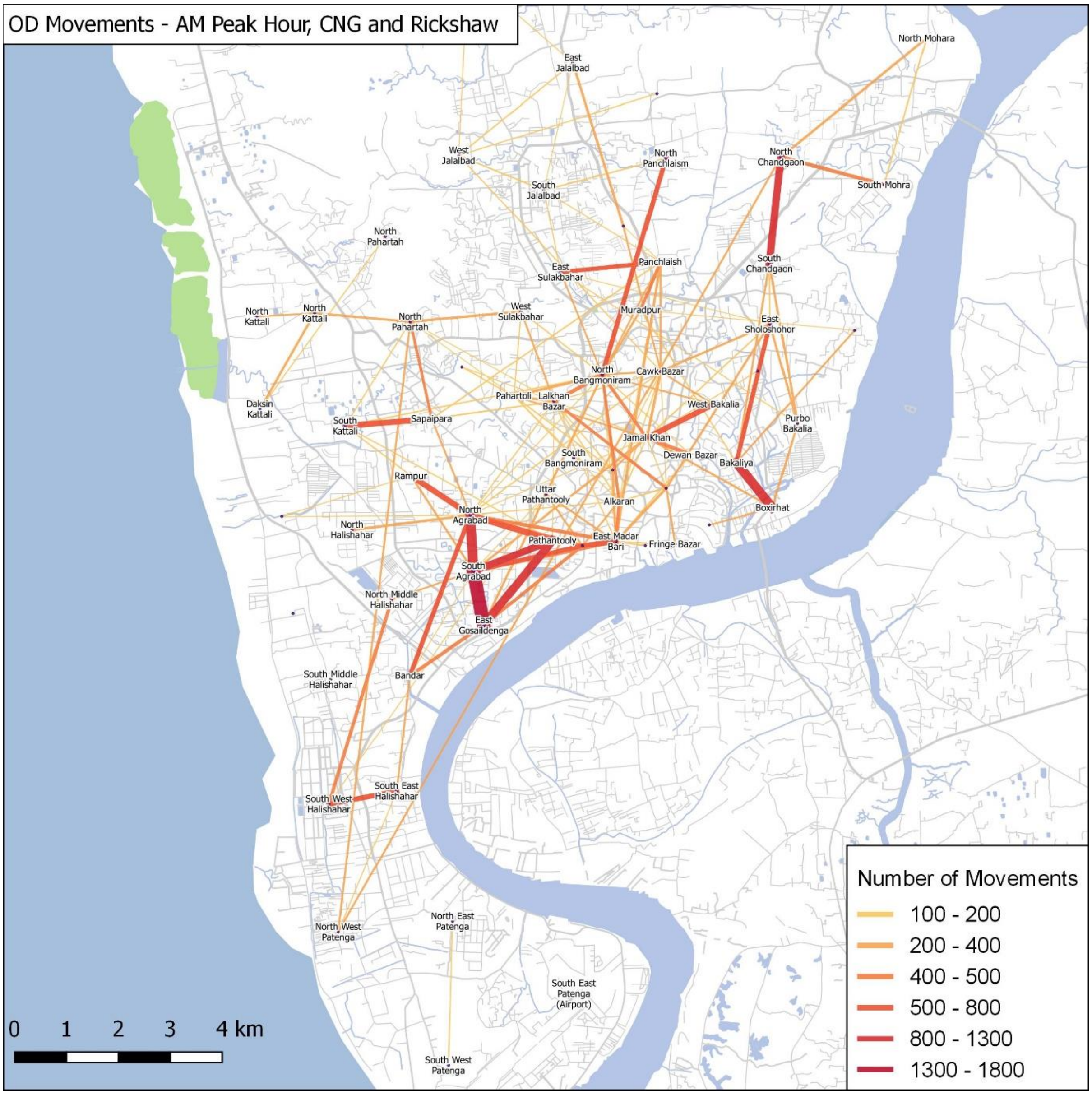
4.5.2 CNG and rickshaw

Figure 4-12. shows that most of the CNG and rickshaw trips occur in the east of the city and around Agrabad and Gosalidenga as well as connecting these areas to the central areas of Pathantooly and East Madar Bari. CEPZ and the surrounding areas are not key trip attractors for CNG and rickshaws.

CNG and rickshaws are important for local accessibility. This is evident through high volumes of short, local movements between outer city areas sujhjio9ch as between; North Chandgaon and South Chandgaon and between South Kattali and Sapaipara. In addition, other popular movements include between Boxihrat and Bakalia, West Bakalia and Jamal Khan.

Although most high volume CNG/Rickshaw movements are short in distance, North Panchaism to North Bangmoniram is a longer distance movement with a high flow. This could suggest a poor PT connection as it is also not a popular movement with public data in Figure 4-11.

Figure 4-12: OD movements in AM peak - CNG and rickshaw

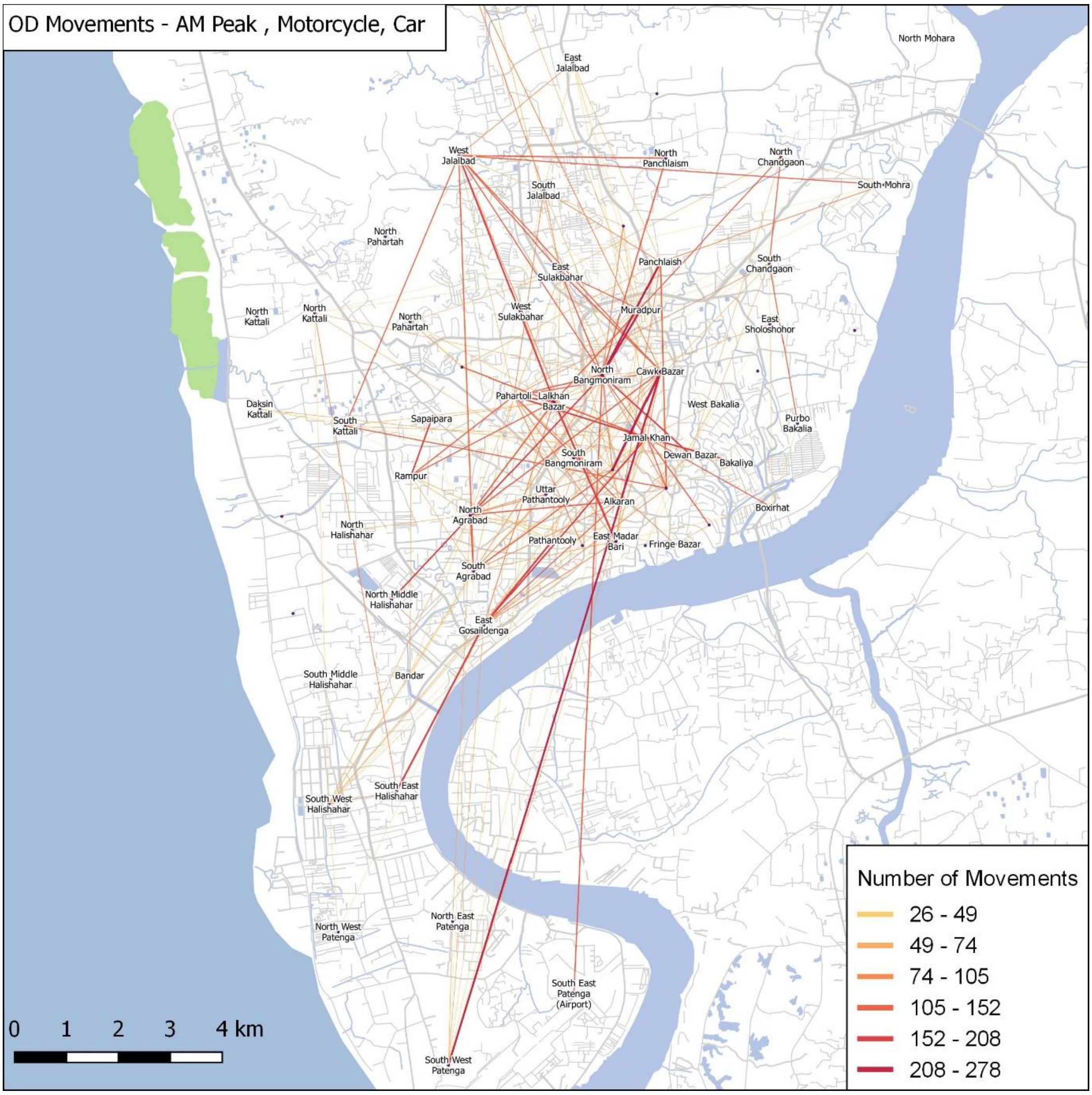


Factored up from the vehicle intercept survey (15,804 trips), household survey (623 trips) and traveller survey (183)

4.5.3 Car and motorcycle

The OD movements for car and motorcycle are shown in Figure 4-13. As car ownership is low in Chittagong (section 0) the volume of movements around the city are low. The data shows that car and motorcycle trips tend to be longer in distance.

Figure 4-13: OD movements in AM peak – car and motorcycle



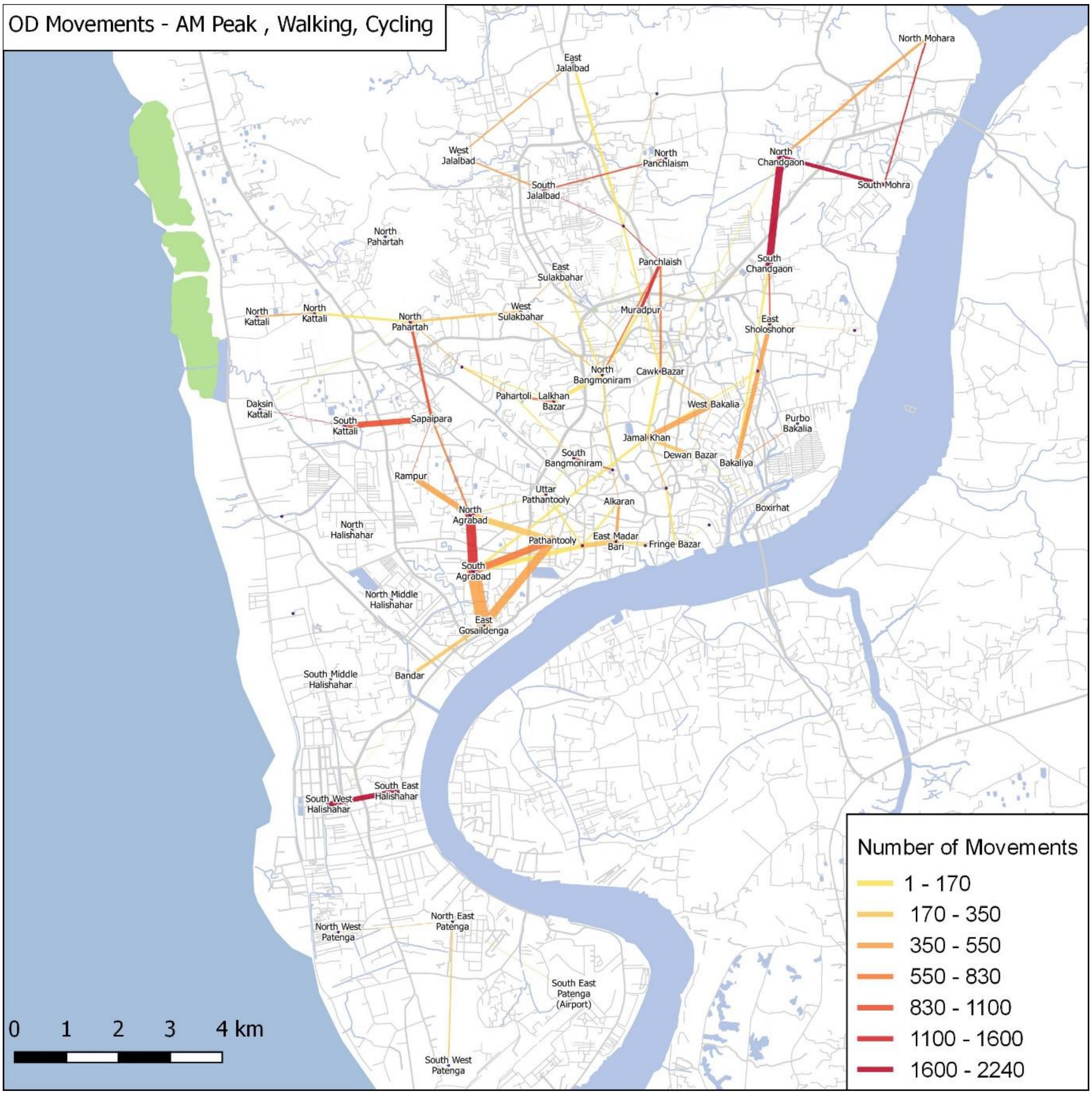
Factored up from vehicle intercept survey (3,625 trips), household survey (185) and traveller survey (104)

4.5.4 Walk and cycle

High volumes of walking trips occur locally in some areas, as shown in Figure 4-14. This includes between South West Halishahar (CEPZ) and South East Halishahar, North and South Agrabad, South Agrabad and East Gosaildenga, North and South Chandgaon.

Figure 4-9 shows the distribution of walking trips by distance. As can be expected walking is mainly used for short distance trips with 54% of walking trips having a distance of less than 0.5 km.

Figure 4-14: OD movements in AM peak - walk and cycle



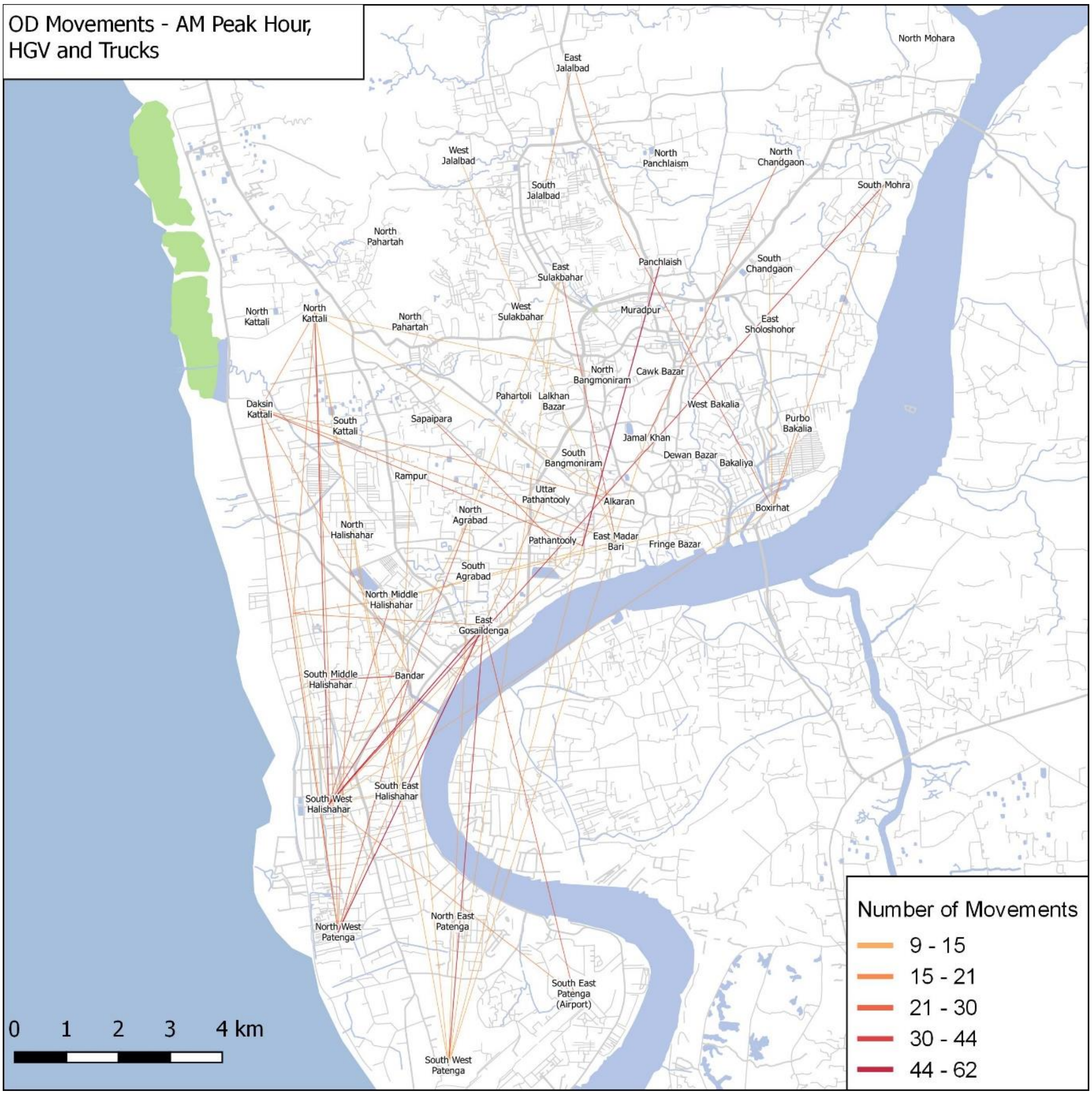
Factored up from household survey (621)

4.5.5 Trucks

Figure 4-15 shows that the general trend of truck movements to be to the south-west of the city, where the Port and CEPZ is located. Unlike passenger transport modes, there are few tuck movements to city centre locations.

Key logistic trip attractors include the container terminal in East Gosaildenga. The industrial areas and factories of the CEPZ mean Halishahar and Patenga are also popular destinations.

Figure 4-15: OD movements in AM peak - trucks



Factored up from vehicle intercept survey (1,697 trips)

4.6 PT interchanges

The boarding and alighting data collected across the city identifies the number of passengers using each PT stop in the city (Figure 4-16). The 20 busiest interchanges (excluding terminals) are listed in Table 4-3.

Figure 4-16: Boarding and alighting movements for all PT modes, AM Peak

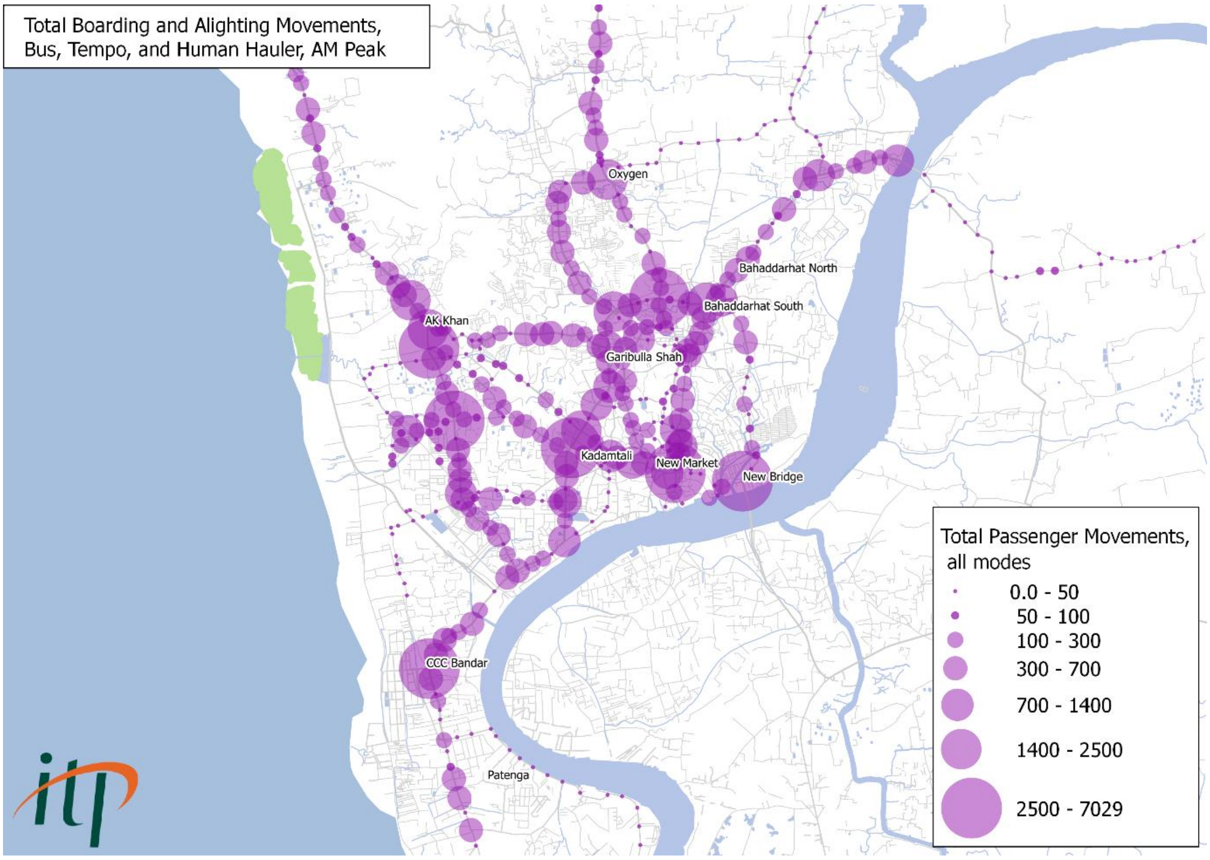


Table 4-3: Top 20 busiest interchanges (excluding terminals)

Interchange name	Lat	Lon	Maximum hourly no. of passengers boarding and alighting
Dewanhat	22.339	91.814	4,137
Muradpur	22.369	91.833	3,408
CEPZ	22.293	91.782	2,948

Interchange name	Lat	Lon	Maximum hourly no. of passengers boarding and alighting
Noya Bazar	22.344	91.788	2,746
Kotwali	22.333	91.837	2,573
2 No. Gate	22.366	91.823	2,158
Tigerpass	22.342	91.816	1,700
GEC Circle	22.359	91.822	1,792
Laldighir Par	22.339	91.838	1,835
Badamtoli Circle	22.328	91.812	1,301
Anderkilla	22.342	91.837	1,261
Agrabad Access Rd	22.329	91.789	1,225
Lal Chand Rd/Nabab Siraj Ud Daula Rd	22.357	91.840	1,580
Ispahani Circle	22.347	91.819	1,016
Arkan Rd/Nabab Siraj Ud Daula Rd	22.358	91.839	1,122
Katgar	22.260	91.791	1,156
Barik Bldg	22.319	91.812	816
Kaptai Rastar Matha	22.394	91.868	820
WASA Square	22.351	91.822	792
Customs	22.312	91.799	650

5. Future Travel Demand

5.1 Development of a transport model

A transport model has been developed using PTV VISUM[13] to:

- understand the impact of the growing demand for trips upon transport conditions in the future,
- help design transport schemes that improve mobility in Chittagong, and;
- help appraise these transport schemes.

A detailed explanation of this model is provided in the report, *D4: Traffic Survey and Demand Analysis: Section B, Model Report*. Elements of this report are summarised here.

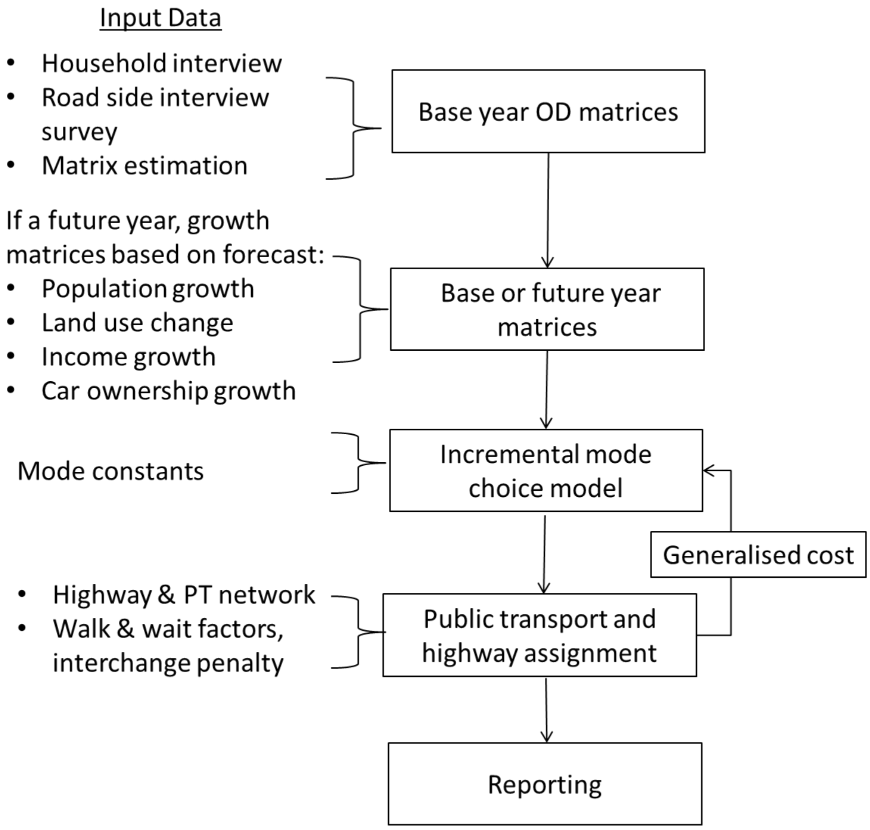
The short time horizon of this study lends itself to a model which assigns the observed trip matrices (growthed up for future years), rather than a 4-step model. The strength of this approach lies in grounding the future matrices in today's observed trip patterns, thereby yielding more accurate forecasts in the near term.

The method of starting with observed trip patterns is well suited to the use of an incremental logit mode choice model which is appropriate for modelling improvements in PT. Improvements in PT are a focus area for this SUTMP. The incremental mode choice model is recommended in the Bus Rapid Transit Practitioner's Guide[14]. It uses the observed mode split data, hence the reason why basing trip demand on observed OD data is well suited.

Figure 5-1 presents a simplified representation of the model structure. A loop occurs between the assignment module and the mode choice module, to allow mode choice to reflect the correct generalised costs, by mode, for travel between each zone pair.

[13] http://vision-traffic.ptvgroup.com/en-us/products/ptv-visum/
[14] TCRP, 2007. *Bus Rapid Transit Practioner's Guide*. Transit Cooperative Research Program, Report 118, p3-14

Figure 5-1: Model structure



The model assigns the following five demand segments:

- Walkers
- PT routes: bus, human-hauler, tempo
- Rickshaw-type: CNG and rickshaw
- Private vehicles: car and motorcycle
- Trucks

Each demand segment has a separate OD matrix and follows different assignment rules.

5.2 Future changes in trip demand

To predict the future transport challenges for the city, forecasts for the growth in trips and changes in the types of trips have been produced up to the year 2030. This covers growth in population, rising income, rising car ownership and expansion of the Port.

5.2.1 Growth in passenger trips

Growth in passenger travel is caused by population growth and an increase in trip rate. Table 5-1 presents the forecast population growth, GDP per capita, trip rate rise and the resulting growth in total daily trips.

The UN forecast the population of the metropolitan area of Chittagong to increase from 4.5M in 2015 to 6.7M in 2030[15] - an annualised growth rate of 2.6%. The city area of Chittagong represents a smaller part of this wider metropolitan area. Considering the UN forecasts, we forecast the population within the city boundary to increase from 2.9M today to 4.1M in 2030 (Table 5-1).

The trip rate is the average number of trips performed by a person per day - in Chittagong this is currently 2.3 trips per day per person. Trip rate is positively related to income level, so that when incomes rise, the number of trips undertaken tends to rise. Research by Diaz Olvera et al (1998)[16] provides a mathematical function for this relationship, the details of its application can be found in the modelling report. Considering the forecast increase in incomes we forecast trip rate to increase from 2.3 today to 2.5 in 2030.

Personal income levels are assumed to rise in line with GDP per capita. In the absence of forecasts specifically for Chittagong, forecasts of GDP per capita for the whole of Bangladesh are used. GDP per capita for the year 2016 is provided by the World Bank. Projected growth is based on the IMF forecast for 2016 to 2021. Beyond 2021 it is assumed that growth in GDP per capita tails off to 5.0% per year between 2025 and 2030, which continues the trend of the declining growth rate in GDP per capita.

[15] UN Population Division, 2014. World Urbanisation Prospectus
[16] Diaz Olvera, L., Plat, D., Pochet, P., 1998. Villes africaines au quotidien. LET, Etudes & Recherches 9, Lyon

Table 5-1: Forecast growth in passenger trips

Year	CCC Area population	GDP per capita (USD, constant 2016)	Daily trip rate (trips per person)	Total Daily Trips
2017	2,900,000	1,400	2.27	6,700,000
2020	3,200,000	1,700	2.33	7,400,000
2022	3,400,000	1,900	2.36	7,900,000
2025	3,700,000	2,200	2.42	8,900,000
2030	4,100,000	2,800	2.50	10,400,000

5.2.2 Rise in car ownership

As incomes rise, car ownership also tends to rise. To project the future growth in car ownership, we have calibrated, to the Chittagong context, a mathematical function that describes this relationship. The details of which can be found in the modelling report.

Data provided by BRTA shows there are currently 29,000 private cars registered in Chittagong which equates to 9.9 cars per 1,000 inhabitants. Considering Income growth, we forecast car ownership to double to 18.2 cars per 1,000 inhabitants by 2030 (Table 5-2). Considering population growth, the total number of cars registered in Chittagong is forecast to increase 150% from 29,000 today to 75,000 in 2030.

Table 5-2: Forecast growth in car ownership

Year	GDP per capita (USD, constant)	Cars per 1,000 inhabitants	Total cars registered in Chittagong
2017	1,400	9.9	29,000
2020	1,700	11.1	35,000
2022	1,900	12.1	41,000
2025	2,200	14.0	51,000

Year	GDP per capita (USD, constant)	Cars per 1,000 inhabitants	Total cars registered in Chittagong
2030	2,800	18.1	75,000

5.2.3 Increase in truck trips

The number of trips conducted by truck is assumed to increase in line with GDP growth. Forecasts for GDP growth are presented in Table 5-3. Forecasts are provided are by the IMF up to 2021 with an extrapolation developed by the study team for years up to 2030.

Table 5-3: Forecast increase in truck trips

Year	GDP (Billion BDT, constant)	GDP Annual growth rate
2017	9,529*	6.9%
2020	11,645	6.5%
2022	13,208	6.5%
2025	15,940	6.1%
2030	21,432	5.7%

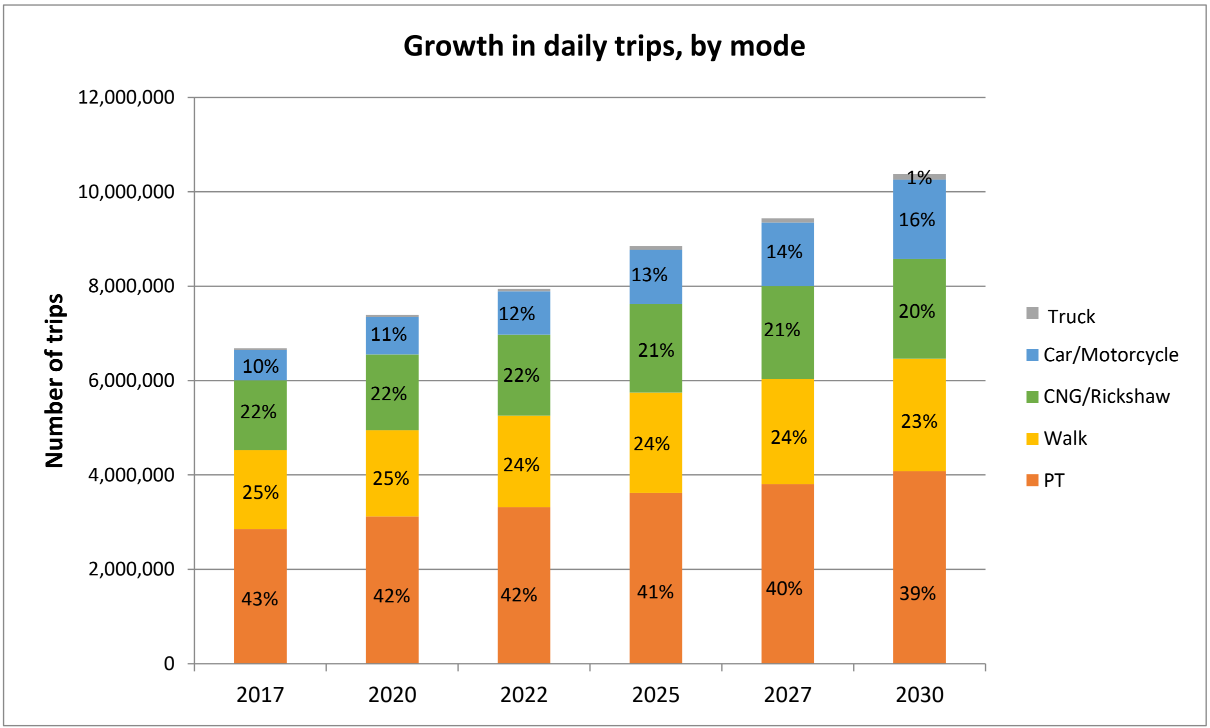
* IMF 2016, World Economic Outlook Database

5.2.4 Overall change in travel demand

The overall forecast growth in daily trips, and associated change to mode split, are presented in Figure 5-2. The following changes are forecast between the years 2017 and 2030:

- Total daily trips to increase by 60% from 6.7M today to 10.4M in 2030
- PT trips to increase by 40% from 2.9M today to 4.1M in 2030
- Walk trips to increase by 40% from 1.7M today to 2.4M in 2030
- Car trips to increase by 160% from 0.8M today to 1.7M in 2030
- Truck trips to increase by 220% from 35,000 today to 113,000 in 2030

Figure 5-2: Projected growth in trips by mode, to 2030



5.3 Specific land-use developments

There are a number of major land-use development projects that are either planned or expected to be implemented before 2030. These are likely to have a significant impact on the spatial pattern of OD trips. Table 5-4 presents the schemes that are considered as part of the modelling exercise.

Table 5-4: Proposed developments that will have a significant impact on future trip demand

Name	Location	Zone	Description	Estimated level of completion		Source of trip demand information
				2025	2030	
Anonnya Residential Project	Oxygen - Quaish Rd	58	2,825 houses 10 commercial plots Hospital, Shopping mall, offices	50%	100%	CDA
Fateabad New Town	Chittagong – Hathazari Rd	64	No information provided – assumed similar as above	50%	100%	CDA

Name	Location	Zone	Description	Estimated level of completion		Source of trip demand information
				2025	2030	
Karnaphuli Tunnel & Anwara		65	Development following the construction of a tunnel under Karnaphuli River near Patenga	50%	100%	Karnaphuli Tunnel Feasibility Study[1]
Boalkhali District	Chittagong – Cox's Bazar Hwy	67	Development following the construction of a new 4 lane bridge over Karnaphuli River at Kalurghat	0%	50%	Consultants estimation based on Karnaphuli Tunnel FS
Chittagong Port Bay Terminal	Chittagong Coastal Rd	43	Container port to handle ~10,000 trucks per day	25%	100%	Chittagong Port Authority

6. Committed Transport Projects

There is a large number of transport projects in Chittagong that are being constructed at the moment or are planned and committed. Many of these projects arise from the 1995 Urban Development Plan and Transportation Plan.

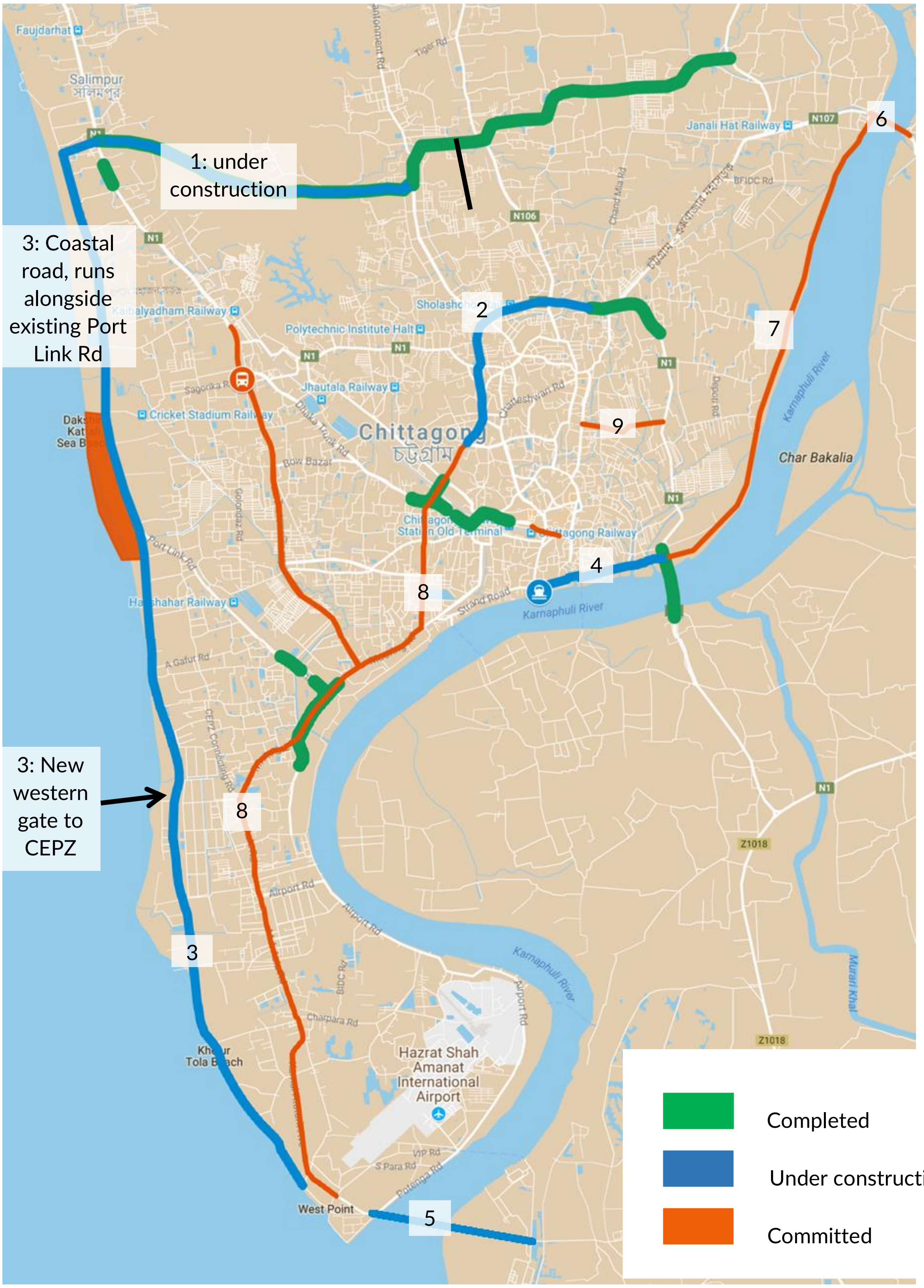
The study team consulted with each of the implementing agencies in Chittagong, CDA and CCC, to catalogue these ongoing and committed projects. Table 6-1 describes the projects, and their locations are mapped in Figure 6-1. This SUTMP assumes that these projects will be delivered, therefore the schemes have been included in the do-minimum scenario when modelling transport conditions in future years.

Table 6-1: Committed major road improvement schemes

	Name	Description	Status in 2017	Included in future year network	
				2025	2030
1	Outer Ring Road: Bayazid Bostami Road to Dhaka Trunk Road	4 lane arterial road	Under construction	✓	✓
2	Elevated expressway: Bahaddarhat to Lalkahan bazar Circle	4 lane elevated expressway Ramps at: • East of Bahaddarhat (existing) • Sholashohor 2 No Gate • North of Lalkhan Bazar Circle	Now complete, but was under construction when this SUTMP study started	✓	✓
3	Outer Ring Road: Coastal Road from Patenga to Fouzdarhat	4 lane arterial road • Runs alongside existing Port Link Rd in the northern section. • Includes western gate to CEPZ • Schematic in Figure 11-1 of D2: Existing Data, Documents and Plans	Under construction	✓	✓

	Name	Description	Status in 2017	Included in future year network	
				2025	2030
4	Inner Ring Road, Mariners Road from Shah Amanat Bridge to Sadarghat	4 lane arterial road	Under construction	✓	✓
5	Karnaphuli River Tunnel	4 lane tunnel	Under construction	✓	✓
6	New Kalurghat Road Bridge	4 lane bridge	Committed		✓
7	Karnaphuli River Embankment Road (Kalurghat Bridge – Chaktai)	4 lane arterial road	Committed		✓
8	Elevated Expressway: Lalkhan Bazar/WASA-Airport	4 lane elevated expressway • Schematic in Figure 11-2 of D2: Existing Data, Documents and Plans	Committed		✓
9	Bakalia Access Road	4 lane distributor road	Committed		✓

Figure 6-1: Map of committed major road improvement schemes



7. Transport Problems

7.1 Accessibility

7.1.1 Slow speeds

The GPS based speeds surveys have shown that average vehicle speeds in Chittagong are low, with the slowest speeds observed in the afternoon when traffic is at its highest (Table 7-1). Figure 4-6 shows that traffic levels typically build through the day, with a majority of vehicles travelling in the afternoon (1pm-6pm).

Cars achieve relatively high speeds during the morning period, but were much slower during the afternoon peak period. Operational bus speeds were the lowest overall, achieving only 13.9Kph in the AM peak and only 10.3Kph in the PM peak. Tempos and human-haulers, were somewhat faster than buses, but were slower than private means of transport.

The travel speeds in the PM period are slow when compared globally. In comparison average operational bus speeds are 13.6kph in London[17], 16kph in Nairobi[18], 18kph in Kiev[19], and 13.4kph for Jeepneys in Manila and 18kph for Buses in Manila[20].

Table 7-1 Average speed by mode (Kph)

Mode	AM	PM
Car	18.3	10.7
Truck	20.8	15.0
CNG	16.0	11.7
Bus	13.9	10.3
Tempo	16.2	12.7
Human Hauler	15.4	12.5

[17] Transport for London,
[18] ITP 2017, Nairobi BRT FS
[19] ITP 2015, Kiev Sustainable Urban Transport Study
[20] ITP 2014, Manila Road Transit Rationalisation Study

Mode	AM	PM
Rickshaw	9.1	8.2

Figure 7-2 and Figure 7-3 map the speeds for car and bus during the PM peak. Specific problem areas include: (i) the roads leading to and from the port and EPZ facilities, and (ii) the three roads that connect the city centre to the northeast periphery, specifically Bayazid Bostami, Chandgaon, Hathazari, and Panchlaish. A summary of the roads with severe congestion (less than 15 Kph) is presented in Figure 7-1.

Figure 7-1: Road segments which experience notably slow speeds

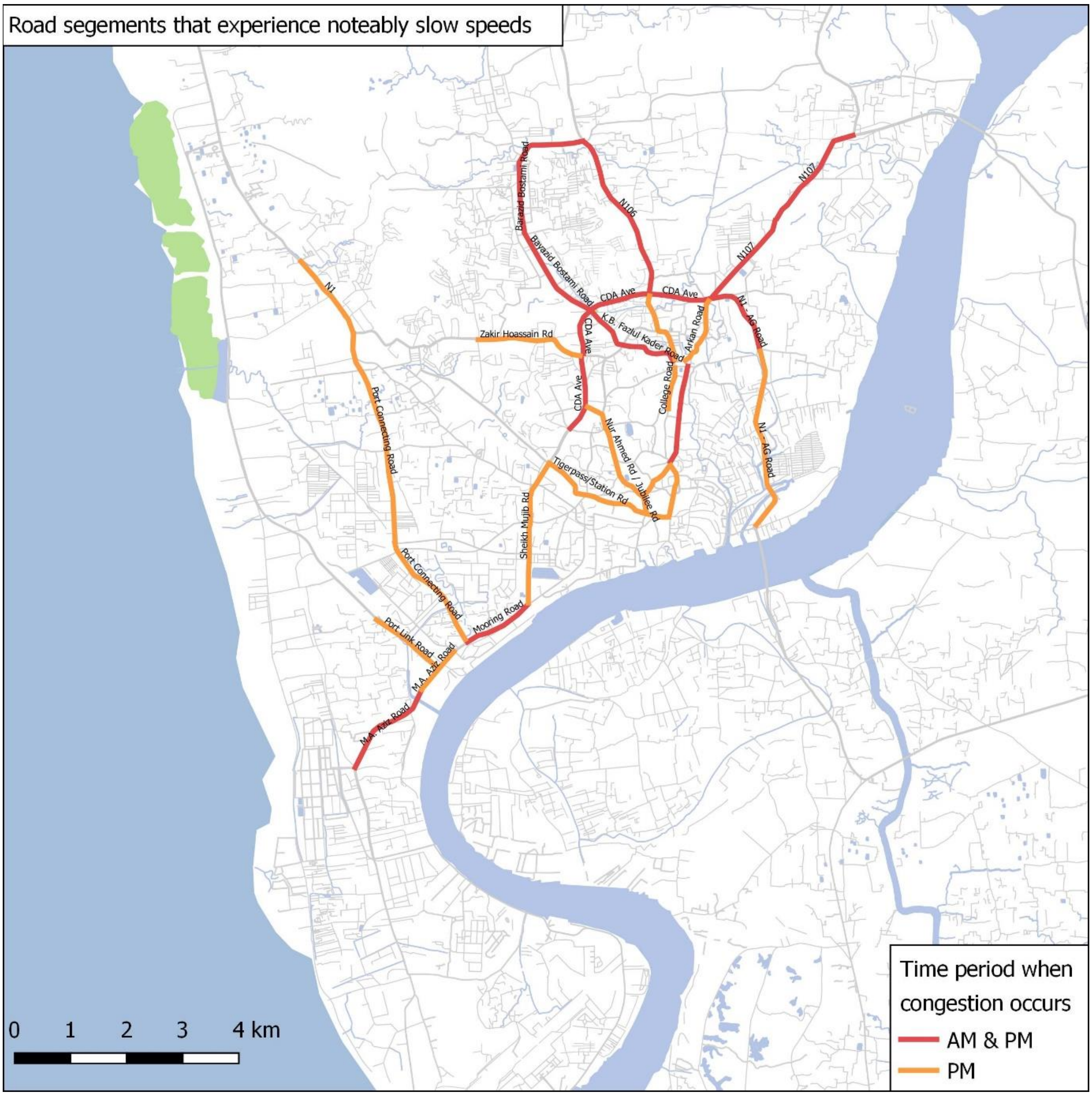


Figure 7-2: Observed car speeds, 2017, PM-peak

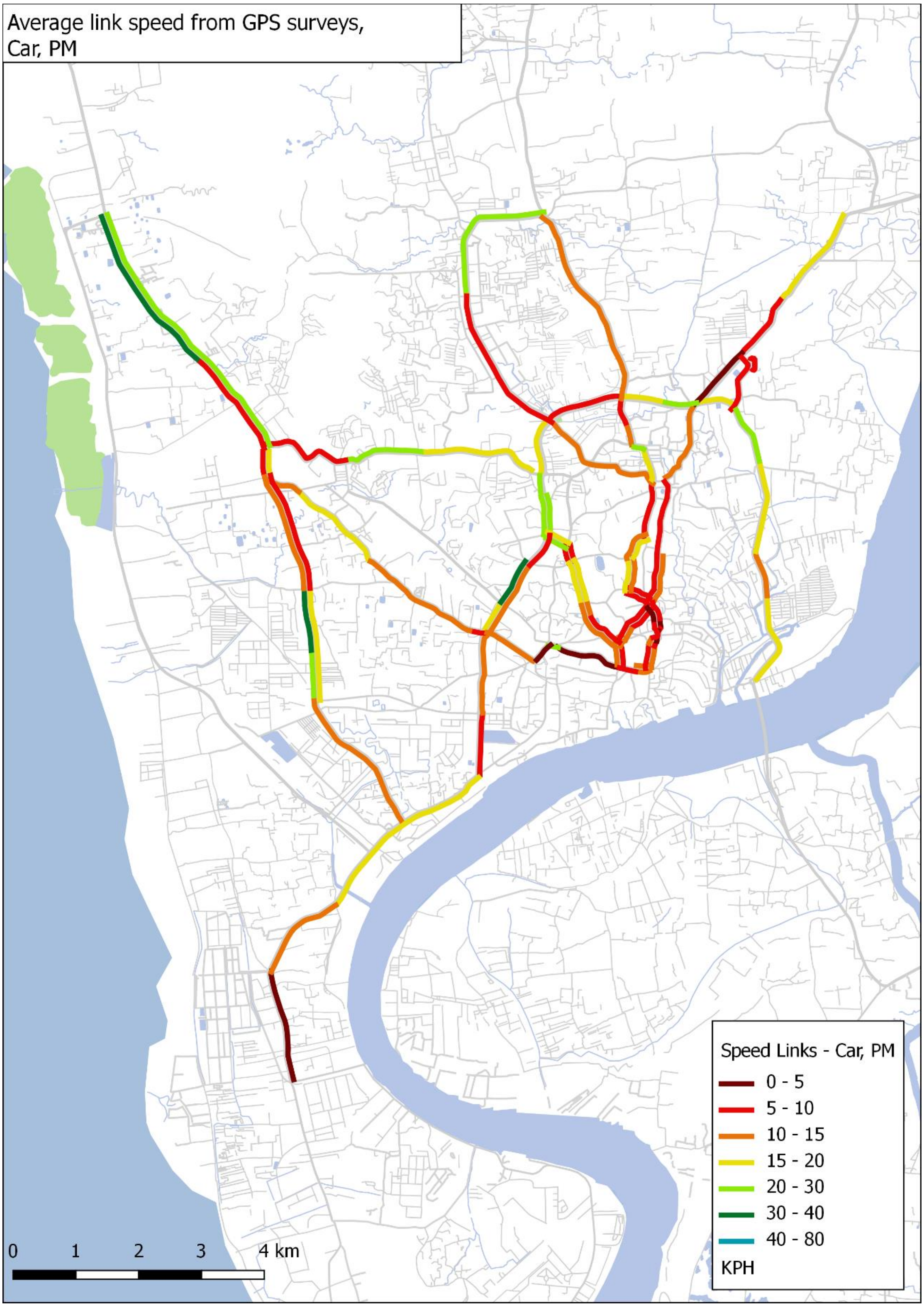
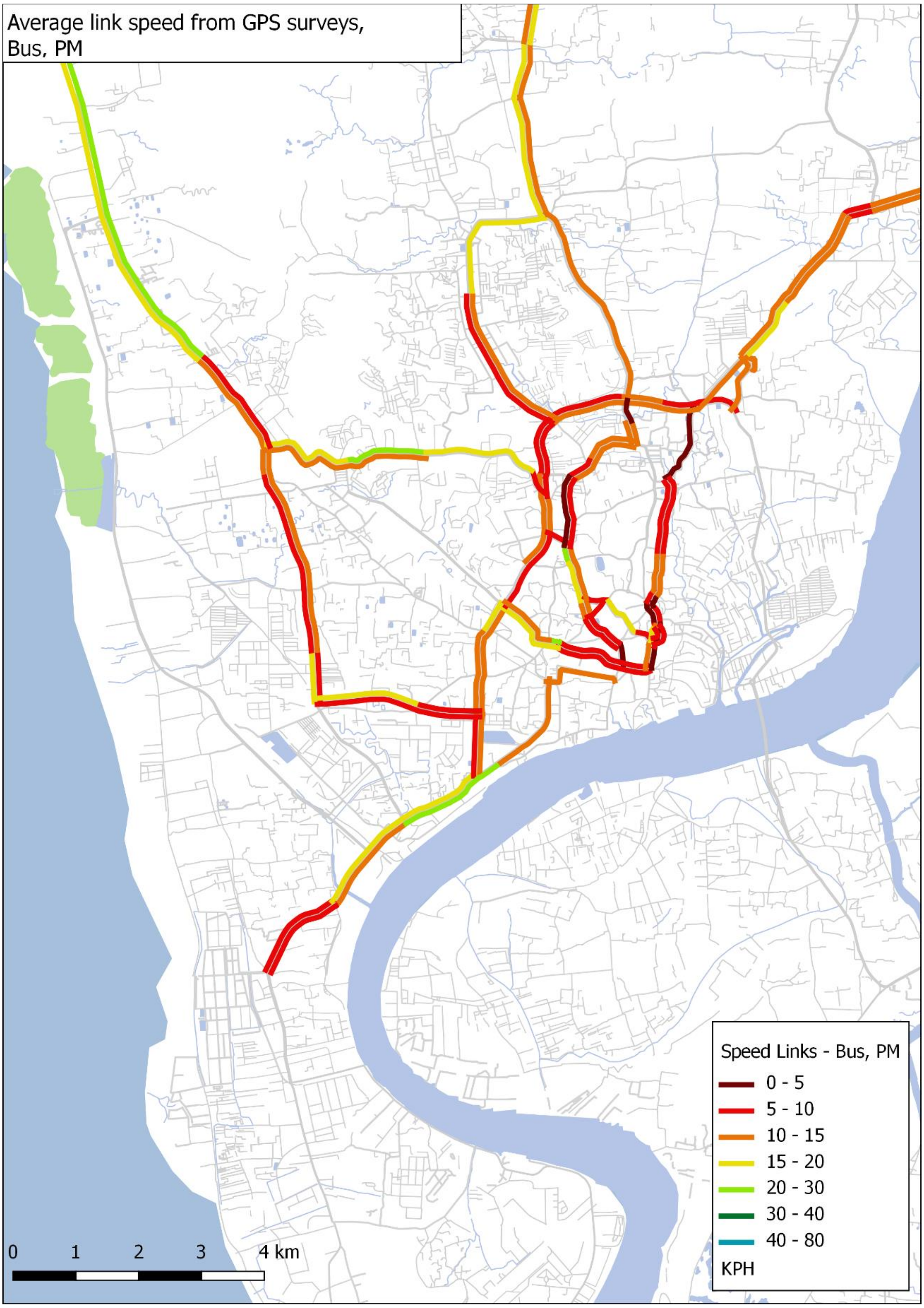


Figure 7-3: Observed bus speeds, 2017, PM-peak



7.1.2 Cause of slow speeds

High volumes of traffic contribute to slower speeds, but they are not the primary cause. This is evident from the traffic counts which show the level of traffic on the roads is within the carrying capacity of each road.

The UK Design Manual for Roads and Bridges[21] identifies the expected carrying capacity for a busy urban road to be 1,140 vehicles per hour per direction for a 2-lane road, and 2,300 vehicles per hour per direction for a 4-lane road (dual carriageway). Figure 7-4 presents the observed total traffic volume at each count site. The maximum observed flow is 1,930 PCU per hour per direction, observed on CDA Avenue north of Tigerpass, a 4-lane road (dual carriageway). This flow comfortably sits within the theoretical capacity of 2,300 PCU per hour per direction.

Figure 7-5 presents the current Volume Capacity Ratio (VCR) at all count sites considering the theoretical carrying capacity. The maximum observed value is 60% which, taking these UK expected figures into account, should not cause such slow speeds.

[21] UK Highways Agency 1999, *Design Manual for Roads and Bridges, Vol.5 Section2, Traffic Capacity of Urban Roads*. Table 2

Figure 7-4: Observed traffic volume at count sites

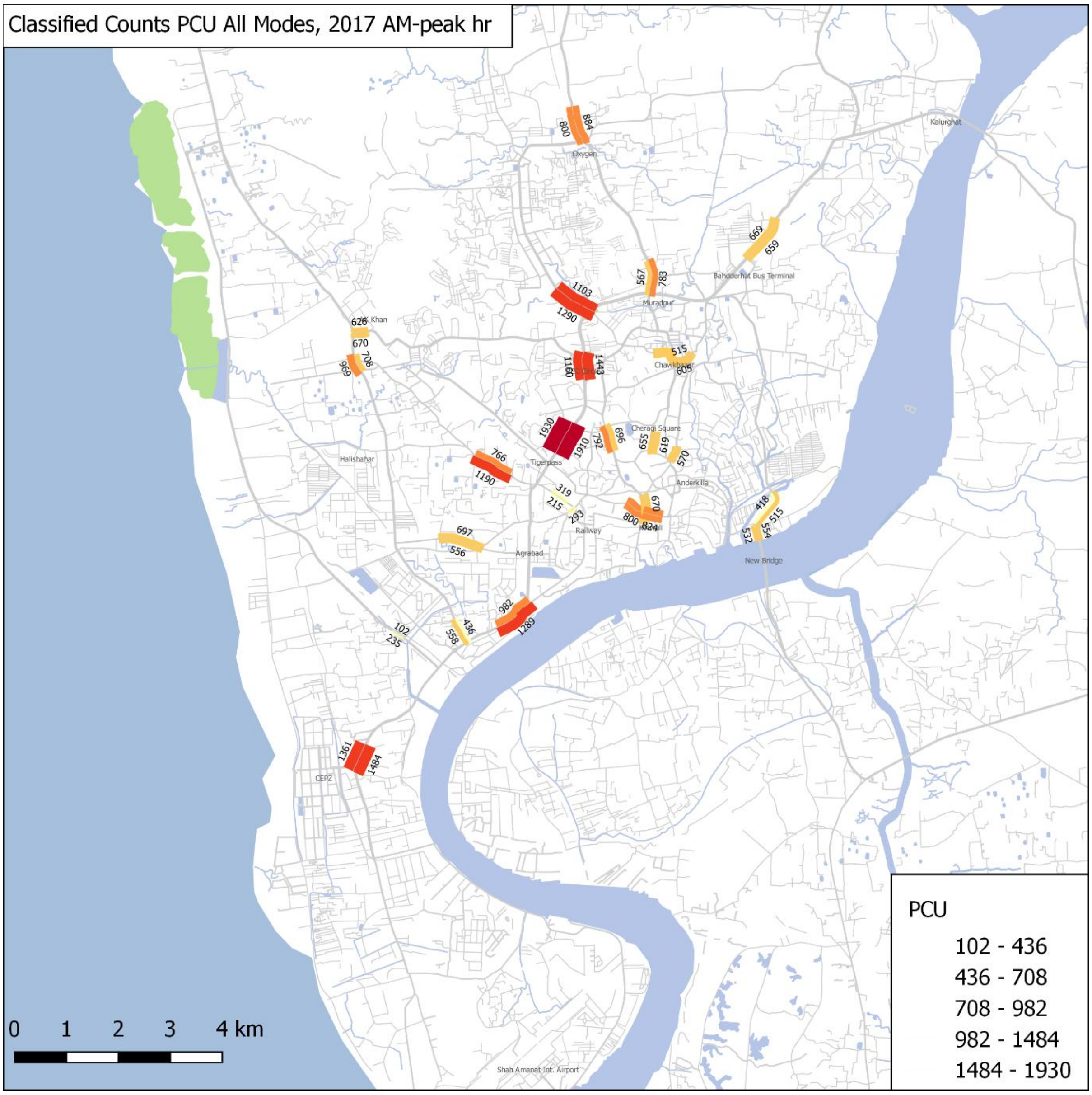
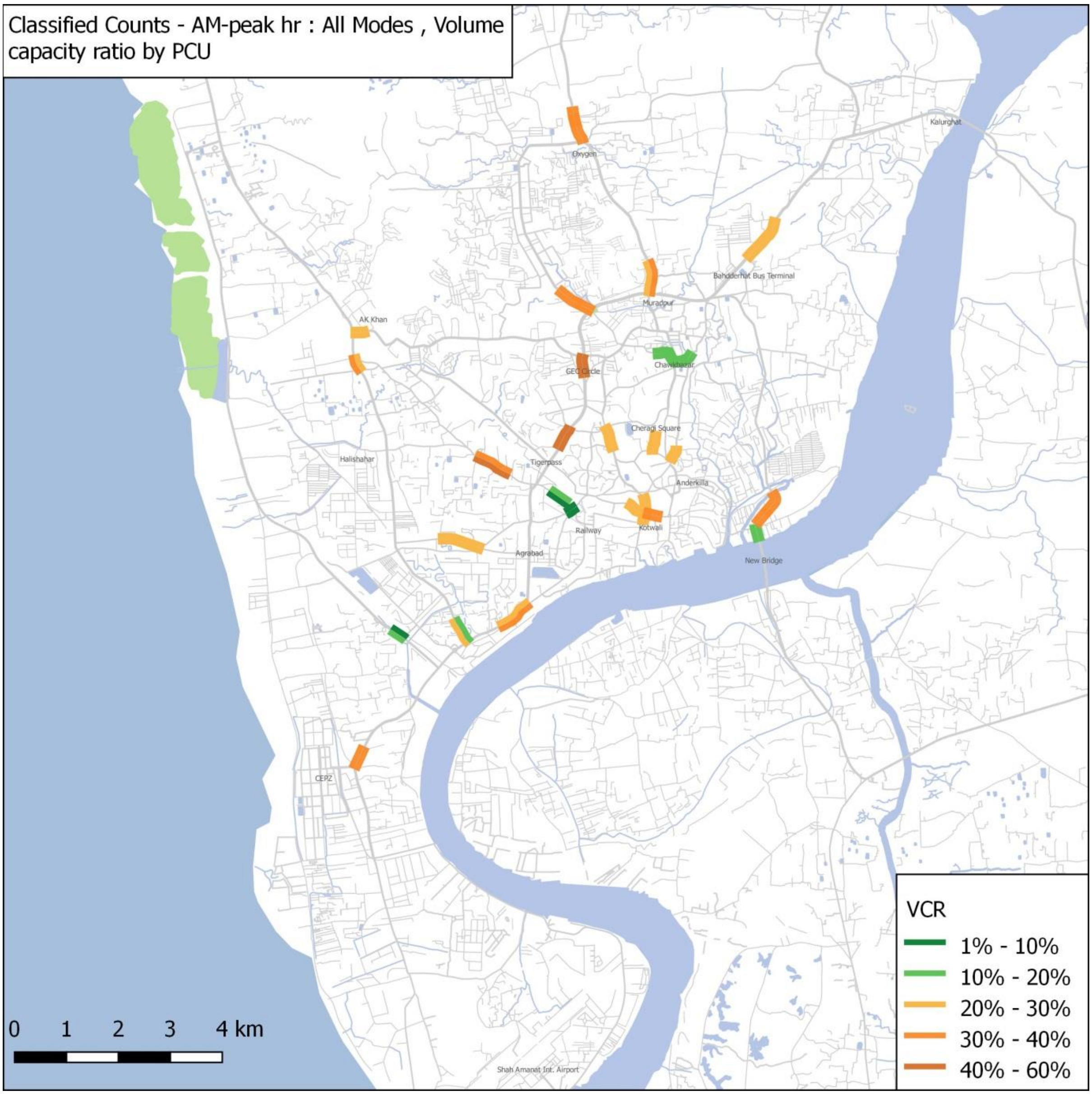


Figure 7-5: Volume capacity ratio at count sites in 2017



Instead, the slow speeds are caused by the inefficient use of the road space. Table 7-2 identifies the primary causes of slow speeds in Chittagong.

Table 7-2: Primary causes of slow speeds

PT vehicles stopping at junctions


Insufficient management of opposing flows at junctions


Rickshaws and CNGs waiting at junctions, and on-roads

Markets encroaching on road space (source: Google)

Parked vehicles (source: Google)

Insufficient pavements placing pedestrians in the roadway


Insufficient junction design


Poor management of NMT


Poor pavement quality

Uncontrolled and exposed railway crossings

The causes of congestion at specific locations on the road network were identified by a visual inspection of the main corridors[22] and are shown in Figure 7-6.

On the Airport to Bahhadarhat corridor, the orange icons in the following figure show the locations were junction capacity is constrained by Public Transport vehicles stopping within the junction area to either load / unload passengers, or to wait for passengers.

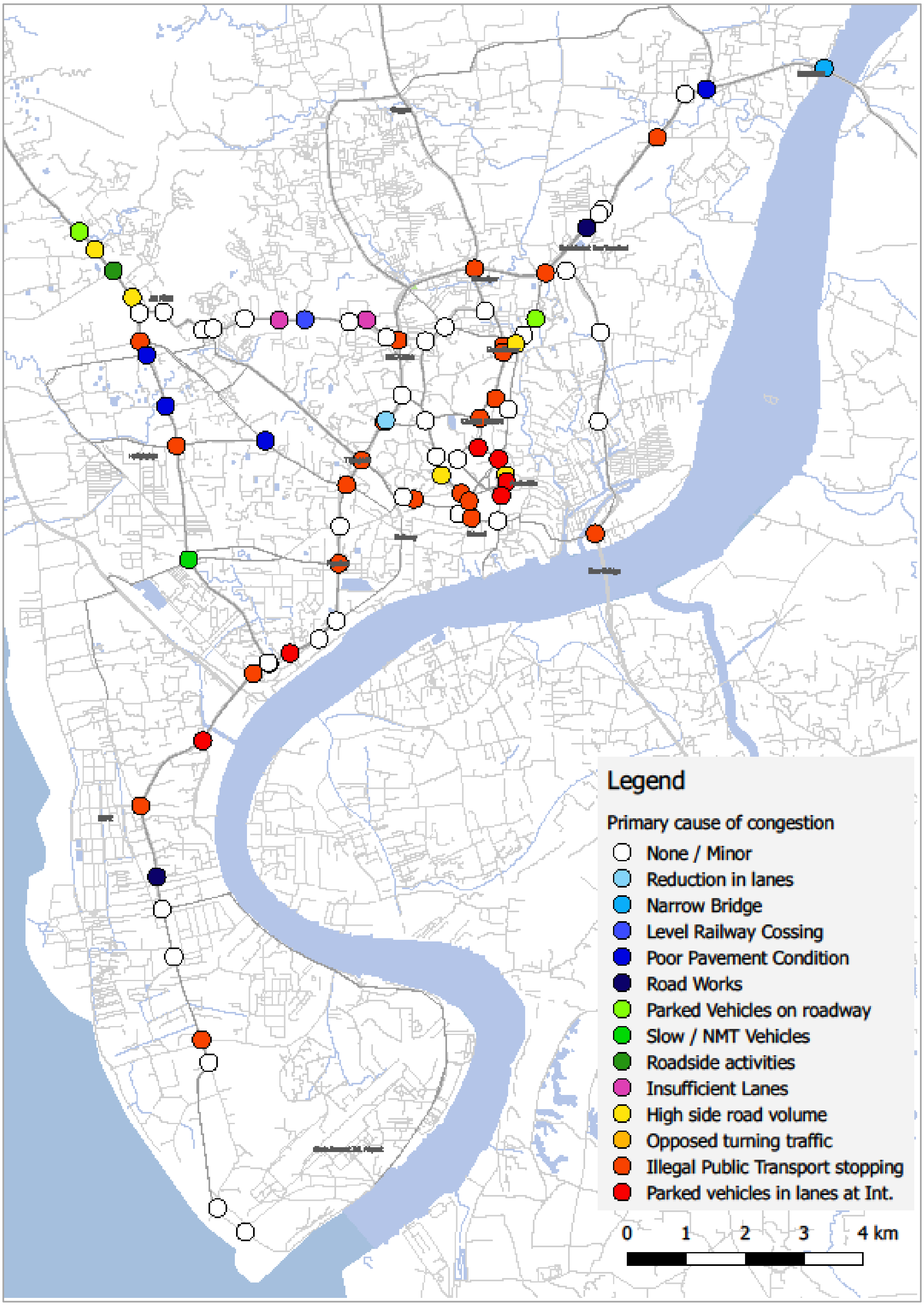
In the vicinity of the port, trucks were observed to be parked not only on the shoulders of the road but also in both kerb-side and median lanes of the roadway, severely restricted through traffic capacity.

At various other locations, notably the Port Connecting Road and N107 to Kalurghat, congestion was caused by poor pavement quality, rather than junction related constraints.

Inoperative traffic signals were observed at a number of locations, however the CMP provides manual control at these locations.

[22] Full details of the Bottleneck Survey will be presented in Deliverable 4, together with the results of the other transport and traffic surveys.

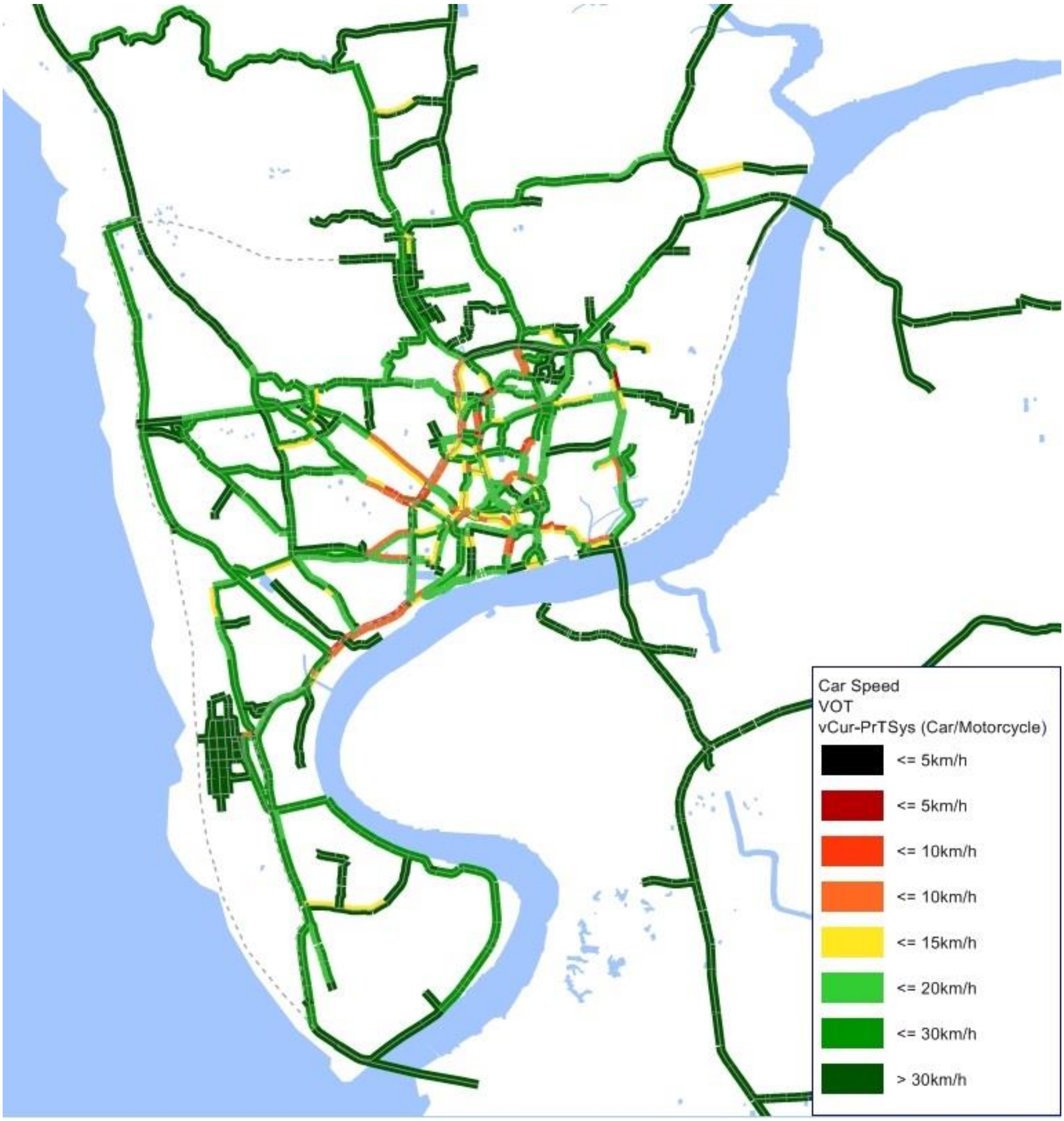
Figure 7-6: Observed causes of congestion on the network



Slow speeds are primarily caused by the problems with the way the road space is used, rather than a lack of road capacity. To highlight this finding, the transport model scenario was run which used the theoretical carrying capacity of each road, based on the UK Design Manual for Roads and Bridges[23]. Figure 7-7 presents the vehicle speeds that could be achieved today if the roads in Chittagong were better managed and the problems in Table 7-2 were dealt with. The modelled results report that the average car speeds could be 19Kph, which is significantly better than today.

[23] UK Highways Agency 1999, *Design Manual for Roads and Bridges, Vol.5 Section2, Traffic Capacity of Urban Roads*. Table 2

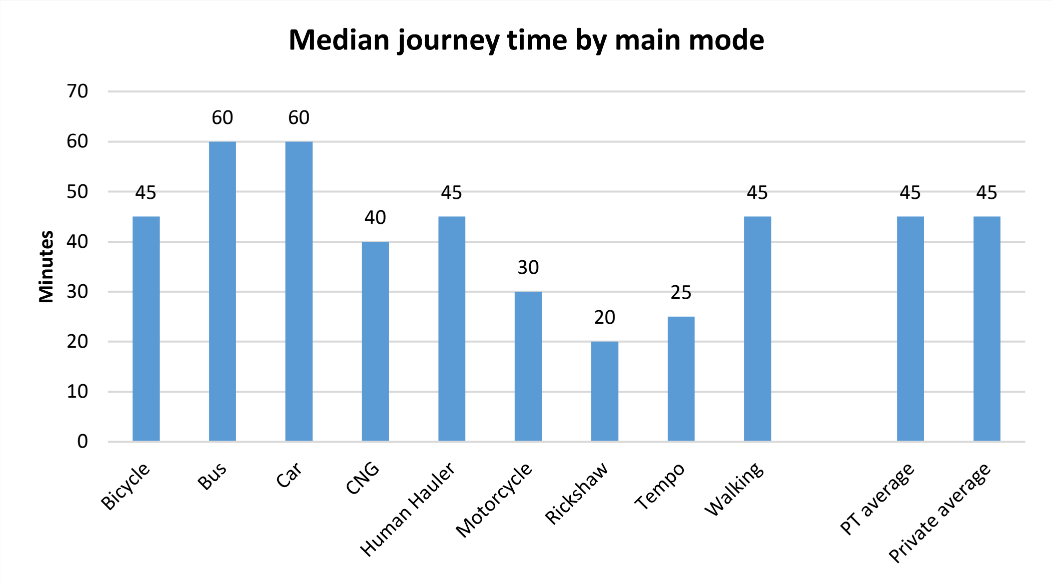
Figure 7-7: Car speeds in 2017 if the roadway were appropriately used



7.1.3 Accessibility

Because of the slow speeds, journeys in Chittagong take a long time. Figure 7-8 presents the median trip times by chosen mode. The average duration for all trips is 45minutes, which is a long time considering the average trip length is 2.6Km (Table 4-2).

Figure 7-8: Median trip time by mode



The city-wide accessibility provided by the PT network is presented in Figure 7-9 to Figure 7-12 for four locations in Chittagong. These maps show travel times to/from these locations using PT average travel speeds and the requirement to interchange where necessary.

Overall, city-wide accessibility in Chittagong is observed to be very poor. This means that the travel time for residents to access jobs, services and education is very long, hindering economic development. Large areas of population reside in locations from which it takes over 60 minutes to access key important employment centres such as CEPZ, the Port and the historic CBD - identified here as New Market.

These poor levels of accessibility are burdensome to the traveller, who may spend a long time travelling to work, but they also act to hold back economic growth - Bertaud (2014)[24] argues that the development of positive agglomeration effects requires the majority of employment sites within a city to be accessible within one hour by all residents.

[24] Bertaud, A., 2014. *Cities As Labour Markets*, Marron Institute on cities and the urban environment, New York University

Figure 7-9: Access times by PT to/from CEPZ

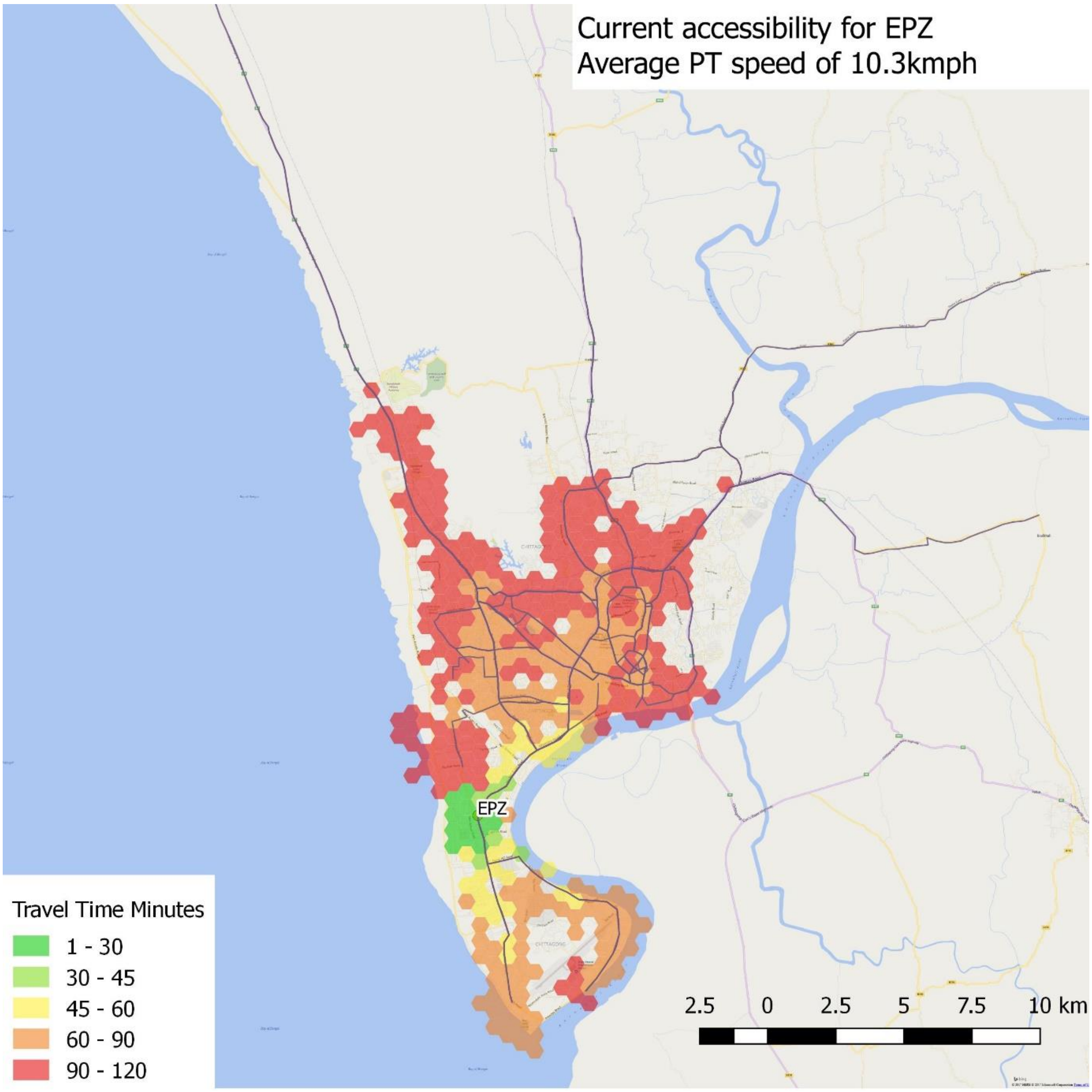


Figure 7-10: Access times by PT to/from New Market

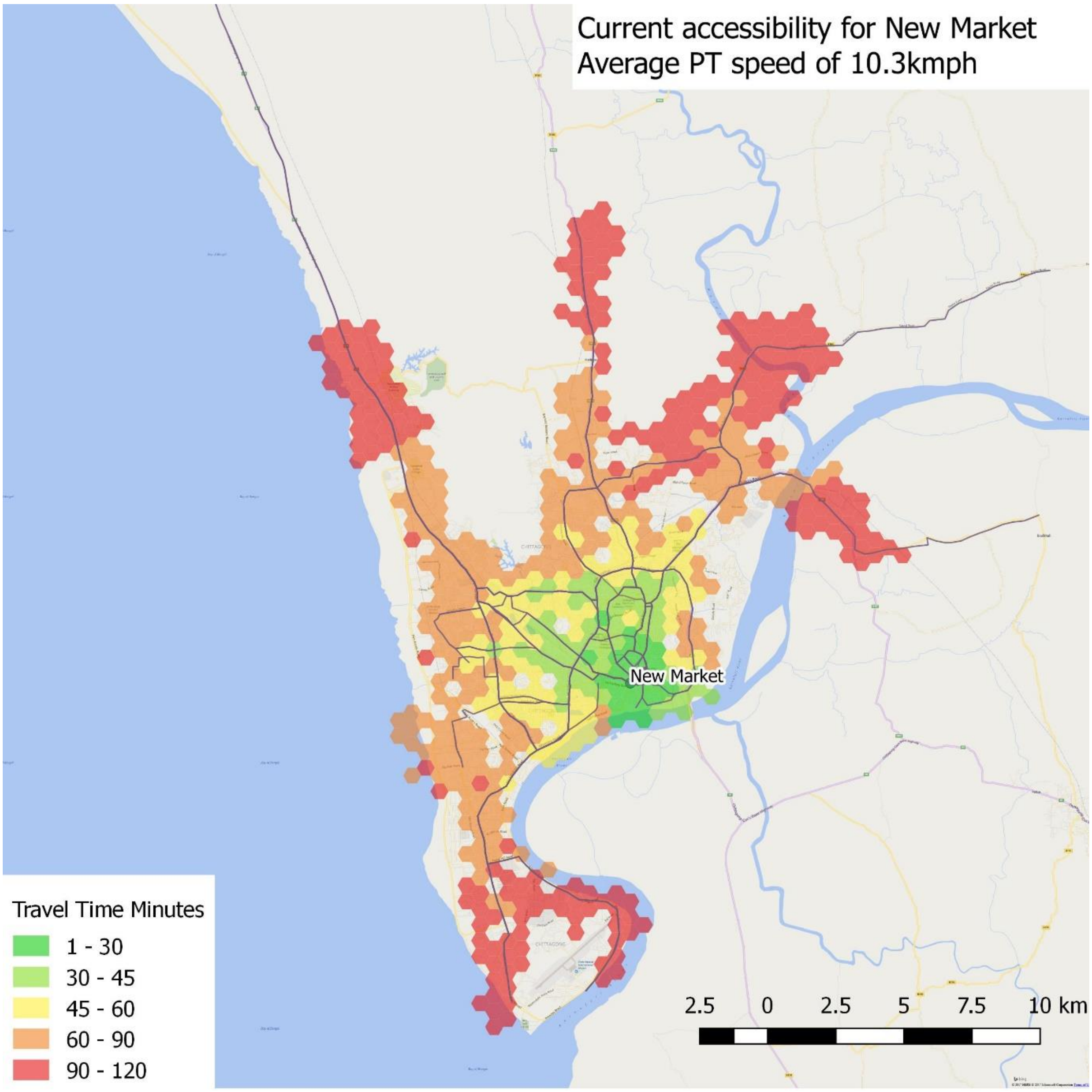


Figure 7-11: Access times by PT to/from the Port

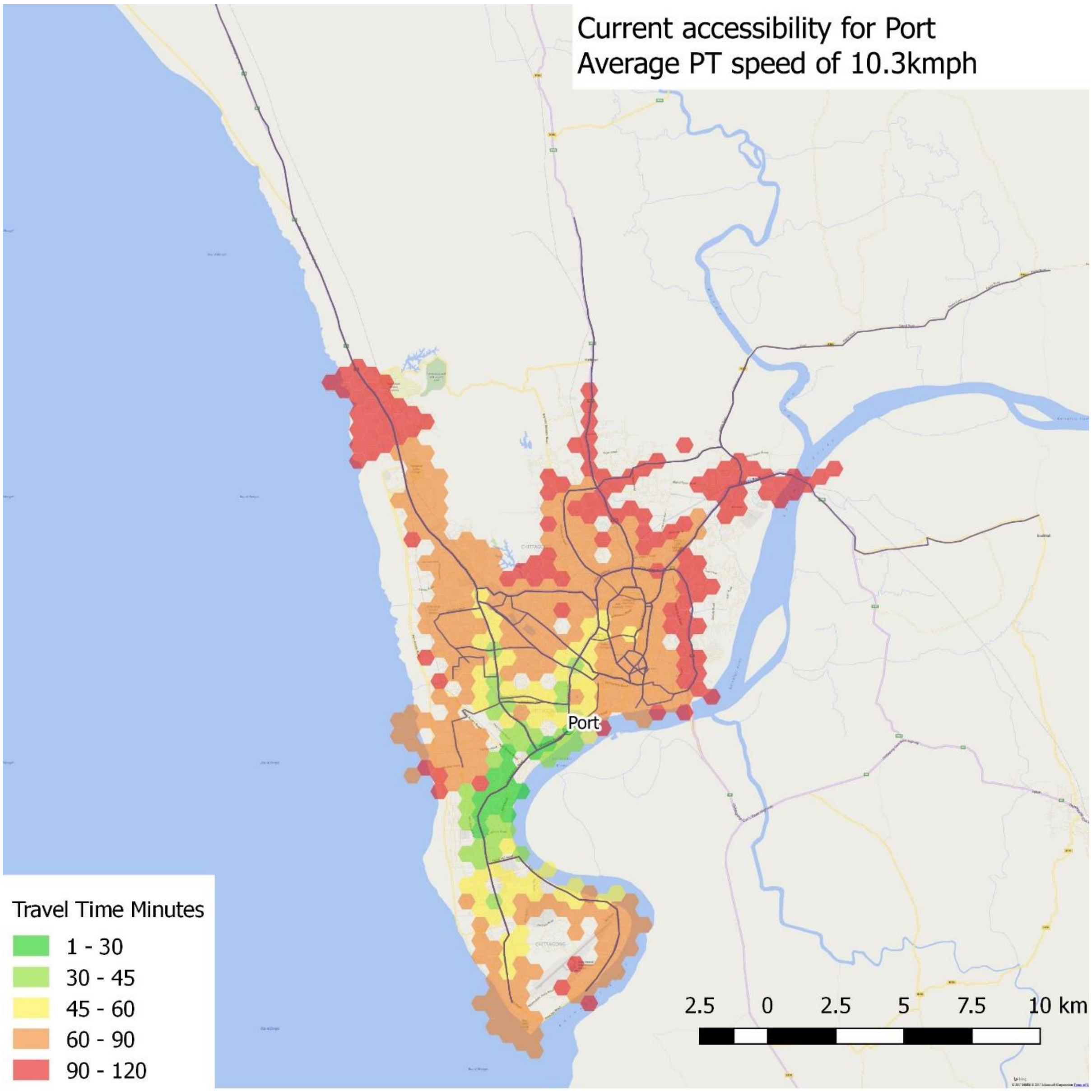
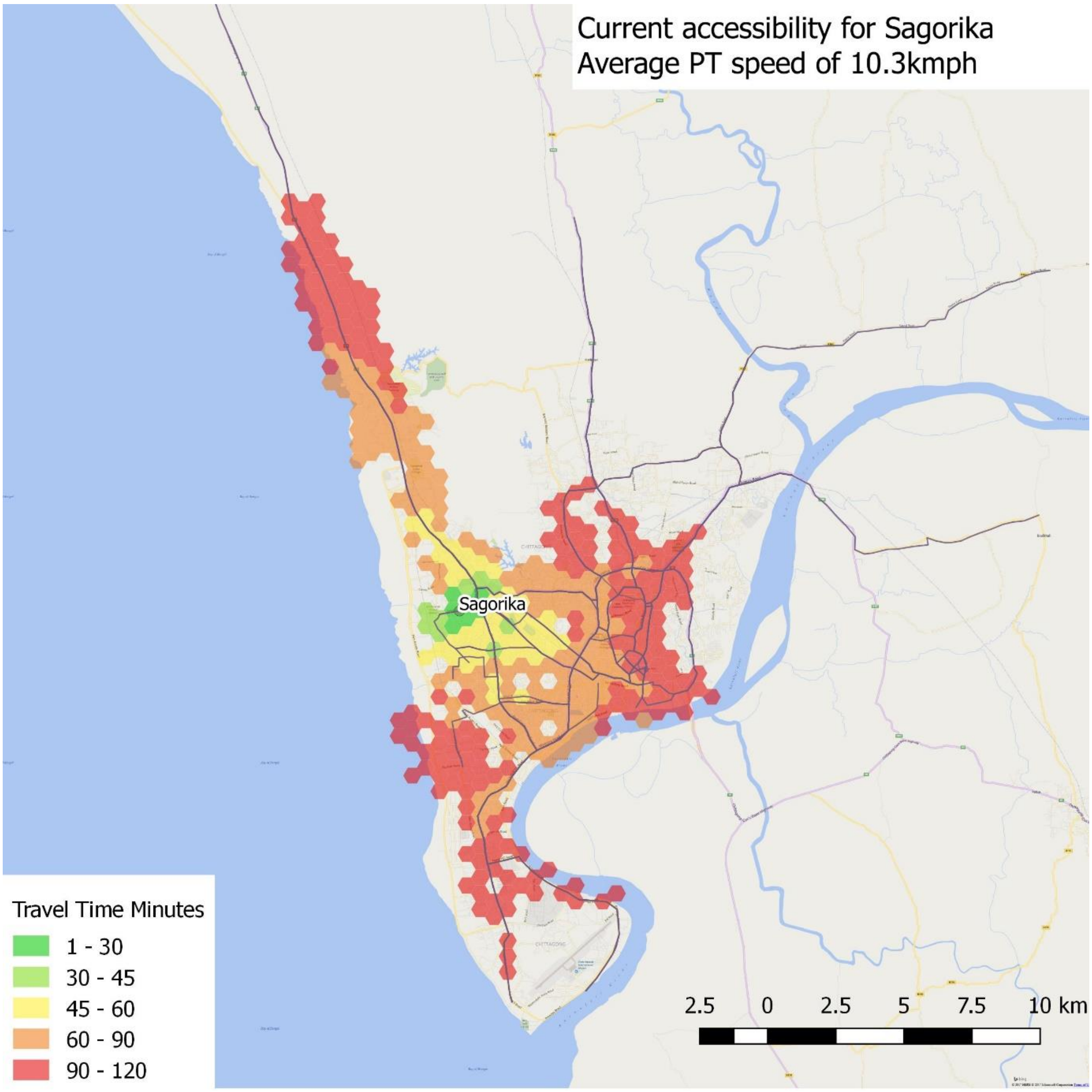


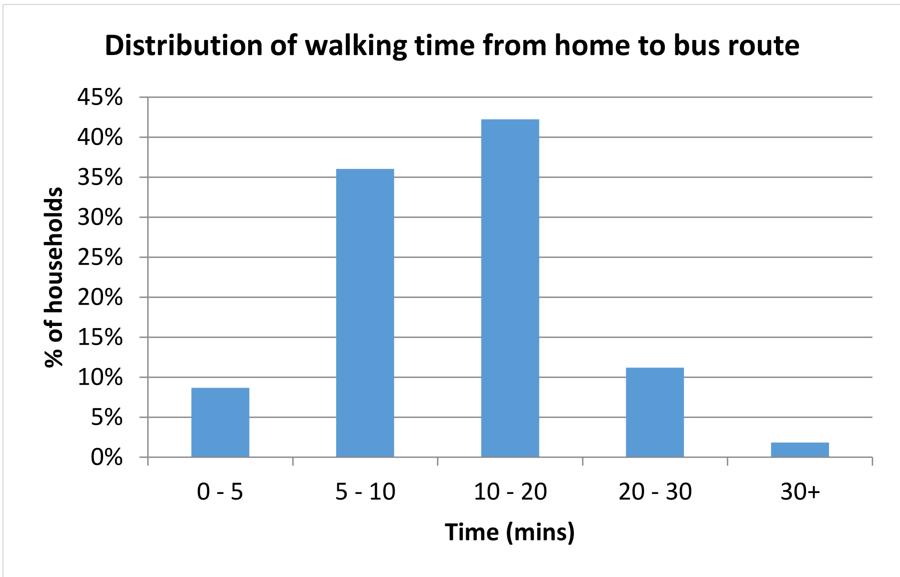
Figure 7-12: Access times by PT to/from Sagorika



7.1.4 Local accessibility

Local accessibility refers to the time it takes to walk to/from the bus stop. The household interview survey recorded the reported time it takes to walk from the house to the usual bus route. Figure 7-13 presents the distribution of responses with the average walk time being 10 minutes to the bus route. This is considered a poor level of local accessibility. Typically walk times of 5 minutes are considered the aim of an accessible public transport network. The long walk times are likely caused by the dense nature of residential areas through which it is hard to ply a bus vehicle.

Figure 7-13: Walking time from home to the usual bus route



Once the traveller has walked to the bus stop, then the average wait time to board a PT service is also high. Results from the traveller interview show average wait times to board a PT vehicle is 8 minutes. However, the majority of trips in Chittagong are chained, which means they require an interchange. The average PT trip is conducted in 1.8 stages, therefore the total average waiting time is 15 minutes for a PT trip.

7.2 PT facilities

Currently the operation of PT terminals and interchanges at junctions is inefficient and often dangerous. This is because:

- Drivers of PT vehicles do not use the designated bus stops as they are meant to
- Drivers of ‘general traffic’ park or stop in the designated bus stops

- Drivers of ‘general traffic’ do not obey pedestrian crossing rules, whether the crossing is signalised or not
- Pedestrians do not necessarily cross at the designated crossing
- Buses allow passengers to exit into the middle of the road instead of onto the pavement, where a pavement exists

Figure 7-14: Bus passengers boarding from the carriageway

Source: EGEN, 1/11/2016

7.3 Pedestrian facilities

25% of trips are completed wholly on foot (Figure 4-2) and many more walk to access PT services. However pedestrian infrastructure in Chittagong is very poor:

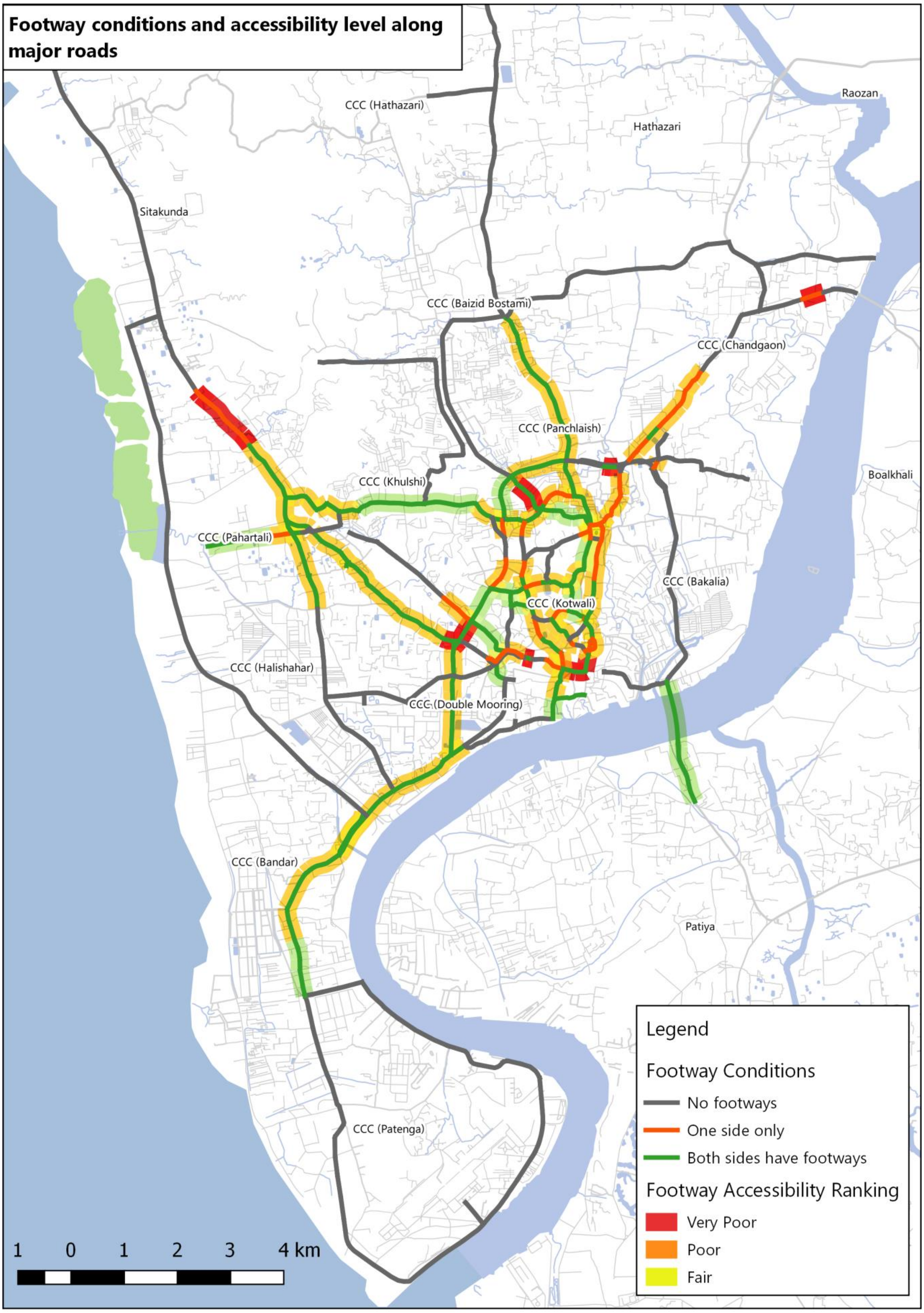
- Many roads in Chittagong lack a footpath along one or both sides and where footpaths do exist they are often of poor quality and are hard to walk along. Pedestrians have to walk in the roadway along many roads (Figure 7-15).
- There is also limited provision to help pedestrians to cross roads (Figure 7-16)

It is therefore hazardous and uncomfortable to walk in Chittagong, and the lack of facilities also slow down the possible walking pace. Figure 7-17 maps the state of current footpath provision along the main roads in Chittagong.

Figure 7-15: Pedestrians walking in the roadway along CDA Avenue towards GEC Circle

Figure 7-16: Pedestrians trying to cross Sheikh Mujib Rd at Dewanhat

Figure 7-17: Current state of footpath provision



Of specific note is the location around CEPZ which experiences extremely high pedestrian flows when textile workers arrive and leave from work (Figure 7-18).

Figure 7-18: High pedestrian flow around CEPZ flow

Photo was taken, 14/10/ 2014, at 06.30 AM, CEPZ Square

7.4 Public transport service quality

Respondents to the traveller interview survey were asked to rank the various elements of their current trip. (Table 7-3) shows the average score given for each element, with 1 being good and 5 being bad.

Table 7-3: Challenges faced by respondents by main mode (1=good, 5=bad)

Main mode	Long Distance	Long duration	Too Expensive	Poor Comfort	Traffic Congestion	Lack of Information	Lack of Waking Space	Poor Safety	Mode average
Overall	3.4	3.7	2.9	3.9	4.3	2.6	2.5	2.9	3.3
Train	3.7	3.7	3.1	4.1	3.9	3.0	3.1	3.3	3.5
Human Hauler	3.1	4.0	3.0	4.2	4.5	3.0	3.0	2.9	3.5
Bus	3.5	3.8	2.9	4.0	4.4	2.7	2.6	2.9	3.4
Car	3.4	3.7	3.0	3.5	4.2	2.7	2.7	3.2	3.3
CNG	3.1	3.5	3.5	3.9	4.2	2.6	2.7	2.8	3.3
Motorcycle	3.2	3.4	2.5	3.6	4.4	2.5	2.2	2.8	3.1
Tempo	2.9	3.2	2.4	3.9	4.2	2.3	2.2	3.0	3.0
Rickshaw	2.8	3.1	3.2	3.5	4.0	2.1	2.1	2.7	2.9
Intercity Bus	3.0	3.3	2.8	3.2	4.4	2.4	1.8	1.8	2.9
Bicycle	4.0	4.0	1.0	3.0	3.0	2.0	3.0	1.0	2.6
Walking	2.3	2.3	2.0	3.3	3.3	1.3	1.3	3.3	2.4

'High Traffic Congestion' is considered to be the biggest problem faced overall. Poor comfort is the second key challenge for many respondents, particularly by users of PT. Expense was generally a low challenge, except for those using CNGs, and rickshaws. Long trip duration is a key challenge for those using human-haulers, bicycles, bus, car, CNG and train.

Respondents were also asked to score their main considerations when choosing how to travel. The list below presents the aggregate order of these considerations. The most important consideration is trip time followed by safety. It is interesting that 'having a seat' also scores high, this has implications for the attractiveness of bus services on which passengers often must stand.

Table 7-4: Importance of passenger considerations when choosing how to travel

1. Journey time
2. Safety
3. Having a seat
4. Comfort
5. Cost/Fare
6. Frequency of service
7. Reliability

7.5 Women and other vulnerable passengers

Female access to public transport in many areas of the world can be dangerous or difficult for a wide variety of reasons. These reasons vary depending on the location, but include discriminatory fare pricing, lack of information, more complicated trip requirements, overcrowding and sexual harassment (often known as 'eve-teasing' in Bangladesh). A separate on-the-street survey was conducted with 600 women to better understand these challenges.

There are certain characteristics which differentiate female transport usage from male, particularly in developing countries. Firstly, women are more likely to work non-standard/off-peak hours, whilst they are also less likely to have access to money for transport fares (due to lower wages etc). Further, they are more likely to hold a higher share of household responsibilities, necessitating more frequent and varied trips (Bhatt et al. 2015[25]).

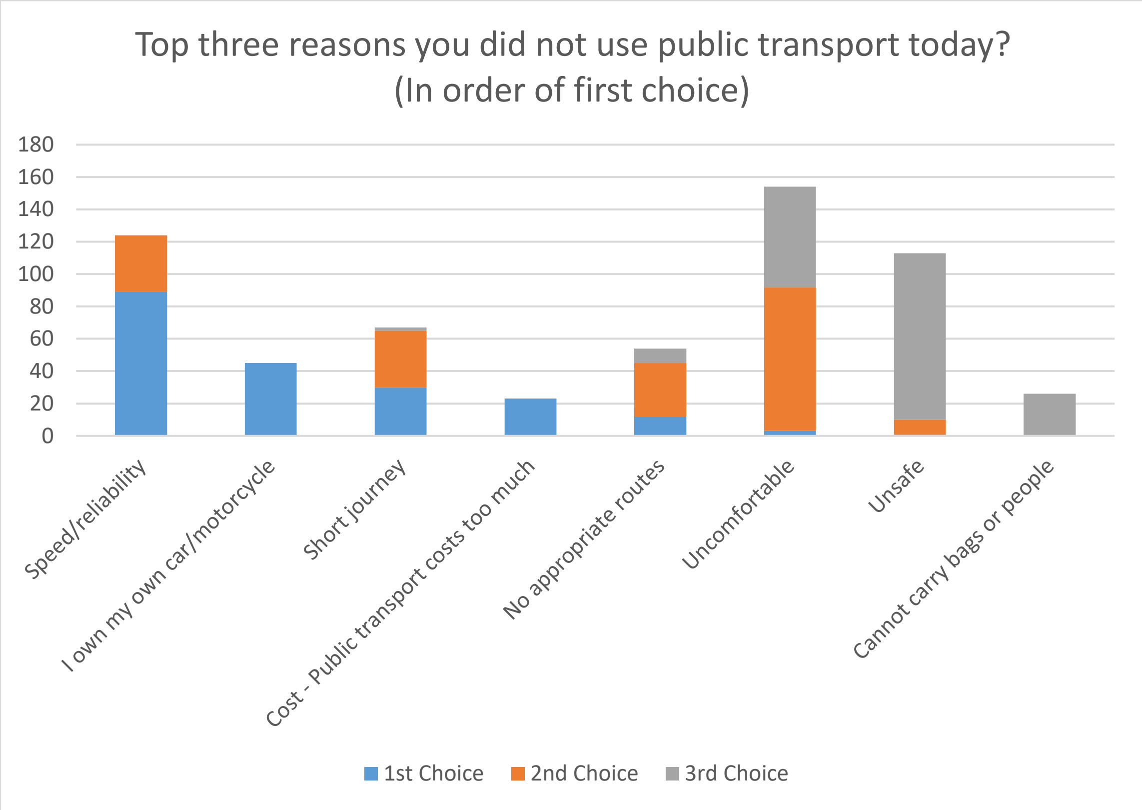
Caregiving responsibilities also mean women are more likely to need special public transport facilities, including space for elderly relatives or carried children. Our survey of women travellers identified that 14% of trips taken by women were travelling either with children or elderly dependents. This represents a sizeable number of trips, which public transport should be able to accommodate. When travelling with dependants women are more likely to travel using rickshaw or CNG instead of the bus: when travelling with dependants they undertake 37% of trips on the bus, compared to 51% trips when travelling alone. This indicates that the trips undertaken with dependants are not well-served by the bus services in Chittagong.

The mode share statistics bear this out - Figure 4-3 (Chapter 4) shows that women are more likely to use CNGs and rickshaws for their trips than men are. As a consequence, women incur a higher fare; rickshaw's charge at least double the bus fare, and CNGs charge 10 times bus fare. These conditions further raise the barriers for access to jobs and services for women.

Figure 7-19 identifies the main reasons why women choose not to use PT. The most common response overall was general discomfort on PT, but the most common first choice was 'speed/reliability'. Safety concerns were also found to be a key concern of women when deciding whether or not to use PT.

[25] Bhatt, A; Menon, R; Khan, A. 2015. *Women's safety in public transport: A Pilot Initiative in Bhopal*. Embarq India, WRI India, UK Aid

Figure 7-19: Top reasons why women don't travel by PT

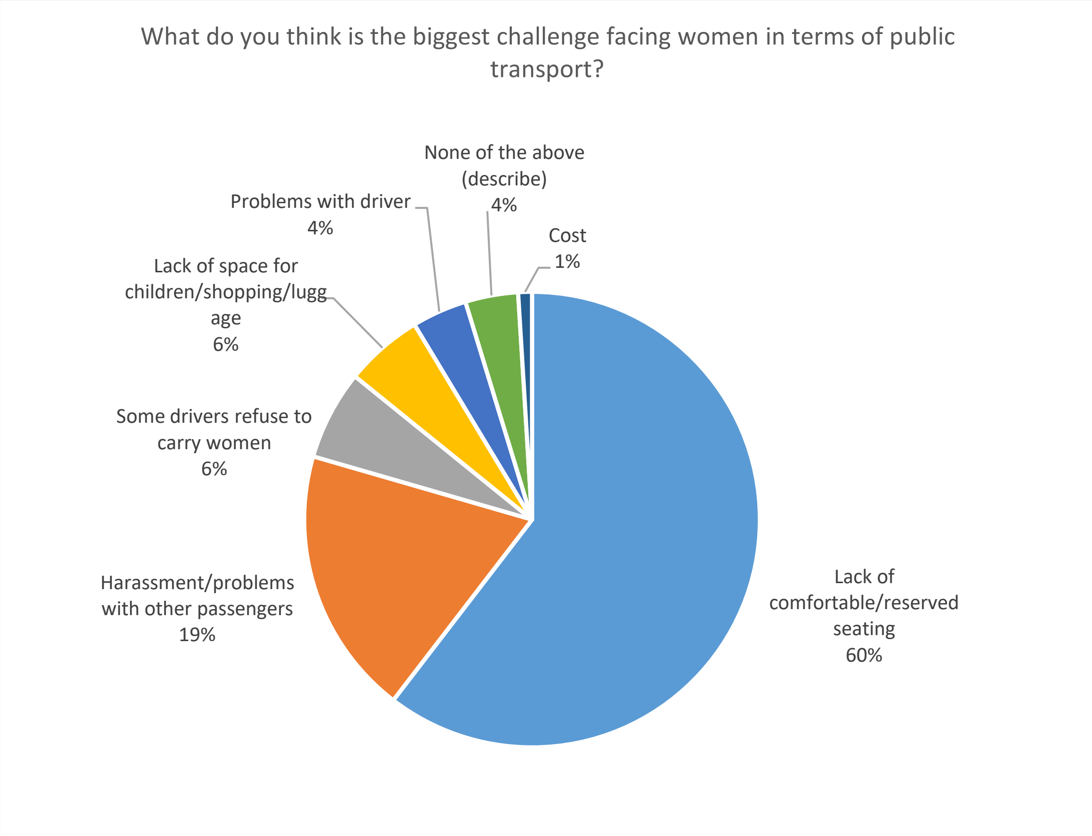


The women's survey enquired on the greatest challenges women face when using PT, the results are presented in Figure 7-20. By far the most popular answer was 'Lack of comfortable/reserved seating', followed by 'Harassment/problems with other passengers' (although this had less than half as many). Cost was considered the least significant challenge for women using PT as PT fares are low.

Women are often less able to stand than men (due to heavy shopping, attendant children or uncomfortable clothing), meaning they may be excluded from busy or overcrowded vehicles which often ply the streets. Buses are also considered largely unsafe for women due to the risks to personal safety including sexual harassment (eve-teasing), sexual assault and rape. 9 of the respondents specifically listed 'eve-teasing' as the most significant challenge.

Walking distances to and from bus stops/terminals also have a much greater effect on women than men, due to similar concerns about personal safety when walking alone in the dark. The relatively high level of violence against women that occurs in this way is compounded by the lack of an accepted system to facilitate reporting, and one which ensures reports are taken seriously and followed up.

Figure 7-20: Greatest challenge facing women in accessing public transport



Other vulnerable users, including children, the elderly and the disabled, experience similar problems. Physical accessibility to buses is a factor which reduces access for women as well as other vulnerable passengers, especially those with mobility impairments. Most buses have a large step up which must be climbed in order to enter the bus. Buses are generally not wheelchair equipped, and they provide poor comfort for those who are unable to stand (Figure 7-21, Figure 7-22).

As a result of these factors, women and other vulnerable users preferentially use rickshaws and CNGs due to their more private nature, their better accessibility and higher comfort (Figure 7-23). However, because these modes are more expensive, these passengers may be placed at an economic disadvantage.

Figure 7-21: Overcrowded buses act as a deterrent for vulnerable users

Source: eGen 1/11/2016

Figure 7-22: Poor quality seating inside a public bus

Source: EGEN, 1/11/2016

Figure 7-23: Female passengers are more likely to use rickshaws

Source: eGEN, 1/11/2016

As more women join the workforce (Rahman & Islam, 2013)[26], they need to be able to access a transport system that provides safe efficient and affordable access to their place of work. The increasing inclusion of women in the labour market will help to drive economic growth in Chittagong - as exemplified by the high rates of female employment in the Chittagong EPZ (Economic Processing Zone). By providing safe and reliable transport to employment opportunities, Chittagong's female labour force should continue to grow, benefitting both the local and national economies, but also improving quality of life for families in the region through increased income.

All over the world, poverty combines with gender to further disadvantage poor women. Chittagong is home to more than 600, 000 slum dwellers (total city population approx. 2.9 million), >50% of whom are female (BBS, 2014). 18% of Chittagong’s slum dwellers are housewives, whilst 17% are garment factory workers. Any new public transportation measures should aim to include these women as well as their more wealthy counterparts.

[26] Rahman, R; Islam, R, 2013.*Female labour force participation in Bangladesh: trends, drivers and barriers*. International Labour Organisation

7.6 Railway and waterway crossings

While street activity is one source of resistance, the physical design of the highway, its management, and its relationship to the built environment are others. Chittagong possesses several sections of highway that are bisected by railways, at-grade, while bridges across rivers and railways are often found to be narrower than their approaches; funnelling and slowing traffic as the effective capacity of the bridge is lower than that of the accompanying highway.

A total of 42 of these pinch-points were surveyed, comprising 33 bridges and 9 railway crossings. Many of the bridges present challenges to the free flow of traffic because they force multiple lanes of traffic into a single one. In addition to causing congestion this is also dangerous for all road users, and particularly disadvantages pedestrians who are likely to be forced to the edge of the bridge – a precarious position (see Figure 7-24). Railway crossings similarly present a challenge to safety and need to be properly upgraded and carefully controlled (see Figure 7-25).

Figure 7-24: The narrow 'Old Bridge' at Kalurghat is a significant bottleneck

Source: EGEN, 2/11/2016

Figure 7-25: Temporary congestion caused by level crossing

Source: EGEN, 1/11/2016

7.7 Enforcement and road management

Chittagong's roads are dangerous for a variety of reasons, not least that drivers often fail to abide by traffic laws. Many road markings and restrictions, where they do exist, are ignored. While CMP reportedly employs a large traffic police force, sufficient numbers of traffic police are not observed on the street. The current force requires additional resources and training to coordinate traffic at intersections and enforce traffic laws along all roads.

Figure 7-26: Traffic police officer

Source: EGEN, 1/11/2016

7.8 Parking policy

One of the key challenges in Chittagong relates to informal parking and its contribution to congestion. On-street parking is deemed to be a significant cause of congestion in GEC, Muradpur, CDA Avenue, Nizam Road, Zakir Hossain Road, Station Road, Dhaka Trunk Road, Madabari, Shuvapur Bus Stand, EPZ and Alongkar, among others.

There is very little regulation of on-street parking in Chittagong currently, as demonstrated by Figure 7-27. This shows that most corridors across the city have cars, rickshaws or other vehicles parked (and thereby reducing road width) on both sides of the road. Figure 7-28 shows the extent to which these parked cars encroach onto the carriageway.

Figure 7-27: On-street parking along key corridors in Chittagong

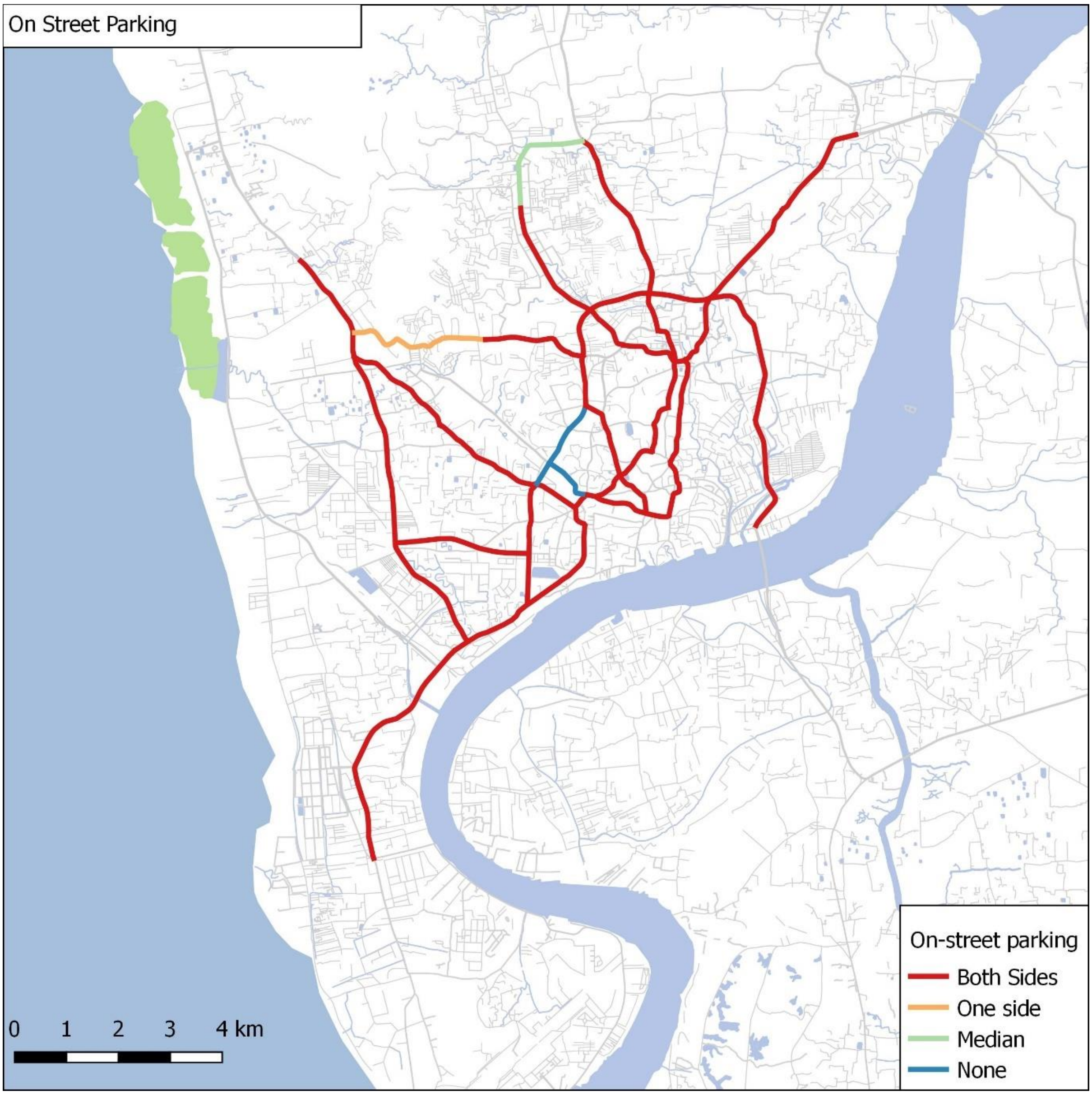
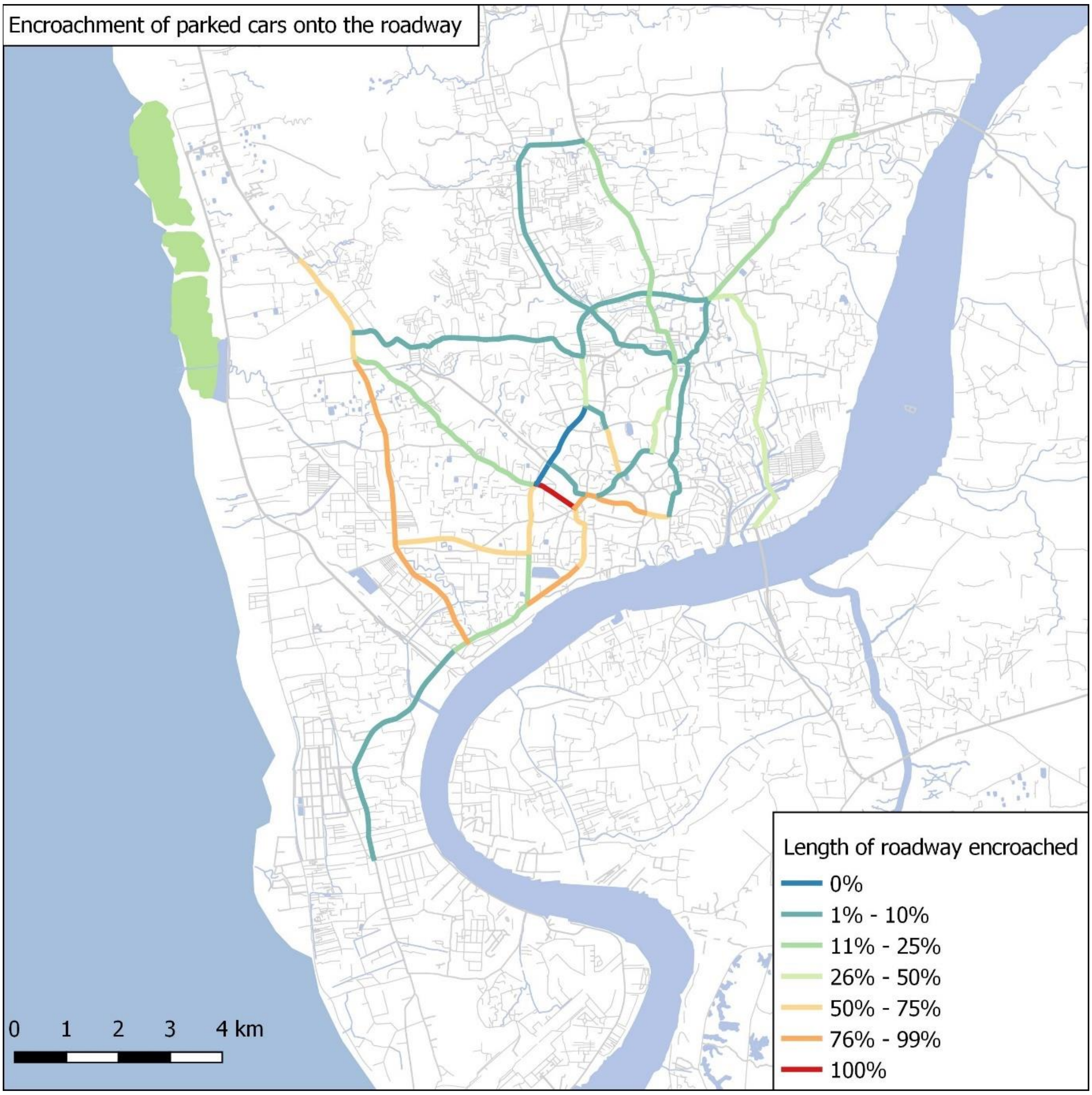


Figure 7-28: Level of encroachment of parked cars onto the carriageway



The congestion which results from such parking is particularly concentrated at certain times of day, and could become significantly worse if private car ownership increases.

7.9 Rickshaws & CNGs

Rickshaws form an important part of the transport mix in many South-Asian cities, including Chittagong. Non-motorised rickshaws are green and clean modes of travel capable of accessing city spaces that more conventional modes such as buses cannot. Further, rickshaws are amongst the most demand-responsive and accessible modes of transport in developing world cities, coming into their own when providing short distance end-to-end journeys or 'last mile' connectivity where, for instance, they are able to act as a feeder mode to a mass transit or other strategic transit system. In Dhaka, the average length of a rickshaw trip is 2.3km (STP, 2005)[27], while in Chittagong it is understood to be between 1.0km and 3.0km. A smaller scale, but nonetheless important factor, is the prevalence of non-motorised cargo vehicles, which generally travel at much slower speeds than even rickshaws. Rickshaws and CNGs are also favoured by women for many trips.

Despite their many advantages, rickshaws can present a challenge when competing for road space with buses on key corridors between important O-D pairs within a city. Non-motorised rickshaws are typically capable of less speed than buses, while they present greater conflict through turning movements, cruising and parking on the carriageway while courting business. In such cases, and as is recognised in Chittagong, they can be a significant contributor to urban congestion, while implicating the journey time reliability of bus services to the overall detriment and smooth-running of the transport system.

Delhi, Dhaka, Jakarta and Manila are examples of cities in developing Asia where rickshaw proliferation has presented a challenge, and for which city officials have sought to restrain their activity (Rahman et al., 2012)[28].

Figure 7-29: Parked rickshaws awaiting customers

Source: EGEN, 1/11/2016

[27] STP, 2005. *Urban Transport Policy: The Strategic Transport Plan (STP) for Dhaka*. Dhaka: BCL and Louis Berger Group Inc.
[28] Rahman, M. S-U., Timms, P., and Montgomery, F., 2012. Integrating BRT Systems with Rickshaws in Developing Cities to Promote Energy Efficient Travel, 15th meeting of the EURO Working Group on Transportation, EWGT. *Procedia – Social and Behavioural Sciences*, **54**, pp261-274.

Consultation with Chittagong Metropolitan Police has identified a particular problem with the operation of Non-motorised vans within the city. These vehicles are not licenced, they are often slow moving, are left parked on the roadway and often disregard traffic rules. As a consequence they are a cause of congestion in the city.

Figure 7-30: Example of a Non-motorised Van causing congestion

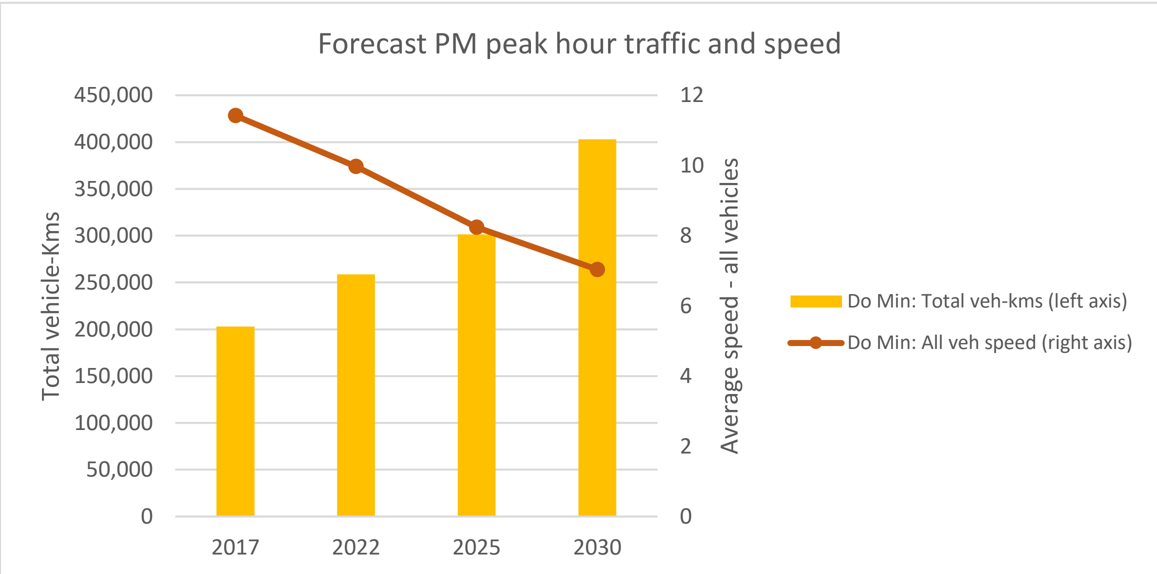
8. Do-Minimum Scenario

8.1 Changes to the overall level of congestion

Population, trips and vehicle volumes across the city are projected to increase (see chapter 5). The do-minimum scenario assumes that the committed road improvement schemes, which are presented in chapter 6 are delivered, but that no overall improvements are made to the way road use is managed.

For the do-minimum scenario, Figure 8-1 shows that Chittagong's vehicle-mileage is forecast to increase by 100% by 2030, while average speeds (including rickshaw trips) are expected to decrease from 11kph today to 7kph in 2030 for the PM-peak. Without intervention, traffic conditions in Chittagong will become significantly worse than today.

Figure 8-1: Forecast Change in vehicle speeds and vehicle-Kms, do-minimum scenario



8.2 Changes in traffic flow

Figure 8-2, Figure 8-3 and Figure 8-4 present the modelled flows of vehicles and passengers carried by all modes in the PM peak hour for 2017, as well as forecasts for 2025 and 2030 under the do-minimum scenario.

The highest vehicle loads occur on CDA Avenue. These are forecast to increase from a maximum of 1,900 PCU per direction in 2017 up to 3,900 in 2030 including the flow on the elevated expressway. Importantly these flows remain within the theoretical carrying capacity of the highway assuming the road space is properly managed. This shows that provided the available road space is properly managed, there is sufficient capacity to cope with the forecast demand. Therefore, other than the committed schemes, there is little reason to increase highway capacity outside of relieving pinch-points.

The highest passenger load also occurs on CDA Avenue. These forecasts increase from a maximum of 9,500 PPHPD (passengers per hour per direction) for passengers using all modes in 2017, up to 17,000 in 2030. Passenger loads exceeding 5,000 PPHPD (on all modes) in 2030 would be suitable for considering for mass transit modes, such as BRT.

The large increase in traffic along the coastal road in 2030 relates to the opening of the new deep-sea Port Bay Terminal in the Bay of Bengal which is expected to double the cargo handling capacity in Chittagong and handle significant cargo traffic from Dhaka.

Figure 8-2: Total passenger flow and vehicular flow, 2017 PM peak hour

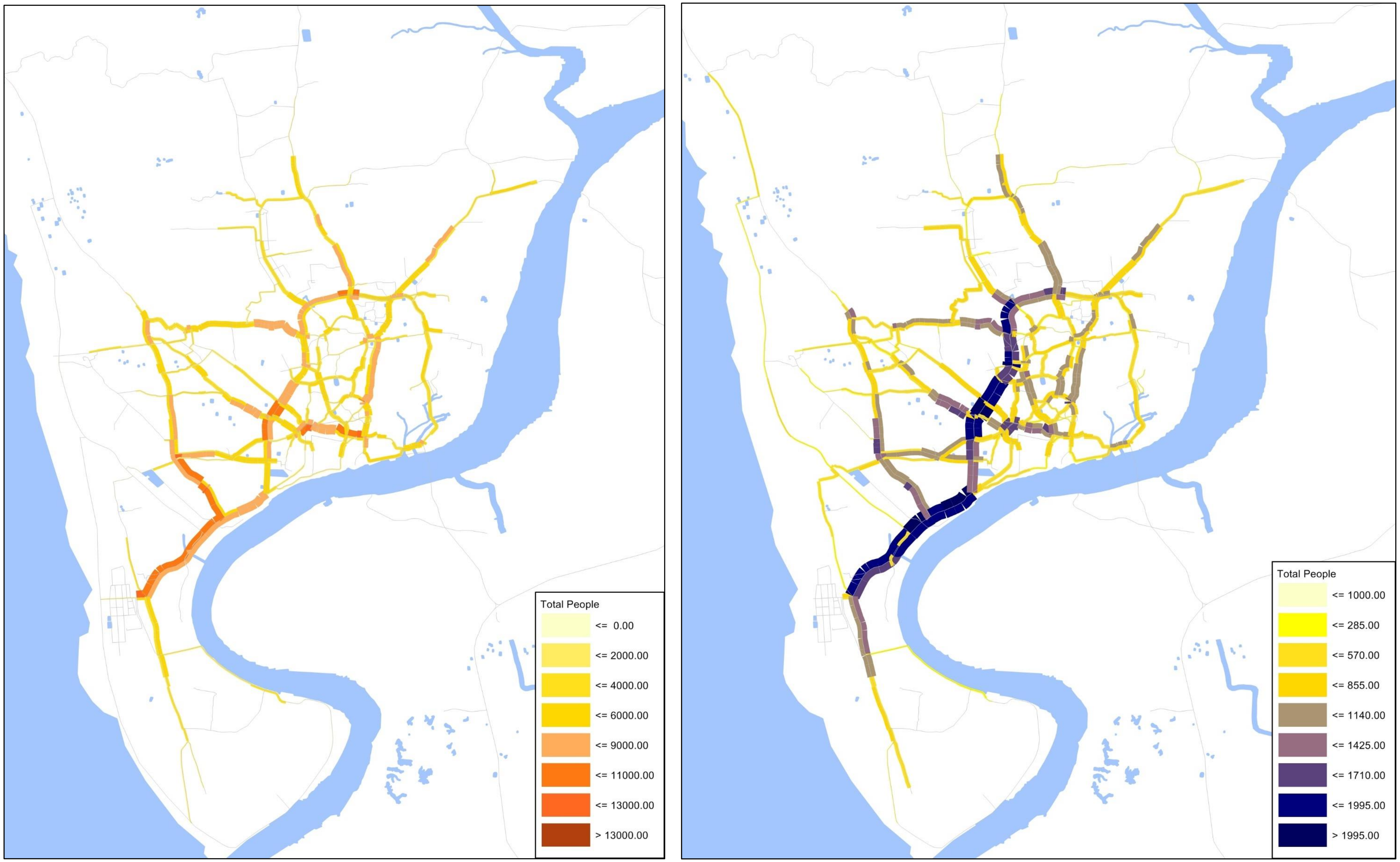
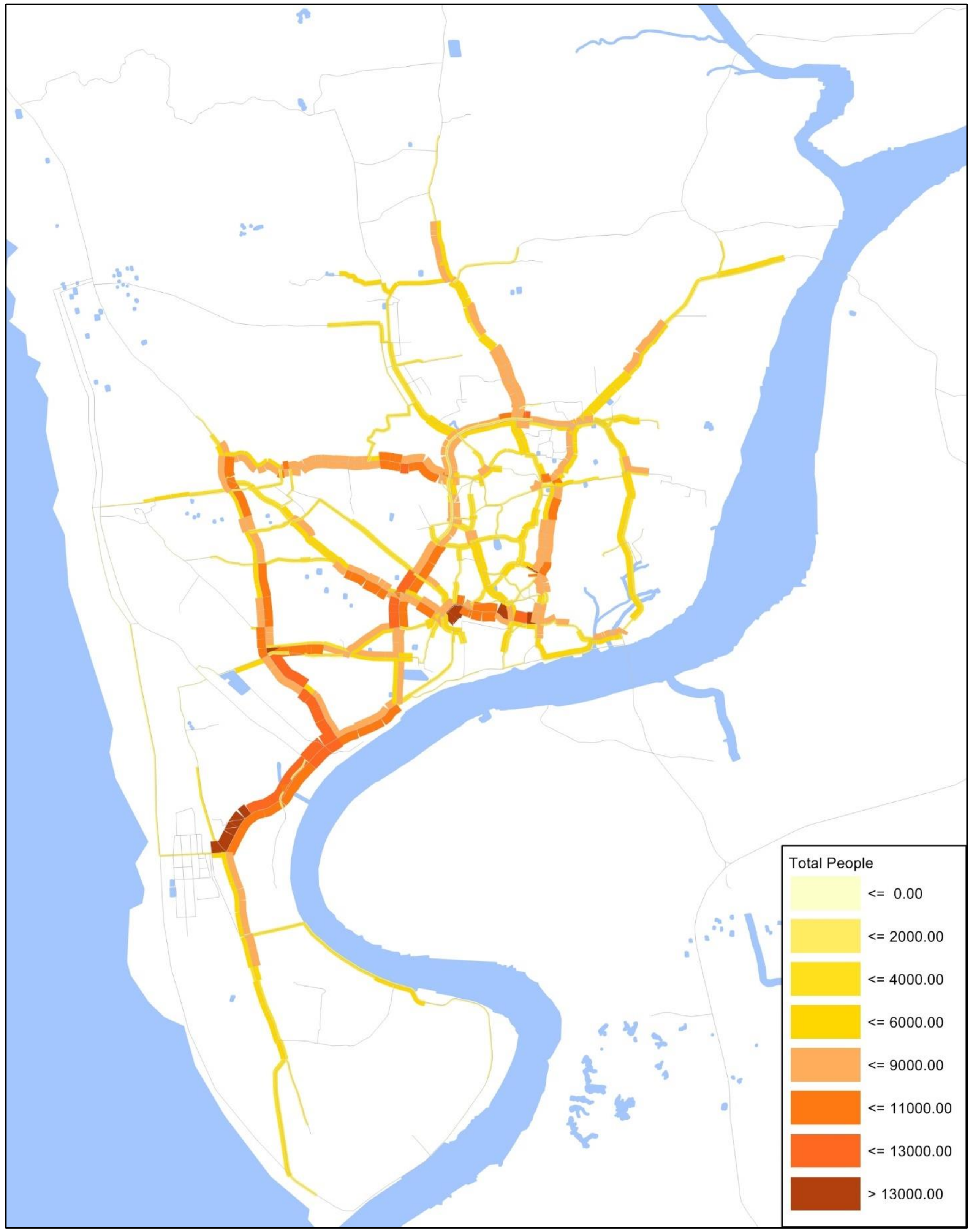


Figure 8-3: Total passenger flow and vehicular flow, 2025 do-minimum, PM pk hour



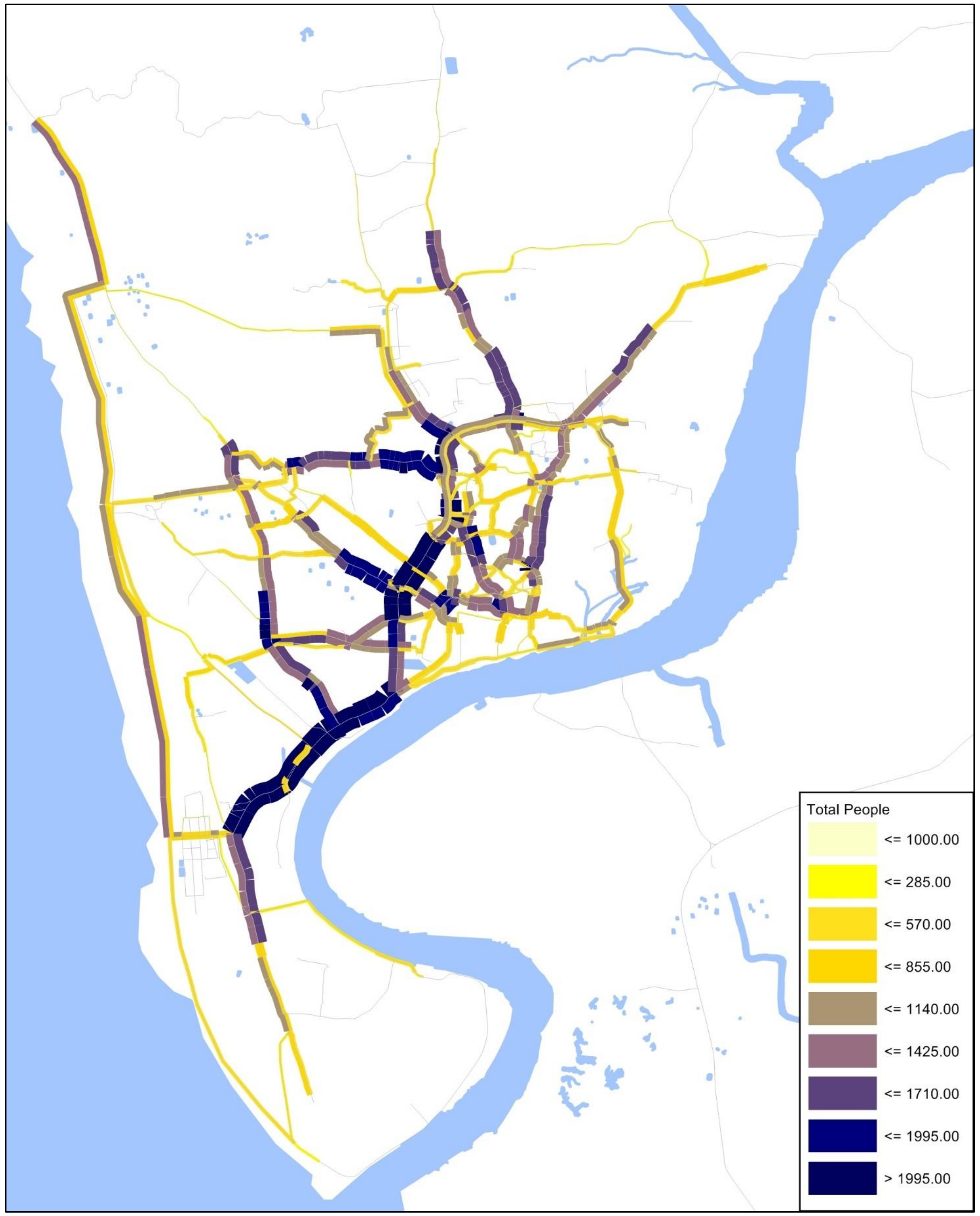
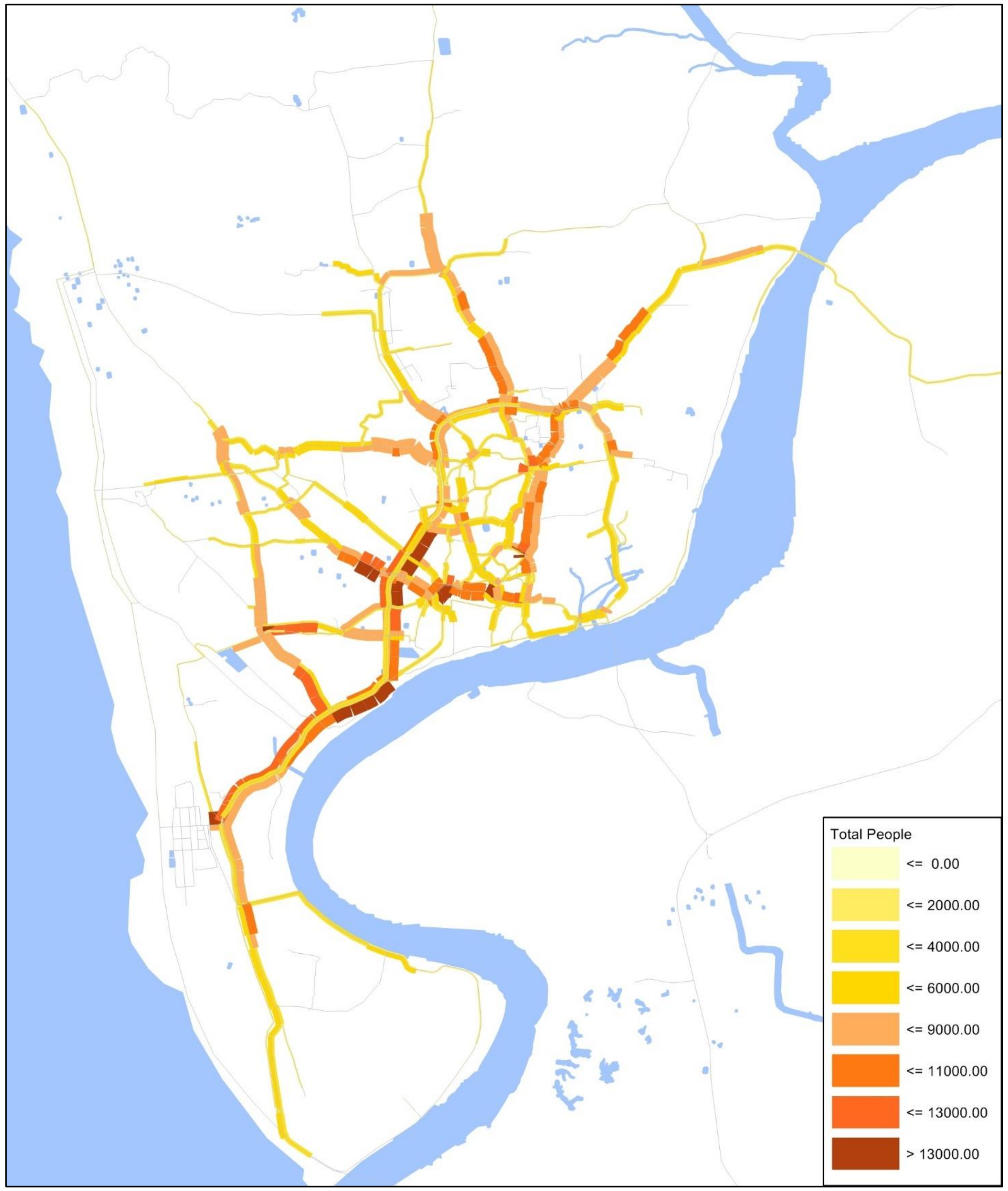


Figure 8-4: Total passenger flow and vehicular flow, 2030 do-minimum, PM pk hour



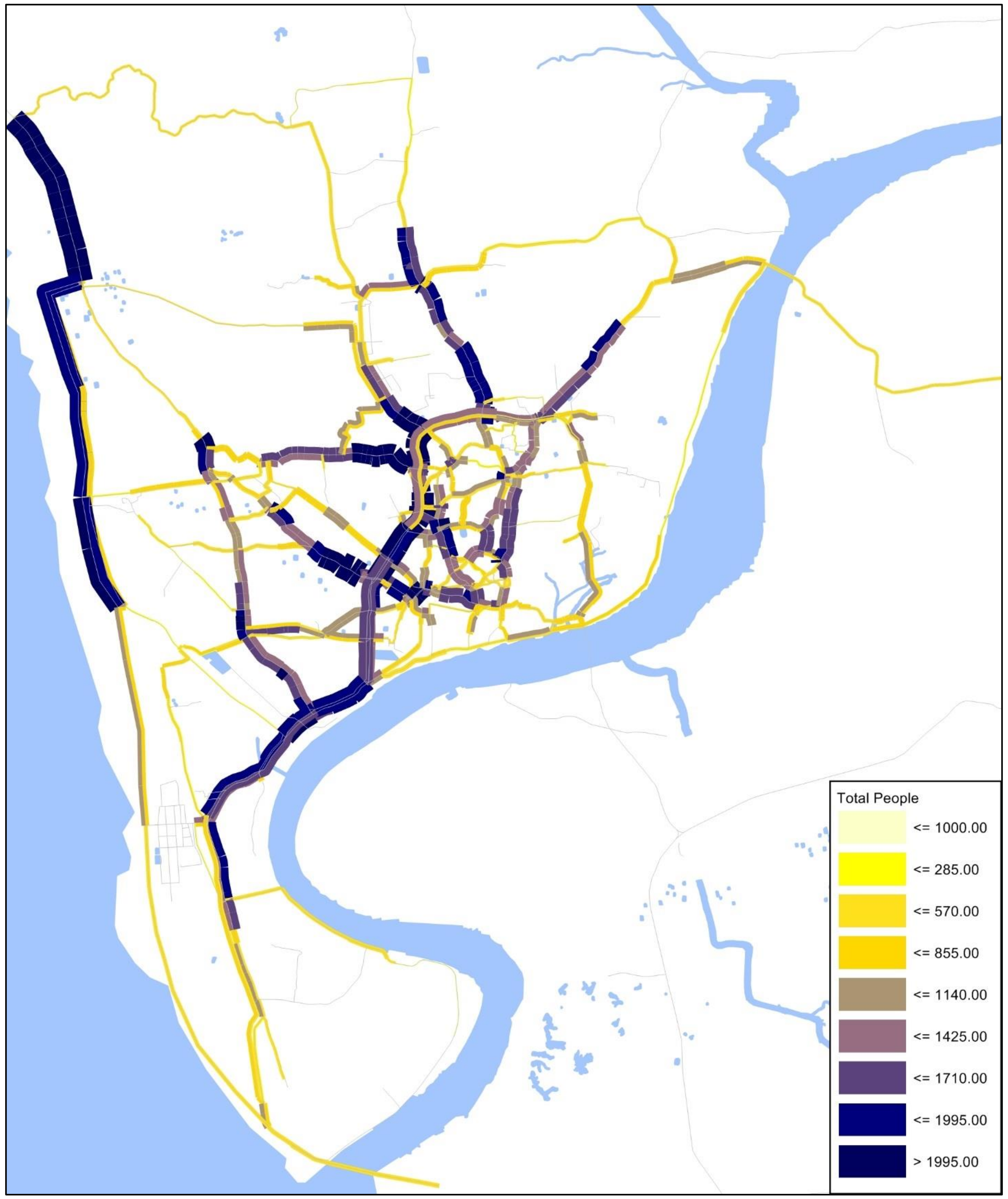
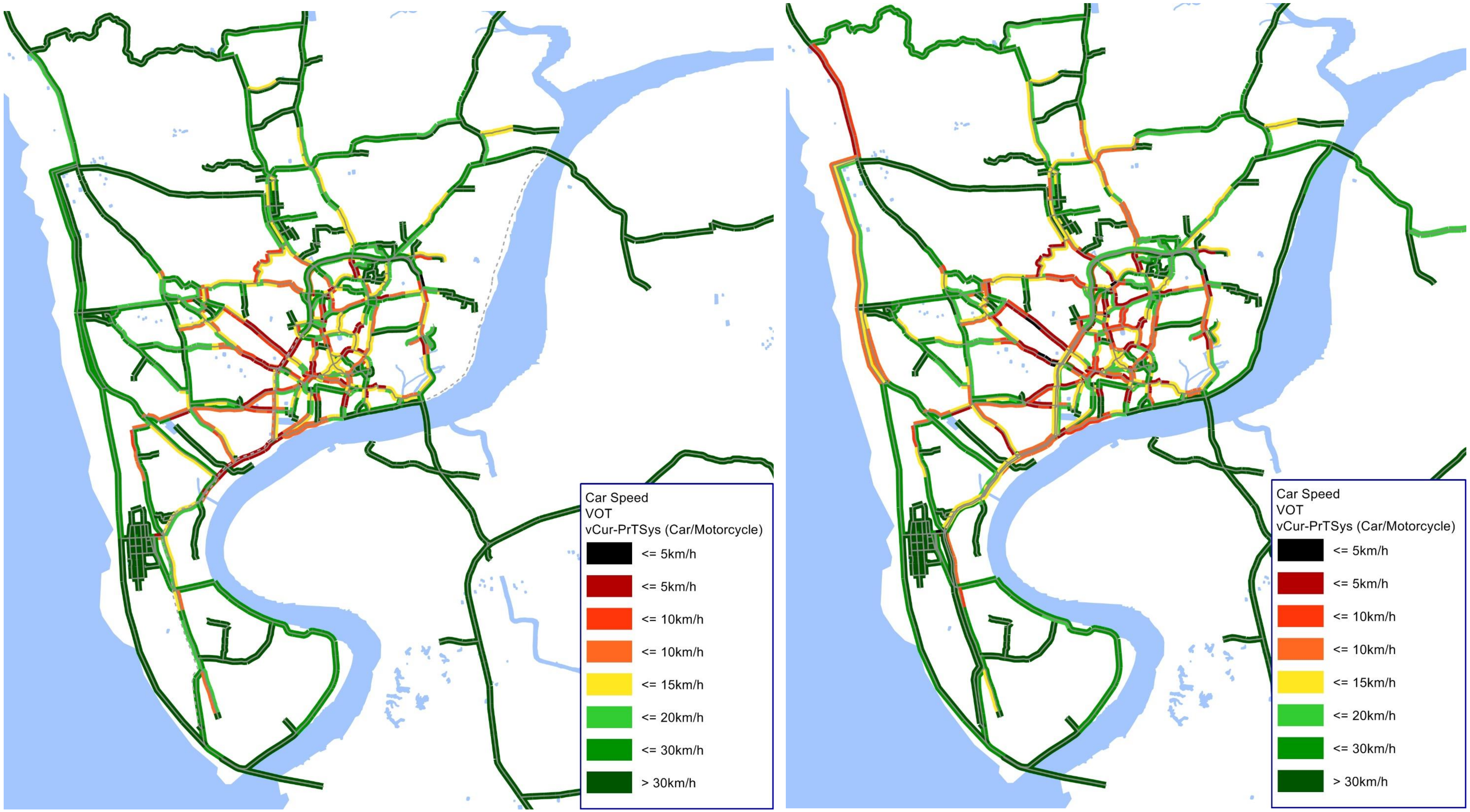


Figure 8-5: Car speed forecasts for the do-minimum scenario in 2025, left and 2030, right



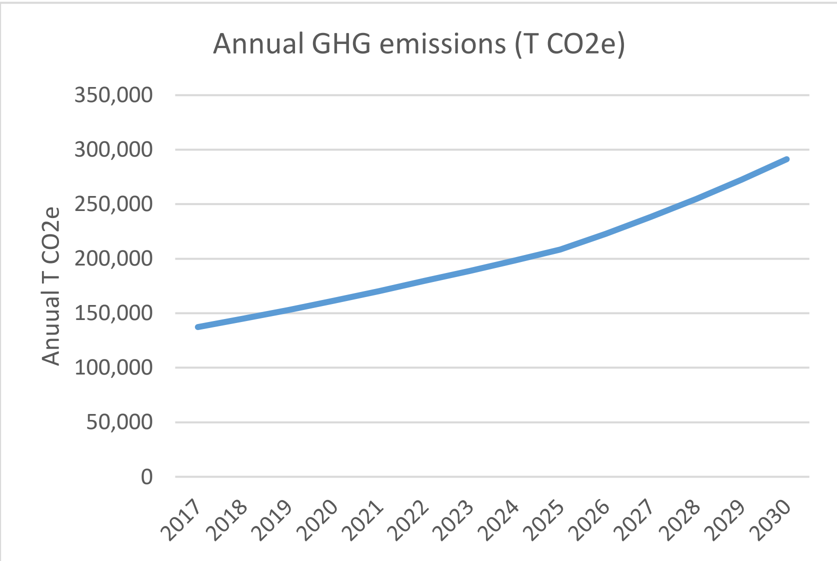
8.3 Air pollution

8.3.1 GHG emissions

The emission of air pollution from transport is modelled as part of the modelling exercise. Emissions are related to total veh-kms by mode. Figure 8-6 presents forecast change in annual Greenhouse Gases (GHG) emissions attributed to all modes of transport on the roads in Chittagong (as measured in Tonnes of CO_2 equivalent). GHG emissions, and their accumulation in the atmosphere cause global climate change.

In 2017 an estimate of 140,000 Tonnes of CO_2e is produced annually. In the do-minimum scenario, this is forecast to double by to 290,000 T CO_2e by 2030. It is the total accumulation of GHGs in the atmosphere that causes climate change[29]. Between 2017 and 2030 GHG emissions are forecast to total 2.8 M Tonnes CO_2e in the do-minimum scenario.

Figure 8-6: Annual GHG emissions, do-minimum



[29] IPCC 2013. *Climate Change 2013: The Physical Science Basis*. https://ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf

8.3.2 Local air pollutants

Transport also creates local air pollutants such as particulates, measured in PMx, and nitrous oxides, measured in NOx. Local air pollution is a primary cause of significant health problems, including early death[30]. The emission of local air pollutants is also related to veh-Kms.

Figure 8-7 and Figure 8-8 present the forecast annual emission of local air pollutants from transport in Chittagong in the do-minimum scenario. Annual particulate emissions are forecast to increase by 88% between 2017 and 2030 while nitrous oxide emissions increase by 82%.

Figure 8-7: Annual particulate emissions, do-minimum

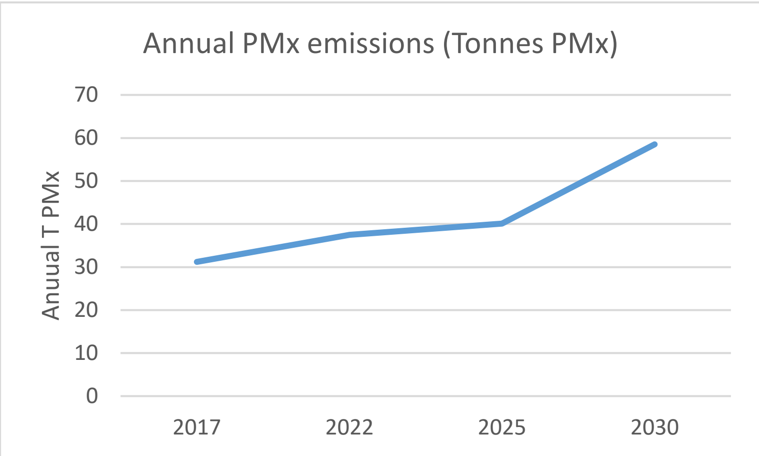
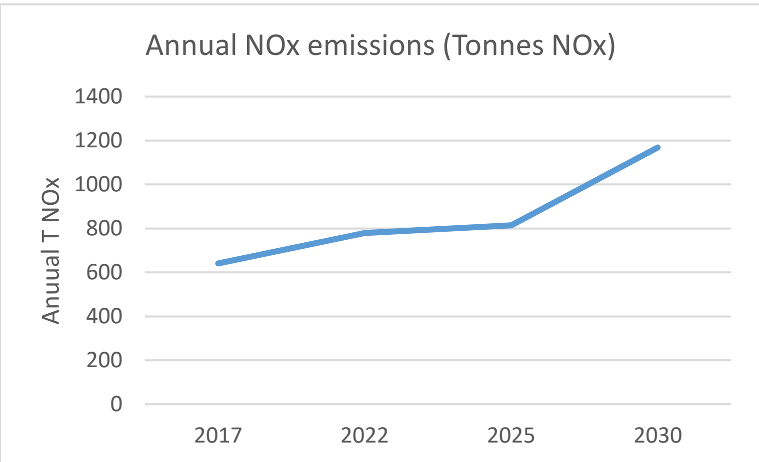


Figure 8-8: Annual nitrous-oxides emissions, do-minimum



[30] World Heath Organisation. http://www.who.int/airpollution/en/

8.4 Outcomes of worsening congestion

The reduction in average travel speeds to 7 KPH in 2030 will have a considerable negative effect on the economy of Chittagong and the city's ability to compete globally. As well as introducing stress and social pressures, rising congestion reverses economic agglomeration effects as it gets harder to access to jobs and services across the city (Bertaud 2014[31]). Agglomeration effects enable a diverse and healthy economy to develop.

Furthermore, increasing congestion typically established two negative feedback loops:

- Congestion encourages urban sprawl and polycentric development, as private developers no longer wish to invest in a city's historic CBD because it becomes too hard to access
- Congestion has a dire impact upon the operational ability of PT vehicles and significantly increase costs for the operator and travel time for the passenger. An increase in PT costs, and a reduction in speed would reduce the relative attractiveness of PT, encouraging passengers to use other modes, most likely CNG or motorcycle. This shift would act to increase congestion further. This negative loop has been observed to have occurred in many other cities where poor PT encourages passengers to use private modes, which in turn increases congestion and makes PT even less attractive.

Dhaka is a good example where rising congestion has not been tackled, as a consequence the city has struggled to conduct functional land-use planning and public transport services have become ever more stretched and unattractive. Of all the cities in the world, Dhaka is placed second last for liveability by the Economist Intelligence Unit in 2018[32], with traffic problems contributing a large part to its low score.

Intervention is therefore necessary now to capitalise on the current high mode share for public transport and walk to prevent unrestrained mode shift to CNG, motorcycle or car in the future. The twin forces of rising incomes and rising congestion encourage the use of private modes such as the car. This reinforces congestion and worsens pollution. Such congestion has a significant negative impact upon a city's health and economic prosperity (e.g. Manila or Jakarta). Sustainable development therefore requires the provision of quality public transport and NMT facilities to ensure these modes are an attractive alternative to the car.

[31] Bertaud, A. 2014. *Cities As Labour Markets*
[32] Economist Intelligence Unit, 2018. *The Global Liveability Index.* https://pages.eiu.com/rs/753-RIQ-438/images/The_Global_Liveability_Index_2018.pdf

9. Long-Term Vision

This SUTMP primarily provides short (up to 5 years) and medium-term (up to 10-years) recommendations for improving transport in the city. However, these short and medium-term recommendations have been developed to meet a long-term vision.

The vision for the SUTMP rests on a range of social research, including workshops and focus groups. The focus groups consulted a range of stakeholders, including disabled people, women, students and representatives from BRTA, CDA and CCC.

The key findings of all the focus groups were that:

- There is insufficient infrastructure in terms of bus terminals.
- Women are not safe on public transport due to eve-teasing and harassment.
- Fares are relatively fair if sometimes a little high.
- Port traffic can be problematic to road conditions in Chittagong, but the Port is vital to the economic success of Chittagong.
- Land use planning is a big cause of traffic problems in Chittagong, with employment centres and residential areas spread at opposite ends of the city.

With these observations in mind, a visioning workshop was held in late September 2017. The key output of the workshop was the agreement of a vision and slogan for the city for transport development in the next 10 years. The chosen vision statement was:

> *"A transport system that provides integrated public transport with walking and cycling provision in a safe, accessible, efficient and environmentally friendly manner for the people of Chittagong."*

The chosen slogan for the city was:

> *"People's City, People's Transport"*

This demonstrates the city's aspiration to prioritise the movement of people above vehicles, through the use of public transport, walking and cycling. The focus on people also demands a focus on access to transport for certain groups such as women and disabled groups. Ensuring safety and accessibility for all people forms a central tenet of this vision, which will be implemented through the range of measures recommended in this plan.

9.1 Objectives

The top 5 objectives for the SUTMP, identified during the visioning workshop held in October 2017 are detailed in Table 9-1. These were the five highest ranked objectives by different groups during the visioning exercise. These objectives are the guiding principles for the SUTMP.

Table 9-1: Five SUTMP objectives for the SUTMP

Objective/criterion	Meaning (visioning workshop)
Safety and security	• Safe for road users • Safe for pedestrians • Safe for passengers • Improved compliance with traffic laws • Improved enforcement • Education and training
People friendly public transport	• Convenient • Comfortable • Inclusive (gender, poverty, elderly, disabled) • Design features for people with disabilities, elderly and infirm • Vehicles, infrastructure and operations are safe for women • Protect cultural heritage • Vibrant public spaces • Minimum negative social impact

Objective/criterion	Meaning (visioning workshop)
Economic efficiency	• Optimum use of road space • Parking management • Traffic management and enforcement • Removal of encroachment • Bus bays and enforcement of loading restrictions • Travel Demand Management • Location of Inland Container Depots
Environment	• Minimised impacts on the environment • Carbon-free • Congestion free • Protection of open spaces/green belt • Protection of waterways • Greening public spaces • Environmental resilience to natural disasters and flooding
Accessible	• Fast journeys • Access to multiple destinations • Public transport routes and stops spaced easy walking distance apart

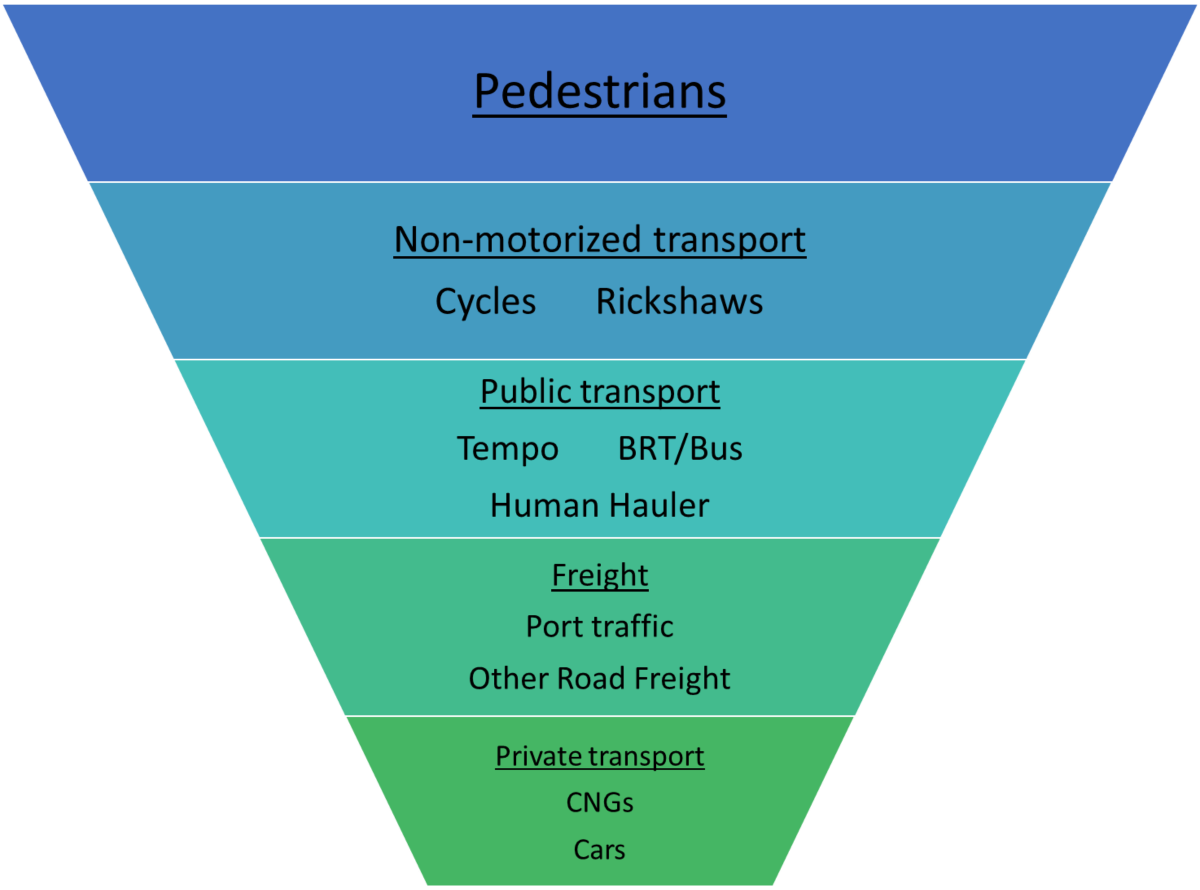
9.2 Future mode hierarchy

According to this vision, we recommend a mode hierarchy that places public transport, walking and NMT above the needs of private transport vehicles (see Figure 9-1), thereby helping to achieve the goal of moving people, not vehicles.

Although automobile dependency is currently extremely low, there is a lot of scope for Chittagong to become car- (or possibly motorcycle) dependent in the future, akin to many cities in other rapidly developing countries. Planning for a quality multi-modal public transport system, which provides an attractive alternative to future car use, is vital to ensure Chittagong does not suffer from the consequences of car-dependency in the future[33]. These consequences include air pollution, congestion, declining health and high rates of road accidents. Car dependency also tends to encourage urban sprawl, which further incentivises private car use.

The development of waterway transport or improvements to the existing rail network are not considered necessary before 2030. Waterway services on the Karnaphuli River would not serve the main OD movements in the city, similarly, the rail network is not best placed to carry the current pattern of OD movements. However, it is thought that rail could become an important mode further into the future, as the city expands northwards. Then the two rail lines which extend to the north (one to Hathazari, the other to Dhaka) could become important commuter lines.

Figure 9-1: Mode hierarchy to meet the long-term vision



[33] http://www.sutp.org/files/contents/documents/resources/B_Technical-Documents/GIZ_SUTP_TD8_Rising_Automobile_Dependency_EN.pdf

Mode hierarchy explanation:

1) Pedestrians – 25% of trips are made wholly by walk, and most PT trips begin or end on foot. Facilities for pedestrians should be significantly improved from their current condition in order to benefit all citizens of Chittagong City, but especially the poorest who have no option but to walk. Quality pedestrian access to public transport terminals is required
2) NMT – Rickshaws and cycles will benefit from the more general improvements to road conditions. However, rickshaws should be encouraged as 'feeder' services and discouraged from operating on bus priority roads once a quality PT alternative has been provided for their passengers. Cycles are not currently used commonly in Chittagong but improving general road conditions is expected to improve their access around the city. Due to their low modal share, they are currently not planned for in terms of regulation or infrastructure.
3) Public transport – Public transport should be the preferred mode for the majority of trips. Prioritizing public transport over any private transport is important in making it an attractive alternative to private transport modes.
   a) Bus/BRT – large buses on a bus priority/BRT system should form the backbone of Chittagong's public transport system. The key focus will be on the bus as the most cost-effective and efficient means of mass transport available for a city like Chittagong.
   b) Tempo – Tempos should serve feeder routes, connecting narrow residential streets with the large buses/BRT.
   c) Human Hauler- Humans-haulers should be phased out of central Chittagong – they are considered too large to perform well in narrow residential streets, but too small to effectively carry passengers in great volumes. They could be used for longer-distance feeder services, linking more rural residential areas with the bus priority and BRT systems.
4) Freight – Chittagong's economic performance relies heavily on freight traffic to and from the Port and CEPZ. Currently, congestion negatively impacts on freight access. On certain roads (such as Port Link Road), freight access should be prioritised.
5) Private transport – Private transport in this context encompasses CNGs, car taxis, private cars and motorcycles. Due to their low occupancy rate and high potential for causing pollution and congestion, these modes are to be the least prioritized in the long-term vision. The public transport system should be improved to a point that it offers an affordable and attractive alternative for the majority of private transport users.

   We do not recommend a ban on CNGs. Instead, the PT system should be improved to a point to become more attractive than CNG on various fronts. In particular, improving women's safety on public transport will help to encourage them out of CNGs and onto public transport. However, forcing this change will disadvantage women significantly because they currently use CNG preferentially due to safety concerns. Banning CNGs would therefore place women in immediate danger by forcing them to use public transport before it has been improved. It is very important that quality PT is offered to provide a viable alternative to the CNG, otherwise there is a risk that CNGs may crowd out poor performing PT services.

10. Option Identification

Addressing the problems identified in Chapter 6 and 7 and meeting the long-term vision in full will require significant intervention in traffic management, institutional/regulatory reform, operational enhancement and infrastructure. The potential options for improvement are discussed in the following areas:

- Bus facility improvement – examining the infrastructure that supports the public transport network
- Bus priority/BRT – addressing a system based approach to improving public transport for both users and providers
- Traffic management – to be multimodal addressing motorised and non-motorised transit. Including junction improvements.
- Pedestrian infrastructure
- Institutional and bus sector reform – addressing enhanced delivery of public transport through a change in the public and private sectors.

10.1 Bus terminal improvement

Existing terminals are a coincidence of activity to which are only lightly planned and regulated. This has resulted in some functional performance but a facility that is suboptimal and does not meet anything more than primary, often commercial, objectives. The operation of these terminals consequently causes congestion.

A terminal is the end of the route and has the following operational functions:

- Enables the bus to turn around and make a return journey. The physical design must accommodate this whilst minimising minimal manoeuvring and conflict with other road users including pedestrians.
- Provide an effective interface between bus and passenger loading points, minimising conflict and the time the bus spends stationary.
- Provide for ‘layover’, that is a space where vehicles can rest in order to maintain appropriate headway between preceding and proceeding vehicles
- Efficient interchange with other transport modes for onward journey.

A terminal should have the following passenger functions:

- Safe access for pedestrians to access the bus service
- Minimise barriers to access bus services for those with disabilities or carrying goods (this might include curb ramps and floor gap reduction/elimination)[34]
- Appropriate levels of information about bus services offered, presented in a manner which is sensitive to those with cognitive/visual impairments or who use different languages
- Safe waiting area of appropriate capacity that is protected from the effects of weather, traffic and noise, with good lighting and comfortable seating if appropriate to the capacity
- Safe and effective bus-passenger interface

In satisfying these functions the terminal must also develop a positive relationship with surrounding land use with, at least, minimal adverse impact and, at best, making a positive contribution to the public realm and land use development. Regarding the latter, the adoption of Transport Orientated Development (TOD) principles can be pursued subject to appropriate regulatory context to enable integration of transport and land use.

All terminals in Chittagong would benefit from re-planning. The approach to be adopted should include:

- Operational assessment and planning to meet the operational need
- User-orientated assessment to determine user needs and to protect users from conflict
- Impact assessment to ensure that the impacts of the terminal can be managed within the local area in terms of safety, capacity, environmental and social.
- Land use and public realm assessment and proposals to ensure a positive contribution and effective integration

10.1.1 Future arrangement inter-district terminals

There are currently 10 inter-district bus terminals spread out across Chittagong (Figure 3-10). Their disparate locations make them hard to access for passengers and the disorganised nature of the terminals causes congestion.

[34] Kuneida & Roberts (2006). *Inclusive access and mobility in developing countries*. Available at: http://siteresources.worldbank.org/INTTSR/Resources/07-0297.pdf

The long-term goal is for PT interchanges to provide easy and safe interchange between different modes, including local bus, BRT, inter-district bus and potentially rail. They should also provide space for lay-over vehicles to wait off-road. The number of inter-district terminals should be rationalised.

Two options are considered for improving inter-district bus terminals:

- Consolidate all inter-district terminals into a single central terminal in the city-centre which integrates with the railway station
- Construct a network of inter-district terminals on the edge of the city which are connected via an efficient cross-city mass transit system

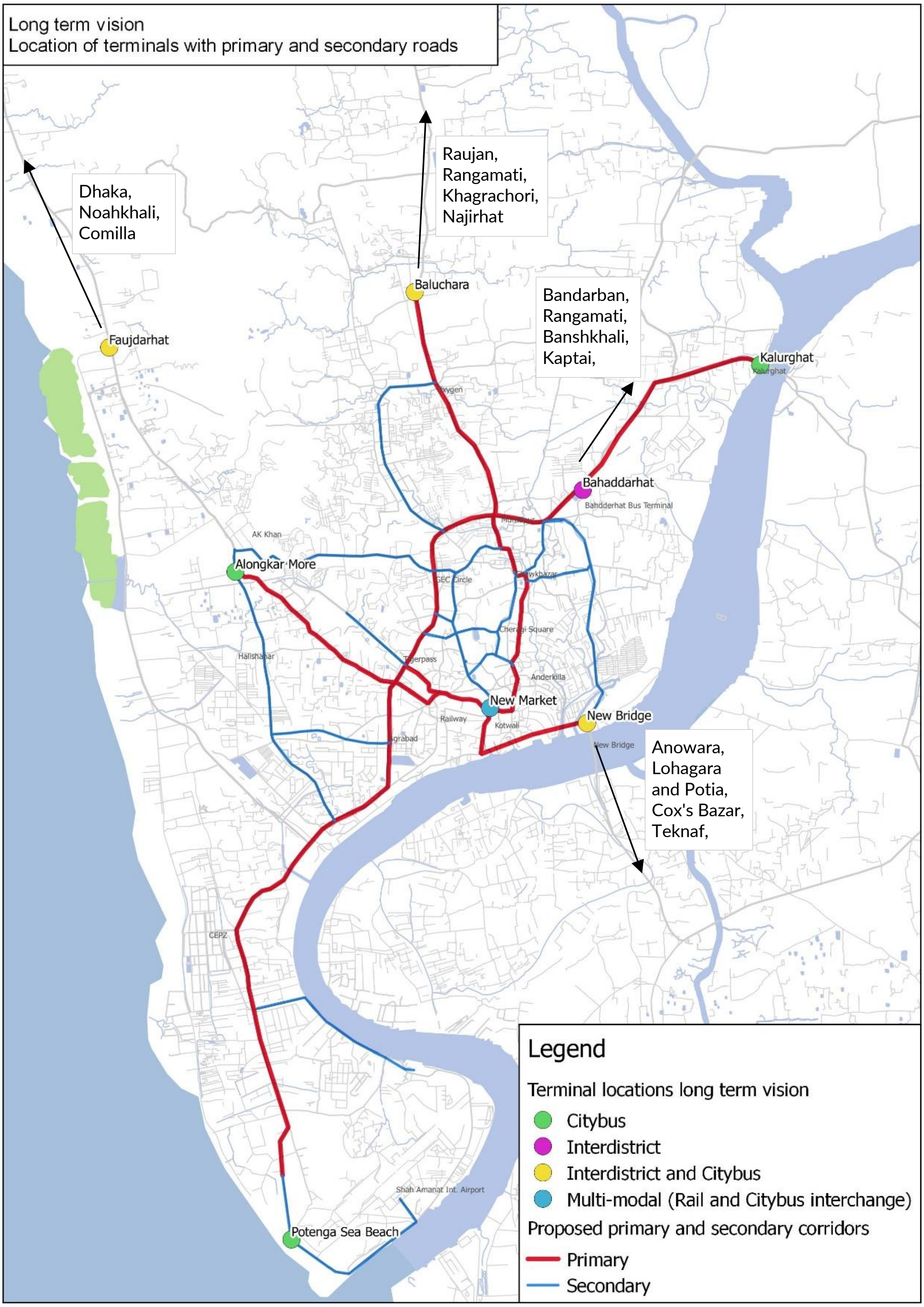
In terms of the level of service to the passenger, it would be better to have a single terminal located in the centre of the city. This would enable easy transfer between inter-district routes and enable access to the suburbs of Chittagong using the urban PT network. The success of the terminal would depend on uncongested access into and out of the city for inter-district coaches using bus lanes where necessary to avoid congestion. The challenge with this option is land availability and cost. The ideal site for a central terminal would be on the site of the central railway station, but this land is not presently available for development.

The second option would see the consolidation of PT terminals at four peripheral sites located on the main highways that exit Chittagong (Figure 10-1). This enables inter-district services to avoid city-centre congestion and prevents these services from contributing to city centre congestion.

There is more land availability on the periphery of the city, for the considerable hectarage required to support parking areas, driver facilities, passenger facilities, workshops, ticket kiosks and potentially depots. CDA has already identified potential sites on the Dhaka Highway (N1) in the vicinity Faujdarhat, and on the Hathazari Rd at Baluchara.

However peripheral terminals will only be successful if they are ‘plugged’ into an effective city-wide mass transit system that enables connections between the PT terminals and to all areas of Chittagong, including the city centre and suburbs. Figure 10-1 identifies how a rationalised set of PT terminals could be connected together, and to the city, through a quality PT network. This SUTMP will seek to develop an efficient PT network, therefore the use of peripheral inter-district terminals is considered appropriate.

Figure 10-1: Long-term vision for PT terminals integrated with rapid PT network



10.1.2 Improving city-bus terminals

There are 7 terminals for city-buses spread across Chittagong, most of these are informal without off-road parking or facilities for passengers and drivers. Formal city-bus terminals should be constructed. Figure 10-1 identifies the appropriate location for 4 city-bus terminals, with a further 3 sites integrated with inter-district terminals.

10.1.3 Design considerations

The basic components of a good terminal which meets the SUTMP objectives are:

1) Safety and security
    a) Policing and enforcement at stations
    b) Good practice safe design at stations in terms of natural surveillance and crime prevention
    c) Security, to ensure the safety of all interchange-users, particularly women and other vulnerable users;
    d) Lighting at stations
    e) Visibility, to avoid conflict between pedestrians, buses and other modes;
2) People friendly
    a) High-quality design standards of bus terminals to contribute to improving public space
    b) Facilities for passengers, including toilets, waiting areas, food and drink, and ticket/information counters;
    c) Facilities for drivers including resting room, canteen, water, toilets
    d) Wayfinding, to ensure pedestrians and drivers alike are able to move along desired lines to reach their destination;
3) Economic efficiency
    a) Purchase of tickets off-vehicle will improve journey times
    b) Largest terminals may provide commercial space for retail outlets
4) Environment
    a) Construction of bus terminals and/or BRT should not negatively impact green belt or open spaces unless the cost-benefit analysis is in favour
    b) Where possible construction of new bus terminals etc. should include new high-quality public space

c) Design principles of all terminals should minimise their ongoing environmental impact

5) Accessible

a) Terminals should give priority to pedestrians within the terminal area, with sufficient pedestrian crossings for this to be possible

b) Ideally, all access to vehicles should be at ground level, to reduce the need for stairs/elevators and to improve disabled and elderly access

c) Any footbridges which are non-avoidable should include ramps to improve access for those with disabilities and the elderly (although ideally implementing footbridges should be avoided where possible)

d) Accessible pavements to ensure people with reduced mobility are able to access the interchange

10.2 Mass transit options

Delivering a quality PT network is a central element of the long-term vision. A variety of modes are considered to provide such a network, these include; standard bus, BRT, Light Rail Transit (LRT), and Metro.

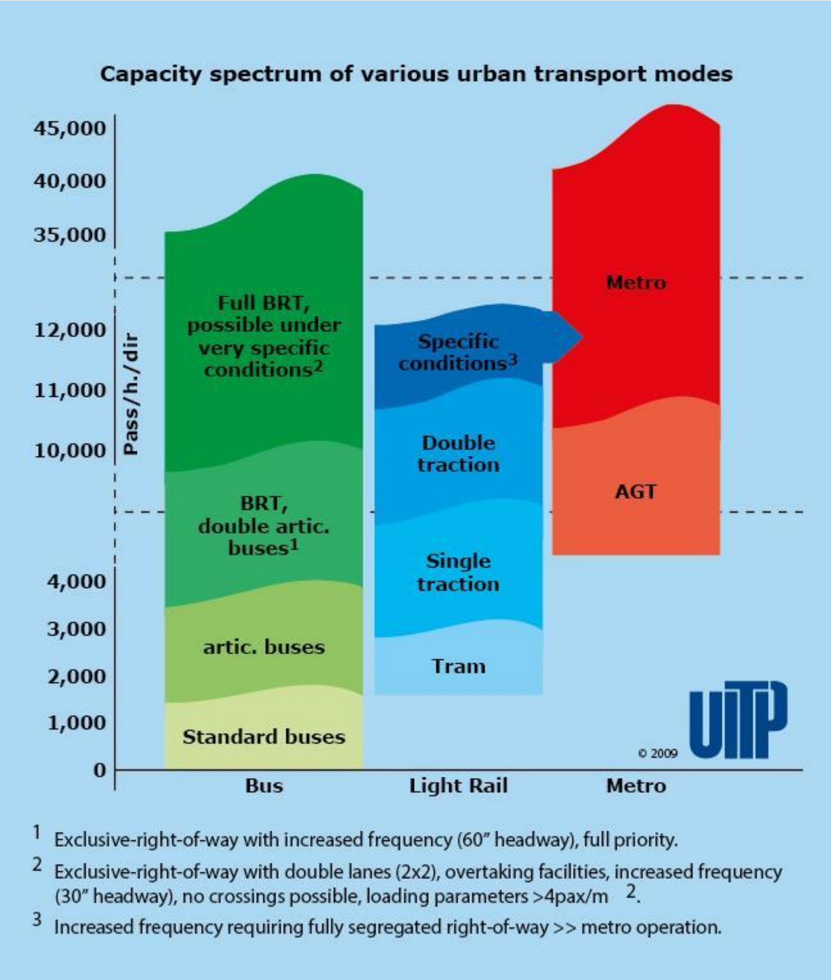
10.2.1 Review of international best practice

Much has been written about different transit systems and their ability to transport large numbers of passengers around or between urban areas. In particular, various studies have developed classifications for the appropriate transit services for a given level of passenger demand.

Based on a review of the performance of different transit systems across the world, UITP developed a capacity spectrum of various urban transport modes, see Figure 10-2. This presents the level of demand that various cities experience and the type of transit system in place to cater for that demand. This shows that for bus-based systems, if demand is below 2,000 passengers per hour per direction (PPHPD) on a given route or corridor, then standard bus services are typically required to accommodate those passengers. From between 1,500 and 4,000 PPHPD, articulated buses are typically used, whereas from 3,500 to around 10,000 PPHPD BRT services with dedicated right of way lanes are the most appropriate bus-based transit mode to accommodate that level of demand. Full BRT services with dual lanes, large stations etc. can be used to accommodate the demand of up to 40,000 PPHPD. What is most evident is that bus services can accommodate varying levels of passenger demand from very low levels to very high levels, highlighting the flexibility of bus-based transit systems.

Figure 10-2 also presents average passenger demand required for different types of light rail and metro systems, with light rail systems carrying between 2,000 and 12,000 PPHPD and metro systems reported to accommodate between 4,000 PPHPD for some automated guideway transit systems and up to 45,000 PPHPD for large metro mass transit systems.

Figure 10-2: Capacity spectrum of various urban transport modes (UTIP)



Source: UITP 2009. *Public transport: making the right mobility choices*

Luke in his 2006 paper titled "Public Transport Mode Selection: A Review of International Practice", produced by Transport for London (TfL) (Table 10-1) shows that there are broadly comparable levels of demand for each mode to those presented in Figure 10-2. This suggests that bus services can accommodate demand up to 2,500 PPHPD, prioritised bus services can accommodate demand up to 4,000 PPHPD while busway systems (BRT) can accommodate up to 6,000 PPHPD. This is significantly lower than Figure 10-2 which suggests and does not take into account examples such as Transmillennio in Bogota which can accommodate up to 40,000 PPHPD, however this is a table adopted by TfL for its needs in London, and given the dense underground rail network in London, it is not necessary for TfL to adopt BRT services in the same way as Bogota adopted them.

Table 10-1: Classifications of transit modes in London (Luke 2016)

Modal Characteristics	Bus	Maximum Bus Priority	Busway	Tram	Light Rail	Heavy Rail
Maximum capacity	2,500 pphpd	4,000 pphpd	6,000 pphpd	12,000 pphpd	18,000 pphpd	30,000 + pphpd
Capital cost per route km	< £1m	£1m - £2m	£1m - £20m	£15m - £20m	£10m - £45m	£45m - £250m
Operating cost per passenger place km	3.8 p – 8.8 p	2.5 p – 5.8 p	2.5 p – 5 p	1 p – 2.1 p	1 p – 1.4 p	1.5 p – 1.8 p
Average speed	10–14 km/hr	14–18 km/hr	15 – 22 km/hr	15 – 22 km/hr	18- 40 km/hr	18- 40 km/hr
Reliability	Improving	Medium	Good	Medium to Good	Good	Very Good
Roadspace Allocation	Mixed running with traffic	Mixed running and on-road bus lanes	Totally segregated alignment required	Mixed running and on-road tram lanes and totally segregated where available	Very largely on segregated alignments	Totally segregated
Theoretical Land Use 'best fit'	Best suited to lower density dispersed urban form	Best suited to lower density dispersed urban form	Best suited to high demand corridors in medium to low density areas	Higher densities of development, or connecting denser urban centres	Higher densities of development, or connecting denser urban centres	Very high density urban development

Source: Luke, S. 2016. *Public Transport Mode Selection A Review of International Practice*

Mackechnie developed a table of appropriate passenger demand for different services as presented in Table 10-2. This table was developed by examining examples of transit systems across the world, but with a particular focus on North America. This suggests slightly different passenger demand values to those noted above, although the general trend of bus-based transit systems accommodating the lowest levels of demand remains evident. The author suggests that BRT can be used to accommodate between 1,350 and 2,700 PPHPD, whereas LRT systems typically accommodate between 4,050 and 8,100 PPHPD. Subway systems accommodate the greatest numbers of passengers.

Table 10-2: Capacity of Different Transit Modes (Mackechnie 2014)

Mode	Average PPHPD	Approximate daily ridership
BRT (at grade)	1,350	20,000
BRT (grade separated)	2,700	40,000
LRT (at grade)	4,050	60,000
LRT (grade separated)	8,100	120,000

Mode	Average PPHPD	Approximate daily ridership
Subway	30,000	450,000

Source: Mackechnie, C. 2014 http://publictransport.about.com/od/Transit_Planning/a/What-Is-The-Capacity-Of-Different-Modes-Of-Transit.htm

Overall, while there are differing passenger demand values for different transit modes used in different urban areas across the world, the general trends are as follows:

- Where demand is lowest, non-segregated bus-based systems are most appropriate
- Where demand is higher, differing levels of BRT/busway systems are best placed to accommodate that demand
- LRT and tramway systems can be used where demand exceeds those that cannot be accommodated by BRT – although full BRT systems can accommodate high numbers of passengers if planned correctly as part of a network of BRT routes and services
- For routes and corridors with the highest levels of demand over 40,000 PPHPD, metro or subway systems are best placed to accommodate such demand.

Based on these examples it is possible to develop a general consensus of appropriate transit modes based on the existing demand evidenced through this study. This is presented below in Table 10-3. This table should be used as a guide for the development of optimised transit services. Each route or corridor will have its own characteristics and so the choice of the necessary transit mode on each route or corridor will be influenced by the characteristics of each route.

Table 10-3: Consensus of transit mode types based on passenger demand

Mode	Average PPHPD	Average Daily Ridership	Cost per Km (USD M)
Standard Bus	Up to 2,500	37,000	
Bus (standard or articulated) with priority	2,500 – 4,000	37,000 – 60,000	4 – 5*
BRT	4,000 – 40,000	60,000 – 600,000	8 – 10*
LRT	6,000 – 18,000	90,000 – 265,000	20 – 30**
Metro	11,000 – 45,000	165,000 – 670,000	100 – 300+

*Cost estimates for bus priority and BRT from Table 15-3

** ERRAC & UITP, 2009. *Metro, light rail and tram systems in Europe*
+ https://pedestrianobservations.com/2013/06/03/comparative-subway-construction-costs-revised/

10.2.2 Appropriate mass transit in Chittagong

The maximum flow of passengers, carried by all modes, is forecast to be 15,000 PPHPD in the PM peak hour in 2030 (Figure 8-4). This maximum flow is located on CDA Avenue (north of Tigerpass) and Mooring Road. Passenger flows of up to 13,000 are also forecast on the Dhaka Trunk Road and Station Road.

Table 10-3 shows that BRT and LRT are suited to carrying passenger flows of 15,000 PPHPD. Metro is also worth considering, but the passenger flow of 15,000 PPHPD is on the low side of what Metros typically carry.

Considering the central value of typical costs, a mass transit line of 10 Km would cost approximately USD 9M if it were BRT, USD 25M if it were LRT and USD 200M if it were Metro. This communicates that BRT and LRT are the most cost-effective, while Metro is considerably more expensive.

It is not recommended that Metro is considered suitable for Chittagong in the medium term because of its high cost and because the passenger forecasts are low compared to the passenger flows that Metro's typically carry. This indicates that the mode might not be commercially viable in Chittagong before 2030, however at the city grows Metro will become more feasible and could be considered in the long term.

While LRT is twice the cost of BRT it generally offers better ride quality for the passenger. However, the operation of LRT is not as flexible as BRT to cater for different levels of passenger flow. The operation of LRT also relies on a reliable power source which may not be present. BRT can be operated in a more flexible way, including the use of direct services into residential areas or industrial areas which would provide a significant advantage in Chittagong. As BRT is a bus-based system it can utilise expertise already present in Chittagong including drivers and mechanics. On balance it is recommended that BRT is pursued for mass transit routes constructed in Chittagong before 2030.

In terms of disabled access, BRT also offers the most appropriate solution, because it enables more flexibility and adaptation as the system develops. It is more practical to implement accessible infrastructure in a phased manner when starting from a relatively low base point. This means that the infrastructure and fleet can be upgraded over time towards the goal of fully accessible (level floor) buses running in the BRT system, with sufficient space for luggage and wheelchairs. BRT is also more socially flexible as routes can also be altered to include peripheral or new settlements as they grow, which often include some of the poorest citizens living in slum settlements. With a more fixed system these kinds of adaptation are harder to achieve, and fleet renewal/upgrading can represent a greater up-front expenditure.

10.3 Bus priority and BRT

The majority of those travelling in Chittagong are public transport users who suffer both poor travel conditions, slow and unreliable journey times. Slow journey times are inconvenient to travellers but also increase bus operational cost. Whilst congestion is ever present the degree of congestion varies resulting in unreliable journey times, and so public transport cannot be relied upon to arrive at a planned destination on time. As such improving run times and runtime reliability would have significant benefit to the city and its citizens.

Immediate run time reductions could be achieved by enforcing stopping restrictions at junctions. This would reduce congestion for all traffic but not the bus over and above other traffic. Bus priority often found in terms of dedicated lanes marked by paint and preferential traffic signals would not have a significant effect and would require strong enforcement and driver behaviour change programmes. Within the Chittagong environment any priority given needs to be self-enforcing and as such physical forms of priority would be favoured over painted lane demarcation. Whilst traffic signals have existed within the city they were, when operational, rarely obeyed and now when not functioning are replaced by police giving direction. Introduction of any form of signal control will require careful design to make the signal clear, a widespread education programme and enforcement.

10.3.1 Corridor options

It is necessary to identify the corridors for which BRT (primary corridors) and bus priority (secondary corridors) would be suitable. This is based on the data collected, including:

- Passenger demand - the likely patronage of the route is important to its viability as a BRT/Bus priority corridor.
- Current PT routes served - the current bus routes which run along a corridor are likely to remain there as they serve the current passenger base, and many trip generators/attractors.
- Roadway width - the implementation of BRT will depend on appropriate road widths able to accommodate a kerbed lane.
- Current bus speeds - slow bus speeds enable identification of areas which would benefit from BRT or bus priority.

- Trip generators/attractors such as employment sites or schools - any bus project will need to ensure that it serves the places which people need to travel to and from, most likely by combining feeder routes into the spine of the BRT/bus priority corridor
- The ability for the mass transit corridors to serve areas high in poverty

10.3.2 Passenger load

Figure 8-3 shows forecast passenger flows for the year 2025 and Figure 3-5 the existing bus routes. These are all based on a modelled 'do-minimum' scenario. It enables a view to be taken of existing usage of corridors.

10.3.3 Identification of candidate corridors

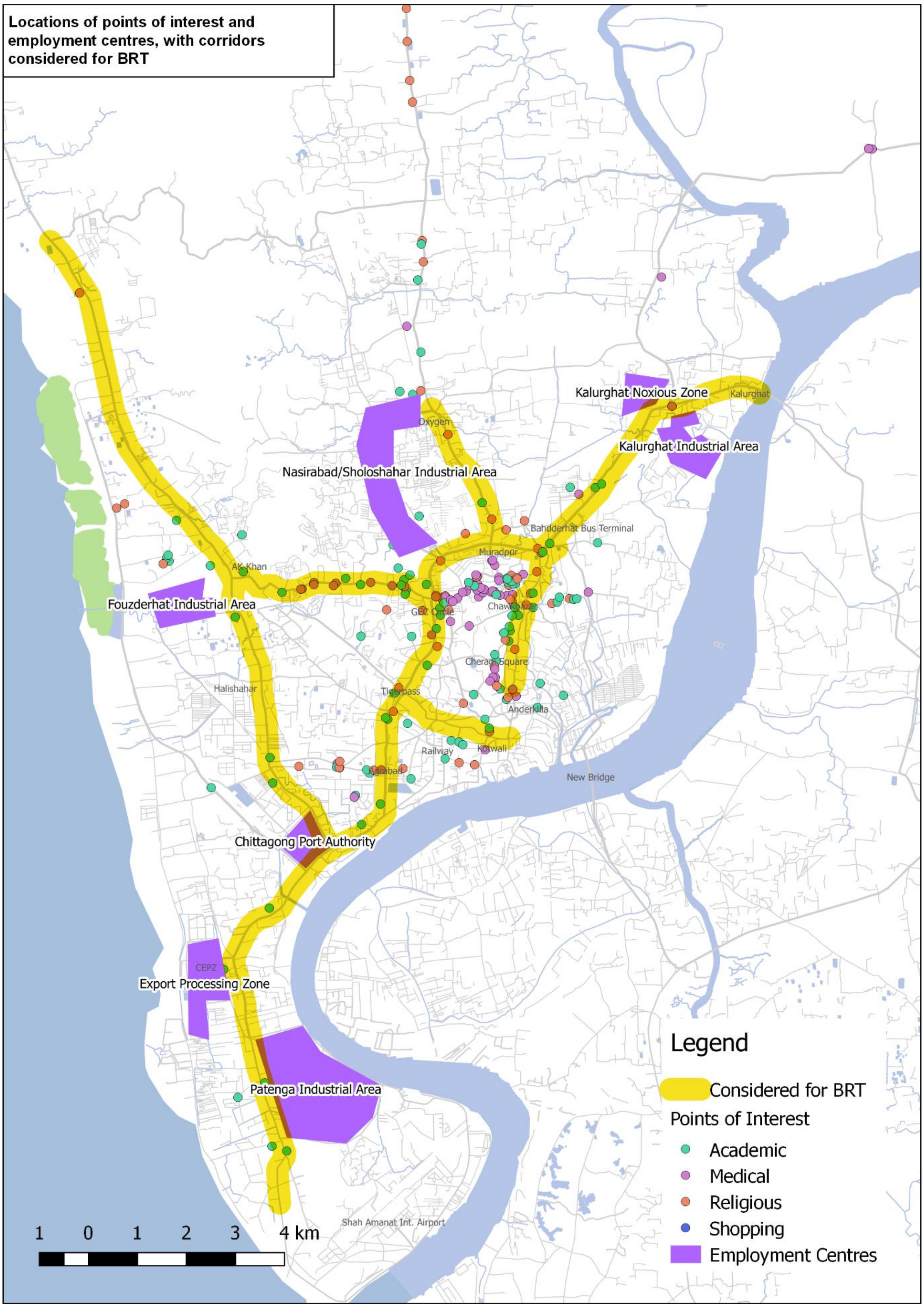
Based on the links with the highest number of bus routes currently, and on the passenger flows along them, the links considered for BRT/bus priority are shown in Figure 10-3. These corridors include:

- Chittagong-Cox's Bazar Highway
- CDA Avenue
- Port Connecting Road
- Dhaka Trunk Road
- Road to Oxygen
- Nabab Siragj Road
- Zakir Hossain Road
- M.A. Aziz Road

Figure 10-3 includes the locations of large industrial employment centres, academic institutions (including schools, colleges, kindergartens and universities), religious institutions or places of worship, and medical centres (including doctors surgeries and hospitals).

Figure 7-3 shows the average speeds of buses travelling across the network during the PM peak periods. This shows that speeds are generally higher towards the outer edges of the city, suggesting that the most suitable position for bus measures is the central area. Nabab Siraj Rd exhibits the lowest bus speeds, probably due to its narrow width and high levels of roadside friction.

Figure 10-3: BRT/Bus Priority Route candidates and location of points of interest



The OD data (Figure 4-11) shows that most movements are made between the CEPZ area to the south of the city and the central area, near New Market.

The following table describes the characteristics of each corridor to enable comparison. This shows that the New Market 'Spur' has the highest passenger demand and number of bus routes. CDA Avenue similarly has very high passenger demand in some areas and a high number of bus routes, followed by M.A. Aziz Road. Despite relatively low patronage, the Chittagong-Cox's Bazar Highway is considered important due to low speeds at some points, and the serving of two key industrial centres, and access to the river crossing at Kalurghat.

The number of traffic lanes is also highlighted in the table as an indicator of available space in which to place dedicated public transport and/or non-motorised transit facilities. The number of lanes does not however imply that this space is available for all road users. It is common throughout Chittagong that roads space is used poorly with parked vehicles, pedestrians and traders often reducing the overall width available for traffic. Further CDA Avenue also possesses an elevated highway (flyover) built to give preferential journey times for through traffic. Figure 10-4 shows the existing flyover and Figure 10-5 that planned for future construction.

Figure 10-4: CDA Avenue Flyover

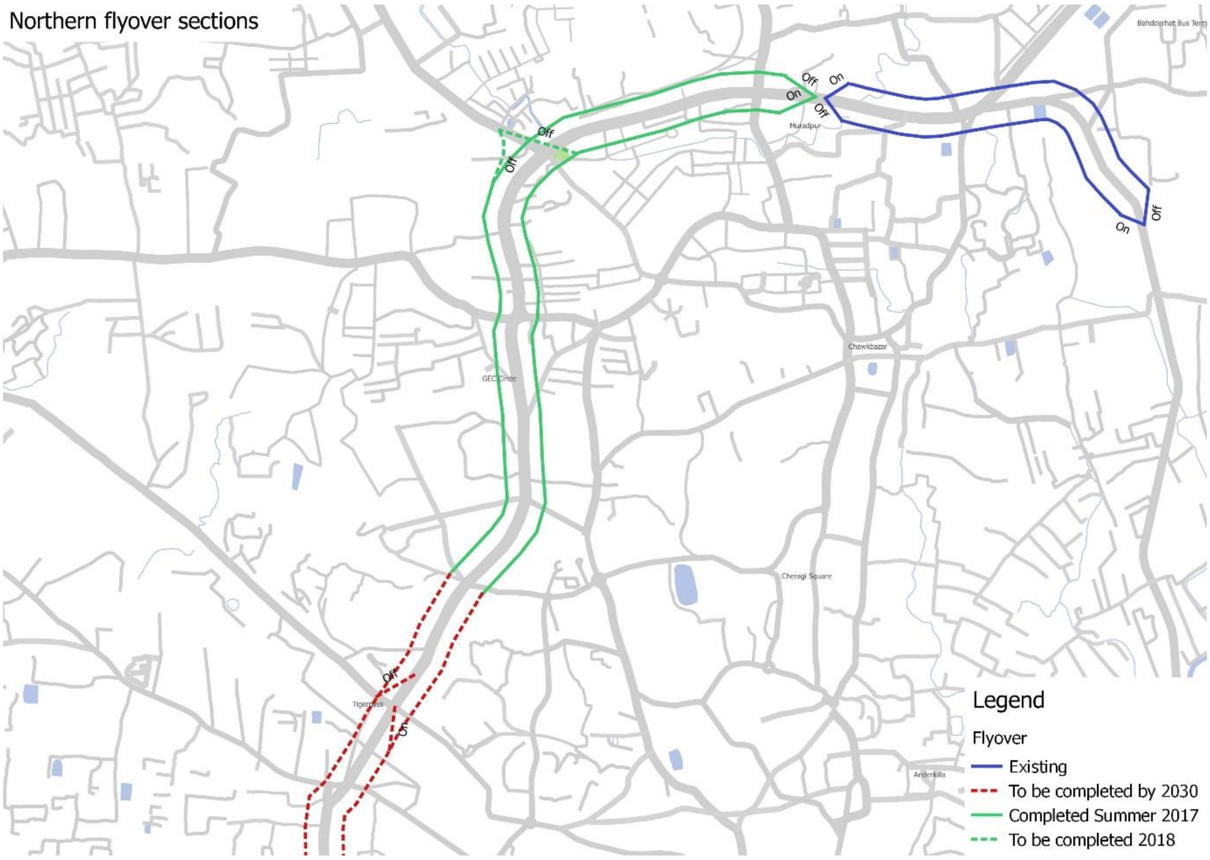


Figure 10-5: CDA Avenue Flyover Planned Extension

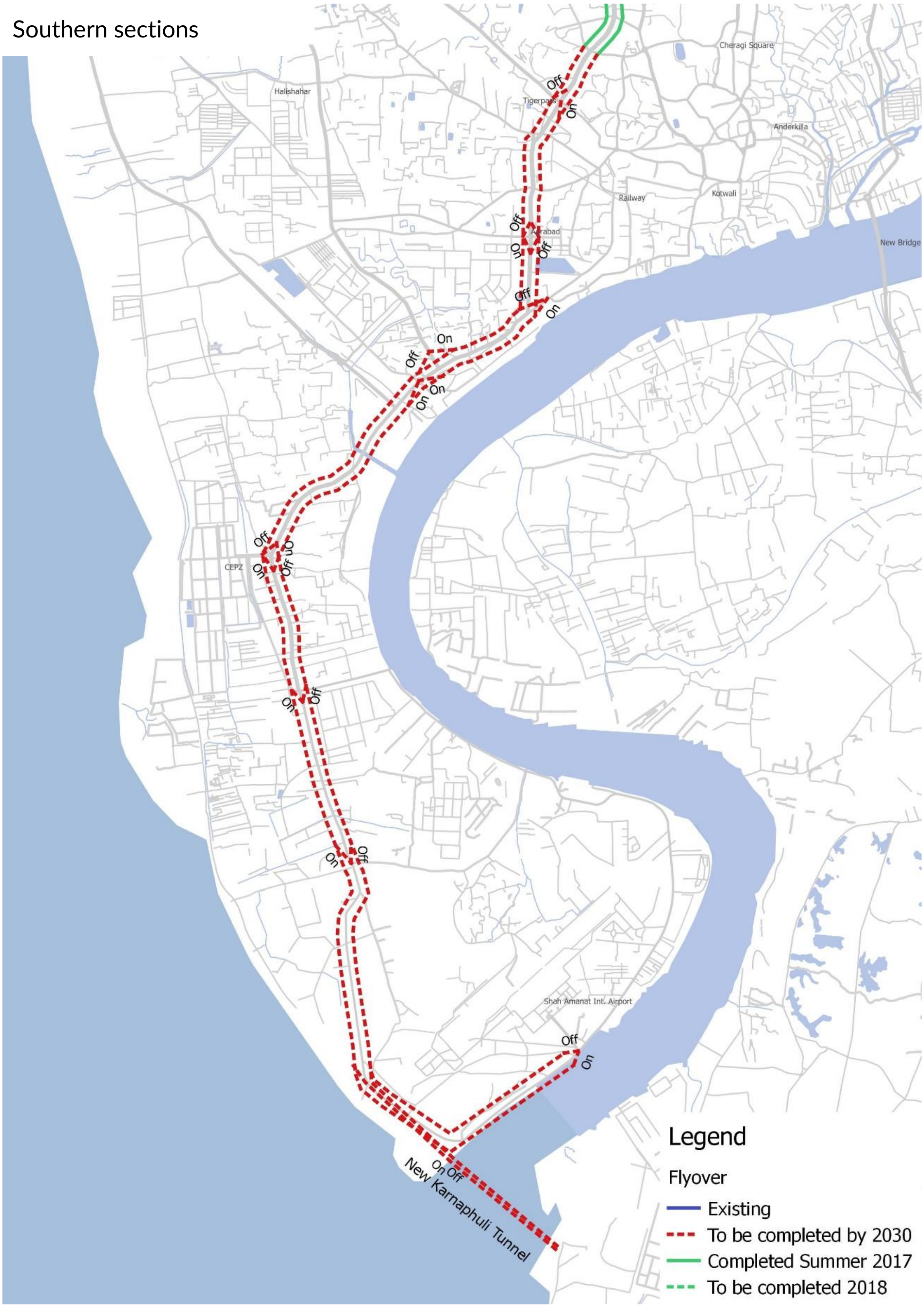


Table 10-4: Summary of bus corridor characteristics

Corridor Name	Passenger Demand, PM Peak, 2017, observed		Passenger Demand, PM peak, 2027 modeled		Width (No. of Lanes)	PT Speed, PM-peak, 2017 observed (kph)	
	Min	Max	Min	Max		Min	Max
Chittagong-Cox's Bazar Highway	1000	1800	1700	6600	4	5-10	20-30
CDA Avenue	1100	6950	4400	15400	4-6	10-15	20-30
Port Connecting Road	2200	4500	1000	11000	4-6	5-10	15-20
Dhaka-Chittagong Highway	2200	4600	Outside model area		8	10-15	30-40
Oxygen Road	0	2200	4400	8800	4	5-10	15-20
Nabab Siragj Road	1100	5600	2200	8000	4-6	5-10	10-15
Zakir Hossein Road	1100	1600	2000	5500	4	10-15	15-20
M.A. Aziz Road	0	5000	0	13200	4	5-10	20-30
New Market 'Spur'	4500	7900	2200	13200	4-6	5-10	20-30

10.3.4 Recommended bus priority/BRT corridor

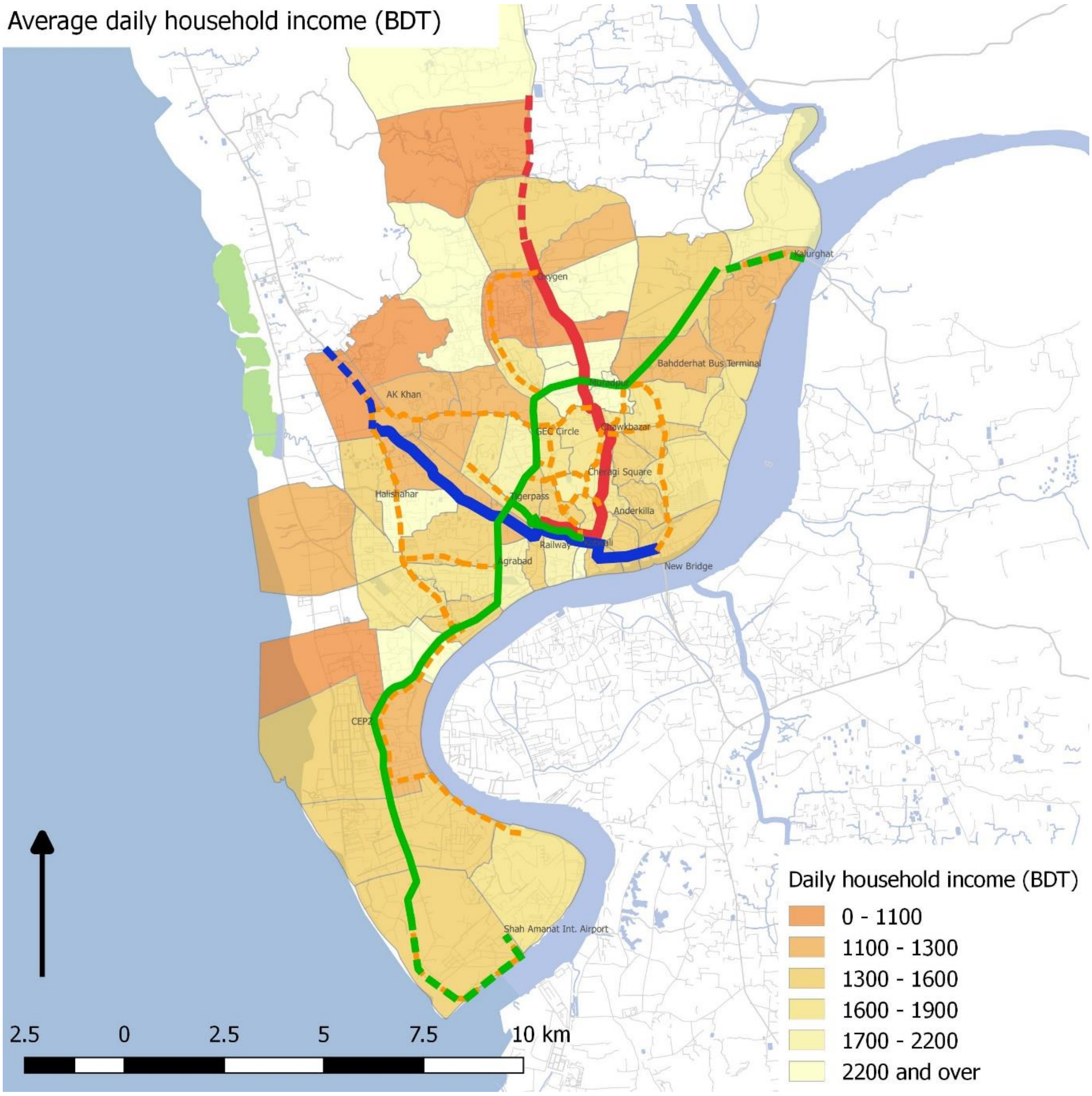
Based on this comparison, combined with the location of points of interest and employment centres served, three viable mass transit corridors are identified. Figure 10-6 identifies how these relate to areas high in poverty. While the green line is the most viable in terms of passenger numbers and physical characteristics, it also provides strategic connections for a range of poor areas in Chittagong including those in the south (around Patenga), Halishahar in the west, and north-east (around Kalurghat).

The corridor most suited for development initially as BRT or bus priority is therefore the green corridor comprising the ‘spine’ of CDA Avenue and M.A. Aziz Road, and ‘spur’ of Station Road. The blue and red corridors also have the potential to support high passenger flows, and provide connectivity for other poor areas, but delivering mass transit on these corridors is technically more challenging due to their constrained nature.

Figure 10-6 also identifies suitable secondary PT corridors to support the mass transit corridors. In general the mass transit corridors are expected to consistently support passenger flows of over 6,000 passengers per hour per direction (PPHPD) by 2030, while the secondary corridors match locations with forecast passenger flows of over 2,500 (see Figure 8-4).

In selecting the corridor for implementation deliverability must also be considered. It is a feature of the most recent generation of BRT systems China, such as Guangzhou and Chengdu, that appropriate corridors have been selected where high demand coincides with physical opportunity. Transferring this approach to Chittagong the treatment of CDA Avenue would be highlighted as it possesses a wide alignment, high public transport use, poor use of available infrastructure. In addition, the presence of the flyover for through traffic would all indicate reduced implementation risk over that of more constrained corridors where land purchase might be required. Other candidate corridors have high levels of demand but carry more implementation risk due to their physical constraints.

Figure 10-6: Relationship of potential mass transit lines to areas high in poverty



10.3.5 An Appropriate form of BRT or enhanced bus

We have defined BRT as a spectrum and the challenge of any subsequent feasibility study will be to determine exactly whereupon that spectrum is most appropriate for Chittagong. However, at this stage of option identification the following is recommended:

- Physical segregation wherever this is physically possible without significantly affecting delivery

- A direct system that incorporates all bus and human-hauler services that currently pass along CDA Avenue, subject to confirmation that they are appropriately routed.
- A new vehicle fleet that seeks to achieve the highest environmental ideals deliverable, with A/C and flexible seating arrangement to accommodate a multitude of needs expressed by users
- Appropriate rationalisation of Tempo, CNG and Rickshaws with emphasis upon their use as feeder modes with the potential to ban such vehicles on CDA Avenue explored.
- Service-based contracts for BRT standard services for all those entering the BRT segregation
- Reinstated footways
- Rationalisation of vehicle parking
- Protected pedestrian crossings

10.3.6 Physical segregation and direct services

Whilst physical segregation is desirable over the whole corridor length, the exact extent by which physical segregation is justified and achievable will depend upon further detailed study. As a minimum this should be the length of the existing longitudinal flyover with bus priority implemented where physical segregation is not possible and/or justified. Where bus priority coincides with planned future flyover extension the design of that flyover (not yet undertaken) should take full account of the need to prioritise public transport and accommodate non-motorised transit.

CDA Avenue has down its centre an elevated expressway with very limited access and egress. Consideration is paid to determine whether BRT should be placed at ground level or on the expressway. The major contributory factor is the ability of the BRT to meet user needs in an effective and efficient manner. The following are key issues:

- Placing the BRT on the elevated expressway would limit the ability to incorporate multiple services as a direct system enforcing some routes to either terminate and passengers transfer or to continue in parallel to the BRT.
- Passenger access would be by a footbridge and lift (to accommodate the mobility impaired). This would add inconvenience to users, would require a sizeable footprint for the landing of bridges and increase cost.
- Stations on the elevated highway would have to be cantilevered out from the existing structure which may require additional supports and bridge strengthening.
- Imposing two BRT lanes within a 4-lane highway designated to carry vehicles swiftly through the city may have an adverse effect

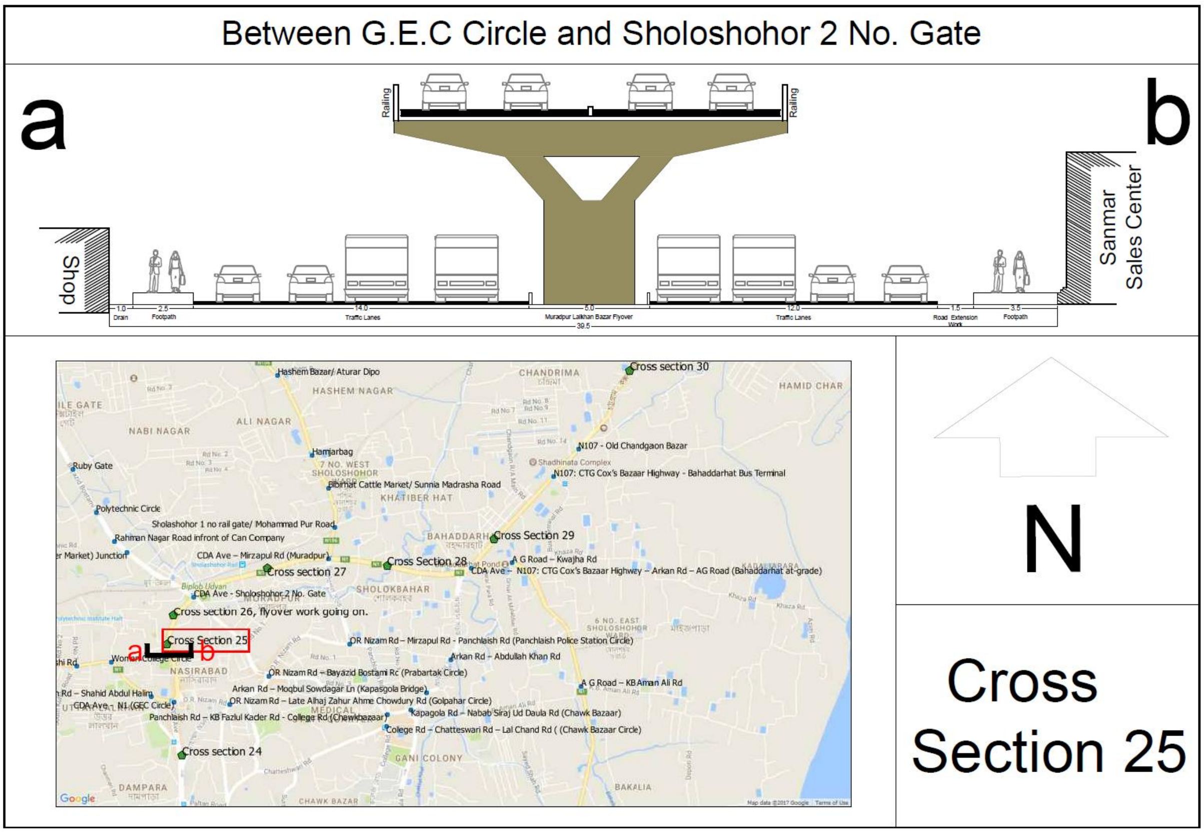
Placing the BRT at ground level has a greater ability to integrate with the street and its various land uses along its length. This however, equally presents a challenge with car parking, side road/building access and pedestrian movements to be considered. It will also be necessary to take one lane away, in each direction, from general traffic. This reallocation of roadway does not necessarily have a great impact upon other traffic when it is considered that some 250 bus and human-haulers in each direction per hour (from surveys of existing services) could feasibly be replaced by large buses operating under some form of performance-based contracts and it is those vehicles have the most impact upon the capacity of the road due to their driving behaviour and multiple stops.

Segregated lanes at ground level appear the most viable. At ground level, BRT lanes could potentially be either in the median or at kerb side. Lanes on the kerb side would however physically block access to commercial and residential properties that flank the road both having a negative impact upon commercial activity and slowing BRT vehicles through almost constant interaction. As such it is recommended that median lanes be adopted as they are able to run without interruption and have no negative impact on local businesses.

The potential has been identified for the lanes to occupy the space underneath the elevated highway. If located in this area, then the space under the highway, in between supports, could be used to locate a station. Figure 10-7 shows the space available within a typical location on CDA Avenue with Figure 10-8 giving a cross section with potential dedicated bus/BRT lanes.

Figure 10-7: CDA Avenue Street Scene

Figure 10-8: CDA Avenue BRT cross section



10.4 Junction improvements

Major improvement to pedestrian safety, general road safety, mobility, and efficient use of the transport network the urban transport system can be achieved through traffic management interventions aimed at facilitating the orderly flow of vehicles and management of pedestrians through the transport network.

The SUTMP aims towards a situation where junction operation in Chittagong:

- Facilitates the efficient movement of vehicles
- Minimises road accidents
- Enables pedestrian movements
- Contributes to a sense of place
- Where appropriate, acts as a focal point for economic activity

There are three elements to junction improvements. In order to realise the capacity benefits they should be addressed in the following order:

1) Control & enforcement (policing - capacity building)
2) Designation of road space for different uses (bus stops, no markets)
3) Infrastructure improvements

10.4.1 Control and enforcement

The infrastructure improvements at junctions will not improve travel speeds in Chittagong unless drivers use them correctly. This requires the rules of the road to be communicated to drivers and enforced on the street.

Chittagong Metropolitan Police (CMP) perform the role of on-street traffic management, their capacity for controlling traffic movements and enforcing traffic rules should be strengthened. CMP should receive additional training and equipment in order to perform the above tasks. Training should include management training, training on signal systems and associated CCTV systems and training for on-the-street traffic management.

Additional systems should include CCTV systems and the clear demarcation of no stopping areas painted onto the roadway. This could include yellow box junctions (Figure 10-9) or painting kerbs where no stopping is allowed.

Figure 10-9: Example clear box marking

Source:
http://www.direct.gov.uk/prod_consum_dg/groups/dg_digitalassets/@dg/@en/documents/digitalasset/dg_070535.jpg

10.4.2 Designation of road space

At present, road space at junctions is largely taken up by public transport vehicles stopping, parked cars and rickshaws/ CNGs, queueing traffic and markets, leading to further congestion and blocking of junctions for important strategic functions. In order for junctions to low smoothly, no vehicles should be allowed to stop or park within 50m of the junction.

Bus stops should be designated and moved at least 50m upstream of the junction. This will help to reduce interference from parked vehicles on the overall traffic flow. Rickshaws and CNGs that are waiting for passengers tend to cluster around junction blocking movement. To move waiting rickshaws and CNGs away from the junction, ranks should be established at least 50m from the junction. Passengers should only be allowed to board rickshaw and CNGs at these ranks. This approach follows that used in Manila, Philippines (Figure 10-10).

Rahman *et al* (2012)[35] identify various desirable features of a rickshaw rank:

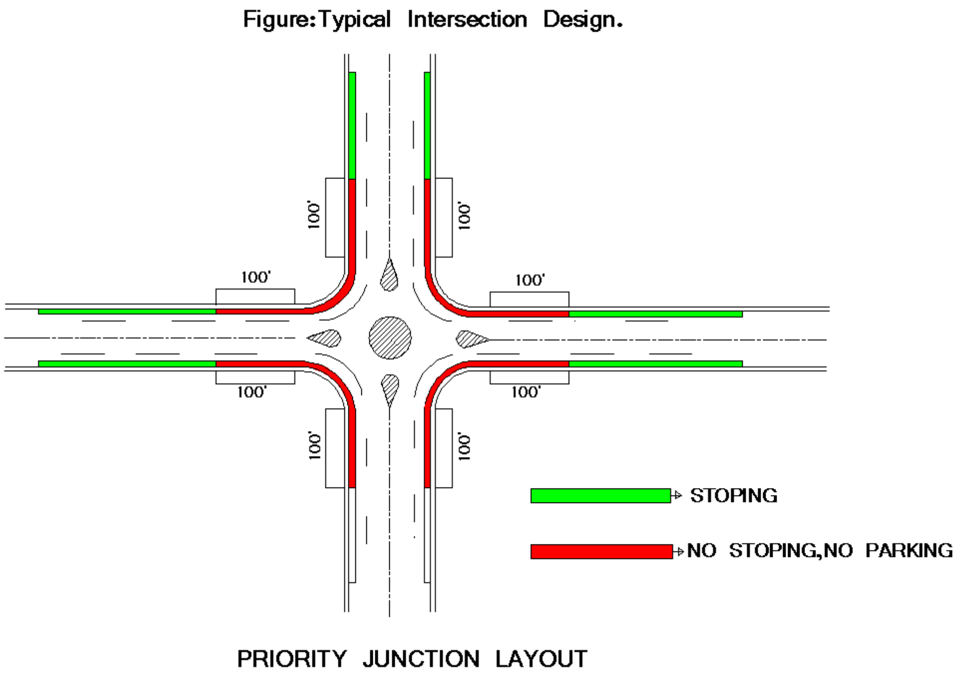
- Location within 200m of, and with step-free access to a PT station
- Dedicated areas for setting down and collecting passengers
- Rank design should preclude rickshaws from leaving out of sequence
- Signage at the head of the rank denoting:
  - The existence of the rank itself
  - The direction of and distance to the BRT station
  - The location of the nearest pedestrian crossing
- Lighting
- Shelter/shading

[35] Rahman, M. S-U., Timms, P., and Montgomery, F., 2012. Integrating BRT Systems with Rickshaws in Developing Cities to Promote Energy Efficient Travel, 15th meeting of the EURO Working Group on Transportation, EWGT. *Procedia – Social and Behavioural Sciences*, **54**, pp261-274.

Figure 10-10: Use of CNG ranks in Manila, Philippines

Off-street parking should also be banned within 50m of the junction and no markets should encroach the roadway.

Figure 10-11: No stopping or parking of vehicles allowed within 50m of the junction



10.4.3 Infrastructure improvements

There are a variety of potential junction features which can improve operation:

- Increasing control – this can be through the construction of a roundabout, implementation of signals, stationing of traffic police (who have powers to enforce fines etc.)
    - Short signal phases are desirable where signalisation is implemented in order to keep traffic flowing
- In certain areas lanes and the 'flare' on the junction approach may need to be widened. The diameter of most of the roundabouts in Chittagong are too small for efficiently separate conflicting movements.
- Every junction should give provision for excellent pedestrian access. Crossings should be provided across every junction arm - at large junctions these should be signalised.
    - Dropped curbs should be provided at crossings to ensure good access for the mobility impaired.
- At large junctions' pavements would ideally attain a width of 3m
- Railings should be avoided along footways if possible, in line with good urban design practice.
- The road surface at junctions is typically poor, which causes slow movement or weaving movements.

10.4.4 Prioritisation of junctions for improvement

101 junctions in the city have been assessed for as to their needs for improvement (Figure 10-12). The following factors have been considered when identifying if a junction would benefit from an upgrade:

- The size of the junction is considered in terms of the number of lanes approaching the junction
- The strategic value of the junction. This encompasses the presence of a public transport terminal, PT route or important truck route.
- The flow of vehicles handled by the junction today and in modelled do-minimum future years
- Speeds through the junction, both observed and modelled
- Speeds and flow were combined to create a measure of 'total junction delay'

- An assessment of the Level of Service provided by the junction today and in modelled future do-minimum scenarios. The Level of Service (LOS) is a score, from A to F where A is free-flowing and F is over congested. The ambition is to provide junctions with a LOS of C or better.

Of the 101 junctions assessed, 49 were identified as requiring improvement by 2025 (listed in Table 10-5) with an additional 17 requiring improvement by 2030 (listed in Table 10-6).

Figure 10-12: Location of 101 junctions assessed

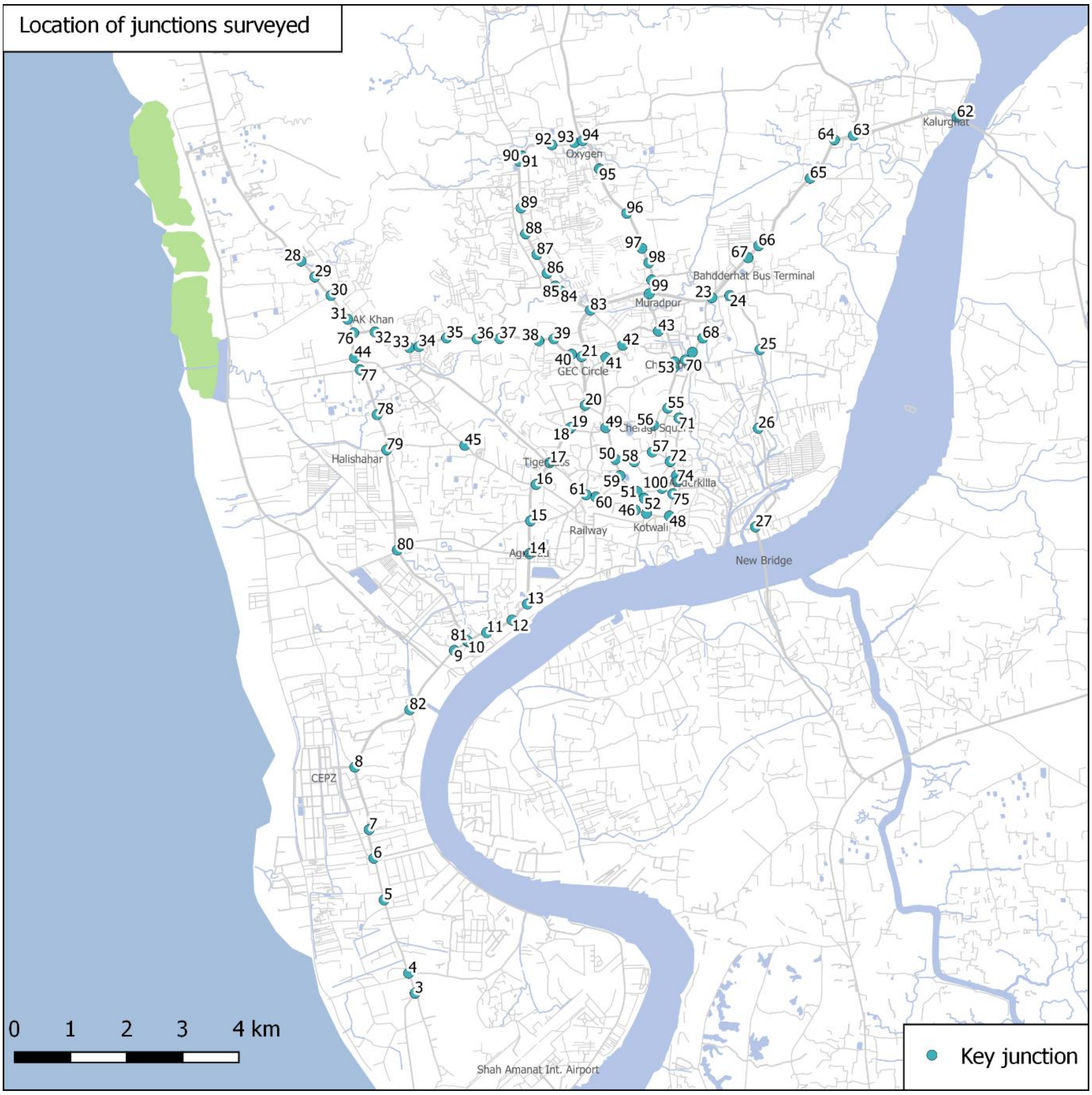


Table 10-5: Schedule of 49 junctions that require upgrade before 2025

ID	Location	Total no. of lanes	No. of PT routes served	On a truck route?	Inter-district bus terminal	Total PCU flow, PM peak-hr 2017	Mean observed car speed (2017, 100m of junction)	Total observed delay, peak hour (mins)	LoS 2017	LoS 2025	LoS 2030
4	Katgar	5	15	Yes		1,062		N/A	A	C	B
8	MA Aziz Rd / CEPZ	7	22	Yes		3,573	9	23,279	E	F	F
9	MA Aziz Rd / Port Colony Rd (CPA) / Mooring Rd	7	22	Yes		4,114	16	15,772	F	F	F
10	Mooring Rd / Port Connecting Rd	6	22	Yes		4,950	15	20,014	F	F	F
11	Mooring Rd / Port gate No. 3	4	22			3,723	14	15,416	F	F	F
12	Mooring Rd / Port gate No. 2	4	22			4,055	21	11,523	F	F	F
13	Mooring Rd / Sheikh Mujib Rd (Barek Building)	5	22			4,084	25	9,785	F	F	F
14	Sheikh Mujib Rd / Agrabad Access Rd (Badamtoli)	7	22			4,351	9	27,863	F	F	F
16	Sheikh Mujib Rd / Dewanhat Overbridge Ramps	8	22			5,358	13		F	F	F
17	CDA Ave .- Ambagan Rd / Md. Yusuf Chowdhury Rd (Tiger Pass)	5	34			3,265	15	13,424	F	F	F
21	CDA Ave/ N1 (GEC Circle)	7	9		Yes	4,585	14	19,030	F	F	F
22	CDA Ave / Mirzapul Rd (Muradpur)	7	22			4,512	15	18,068	F	F	F
23	CDA Ave / N107: CTG Cox's Bazaar Highway / Arkan Rd / AG Road (Bahaddarhat at-grade) (New Chandgaon?)	8	22		Yes	3,258	27	7,184	D	E	F
27	N1 / Chaktai Rd/New Bridge approach road Roundabout (Shaheed Boshiruzzaman Square)	5	9		Yes	1,581	0		C	D	D
36	Zakir Hossain Rd-Pahartali College Rd (Wireless)	5	9	Yes		1,772	21	5,013	C	F	F
37	Level railway crossing	5	9	Yes		1,979	20	6,025	C	F	F
39	Women College Circle	4	9	Yes		2,155	19	6,885	E	F	F
44	Dhaka Trunk Road / Port Connecting Road (Alongkar More)	6	22		Yes	1,802	10	11,253	B	D	F
45	Dhaka Trunk Road from Port Connecting Road to Dewanhat	5	9			1,920	19	6,047	C	F	F
47	Station Road / Jubilee Road (New Market Circle)	7	34			3,218	8	24,204	D	F	F
51	Jubilee Road / Chaitana Goli (Golam Rasul Market)	6	9			2,090	12	10,124	C	E	F

52	Jubilee Rd / KC Dey Rd (Amtala)	5	9			2,440	12	12,184	E	F	F
53	Panchlaish Rd / KB Fazlul Kader Rd/College Rd (Chawkbazaar)	6	15			2,296	8	17,921	C	D	E
54	College Rd / Chatteswari Rd / Lal Chand Rd ((Chawk Bazaar Circle)	6	15			2,377	10	14,775	C	D	E
55	College Rd / Jamal Khan Rd / KB Abdus Sattar Rd (Gani Bakery Circle	3	15			1,806	18	5,989	F	F	F
57	Jamal Khan / Monmin Rd (Cheragi Pahar)	4	15			2,616	16	9,625	F	F	F
59	Enayet Bazaar Rd / Jubilee Rd / Batali Rd (Enayet Bazaar Circle)	6	15			2,390	14	10,335	C	E	F
61	Station Rd / Kadamtali Rd (Kadamtali CRB Circle)	6	34		Yes	4,315	13	19,586	F	F	F
63	N107 / Kaptai Rd	6	22			979	12	4,987	A	A	D
65	N107 / Kalurghat Industrial Area Access Road (C & B Circle)	6	22			719	15	2,850	A	A	A
66	N107/Old Chandgaon Bazar	4	22			1,455	11	7,899	C	E	F
67	N107: CTG Cox's Bazaar Highway/Bahaddarhat Bus Terminal	4	22		Yes	1,561	6	14,615	C	F	F
70	Kapagola Rd / Nabab Siraj Ud Daula Rd (Chawk Bazaar)	6	15			1,836	11	10,053	B	D	F
72	Nabab Siraj Ud Daula Rd / Momin Rd / JM Sen Ave (Chittagong City Corporation	5	9			3,445	9	22,628	F	F	F
73	Terri Bazar Circle-JM Sen Avenue	4	15			1,625	7	13,662	C	F	F
74	JM Sen Rd / Lal Dighi Par Rd	4	15			1,635	9	10,982	D	F	F
77	Sagorika Road	8	22	Yes		1,805	14	7,833	A	D	F
78	Sarai Para	5	15	Yes		1,938	16	7,068	C	F	F
82	Salt Gola Crossing	5	22			3,479	11	19,228	F	F	F
83	CDA Ave/Sholoshohor 2 No. Gate	7	34	Yes		4,141	13	18,464	F	F	F
84	Adorsho Para Road/Tulatuli Rd (Baby Super Market) Junction	4	9	Yes		1,888	13	8,645	D	F	F
85	Rahman Nagar Road in front of Can Company	0	9	Yes		-	33	-	N/A	N/A	N/A
90	Bayezid Bostami Circle	5	9	Yes		347	24	851	A	A	A
92	Abdur Rab Road Junction opposite of BSRM Steel Meel Area	4	9	Yes		771	25	1,845	A	B	E
94	Oxygen Circle	6	15	Yes	Yes	2,214	7	18,425	C	F	F
95	Roufabad	4	15			1,680	13	7,789	D	F	F
96	Hashem Bazar/ Aturar Dipo	4	15			1,729	16	6,377	D	F	F
97	Hamjarbag	5	15			2,026	21	5,884	C	E	F
99	Sholashohor 1 no rail gate/ Mohammad Pur Road	5	15			2,029	13	9,251	C	E	F

Table 10-6: Schedule of 18 junctions that require upgrade before 2030

ID	Location	Total no. of lanes	No. of PT routes served	On a truck route?	Inter-district bus terminal	Total PCU flow, PM peak-hr 2017	Mean observed car speed (2017, 100m of junction)	Total observed delay, peak hour (mins)	LoS 2017	LoS 2025	LoS 2030
30	N1 / Colonel Jones Rd	4	34	Yes		411	12	2,083	A	A	D
18	CDA Ave / Shahid Saifuddin Khaled Rd (Lalkan Bazaar)	7	34			4,530	10	27,518	F	F	F
60	Batali Rd / Station Rd (BRTC Circle)	5	34		Yes	2,759	25	6,632	F	F	F
15	Sheikh Mujib Rd / Halishahar / Pathantuli Rd (Choumuhuni)	7	22			4,922	14	21,524	F	F	F
20	CDA Ave / High Level Rd (WASA Square)	8	34			4,371	15	17,181	E	F	F
49	Chatteswari Rd / Shahid Saifuddin Khaled Rd / Nur Ahmed Rd (Kazir Dewri)	7	15			3,596	13	16,708	E	F	F
76	N1 / AK Khan	6	34	Yes	Yes	2,451	18	8,115	D	F	F
38	Zakir Hossain Rd / South Kulshi Rd	4	9	Yes		2,142	23	5,708	E	F	F
40	Zakir Hossain Rd / Shahid Abdul Halim	5	9	Yes		2,121	10	12,207	D	F	F
34	Zakir Hossain Rd / Shahid Lane (extension of Ambargan Road)	5	9	Yes		2,095	21	6,002	D	F	F
46	Station Road / Chittagong Railway Station Entrance	4	34			2,116	5	25,202	E	F	F
56	Jamal Khan / Shahid Saifuddin Khaled Rd (Dr MA Hashem Sq)	4	15			2,302	21	6,523	F	F	F
43	OR Nizam Rd / Mirzapul Rd/Panchlaish Rd (Panchlaish Police Station Circle)	3	15			1,676	16	6,149	E	F	F
42	OR Nizam Rd / Bayazid Bostami Rd (Prabartak Circle	4	5			2,012	16	7,537	E	F	F
71	Nabab Siraj Ud Daula Rd / Darul Ulum Rd	4	9			1,969	15	8,030	E	F	F
25	AG Road / KB Aman Ali Rd	4	9			1,972	14	8,692	E	F	F
35	Zakir Hossain Rd- Foy's Lake Approach Road	4	9	Yes		1,580	16	6,009	C	F	F
50	Nur Ahmed / Love Lane / Jubilee Rd (Lovelane Circle)	5	15			2,246	23	5,835	D	F	F

10.5 Pedestrian improvements

The long-term vision is to deliver public transport that is integrated with walking and cycling and greater accessibility for all people. Currently 25% of trips are made on foot, and these trips are more commonly performed by poorer residents (Figure 4-4). Providing quality footpaths on all major roads will help to satisfy this demand, improve accessibility for poorer groups, and provide safe access to the public transport network.

10.5.1 Footpaths

Figure 7-17 shows that many roads lack a footpath on one or both sides, and where footpaths so exist they are often of poor quality, too narrow and hard to walk along.

The construction and improvement of pedestrian footpaths will help achieve the vision and objectives. By providing a minimum standard of footpath on all major roads these spaces will become more people-friendly environments, accessible and lead to increased levels of environmentally friendly modes of transport such as walking and access to PT.

Required footpath widths depend on the street type and its use. Widths should not fall below 1.5m but should be 3m in busy areas. Figure 10-13 provides a good example of a wide uncluttered footpath that has been constructed in Dhaka. It features trees on the right-hand side which provide shade, help to absorb air pollution and are attractive. The figure also provides an example of a dropped kerb which makes walking easier and especially assists those with mobility problems.

Street lighting should be provided at regular intervals where appropriate, especially in commercial and high-intensity commercial zones.

Figure 10-13: Wide pavement and dropped kerb in Gulshan 2 District, Dhaka

10.5.2 Pedestrian crossings

Two broad options exist for the provision of pedestrian crossing facilities:

- At grade crossings that provide signal time for pedestrians to cross or provide infrastructure and priority to allow pedestrians to cross without a signal.
- Pedestrian overbridges

Considering the work of Southworth[36] and Walkability Asia[37] pedestrian facilities at junctions should achieve two broad objectives:

- Provide safe, unobstructed crossings that support disabled access
- Create a space for a vibrant pedestrian, ground level domain

Research conducted by ADB, the Centre for Liveable Cities and Southworth (2005) argue at-grade crossings should be provided where possible instead of overbridges. The findings of their research are presented in the text box below.

Safe at-grade crossings require a clear right of way given to pedestrians through well enforced and obeyed traffic rules supported by working traffic signals or good driving behaviour that prioritises pedestrians. The recommendations for redesigning the major junctions in Chittagong (section 10.4) include these measures as well as the requirement to significantly enhance police capacity to enforce traffic rules.

However, there are a number of locations in Chittagong where the junction works are not expected to sufficient provide safe crossing environments for pedestrians. These are locations where roads may be wide and travel speeds high, or where pedestrian flows are high and the land is not available to provide sufficiently wide sidewalks, e.g. 3m or greater. In these locations we will recommend the installation of foot overbridges in order to provide a safe walking environment. These locations include:

- CEPZ junction on M.A. Aziz Road
- Sholoshahar No. 2 Gate on CDA Avenue
- GEC Circle on CDA Avenue
- Shaheed Boshiruzzaman Square on the approach to Shah Amanat Bridge

[36] Southworth, M. 2005. *Designing the Walkable City*. Journal of Urban Planning an development, Vol 131 Issue 4 p246-257
[37] https://walkabilityasia.org/

- New Market Circle

Preference for at-grade pedestrian crossings

ADB's BRT walkability Strategy developed for Dhaka[1] calls for safe at-grade crossings to developed along all roads with high and medium motorised traffic volumes and that foot overbridges are not practical or safe,

> *As evidenced through the perception study, mothers and the elderly find these types of crossings to be particularly problematic to navigate. In addition, people living with disabilities can face insurmountable difficulties as they are unable to go up and down the stairs. When traffic is already slow moving (as is the case on most roads in Dhaka), at-grade crossings can actually improve traffic flow by giving vehicles the opportunity to advance. They certainly do not impede traffic flow given Dhaka's typically congested situations. The current reality is that although foot over-bridges exist, many (if not most) pedestrians choose to cross at grade along the street (instead of at specific locations), thereby creating a haphazard and dangerous situation. By providing at-grade crossings at regular intervals, predictability is created for both pedestrians and motorists, which in turn has the potential to simultaneously increase traffic flow and pedestrian safety.*

The preference to use safe at-grade crossings instead of foot over bridges is supported by research conducted by the Centre for Liveable Cities[3]. Their study of perceived walking time in Singapore found that pedestrians perceived foot overbridges to have a value of 4.2 minutes compared to 1 minute of time waiting at a traffic light. They concluded that "clearly the overpass is perceived as a huge impediment to walkability". They further conclude,

> *"Bridges inhibit pedestrian movement and hence street life. Detached skywalk structures visually cut up or conceal building facades destroying shop-front value in the process...There should be some prudence in assessing the need to introduce elevated pedestrian walkways. Their use should not dilute the vibrancy of the pedestrian ground level domain. Fundamentally where street-level pedestrian use is suitable, it should not be replaced with elevated walkways"*

Southworth (2005) argues that the installation of pedestrian overbridges increase the likelihood of accidents, "environments that support fast and efficient auto travel are not enjoyable safe, or interesting for pedestrians and cyclists, not surprisingly there is much more likelihood of injury or death for pedestrians and motorists". At-grade crossings are also more accessible to those with mobility impairments, parents and children, and pedestrians carrying heavy items. While the efficient movement of vehicles should be incorporated into junction design on highways, for city centre roads junction design should enable safer speeds. Where-ever possible safe at-grade crossings should be used instead of foot overbridges.

[1] ADB 2011. Dhaka's BRT Walkability Strategy: Ensuring that Dhaka's Transportation Infrastructure is Pedestrian-Friendly.
[2] JICA 2015. *Revision and Updating of the Strategic Transport Plan for Dhaka*. Pp4-1
[3] Centre for Liveable Cities 2017. *Elevated Pedestrian Links – Boon or Bane?* https://www.clc.gov.sg/documents/books/research-workshop/2017/elevated-pedestrian-linkways.pdf

10.6 Rickshaw and CNGs

Rickshaws and CNGs form a vital component of the transport system for many people in Chittagong, with particular importance for school children and women, therefore an abrupt removal would be socially devastating, and would disproportionately impact some of the most vulnerable transport users in Chittagong.

In the long run it is envisaged that the use of CNGs and Rickshaws are replaced with quality public transport. They would be removed from the main roads but continue to play an important service on side roads. The regulation of the sector should be improved with a limit on total permits, regulations on fare and safety as well as enforcement to ensure traffic rules are adhered to.

However, the introduction of the proposed public transport measures *must* be implemented before any measures to remove rickshaw or CNG from any major road are considered. The public transport system should run efficiently enough to attract users from rickshaw and CNG without unnecessarily harsh action.

The experience of Dhaka is that on many roads where rickshaws were banned, parked cars have in-filled the old rickshaw lane negating any benefits to roadway capacity. Therefore, the removal of rickshaw should only be considered if an attractive PT system is in operation as well as an effective traffic management and parking scheme in place.

10.7 Institutional reform

A detailed explanation of the current institutional landscape in Chittagong is presented in report *D7: Bus Restructuring & Institutional Assessment*. That report details the options for institutional and bus sector reform and develops a recommended plan. A summary is presented here.

Whilst functions relating to transport policy creation and licensing exist in Chittagong there is no body responsible for the implementation of public transport plans. A form of Public Transport Authority is needed to fill the gap and play the role of an implementing agency capable of organizing, managing and developing public transport operation.

Such an authority would provide the City with the organization, competencies and tools to manage and improve the entire public transport system of Chittagong, executed by private operators. Accepting that such functions are necessary, where such functions should sit must be considered.

Whilst CDA has the remit for forward planning, CCC has the political mandate under the mayor. Neither currently has the capacity. Elsewhere in the world where the creation of a strategic planning function has been considered the key issues have been; mandate, accountability, vision and sustainability. In cities with a single political leader (such as Bogota, Jakarta, Johannesburg) significant achievements have been made through the pursuit of a defined vision pursued by a political champion. Where there are many political interests within a city (such as Manila, London, Paris) there is a need for a coordinating authority that acts across political borders but often still acting under a single political champion whether it be mayor or minister.

There are essentially three options as to where the function might be placed in Chittagong and these are considered below.

1) CDA
2) CCC
3) Independent

10.7.1 Option One: CDA

Benefits of CDA as a strategic body responsible for transport:

- Area of responsibility covers both city and hinterland
- Has a strategic forward planning remit
- Potential to provide an integrated land use and transport planning function
- Is familiar with the management of large highway, and other projects with multiple funding sources
- Reports directly to a Minister

The dis-benefits of CDA as a strategic body responsible for transport:

- Does not have public accountability
- Despite mandate, it lacks planning capacity and knowledge
- Dependency on its own project income creates a commercial bias and conflict of interest
- Lack of clearly defined productive relationship with CCC

If responsibility is allocated within CDA then there would need to be a clear separation between development control and forward planning as well as isolation (or separation) of the development implementation functions.

10.7.2 Option Two: CCC

Benefits of CCC as a strategic body responsible for transport:

- Mayor carries a city vision that, at present, he is limited in his ability to implement
- The organisation is directly accountable to the citizens of the city

Dis-benefits of CCC as a strategic body responsible for transport:

- Currently has no forward planning mandate and its creation would conflict with the un-implemented, planning mandate of CDA
- Reliance upon central Government support might become fractious if Mayor and Minister is from a separate party
- Lack of capacity and knowledge
- Limited to the boundary of the city and as such there would be a void of responsibility between city and CDA boundary.

If the strategic body is created within CCC it could sit without internal conflict.

10.7.3 Options Three: Independent Body

Benefits of an independent strategic planning responsible for transport:

- Ability to be independent, taking a coordination role, of CDA and CCC
- Not burdened with existing institutional conflicts
- Able to define its own boundary (most probably the CDA boundary) and remit

Dis-benefits of an independent strategic planning responsible for transport:

- Creating a new body will add to the complexity of inter-institutional responsibility and decision making
- May be seen as a threat to existing institutions and responsibilities of individuals
- Management/oversight would have to be, at least in part, political requiring a decision over national and local influence
- Would need to act to a vision and objectives that are in line with that of the mayor
- Would need to be appropriately resourced and financed

If a new body is created it will need to be empowered, funded, resourced and supported by existing institutions who will require their own remit and responsibilities (possibly with funding and staffing implications) modified. To manage the risk of creating opposition and maximising the sustainability of such an organization, the organisation needs to be established through a cross-institutional working and agreement with immediate responsibility for future plans and immediate implementation. The Regional Transport Committee provides an appropriate grouping from which to develop such an organisation although the responsibilities within the committee might not be ideal.

An example of an independent body is the Dhaka Transport Coordination Authority (DTCA). This is a strategic authority which has the responsibility for the coordination of public transport across the Dhaka area. The need for an organization to coordinate the concerned agencies and districts of Dhaka was first identified as part of the Dhaka Urban Transport Project in 1999. To implement this project the Greater Dhaka Transport Planning and Coordination Board was established in 1999. The composition and responsibilities of the authority have strengthened over time. The board has evolved and gained responsibilities and in 2006 it became the DTCA with government funding and 70 employees.

DTCA works under the Ministry of Roads and Bridges and is headed by the Minister for Roads and Bridges. The Mayors of each of Dhaka's City Corporations are vice-chairmen of the board with board members comprising elected representatives and the heads of the concerned departments.

The creation of the Dhaka Transport Coordination Authority (DTCA) provides some guidance on issues and conflicts in establishing a strategic organisation in Bangladesh but the context in Chittagong is quite different being a city controlled by a single Mayor. And unlike Dhaka, there is little knowledge of strategic planning in Chittagong at the outset. Furthermore, Chittagong is remote from the seat of Government, therefore will benefit less from being chaired by a Minister.

10.7.4 Recommendation

There is no perfect placement of the transport authority function, as each option has strong benefits and disbenefits. However, discussion with the stakeholders essential to successful reform concludes that a new body has less risk than placing it within existing bodies who carry historical interest that is hard to address. Such a body must however be developed through consensus of the bodies whose functions must, in part, migrate to the new body.

Such an authority would provide the City with the organization, competencies and tools to manage and improve the entire public transport system of Chittagong, executed by private operators.

The Study Team has performed a review of the public institutions involved with the provision of transport services, such as CDA, CCC, BRTA, and other organisations with an interest in transport provision and assessed a number of options to form the PTA. It is recommended that a new independent body is established to become the PTA. Such a body must however be developed through consensus of CDA, CCC, and BRTA whose functions must, in part, migrate to the new body.

The development of the SUTMP has established a coordinating committee that involves all stakeholders and this has been used to share information and receive guidance throughout the study. A byproduct of this process has been the increase in knowledge of attendees in the need for cross-transport integration and the wider policy/strategy integration of transport, particularly with land use planning. As such, this committee is in a good place to provide focus to a transport authority function.

The long-term goal is to establish an institution like the DTCA in Chittagong with the responsibility for the whole urban transport system. However the formation of such a government institution is expected to take over 5 years. To deliver, in a timely manner, the public transport projects that form the focus of the SUTMP, and to minimize the considerable institutional risk, it is recommended that these projects be started under the guidance of a Public Transport Authority (PTA) that ensures a focus on PT improvements. The board members should comprise the members of the existing coordination committee which includes CCC, CDA, CMP, CPA, and BRTA. This authority will obtain legal authority from the GOB and be placed under the Ministry of Road Transport and Bridges. Alike the establishment of the DTCA, this coordinating authority should evolve over a number of phases until eventually becoming an Urban Transport Authority.

While the DTCA is chaired by the Minister for Roads and Bridges, it is considered that Ministerial chairmanship of Chittagong's equivalent body would not be as effective as local representation. This is because Chittagong's distance from the seat of Government would limit the scope of the Ministers engagement. While the coordination committee is currently chaired (but as a secretarial function) by CDA, the formal chairman role would ideally be placed with the mayor of Chittagong who carries both a mandate from the people and clear territorial interest.

In the initial stages, the board will concentrate upon policy and direct the need for institutional strengthening that will allow it to remain an authority that gives guidance to an executive of trained personnel whose purpose is to implement.

This institutional rearrangement would be the consequence of a decision from the public sector to exercise much better control of the bus transport industry and eventually the whole Urban Transport System. Essentially, the way to achieve this position is by taking some of the risks it can better manage directly and by organizing the activity following a more sustainable business model for bus operation at the early stages.

Under this conception a new policy approach is required whereby:

- Government reasserts its role in the business of private transport; accepting some risk to strengthen its hand in the control of the outcomes;
- The government also takes a managerial role as a network manager, taking supervision responsibility for customer service delivery;
- A sustainable business model needs to be supported by an efficient transport infrastructure;
- Risk sharing among public and private sectors must be assigned to where it can be best managed

10.8 Bus sector reform

10.8.1 Current status of the sector

Table 10-7 presents the number of public transport vehicles registered in Chittagong in 2016 based on BRTA data. There are a total of 1,318 buses that operate 11 routes. These are in addition to human haulers and tempos which also operate on fixed routes.

Table 10-7: Total Registered Vehicles by Classification in 2016

Vehicle Type	Approximate Seats	Registered Vehicles
Auto Rickshaw (CNG)	5	24,903
Auto Tempo	10	1,710
Bus	55	1,318
Human Hauler	15	2,721

There is essentially one type of bus operator in Chittagong. These are small enterprises or individuals that own one to a few buses, sometimes without route permits. From the Bus Route Data obtained from BRTA it is found that there is only one company in operation at present, Metro Services Ltd., with a fleet of 40 buses in route no.-10 (Kalurghat to Potenga Sea Beach).

The individual owners in Chittagong do not operate buses in their name. Rather they are in operation in the name of different Owner's Associations. From the route permit data, it was found that there are 8 such Associations in addition to the only company named Metro Services Ltd are in operation in Chittagong. Individual owners become a member of one of the associations as per his will and operate their bus under the banner of that association.

The members normally pay a service charge to the association in the region of Tk 100 to Tk.200 per day per bus. In return, they use the banner of association and get help in a crisis like accident or harassment by the administration, as they pointed out.

The individual owners appoint drivers, conductors and helpers for the operation of their buses with a verbal contract that they will receive a certain amount of money per bus for one day. This operates as a form of leasing the bus to driver and conductor on daily basis. The driver as the leader of the three starts operation of the bus on a specific route and at the end of the day hands over the contracted amount of money to the owner, keeping rest for themselves. The amounts handed over vary from route to route.

The drivers bear all operational costs including minor maintenance. Repair and major maintenance is for the account of the owner.

In Chittagong there are two federations that represent transport workers and owners:

- The Bangladesh Road Transport Workers Federation looks after the interests and general welfare of transport workers. It acts to negotiate on workers' behalf and gets involved in individual support if action is taken against any of its members. It is able to call a strike if members support such action. It also has a welfare fund for drivers who are temporarily unable to work through injury or incapacity. It also takes action against members or if they are acting badly or inappropriately. The support of the federation will be important through scheme development and great care should be taken to involve them at all stages. Effort should be made to secure their support.
- The Federation of Chittagong City Bus, Minibus and Human-Hauler Owners represents over 1,000 transport owners who collectively operate approximately 2,000 vehicles. The federation and associations take daily income from owners in return for protection in the form of assistance with route permits and negotiation in the event of accidents. Not all of the 6 owner associations in Chittagong are members of the federation. The fragmentation of the industry makes a collective voice particularly important in both protecting the interests of owners and in negotiating a way forward for bus sector reform. The Federation reports a willingness amongst its members to improve the quality of transport and to amalgamate to form more capable organisations. The Federation and the constituent Associations could play a crucial role in bus sector reform. They represent a collective voice but care needs to be taken to fully understand their interests and the nature of their representation.

10.8.2 Problem statement

The public transport sector is characterised by weak public and private institutions, and a low level of investment. It also operates in a physical environment of high levels of risk. The general quality of services at all levels and by all modes has been poor. The overcrowded buses, with poor safety and security records and unreliable service operations are quite common.

The ownership of public transport services is extremely fragmented which creates many problems. One such drawback is a scarcity of capital. In the absence of big companies, banks are reluctant to give loans for capital investment in this sector. Today, the suppliers of the transport vehicles sell the vehicles to the potential operators using a deferred payment system where the sellers fix an Equated Monthly Instalment (EMI) after payment of an initial amount. Thus, it is found that the capability for investment by the operators in this sector is not satisfactory. This could be solved by forming bigger companies in this sector.

The drivers and conductors are not properly trained. In addition to this, their service is not regulated by proper and sufficient legislation. There is a lack in awareness of the safety of the vehicles, passengers and the other road users. The formation of organized companies will enable skill development schemes and training programmes for operators.

There is also a limitation in capacity regarding fleet management, repair, maintenance and operation. The prevailing business model in the bus sector prevents formalisation, as drivers and crews rent the buses on a daily or monthly basis. They operate the buses on their own revenue risk, requiring enough passengers per day to repay the bus rental fees, cover fuel cost, basic maintenance cost and make a profit. As a result, the present bus industry of Chittagong city has not been developed as a healthy one.

10.8.3 Option identification

Development of a bus network that actively seeks to grow the public transport market through the operation of high service level standards will require the following functions to be defined and undertaken:

1) Planning of the bus network
2) Licensing of buses and operators
3) Contracting, or at least defining service requirements
4) Monitoring & Evaluation of network performance
5) Operating services

6) Financial management (fare collection and distribution)
7) Marketing
8) Information provision

Items 1 – 4 are most normally public sector functions. 5-6 can be either private or public sector functions. If private they operate under a contract issued by the public sector who guards public interest and the well-being of the city. In analyzing options it is assumed that a form of *Public Transport Authority* exists as defined above.

10.8.3.1 Public-private sector relationships

The division of responsibility for the planning and provision of bus services can take many forms. Three specific modes of operation have been examined:

1) Privatisation with public sector responsibility for safety and oversight
2) Competitive contracting with public policy setting
3) Direct public operations

These options are considered in turn below.

Privatisation with public sector responsibility for safety and oversight

Under this scenario, the planning of the bus network would be undertaken within the public sector. Appropriate operators are sought, with the public sector retaining responsibility for evaluating performance and safety. The operator may be either public or private but the level of service expected would be defined through a performance-based contract that can be monitored by the oversight authority.

Competitive contracting with public policy setting

This scenario is a development of that defined above. The *Public Transport Authority* would let competitive contracts to private operators who would provide services according to define quality standards for a defined period of time. The performance of the contract would be monitored with appropriate penalties applied for non-compliance. The form of contract could be either *gross cost* or *net cost,* these alternatives are discussed below.

Direct public operations

This scenario would see the public sector as both developing strategy and undertaking operations. Under such a scenario there are distinct benefits in creating separation through contracting.

Ensuring that the operator performs as would a competitive contractor in order to meet the quality objectives required to increase bus modal share in the city. As such, the same principles that are considered above should apply. The creation of a body with Public Transport Authority functions remains who issue contracts that are not competitive but negotiated with a single public-sector provider. In order to ensure value for money under such an arrangement, there would be a need for benchmarking and/or open book review of operating costs.

10.8.3.2 Forms of operating contract

An operating contract is formed between the manager and operator and specifies the level of service required. The means of payment for those services is largely dependent upon the apportionment of revenue risk

The revenue risk can be either allocated to the transport operator or the Transport Authority. The two options for the allocation of the revenue risk is reflected in two main types of contracts that are commonly used for public transport services are:

- Net cost contract
- Gross cost contract

Net cost contract

Under a net cost contract, the operator retains the fare revenues and the authority pays the operator a fixed compensation for bridging the gap between fare revenues and operating costs.

Under a net cost contract, the transport operator will take both the cost risk and the revenue risk. This risk allocation applies in the case that the operator is free to determine the fare level and adjust the network. Only then will the operator be in the position to manage the revenue risk.

Net cost contracts can reduce accessibility for women and disabled users who might take up more space or take longer to board than their male or able-bodied counterparts. This is because operators are incentivised to provide service to the largest number of passengers in the shortest amount of time, regardless of the level of service provided.

Gross cost contract

Alternatively, under a gross cost contract, the transport authority retains all fare revenues and assumes the revenue risk. The transport operator gets paid for providing transport services on the basis of a fixed price per bus kilometer as agreed under the contract. This is the most common contract type used in many countries, for instance for the urban bus network in London. The price per bus kilometer is therefore the main tender criterion: the operator that offers the lowest price per bus kilometer will win the contract.

This contract is the most appropriate in the case of a Public Transport Authority that defines the network, sets the fares and outsources the operation.

Public service contract

In the development of a Public Service Contract (PSC), it is essential that the transport authority define the rights and responsibilities of the authority and the operator of the service. These definitions should provide methods of improving service quality and maintaining high standards of standards, such as reliability, safety and customer satisfaction levels.

Performance-based incentives

In order to maintain service standards, a set of performance-based subsidies, rewards and penalties can be applied. These must be included in the PSC in order to take effect. Rewards should be based on a specific standard of service. Rewards may be allocated from the collection of penalties.

Standards

The PSC should also include standards that allow for a uniform service on all routes, regardless of the operator. Standards might include:

- Vehicle livery
- Coordinated infrastructure
- Availability of standard fare payment system as decided by the Authority
- Use of standard ticket(s) as decided by the Authority
- Cleanliness standards
- Safety standards (reference to the relevant laws and regulations)

Evaluation & monitoring needs

The application of rewards and penalties together with the achievement of policy objectives, should be based upon objective measurements or observations, based on regular routine monitoring. Monitoring of the performance measures for both rewards and may include:

- GPS: Monitoring of production, such as vehicle trips and vehicle KM.
- Monitoring of production and performance of the service.
- Customer Satisfaction Surveys: Completed on an annual or semi-annual basis by the Transit Authority on all routes.

- In Person Monitoring: Using mystery customers and monitors at stops, garages and stations in person.

Regular routine monitoring should be undertaken by the public-sector authority responsible for performance.

10.8.4 Recommendation

Considering the above, we derive five business model options for the future operation of bus service in Chittagong. These are:

- **In-house operations**: all system assets and operations are under the control of a public agency:
- **Management contract**: system assets remain in control of the public sector but certain operational and management functions are contracted to private firms;
- **Gross-cost contract**: private firms compete to operate routes but are paid on the basis of performance and not on the basis of passenger revenues;
- **Net-cost contract**: private firms compete to operate routes and are paid on the basis of passengers revenues;
- **Free market**: services are market-initiated; routes, schedules, fares, number of operators and vehicles are left to private initiative. Some regulation is still needed.

Considering precedents, experience and need, it is clear that future operations should be undertaken by the private sector with controls and regulations exerted by a public sector entity. This regulating body will ascertain the requirement of the number and type of buses on each route after conducting a proper survey. It will form a committee for route permits and fare calculation and coordinate as a whole. It is proposed that the routes, schedules, fares, number of operators and vehicles are to be determined and regulated by the proposed Body.

Many of the SUTMP recommendations, in the first 5 years, are focused upon the CDA Avenue corridor, it is recommended that services plying this corridor are prepared for performance-based gross cost contracting administered by the new transport authority. This will enable the issues of bus sector reform in the local context to be explored and developed before being rolled out across the city by a maturing transport authority.