URBAN LEDS
URBAN LOW EMISSION DEVELOPMENT STRATEGIES

Narayanganj City, Bangladesh

Greenhouse Gas Emission Inventory Report 2018-19

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Contributing Team from ICLEI South Asia:
J A M Mostahidul Alam, Jubaer Rashid, Prateek Mishra, Bhaskar Padigala, Nikhil Kolsepatil, Soumya Chaturvedula

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Contact:
ICLEI South Asia
C-3, Lower Ground Floor, Green Park Extension
New Delhi - 110016, India
iclei-southasia@iclei.org
http://southasia.iclei.org/

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1 CITY PROFILE

Located at the heart of the country, Narayanganj is Bangladesh's most prominent river port. Known as the 'Dundee of East', Narayanganj is the leading economic and industrial hub of the country. The city is famous for its jute mills and textiles. Its strategic location, pro-business environment, and rapid industrialization over the years has attracted both local and foreign investors as well as the migrant workforce from neighbouring districts, which has resulted in rapid urbanization in the city. Most of the industrial units are primarily located on two banks of the Shitalakshya River and the eastern bank of the Buriganga River and provide a number of employment opportunities in the city.

The Narayanganj subdivision was established in 1882 and was turned into a district in 1984. The total area of the Narayanganj district is around 684 sq.km and the total population, as of 2011, is around 2,948,217. Owing to rapid urbanization and industrialization in recent years, Narayanganj city was upgraded to a city corporation in 2011, unifying three municipalities namely Narayanganj, Shiddhirganj and Kadamrasul, through Rule 6 of the establishment of Local Government (City Corporation) Rules, 2010. This process was aimed to better manage the city's urban services and stimulate growth.

1.1 Location

Geologically Narayanganj city lies on the edge of the Madhupur Tract and the Holocene floodplain deposits from the aquifers. The city is located at 17 km southeast from Capital Dhaka and lies between latitudes 23°33' and 23°57' North and longitudes 90°26' and 90°45' East. Situated on the banks of the Shitalakshya River, beside the confluence of the rivers Shitalakshya and Buriganga, Narayanganj city is a land of mixed topography. The present urbanized areas and the levees of the Shitalakshya, the Buriganga, and the Old Brahmaputra rivers are at a comparatively higher elevation as compared to the rest of the city. The city is bounded by Syedpur- Madabpur road on the east, Sonargaon sub-district and Dhaka-Chittagong highway on north-east, Dhaka district on west and Munshiganj district on south.

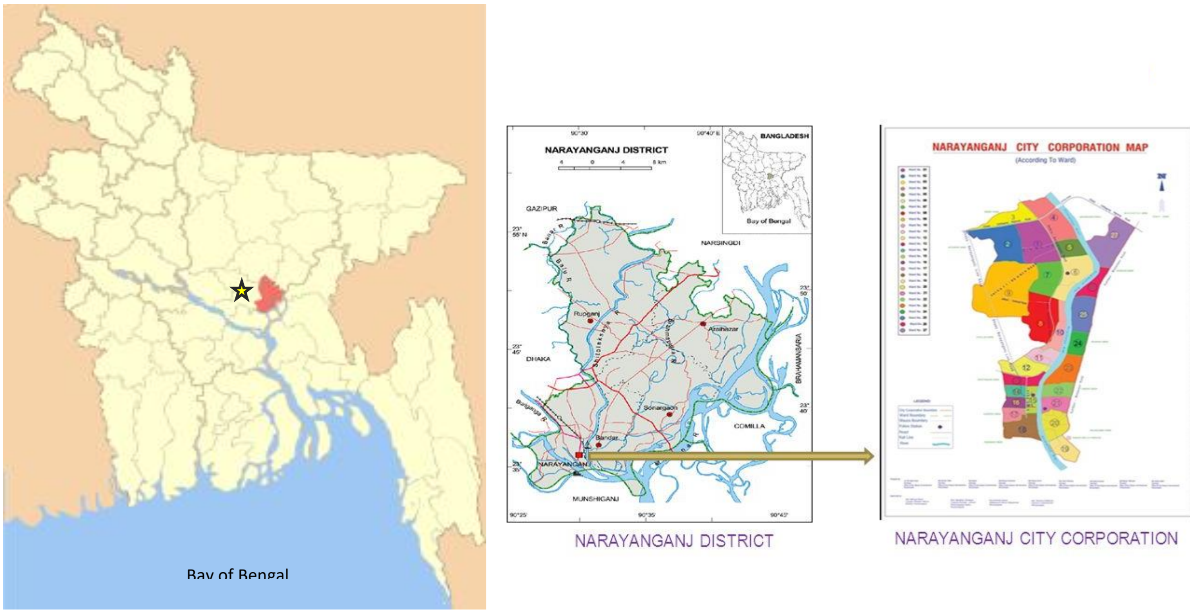


Figure 1: Location Map of Narayanganj City Corporation

1.2 Connectivity

By Air: There is no airport located in Narayanganj. The nearest Airport is Hazrat Shahjalal International Airport, located 34 km away in the capital Dhaka. The airport operates a number of domestic and international flights daily. The airport is accessible by Dhaka – Narayanganj Road (R111), which connects Narayanganj and Dhaka through national highway 1.

Railway: A 17 km meter-gauge track connects Narayanganj Railway Station with Kamalapur Railway Station and extends to Mymensingh district. More than thirty thousand people travel by train every day. To meet the increasing demand, The government has undertaken a plan to construct a 16 km underground Mass Rapid Transit Line -4 from Kamalapur to Narayanganj by 2030.

Road: Narayanganj is well connected with adjacent cities by National and Regional highways. Being located at the centre of the country, a number of national and regional highways pass through the city. National Highway (N 1) connects Dhaka and Narayanganj with the South-East region. Dhaka – Chattogram Highway (N1) passes through the northern part of the city corporation area and carry the majority of the motorized traffic to and from NCC area. Regional Highway R110, named Demra – Narayanganj road is connected with Dhaka – Chattogram highway is one of the major primary roads that run parallel to the Shitalakshya River. Dhaka – Narayanganj Road (R111) is the spine road that connects NCC with Dhaka through N1.

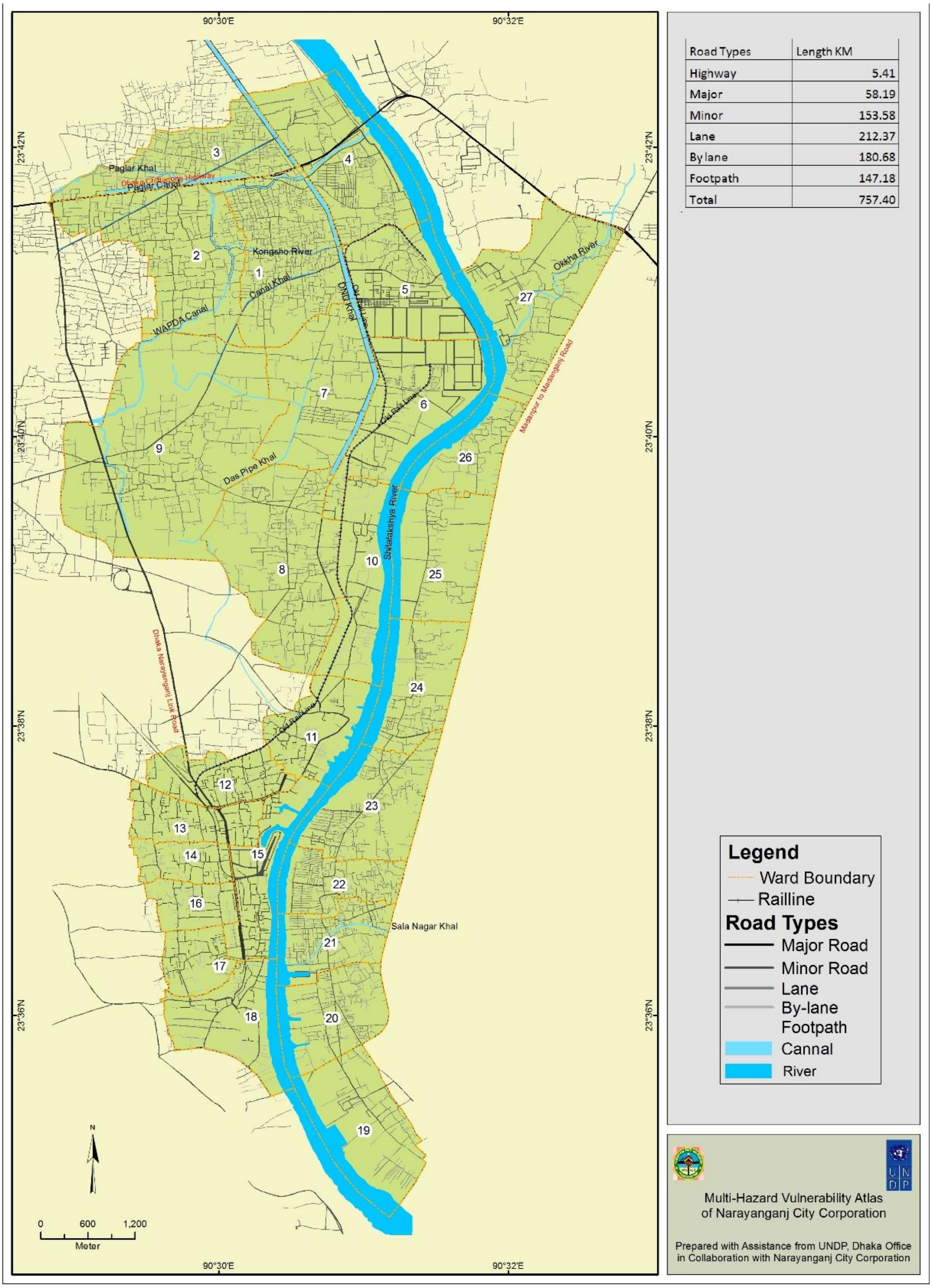
In addition, NCC has an internal road network of 609.43 km. The roads can be classified based on the material of construction as RCC, CC and HBB. Out of the total road network, the majority of roads are of CC type followed by RCC and HBB, respectively. Table 1 shows detailed information on different types of roads and their network length within the city corporation area.

Table 1: Length of different types of roads in NCC

Road Type	Length (Km)
Roller Compacted Concrete (RCC)	210.51
Cement Concrete (CC)	316.15
Herring-Bone-Bond (HBB)	82.77
Total	609.43

(Source: NCC Area Action Plan, 2016)

Waterway: Flanked by rivers, Narayanganj is well connected with the port cities of neighbouring Asian countries, such as Myanmar (Rangoon and Akyab) and India (Kolkata, Assam, and Kachar), through waterways. This makes it easy for the city to export and import goods and services. The Narayanganj river port is one the oldest and busiest port in the country.



Road Types	Length KM
Highway	5.41
Major	58.19
Minor	153.58
Lane	212.37
By lane	180.68
Footpath	147.18
Total	757.40

River

Figure 2: Road and Rail Network of Naryanganj

(Source: NCC Area Action Plan, 2016)

1.3 Demography

The population of Narayanganj city is 709,336 with a population density of 15,021 people/sq. km. According to BBS 2011, the number of males exceeds that of females with 51.48% of the total population being male (106 males per 100 females). Bengalis and Muslims are the major population groups in the city. According to BBS 2011, 91.19% of the total population follow Islam, while 8.71% of the total population are Hindus. The decadal growth of population in the city has increased from 10.7% in 1961–1974 to 49.9% in 2001–2011with an annual average growth rate of 4.7%, which is three times higher than the national growth rate of 1.2%. One of the primary reason for the rapid growth in the city population can be attributed to the rapid industrialization which has attracted a large labour force from the adjacent districts. Table 2 shows the ward-wise population of NCC as of 2011.

Table 2: Ward-wise Area and Population of Narayanganj City Corporation, 2011

Ward No.	Total Population	Male Population	Female Population
Kadamrasul Paurashava			
1	11,822	5,977	5,845
2	17,649	8,777	8,917
3	22,176	11,380	10,796
4	30,728	15,633	15,095
5	30,572	15,553	15,019
6	20,308	10,029	10,279
7	12,636	6,431	6,205
8	6,812	3,462	3,350
9	13,543	7,020	6,523
Total	**166,246**	**84,262**	**82,029**
Narayanganj Paurashava			
1	20,489	10,685	9,804
2	24,550	12,782	11,768
3	40,187	20,871	19,316
4	47,079	24,400	22,679
5	29,431	15,372	14,059
6	24,096	12,707	11,389
7	34,496	17,659	16,837
8	35,518	18,126	17,392
9	30,484	15,612	14,872
Total	**286,330**	**148,214**	**138,116**
Siddirganj Paurashava			
1	36,592	18,961	17,631
2	25,585	13,180	12,405
3	35,947	18,931	17,016
4	23,385	12,240	11,145
5	18,421	9,334	9,087
6	25,100	12,878	12,222
7	21,888	11,165	10,723
8	42,704	22,169	20,535
9	27,138	13,840	13,298
Total	**256,760**	**132,698**	**110,764**
Grand Total	**709,336**	**365,174**	**330,909**

According to the Bangladesh Bureau of Statistics 2011, urbanization rate of Narayanganj was 33.54% against the national urbanization rate of 23.30%. As a result, the population growth rate of Narayanganj has rapidly increased to 3.05% in 2011[1], from 2.16% in 2001. As per the estimates of City Population[2] , with the estimated annual growth rate the projected population of Narayanganj city is expected to be almost 3 million in 2051 (Figure 3).

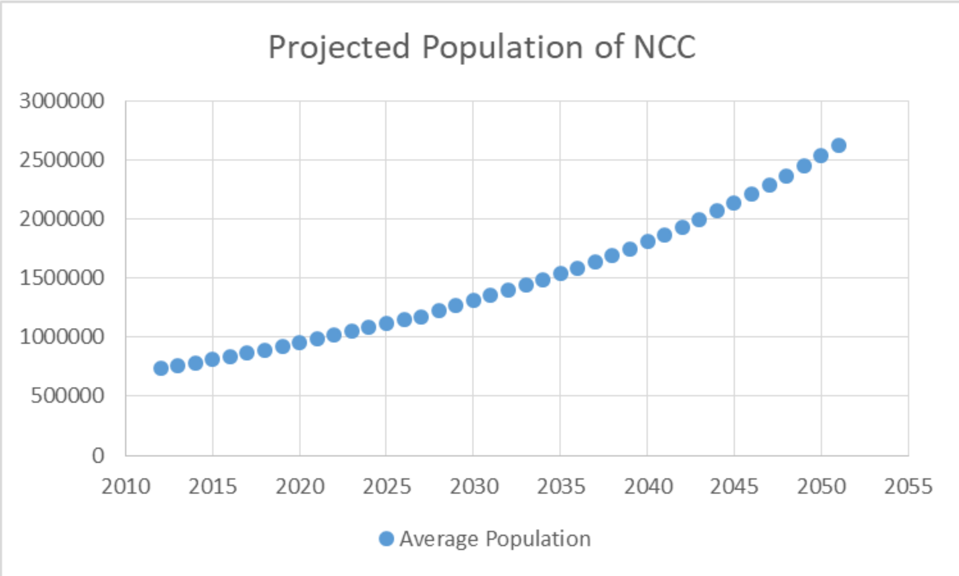


Figure 3: Population Projection of NCC

1.4 Land Use

The rapid industrialization over the years has resulted in urban sprawl in Narayanganj. The rapid urbanization in the city has placed a lot of pressure on the land as well as urban planners. The existing architectural structures and land-use control mechanism have lost their significance due to the haphazard industrial and urban development. The city now has a limited portion of land available to initiate new development plans with the majority of land being under residential and mixed-use. In view of this situation, the city has recently developed an Area Action Plan (AAP) to develop a new land-use control mechanism.

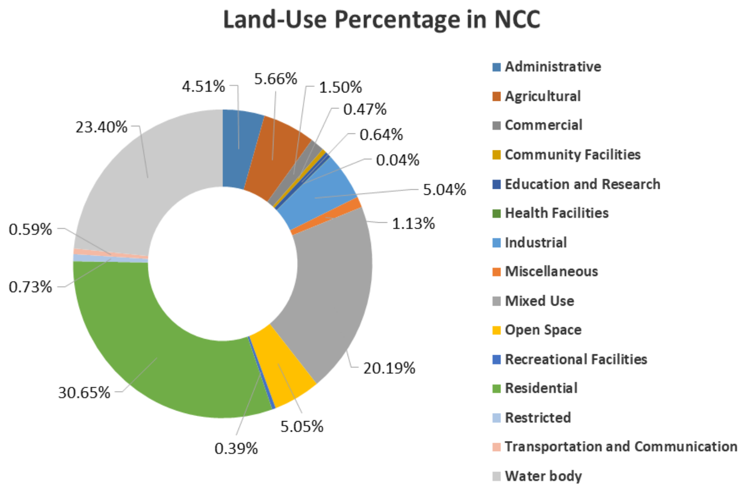


Figure 4: Percentage of Land Use in NCC Area

(Source: NCC Area Action Plan, 2016)

[1] Ministry of Housing and Public Works, 2014: Social Assessment and Social Management Framework Report
[2] http://www.citypopulation.info/php/bangladesh-admin.php?adm1id=67

The land use pattern in the Area Action Plan of NCC has been divided into fifteen broad categories. These categories are administrative, agriculture, commercial, community facilities, education and research, health facilities, industrial, miscellaneous, mixed-use, open space, recreational facilities, residential, restricted, transportation and communication and water body. In terms of land distribution and land-use, around 30.65% of the total NCC area is used for residential purposes, followed by water bodies which occupy a considerable 23.40% of the land space. Being a historic industrial city, NCC has been subjected to haphazard development. This promoted the concept of mixed-use land space development in the city. Presently, almost 20% of the land space is used for mixed development. Industries occupy 14% of the area mostly along the Shitalakshya River, while commercial entities occupy 11.74% of the land space. Government and non-government organizations occupy 4.51% land and open space (mostly vacant land) covers 5.05% of the City Corporation area. Open green spaces are seemingly non-existent in the city, as most of these lands have been gradually transformed into profitable business set-ups or have been gradually encroached by slum-dwellers. This land-use pattern for housing and industries has resulted in the reduction of agricultural activities as well as the social spaces in the city.

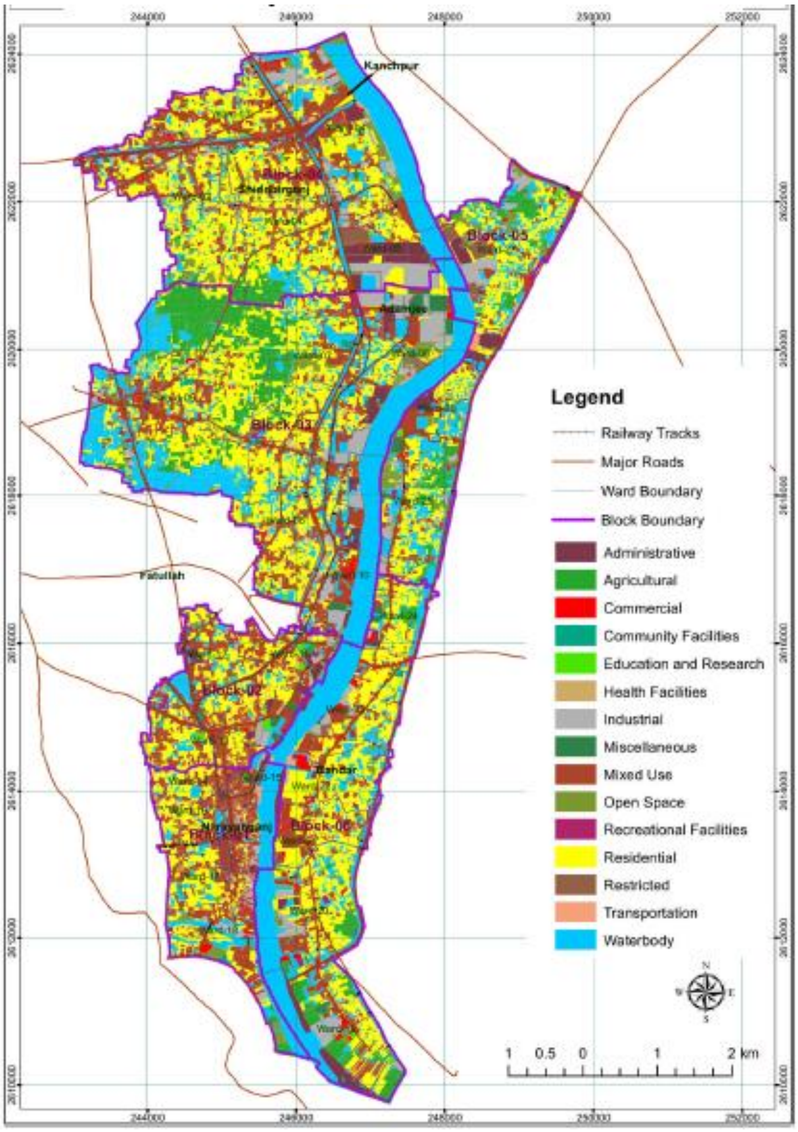


Figure 5: Land-Use Pattern of NCC

(Source: NCC Area Action Plan, 2016)

1.5 Economic Activities

Narayanganj is one of the major industrial towns in Bangladesh. The city was once renowned for its jute industries, which declined over the decades. However, around 55% of Bangladesh's total exportable knitwear is still produced in Narayanganj. The city accommodates a number of textile and garment industries. Both, textile and garment industries, are labour intensive and generate thousands of employment opportunities in the city. The other major trades and businesses include oilseed trade, processing plant, cement manufacturing etc. Details of major economic activities and share of the population involved (as of 2013) are highlighted in Table-2.

Table 3: Sector-specific Employment in Narayanganj

Major Economic Activities	Total Person Engaged	Percentage
Manufacturing	536,919	62.30%
Wholesale and Retail Trade, Repair of motor vehicles	184,866	21.45%
Other Service Activities	48,162	5.59%
Accommodation and Food Service Activities	31,301	3.63%
Education	17,862	2.07%
Transportation and Storage	10,158	1.18%
Other Economic Activities	32,524	3.77%

(Source: Bangladesh Bureau of Statistics, 2013)

In 2016, the city had more than three thousand industrial units, which are categorized into three board categories namely, Green, Red and Orange, based on their impact on the environment. Around 43.37% of the industries were listed under Orange category, which includes dairy farms, food and beverage industries, poultries, grinding and husking mill, handloom mills, garments mills, ship breaking, plastic and rubber industries, manufacturing and printing, automobile repairing works, leather production, salt production, PVC items, brickfield, lime, jute mill etc. 10.27% of the industries were listed in Red category. This includes fertilizer industries, chemical industries, cement, oil factory, iron and steel mill, natural gas, tire and tube industry, paper mill etc. The remaining 8.88% were listed under Green category which includes assembling, goods re-packing, jute, cotton and artificial fiber industries etc.

1.6 Local Government Bodies

Narayanganj is run by two governing bodies, Narayanganj City Corporation (NCC) and Rajdhani Unnayan Kartripakkha (RAJUK). NCC formed in 2011, administers 27 wards within Narayanganj Sadar municipality, Siddirganj municipality and Kadamrasul municipality, covering a total area of 72.43 sq. km. RAJUK administers a total area of 1528 sq. km consisting Dhaka City Corporation and areas under 14 metropolitan thanas, Narayanganj, Siddhirganj, Bandar, Kadamrasul, Sonargaon, Fatulla, Araihazar, Keraniganj, Savar, Gazipur and Tongi municipality.

Narayanganj City Corporation Council consists of elected members including a Mayor and 27 councillors. The council also consists of nine reserved councillors. The Chief Executive Officer (CEO) is the administrative head and is responsible for the functioning of the Municipality including tax collection, estates maintenance, projects, among other things. The corporation has multiple sector-specific departments that are responsible for day-to-day functioning of the corporation. The Mayor and Councilors are responsible for all the policy decisions, whereas the administrative decisions rest with the CEO. The Corporation is chaired by the Mayor and a total of 147 employees work under 6 departments- Engineering (Mechanical Engineering, Electrical Engineering, Civil Engineering), Conservancy, Accounts, Social Welfare, Health and Planning.

The Narayanganj City Corporation provides and maintains services which include water purification and supply, sewage treatment and disposal, garbage disposal and street cleanliness, solid waste management, building and maintenance of roads and streets, street lighting, maintenance of parks and open spaces, cemeteries and crematoriums, registering of births and deaths, conservation of heritage sites, disease control including immunization, and public corporation schools etc. The current organogram of NCC is as following (Figure 6).

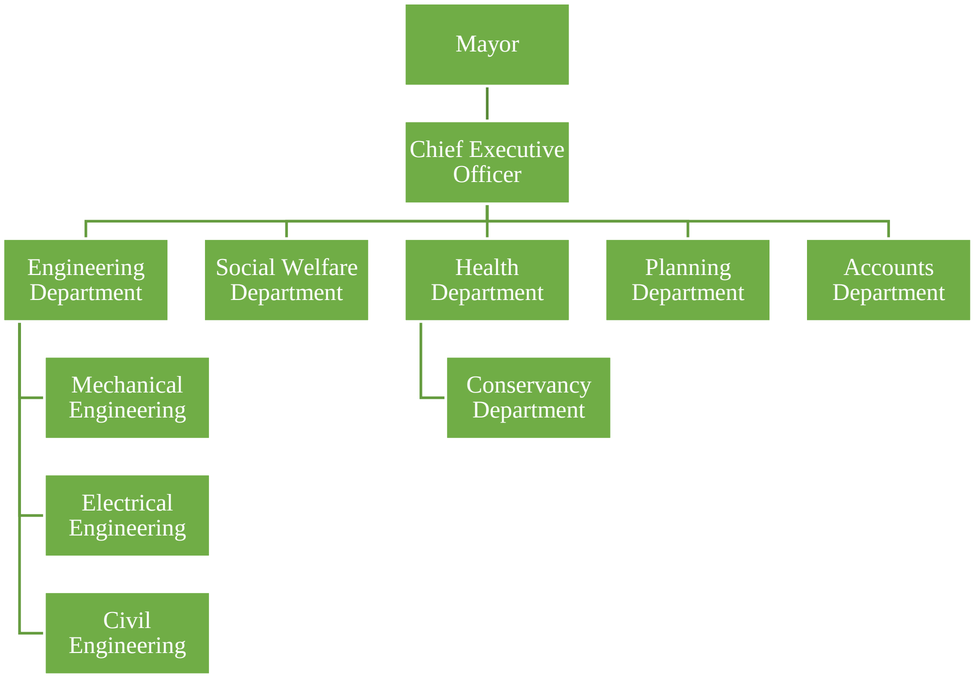


Figure 6: Narayanganj City Corporation Organogram

Dhaka Improvement Trust (DIT) was formed in 1956 under the provision of 'Town Improvement Act, 1953' to develop the physical and urban condition of Dhaka city. Later in 1987, RAJUK was established to replace DIT with an objective to administer Dhaka city and its peripheral areas. An administrative structure of total 1081 officials including 253 in the planning section was prepared and placed in 1987. With the increasing workload, RAJUK proposed a new organogram in 1999 consisting of 1232 officials including 318 in the planning section. This proposal is currently under revision phase. At present, RAJUK is responsible for preparing Master Plan and development policies for Narayanganj.

2 Baseline Assessment

2.1 GHG Emission Inventory

Narayanganj city's GHG emissions inventory is prepared based on the data collected for the years 2014 - 19. The inventory is in accordance with the approved principles and standards of the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC) created by a collaborative effort between World Resources Institute, C40 Cities Climate Leadership Group, and ICLEI – Local Governments for Sustainability. In particular, it complies with the BASIC level reporting which covers Scope 1 and Scope 2 emissions from stationary energy and transportation, as well as Scope 1 and Scope 3 emissions from waste (Refer Appendix).

The GHG emissions inventory consists of two analyses, one for the emissions within the community determined by the geographical boundaries of the city's municipal jurisdiction and the other for urban services provided by the NMC.

Community-level inventory is a useful tool to establish a baseline status of GHG emissions and in developing mitigation actions for the entire city community. It includes emissions from community activities that occur within the municipal government's jurisdiction. This includes emissions due to activities such as residential buildings, commercial/institutional facilities, industrial units and processes, agriculture, forestry and land-use, and mobile transportation units.

Local Government inventory includes emissions from all local operations that the municipal corporation owns or controls. The various sectors considered for this inventory include local government buildings, facilities such as street lighting and traffic lighting, water, waste and sewage facilities, and municipal vehicle fleet. Based on the inventory data for the baseline year, the municipal government can develop innovative approaches to provide sustainable urban services and can demonstrate leadership in pursuing emission mitigation efforts that illustrate the possibilities of different mitigation actions to the community.

A city's GHG inventory is not just simply the sum of GHG emissions from its community-level activities and from the operations carried out by the local government body to provide basic urban services. Usually, a major part of the emissions due to local government operations is a subset of the community-level emissions. Often the community inventory data already accounts for the data pertaining to municipal government operations and so due care should be taken to avoid double accounting of emissions.

For example, the electricity consumption in municipal facilities for water supply, sewage treatment, and street lighting may already be accounted in the community-wide electricity consumption data based on relevant customer/end-user categories as prescribed under the electricity distribution and tariff arrangements. Adding the electricity consumption data from such facilities, obtained from the respective departments within the local government, to the community-wide data again will result in double accounting of the emissions and such overlaps have to be prevented by careful handling of data.

However, it is necessary to acknowledge that analyzing community-wide GHG emissions present its own challenges as the natural flow of energy and materials is typically most accurate at the national level. Reducing the spatial area of analysis, from national to sub-national and local levels result in a less accurate reflection of the material and energy flows. Therefore, a community-level GHG emission accounting means that a combination of national and local area information is required in order to model the emissions. This report identifies the main energy carriers and the intensive GHG emitting sectors that contribute to the local carbon footprint and air pollution within the geographical boundary of Narayanganj City Corporation (NCC).

2.1.1 Methodology for GHG emission inventory

The GHGs considered in the GHG emission inventory are carbon dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O), gases which account for nearly 99% of global GHG emissions.

The GHG inventory has been reported in terms of emissions of each individual GHG and the total carbon dioxide equivalent (CO_2e) emission. To arrive at the CO_2e, the global warming potential (GWP) of each gas for a 100-year timeline is factored. The GWP gives the climate change impact, in terms of the warming effect on the atmosphere, for each GHG with reference to CO_2. The GWP values based on the IPCC's Fourth Assessment Report are presented in Table 4 below.

Table 4: 100 Year GWPs of the GHGs with respect to CO2

Gas	Lifetime (years)	GWP for 100 years
CH_4	12	25
N_2O	114	298

Emissions Factors

For estimating the GHG emissions from the various activities or sources in a region, it is not feasible to carry out a direct physical measurement of GHGs emitted. The common methodology for estimating GHG emissions is by using the principle of emission factor and the relevant activity data to estimate the emissions.

$$GHG_A = EF_A \times D_A$$

Where GHG_A = GHG emissions resulting from activity A
EF_A = emission factor for activity A
D_A = data for activity A

The emission factor for a particular activity is dependent on the energy use and the direct emissions of GHGs resulting from the activity. As the emission factors are dependent on the energy use and the direct GHG emissions, they tend to vary over locations or even for different technologies. For example, the emission factor per kWh of electricity used would vary over countries or regions due to the varying energy mix, characteristics of fuel used and the efficiency of electricity generation. The emission factor per km travelled would vary depending on the fuel characteristics, the engine characteristics for the vehicle, the driving and traffic patterns prevalent. For accurately estimating a GHG inventory, it is thus important to use the emission factor best suited to the location.

For the present study, relevant emission factors as available in HEAT+ tool have been used to arrive at GHG emissions from activities in the region. HEAT+ contains numerous country-specific emission factors and energy densities for a wide range of fuels, combustion technologies and waste types. HEAT+ uses these values to calculate the GHG emissions resulting from electricity usage, fuel consumption and waste decomposition.

2.1.2 Harmonized Emission Analysis Tool plus (HEAT+)

ICLEI's Harmonized Emission Analysis Tool *plus* (Heat+) is an online emissions accounting software package that helps local governments to account for GHG emissions and develop a comprehensive energy and carbon inventory of their respective cities. The tool helps them in making informed climate action decisions and was utilized to assist with the accounting of Narayanganj's level of GHG emissions during the 5-year period of the inventory. The Heat+ tool incorporates the latest technical findings (IPCC, 2006) and is based on the International Local Government GHG Emissions Analysis

Protocol (IEAP). It also incorporates the new international reporting requirements and standards outlined in the Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC).

HEAT+ is now GPC compliant. However, the government module is retained from the differentiation that was brought in with IEAP.

The Harmonized Emissions Analysis Tool (HEAT+) is a specialized online application designed to help local governments:

1. Create emissions inventory of GHGs as well as air pollutants such as nitrogen oxides, Sulphur oxides, carbon monoxide, volatile organic compounds, and particulate matter;
2. Forecast growth of these emissions for a future year;
3. Evaluate policies and measures to reduce emissions of these pollutants; and
4. Prepare action plans to reduce emissions.

While ICLEI designed HEAT+ as a GHG planning tool for its local government members to use while undertaking the five-mile stone process of the Cities for Climate Protection TM (CCPTM) Campaign, this tool has been substantially updated to support cities in the implementation of ICLEI's latest Green Climate Cities Program. Decision-makers from other levels of governments as well as from the private sector and non-governmental organizations will also find the tool useful. With an easy to navigate interface, numerous built-in reports, extensive Intergovernmental Panel on Climate Change (IPCC) and country-specific emissions coefficient data sets, HEAT+ provides an unparalleled software environment for everything right from preparing city-specific GHG inventories to evaluating the benefits of individual policies and measures for developing comprehensive action plans.

2.1.3 Data Sources and Collection

The baseline year for this study was the financial year of 2017-18 (i.e. April 2017-March 2018). A full GHG inventory includes emissions from energy, waste, agriculture, forestry, and land-use change. However, due to limited resources and data constraints, the direct emissions from agriculture, land-use change and forestry sectors were not included.

ICLEI South Asia and NCC staff members engaged through meetings and letters with a number of municipal, local and sub-national stakeholders to source the relevant energy consumption data focusing on the large carbon emitters within the municipal area. Supply and demand-side data were therefore collected and analyzed. The various sources of energy & other relevant data used in the report are elaborated in Table 5.

Table 5: Sources of the data used for GHG emission calculation

Fuel Type	Sector	Source of Data
Electricity	Residential	Dhaka Power Distribution Company (DPDC) and Rural Electrification Board (REB)
	Commercial/Institutional	Dhaka Power Distribution Company (DPDC) and Rural Electrification Board (REB)
	Manufacturing Industry and Construction	Dhaka Power Distribution Company (DPDC) and Rural Electrification Board (REB)
	Municipal Buildings	Narayanganj City Corporation
	Waterworks department – Water Supply	Narayanganj City Corporation
	Street lights	Narayanganj City Corporation
Diesel	Community Transport	Padma, Meghna, and Jamuna Oil Company Limited

Fuel Type	Sector	Source of Data
	Municipal Buildings	Narayanganj City Corporation
	Municipal Vehicles	Narayanganj City Corporation
Octane	Community Transport	Padma, Meghna, and Jamuna Oil Company Limited
	Municipal Vehicles	Narayanganj City Corporation
LPG	Residential	JMI Group
	Commercial/Institutional	JMI Group
PNG	Residential	Titas Gas Transmission and Distribution Company
	Commercial/Institutional	Titas Gas Transmission and Distribution Company
	Manufacturing Industry and Construction	Titas Gas Transmission and Distribution Company
CNG	Community Transport	Titas Gas Transmission and Distribution Company
Solid Waste Management		Narayanganj City Corporation
Wastewater		Secondary Research and Estimations

2.1.4 Economy-wide Trend of Energy Consumption and GHG Emissions

Economy-wide analysis of the data collected for GHG emissions inventory helped in determining the average growth or decline in energy consumption and GHG emissions from different sectors, classified based on their activities within the city boundary. Table 6 represents information on energy use by different sectors of Narayanganj city between the years 2014-15 and 2018-19. During the baseline year 2018-19, Narayanganj's total energy consumption stood at 9.63 Million Gigajoule (GJ), which was 7.89 Million GJ in 2014-15.

Table 6: Sector-wise Trend of Energy Consumption in GJ per year

Sector	Energy Consumption (GJ)				
	2014-15	**2015-16**	**2016-17**	**2017-18**	**2018-19**
Residential Buildings	1,078,132	1,228,947	1,239,884	1,316,487	1,378,311
Commercial and Institutional buildings/facilities	450,689	494,286	522,549	555,423	590,187
Manufacturing Industries and Construction	5,994,840	6,230,076	6,369,629	6,650,918	7,214,724
Transport	371,042	387,359	369,896	412,504	455,607
Total	**7,894,702**	**8,340,668**	**8,501,958**	**8,935,333**	**9,638,828**

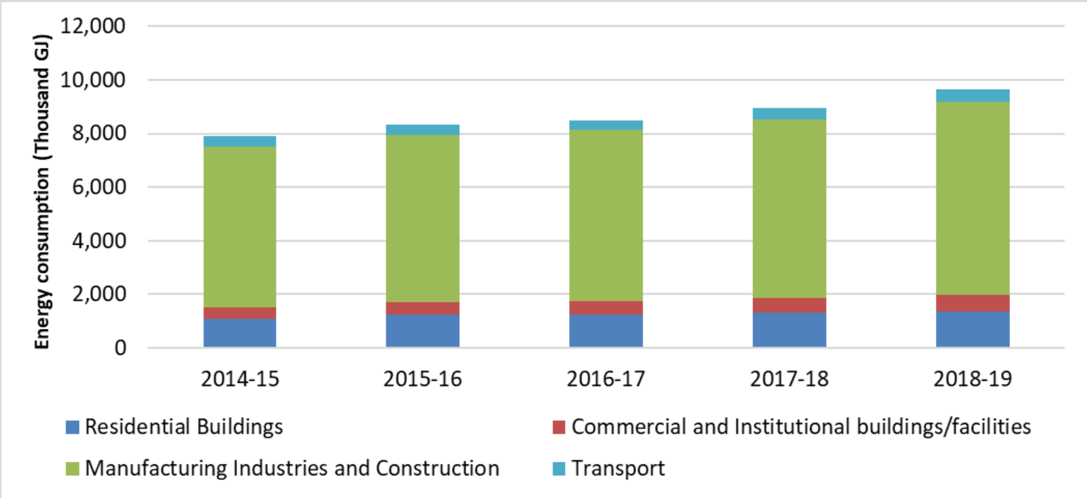


Figure 7: Trend of Energy Consumption in GJ from 2014-15 to 2018-19

From Figure 7, it is evident that the total energy use by the city has increased significantly during the inventory period, at an annual average growth rate of 4.42%. Among the sectors, the average annual growth rate (AAGR) is observed to be the highest in the commercial sector at 6.2%, followed by the residential sector at 5.6%. Despite having the highest share in the energy use, the industrial sector's energy use AAGR stands less than the overall AAGR of 4.1%.

The overall GHG emissions contribution from various sectors across the city's community has been exhibited in Table 7 below. The total GHG emission for Narayanganj city in the year 2018-19 stands at 1.06 million tonnes of CO_2 equivalent (tCO_2e). Taking this into consideration, the per capita emission of Narayanganj translates to 1.19 tCO_2e, which is almost twice the per capita emissions of Bangladesh for the year 2018 (0.56 tCO_2e)[3]. Gas-wise emissions (CO_2, CH_4 and N_2O) along with notation keys for sectors and sources not considered in the inventory for the base year are available in a summary table in section 3 of this report.

Table 7: Sector-wise Trend of GHG Emission per year

Sector	GHG Emissions (tCO_2e)				
	2014-15	**2015-16**	**2016-17**	**2017-18**	**2018-19**
Residential Buildings	190,346	217,203	218,732	232,009	242,847
Commercial and Institutional buildings/facilities	63,507	70,657	73,871	79,593	86,161
Manufacturing Industries and Construction	484,061	515,314	530,414	562,162	610,675
Transport	23,280	24,476	23,981	27,107	29,449
Waste	65,755	71,857	79,876	81,821	92,277
Total	**826,950**	**899,507**	**926,874**	**982,691**	**1,061,409**

[3] Knoema - Bangladesh - CO2 emissions per capita. Available at: https://knoema.com/atlas/Bangladesh/CO2-emissions-per-capita

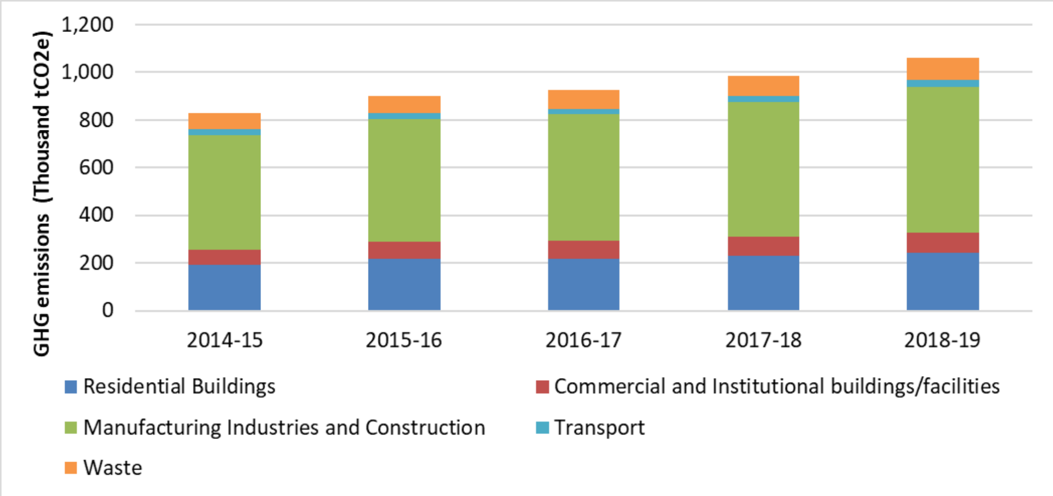


Figure 8: Trend of GHG Emissions in tCO_2e from 2014-15 to 2018-19

Figure 8 depicts the sector-wise GHG emission trend in Narayanganj between 2014 and 2019. As can be observed from the graph, the GHG emissions in the city have increased over the years, with an average annual growth rate of 5.7%. The highest increment in emissions was observed in the waste sector, which experienced an annual average growth of 8.1%, followed by commercial/institutional sector, which experienced an average annual growth rate of 7.1%. Industrial sector portrays the same course of growth as it exhibits in energy use trend (Refer Table 6).

2.1.5 Baseline Energy Consumption and Emissions

A baseline year is a historical reference point against which comparisons can be made to measure changes in the past and current data trends. This reference point in time helps track the effects of energy efficiency and emission targets set forth by climate action plans. 2018-19 was chosen as the baseline year for the GHG emission inventory prepared for Narayanganj city. With the study significantly dependent on secondary data sourced from various government and private agencies, the base year is set as a financial year to align with most of the data accounting practices in these agencies. 2018-19 is also the latest year wherein requisite information was documented and available across all sectors. Data for a time period of 5 years has also been collected in order to understand the trends of energy use and GHG emission across the sectors in the city.

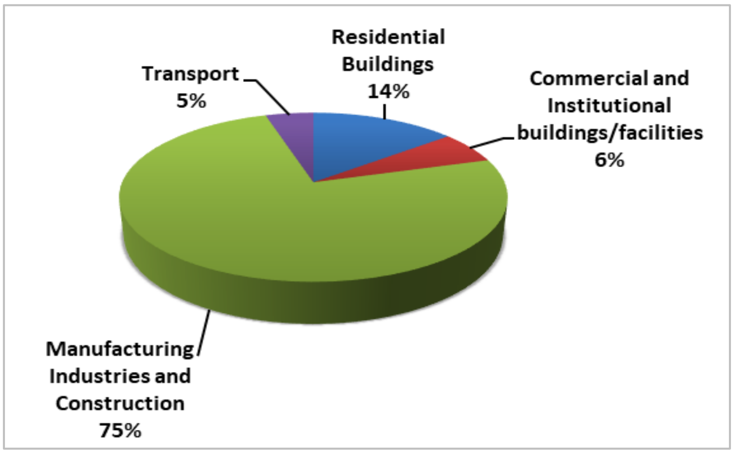


Figure 9: Sector-wise Energy Consumption in 2018-19

Sector share in energy use is depicted in Figure 9. The industrial sector is the largest consumer of energy in Narayanganj, correlating to it being the industrial hub of Bangladesh, with a share of 75% of total energy use, even though the average growth rate of the sector is lower than that of other sectors. Relatively higher use of fuels with high calorific value like PNG in the industrial sector, as compared to the residential and commercial sector, has resulted in a much larger share of the industrial sector. The residential sector with a 14% share in total energy consumption is the second-largest consumer of energy followed by the commercial and transport sector, which have a share of 6% and 5% respectively.

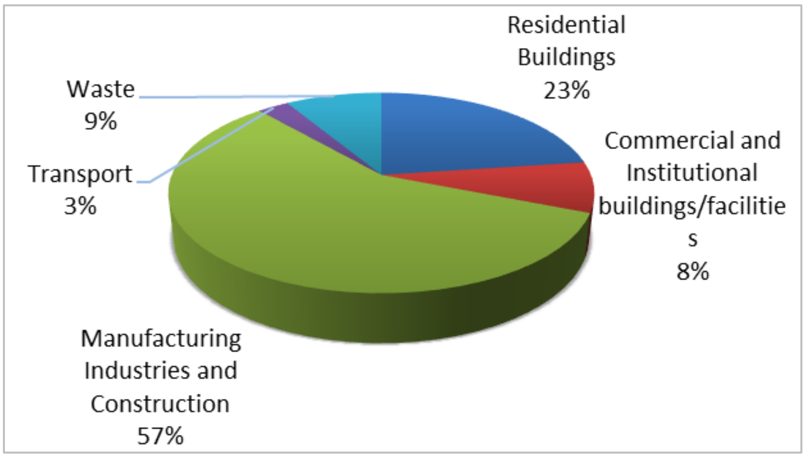


Figure 10: Sector-wise GHG Emissions in 2018-19

As exhibited in Figure 10, the industrial sector with a share of 57% is the highest contributor to the overall GHG emissions, an obvious corollary to its energy use share. The significantly higher GHG emission contribution by the industrial sector is mainly because of the haphazard industrialization in the city over the last few years. The residential sector is the second-highest contributor to GHG emissions in the city with a 23% share. The higher contribution of the residential sector as compared to commercial, transport and waste sector is mainly due to the internal migration of population to Narayanganj from nearby districts and towns, in search of job opportunities.

2.1.6 Supply Side Energy Consumption and Emissions

Primary and secondary energy sources supplied to the demand-side sectors for consumption are referred to as the supply-side sources. These include liquid, solid and gaseous fuels, electricity and renewable sources of energy. Demand-side energy refers to the energy end-user, i.e. the sectors like residential, commercial, industrial users of energy within an urban jurisdiction. Grid electricity is the dominant energy type that is typically used in almost all sectors. Petroleum products form the second group and are used extensively for community transportation in the city and in the industrial sector.

In terms of energy use, PNG is the main fuel source used in Narayanganj City, catering to about 59.5% of the total energy consumed in the city. Grid Electricity is the next major source of energy with a contribution of 35.5% to the supplied energy.

Contrary to it having the highest share of energy use in the city, PNG does not have the highest share in the city's emission. In fact, GHG Emission from grid electricity has the highest contribution to the city's emission with a share of 63.6% in the overall GHG emissions. It is followed by PNG which contributes around 33.2% of the total emissions. Share of energy sources in energy use and emissions is depicted in Figure 11.

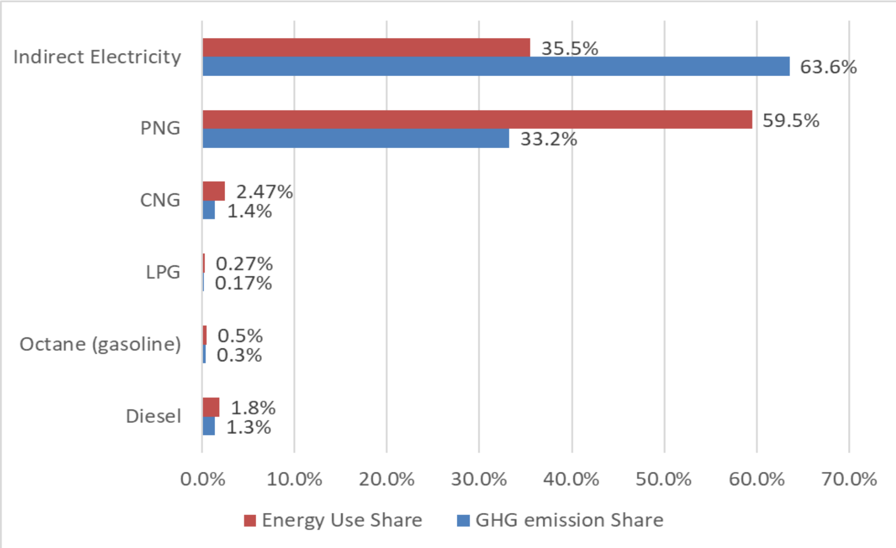


Figure 11 : Share of Energy Consumption and GHG Emission by Energy Source

2.1.7 Energy Indirect emissions from Grid electricity at the community level

2.1.7.1 Sector wise grid electricity consumption at the community level

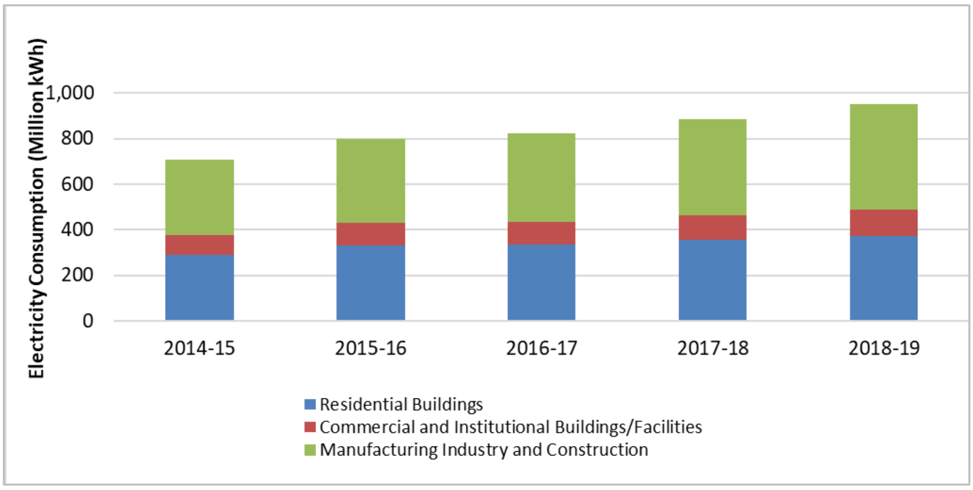


Figure 12: Sector-wise Grid Electricity Consumption at the community level

At the community level, electricity is the most common form of energy across sectors and is used in almost all homes, offices, other buildings, and outdoor lighting. Figure 12 depicts cross-sectoral electricity consumption in the city. This information helps in the analysis of the city's economic profile and electricity-intensive sectors. Figure 12 portrays a growing trend in electricity consumption in the city which has steadily increased from 707 million kWh in 2014-15 to 951 million kWh in 2018-19.

It can be seen that the electricity use by the industrial sector has increased substantially over the years and is expected to increase further, considering the haphazard industrial development in the city over the years. Also, the majority of industrial units in Narayanganj depend upon grid electricity for their operations. A similar increasing trend can be observed for both the residential and commercial sector in the city. Residential electricity use, with industrial development and its consequent population migration, is also expected to increase with time.

For the commercial sector, a steady increase can be observed, the primary reason for this being new commercial entities such as IT industries, malls, cafés. have started their operations in the city. The recent infrastructural development is likely to boost the commercial establishments in the vicinity.

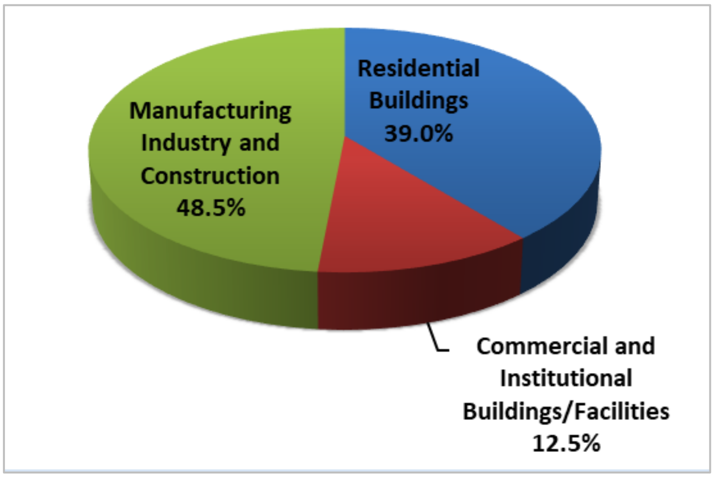


Figure 13: Sector-wise share of Electricity consumption in 2018-19

As shown in Figure 13, the main consumer of grid electricity at the community level is the industrial sector with a share of about 48.5% in city-wide consumption. The residential buildings sector with a 39% share is the second-largest consumer of grid electricity in the baseline year 2018-19. The remaining 12.5% of the grid electricity is consumed by the commercial and institutional sector.

2.1.7.2 Sector wise indirect GHG emissions from Grid Electricity consumption

Grid-supplied electricity entails emissions produced at generation facilities off-site from the consumption facilities. Based on the city and electricity grid structure, the energy generators can be located outside the geographic boundary at various locations tied to or exporting to the regional grid. Thus, the consumption of grid electricity contributes to indirect GHG emissions on the community level.

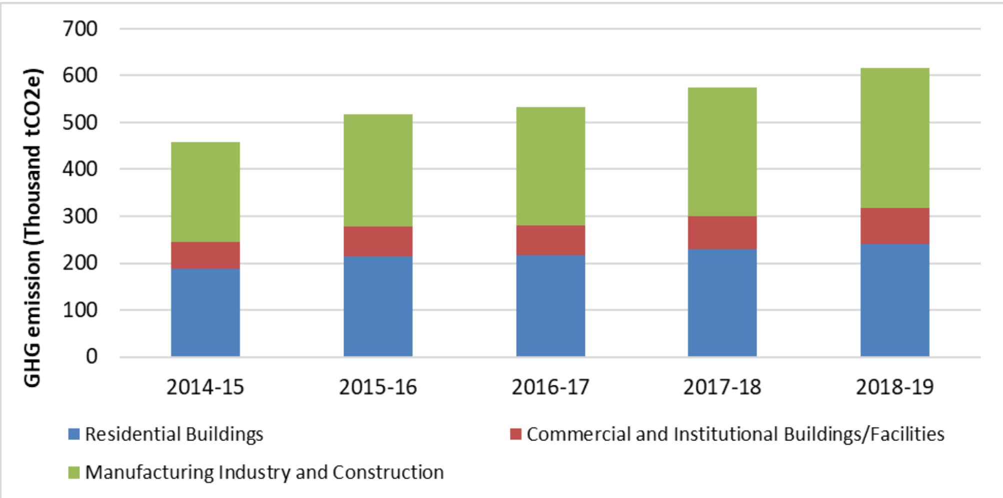


Figure 14: Sector-wise indirect GHG emissions due to Electricity Consumption

Figure 14 above, shows that the indirect emission due to grid electricity has increased uniformly between the years 2014 and 2018. This increase in the emission trend is mainly due to higher growth of electricity consumption across the sectors. In Narayanganj, electricity generation solely depends on thermal-based power units and supply is dependent on the regional grid. Since the GHG emission is derived by multiplying the applicable single emission factor with the electricity consumption values, the sectoral shares of GHG emission are the same as those for the consumption of electricity. The Industrial sector contributes the most, emitting 298,728 tCO_2e. It is followed by Residential buildings sector and Commercial sector respectively (refer Figure 15)

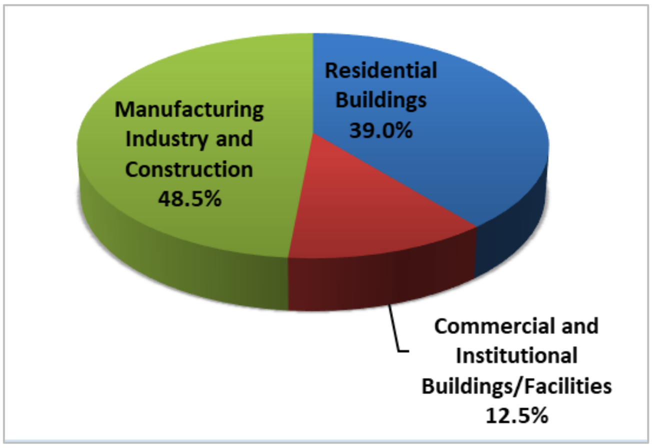


Figure 15: Sector-wise share of GHG emissions from electricity consumption

2.1.8 Direct Emission from Stationary Combustion at the Community Level

Direct emission from stationary combustion refers to the emissions from the intentional oxidation of fuels within a stationary apparatus that is designed for producing heat or mechanical work in a process (e.g. burning of kerosene and LPG for residential use, furnace oil for industries). It does not include fuel used for transportation. The quantity of direct GHG emission for stationary combustion depends on the volume and type of fuels used across sectors such as residential, commercial/institutional and industrial. It is estimated by multiplying the fuel consumption by the GHG emission factor for the specific fuel.

2.1.8.1 Residential buildings sector

LPG and PNG as the primary fuels used to meet the energy requirements of heating and cooling in the residential buildings in the city. Titas is the responsible agency for the PNG supply in the city. Figure 16 depicts the energy consumption by PNG and LPG. An increasing trend in the consumption of both LPG and PNG can be observed. LPG consumption has increased with a compound annual growth rate (CAGR) of 18.69% and reached 325 tonnes as of 2018-19 from 138 tonnes as of 2013-14, while PNG consumption increased consistently with a compound annual growth rate (CAGR) of 3.16% and reached 829600 Cu.m. in 2018-19. This steep increase in the consumption of LPG can be attributed to an increase in low-income households in the city, as a consequence of haphazard industrial development.

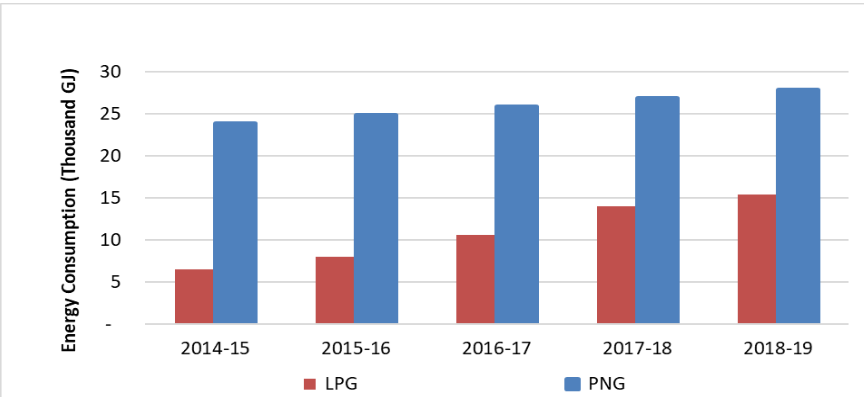


Figure 16: Trend of stationary energy use by Fuel in the Residential sector

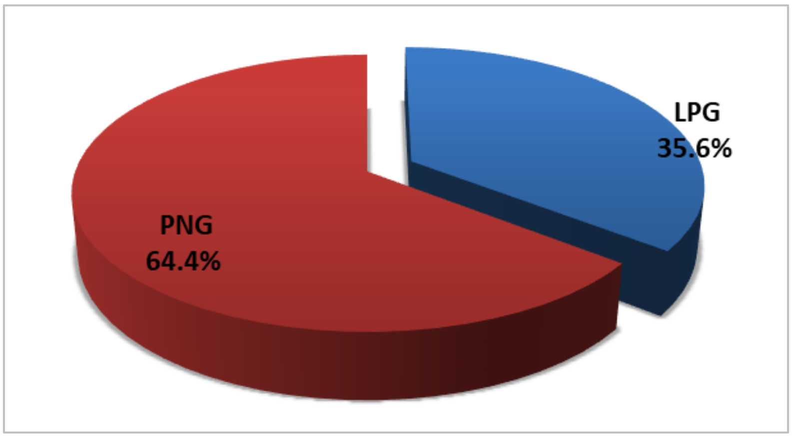


Figure 17: Share of stationary energy use by Fuel in the Residential sector, 2018-19

From Figure 17, it is clear that PNG is the major stationary fuel in the residential sector of the city and contributes to approximately 64.4% of the domestic energy use. In contrast, LPG has a share of 35.6% in total energy use. This trend exhibits that PNG is now the primary domestic fuel in high and mid-income households, while LPG consumption is now limited to low-income households only.

The GHG emissions from the residential sector of the city have certainly increased during the study period with the increase in domestic fuel consumption, as can be seen in Figure 18. The total emission from stationary fuel use in the residential sector of the city stood at 1,752 tCO_2e in 2014-15 while in 2018-19 it increased to 2,536 tCO_2e. PNG is the largest emitter among the two fuels used, an obvious corollary to its large share in energy use, with LPG being the distant second (refer Figure 19).

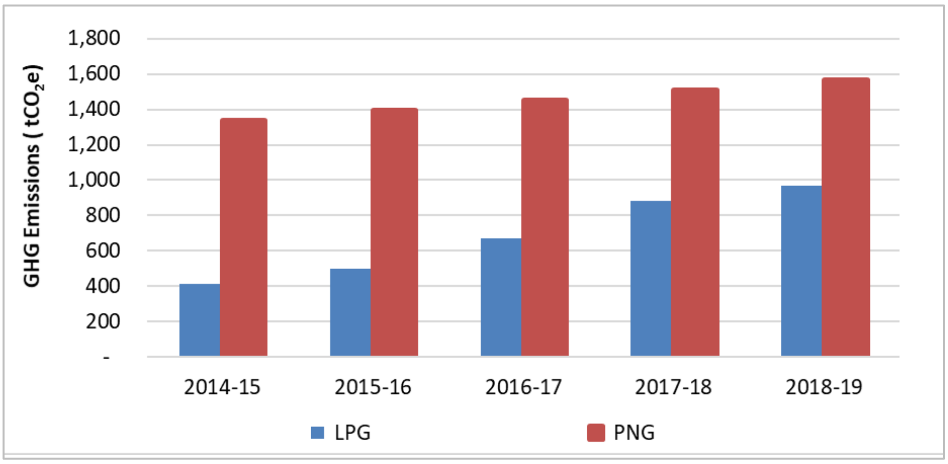


Figure 18: Trend of GHG emissions from fuel use in the Residential Sector

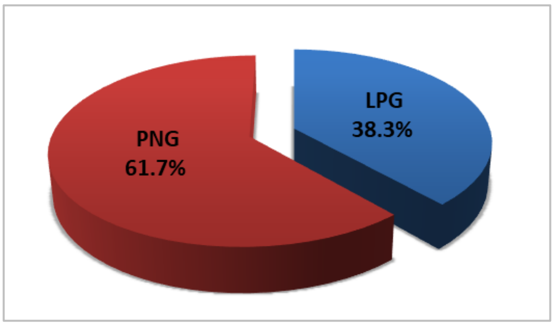


Figure 19: Share of GHG emissions by Fuel in the Residential Sector, 2018-19

2.1.8.2 Commercial and Institutional buildings/facilities sector

The primary fuels used by commercial end-users in Narayanganj such as hotels, shops, malls, educational institutes, private office buildings etc. are Liquefied petroleum gas (LPG) and Piped Natural Gas (PNG). Both PNG and LPG are combusted to meet energy requirements for cooking and water heating purposes. The LPG consumed by the commercial sector of Narayanganj stood at 215 metric tonnes in the year 2018-19, while PNG consumption stood at 4,538,068 Cu. Meter.

Figure 20 exhibits the trend of energy consumption by LPG and PNG in the commercial/institutional sector. As the figure portrays, a significant rise can be observed in both PNG and LPG consumption. This trend establishes that a number of commercial entities, especially in hospitality services, have started their operations in the vicinity in recent years.

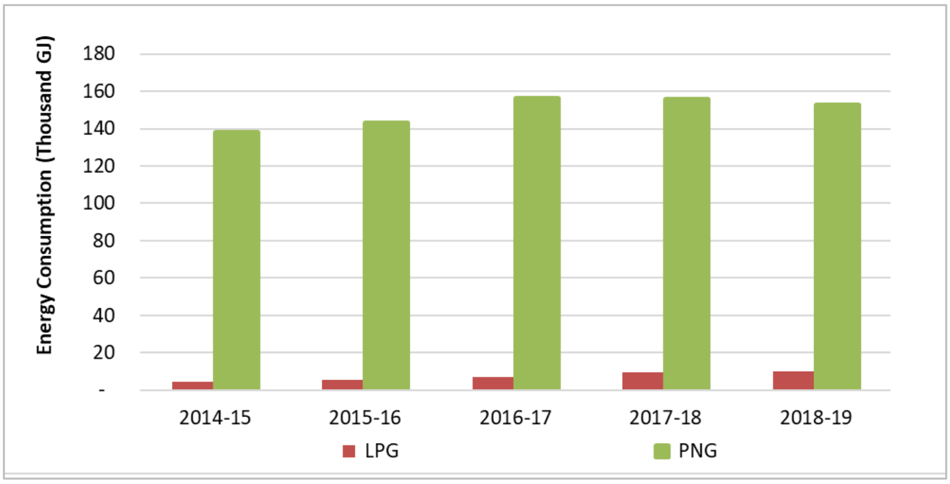


Figure 20: Trend of Energy Consumption by Fuel in Commercial/Institutional Sector

It is seen that LPG consumption increased with a compound annual growth rate (CAGR) of about 18.5% during the inventory period, while PNG consumption increased at a compound annual growth rate (CAGR) of 1.99%. This explains the radical increase in fuel use in the commercial sector of the city. This can be further understood from Figure 21, which gives the share of LPG and PNG in the energy use of commercial sector. As can be seen from the figure, PNG contributes to 94% of the total energy use, while LPG has a share of just 6%.

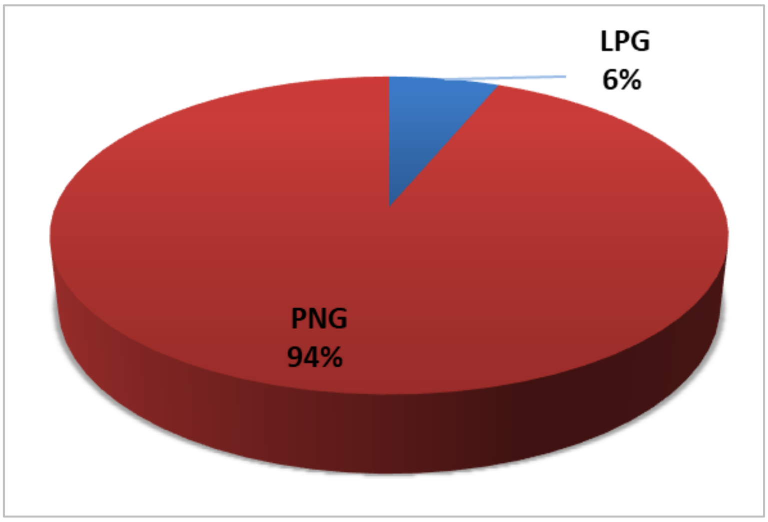


Figure 21: Share of stationary energy use by fuel in the Commercial/Institutional sector, 2017-18

Figure 22 portrays the GHG emission trend of the commercial/institutional sector in Narayanganj, in the inventory period. From the figure, it can be observed that emissions from PNG and LPG consumption in the sector follows the same trend as that in energy consumption. The LPG consumption by commercial sector contributed to 642 tCO_2e of the total GHG emission by the city in the year 2018-19, whereas the PNG consumption contributed to 8,562 tCO_2e of the total GHG emission by the city in the year 2018-19.

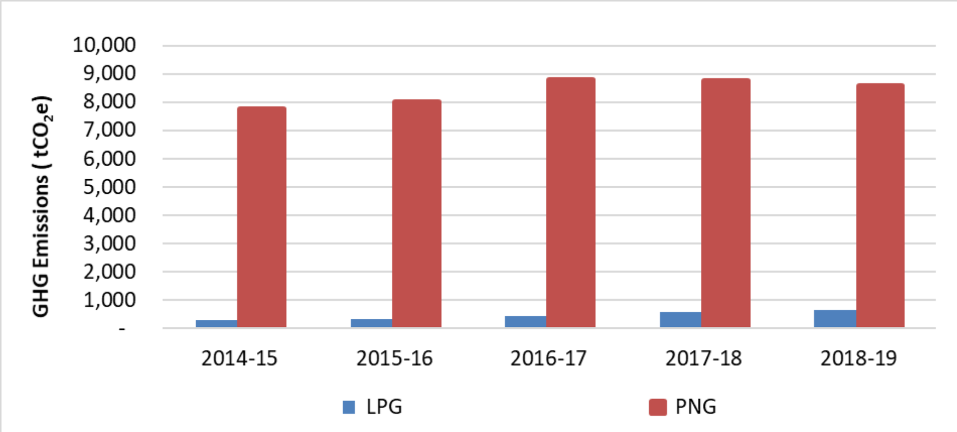


Figure 22: Trend of GHG Emissions by Commercial/Institutional sector

2.1.8.3 Manufacturing Industries and Construction Sector

PNG is the only primary fuel used to meet the stationary energy demand in the Manufacturing and construction sector of Narayanganj. In the last five years, a steep increase in the energy consumption trend can be observed for PNG in the sector. The total PNG consumption by the sector stood at 165,331,060 Cu.M in the year 2018-19, which was 142,990,000 Cu.M in 2014-15. The reason for this growth is the rapid industrialization in the city over the last few decades. Figure 23 exhibits the trend of energy consumption from direct fuel use in the manufacturing/construction sector of the city between 2014-15 and 2018-19. The total energy consumption by the manufacturing/construction sector from fuel use in 2018-19 stood at 5,555,124 GJ.

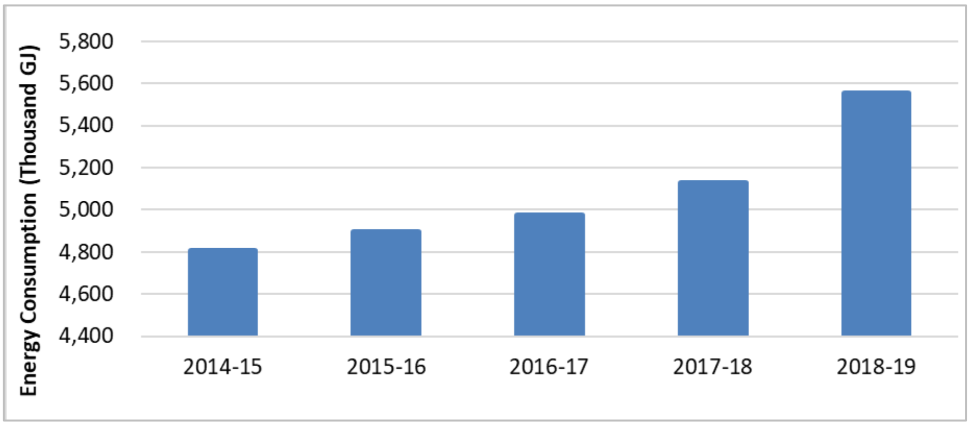


Figure 23: Trend of Fuel Consumption in Manufacturing Industries and Construction sector

In the last five years similar to the energy consumption trend, there has been a significant increase in the level of GHG emissions from fuel use in the manufacturing industries sector in Narayanganj. The GHG emissions from stationary fuel use in manufacturing industries sector increased from 269,794 tCO_2e in 2014-15 to 311,947 tCO_2e in 2018-19 (as seen in Figure 24).

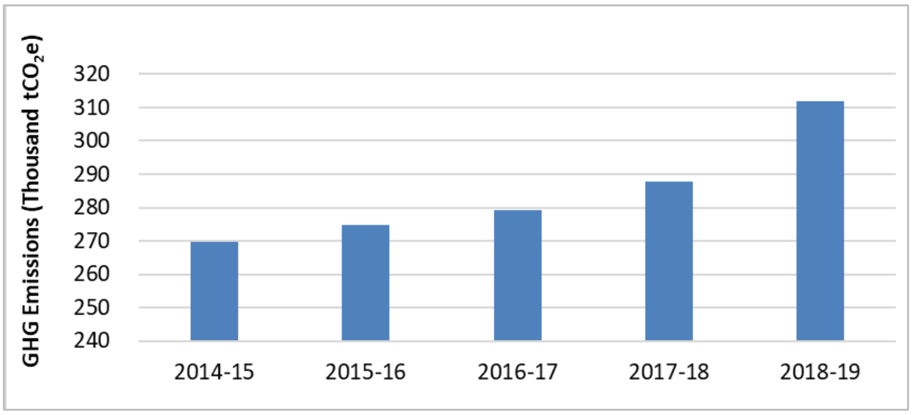


Figure 24: Trend of GHG Emission from Fuel Use in the Manufacturing Industries and Construction Sector

2.1.8.4 Road transportation

Octane, Diesel and CNG are the primary fuels used in the transportation sector of Narayanganj. CNG and diesel are fuels, commonly used by four-wheeled vehicles and heavy vehicles. While octane is used by two, three and four-wheeler motorists in the city. CNG is the major transport fuel as depicted in Figure 25. Figure 25 depicts the trend of energy consumption by the transport sector in the city. From the figure, a variation in fuel use can be observed for CNG and diesel. CNG consumption in the city declined between 2015-16 and 2016-17 and then significantly increased in the later years. A similar scenario has been observed for diesel. Diesel consumption did experience increase in the first four fiscal years of the inventory period but declined in 2018-19. A possible explanation for this trend can be the government's push for cleaner alternative fuel such as CNG for four-wheelers and heavy vehicles. On the other hand, octane consumption has experienced steady growth during the inventory period. This can be attributed to the increase in the number of two-wheeler vehicles which ply on the city's roads.

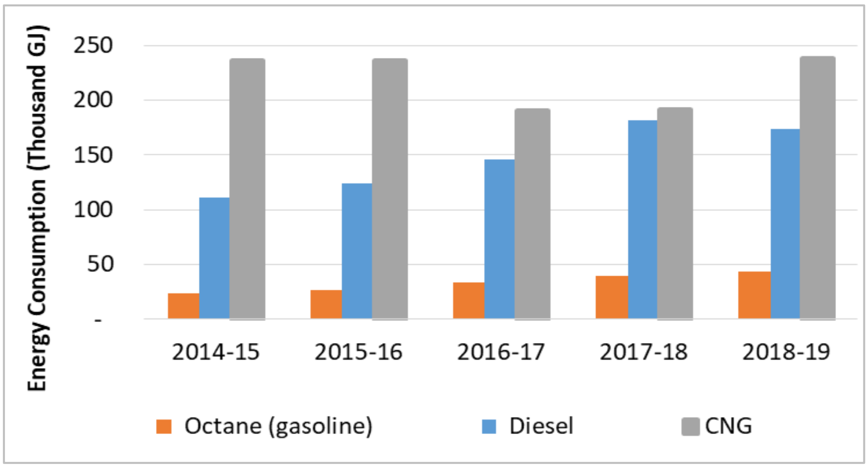


Figure 25: Trend of Fuel Consumption by Road Transportation

From Figure 25, it can be observed that only octane has experienced significant growth during the inventory period, and has increased by almost 12.88%. Diesel consumption increased by 9.33%, while CNG consumption growth has been just 0.18%.

Figure 26 exhibits the share of transportation sector fuels in energy use. As anticipated, CNG has the highest share in energy use by the transportation sector, followed by diesel and octane.

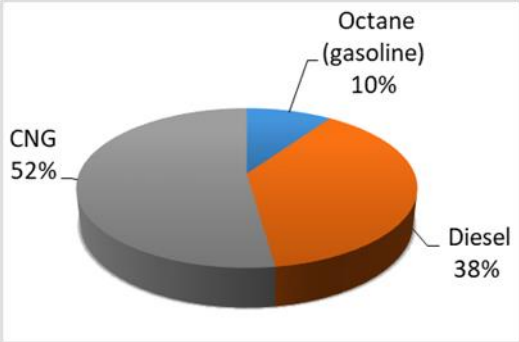


Figure 26: Share of Energy Use by Fuel in the Transportation sector, 2017-2018

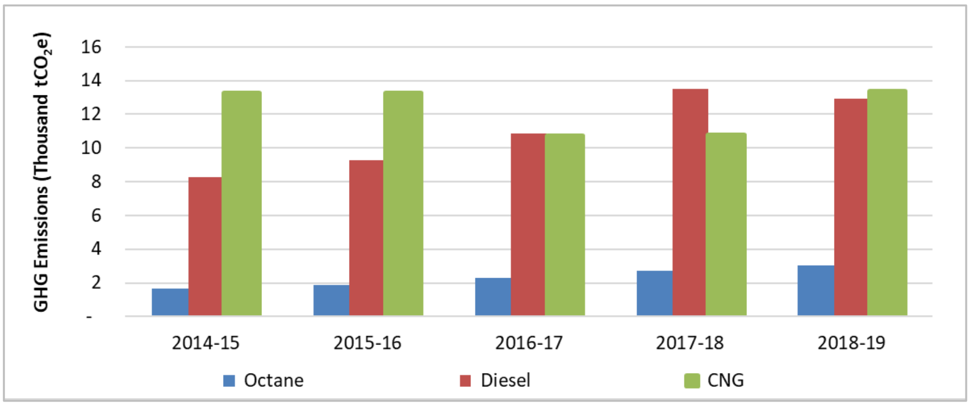


Figure 27: Trend of GHG emission by the On-road Transportation sector

Figure 27 shows the GHG emissions trend from On-road transportation sector in the city. The total GHG emissions from the sector stood at 29,357 tCO_2e in the year 2018-19. The trend is similar to that observed in energy consumption. However, being a cleaner fuel CNG's contribution to emissions has slightly decreased as compared to its contribution to energy consumption. CNG contributes to 46% of the sector's emissions while diesel contributes approximately 44% of the emissions. Octane's contribution stands at 10% (refer to Figure 28).

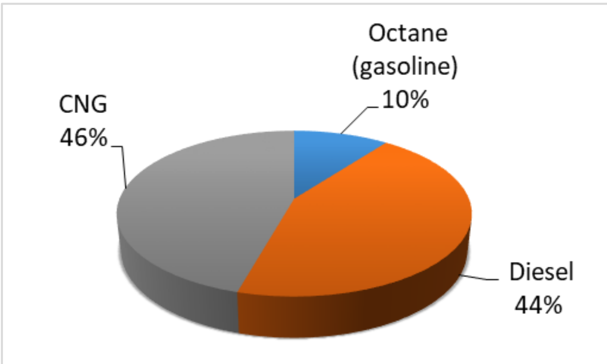


Figure 28: Share of GHG emission by fuel in the transportation sector in 2017-18

2.1.8.5 Rail transportation

Diesel locomotive trains are used to connect Narayanganj with the country's capital city of Dhaka. Passengers using rail as a mode of transport have increased year on year[4]. Emissions from passenger transport through railways amounted to 91 tCO_2e in 2018-19, rising from 76 tCO_2e in 2014-15. Although the total length of this rail network between Narayanganj and Dhaka is 17 km, only 4 km falls within the city boundary, and this track length was considered to estimate the GHG emissions.

2.1.8.6 Solid Waste treatment at the community level

Municipal solid waste (MSW) generally includes degradable matter (such as paper, textiles, food waste, and straw and yard waste), partially degradable matter (such as wood, disposable napkins, sludge) and non-degradable materials (such as leather, plastics, rubbers, metals, glass and electronic waste). GHG emissions from anaerobic decomposition of bio-degradable matter present in the municipal solid waste, from treatment facilities and methane (CH4) emissions from solid waste disposal sites are major sources of GHG emissions in the waste sector. Anaerobic decomposition of bio-degradable matter present in MSW generates GHG emission. CH4 emissions from solid waste disposal sites are the largest source of GHG emission in the Waste Sector.

In order to estimate the GHG emissions from municipal solid waste based on the IPCC guidelines, the condition of the landfill site has been identified as wet, considering the annual rainfall of Narayanganj which is more than 2000 mm, for the analysis. Given that the city's disposal site is not a scientific landfill, for the emission estimation, as per the IPCC guidelines, the type of landfill site applicable is uncategorized solid waste disposal site (SWDS).

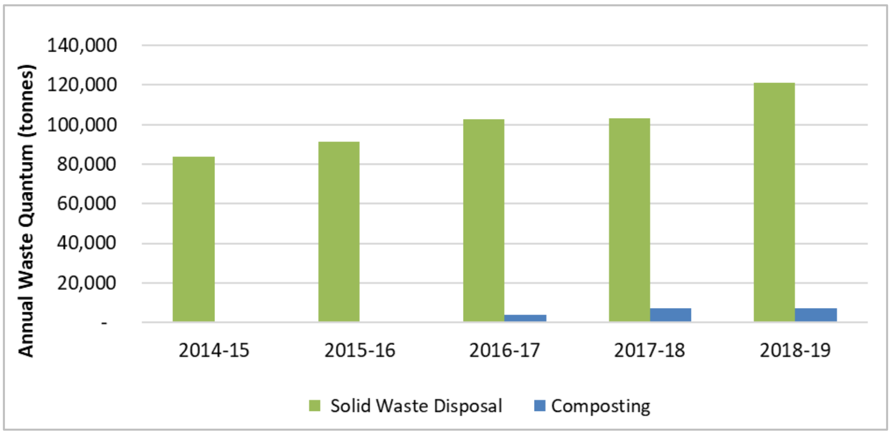


Figure 29: Annual Trend of Solid Waste Processing and Disposal in Narayanganj

The solid waste generation in the city has experienced significant growth throughout the analysis period, as depicted in Figure 29. The total waste generation in the city stood at around 400 tonnes per day in 2018-19. Coverage of waste collection by NCC stood at 87.5% of households. Narayanganj has a composting plant, operational at Panchabati since mid-2016 that processes about 20 tonnes per day of biodegradable waste. In 2018-19, this plant has composted nearly 7,300 tonnes of biodegradable waste and resulting in GHG emission of nearly 1,252 tCO_2e, which is relatively lower than emissions resulting from this organic waste quantum decomposing at the waste disposal site. The remaining waste generated is directly dumped at the disposal sites. Given the absence of significant waste processing infrastructure to divert waste going to landfill, solid waste disposal in the city leads to significant methane emissions (65,259 tCO_2e in 2018-19). Figure 30 portrays the GHG emissions trend from solid waste disposal and composting in the city.

[4] As per World Bank data on Railways, annual growth rate of passengers carried (million passenger-km) from 1995-2016 is around 4.43%. https://data.worldbank.org/indicator/IS.RRS.PASG.KM?locations=BD

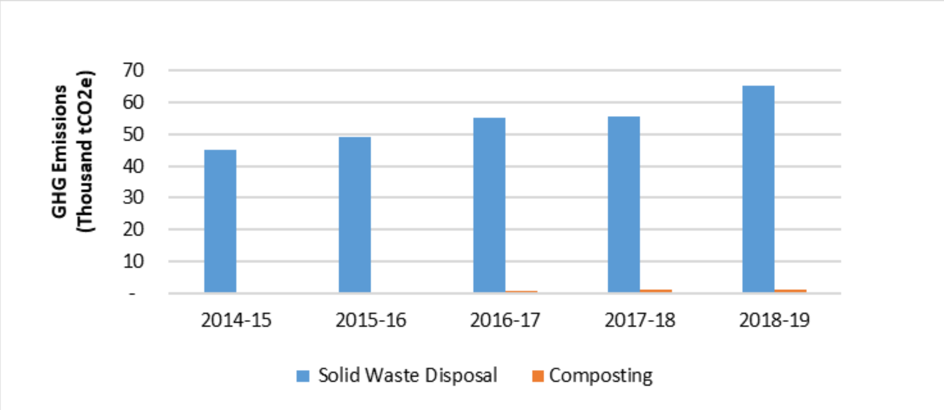


Figure 30: GHG emissions from Solid Waste Disposal at the community level

2.1.8.7 Domestic Waste Water management and associated emissions

Wastewater from domestic sources generates CH_4 emission on its treatment (on-site, sewered to a centralized treatment plant or disposed of untreated into nearby areas or via an outfall) or disposal anaerobically. The extent of CH_4 emission from wastewater depends primarily on the quantity of degradable organic material in the wastewater, the volume of wastewater generated and the type of treatment system. As per 2006 IPCC Guidelines, CH_4 emissions are impacted by the type of treatment system or wastewater discharge pathway being used (such as sewers, septic tanks, latrines, centralized treatment plants, and direct discharge to sea, lake or river) and its corresponding methane generation potential, and the proportion of the resident population that uses these different wastewater treatment/discharge pathways or systems.

Narayanganj does not have a central sewerage collection and treatment system and most of the wastewater generated is discharged into rivers and nearby nallahs. However, the city does have open drains for sewerage discharge. Around 10% of the population use pit latrines in the city, while 15% use septic tanks. The total wastewater generated in the city is estimated to be nearly 52 MLD in 2018-19, out of which only 25 % is collected and treated to some extent, the remaining 75% is discharged into the river without treatment and collection. Based on the data collected from secondary research, the Biological oxygen demand (BOD)[5] value of the city's wastewater is estimated to be about 256.8 mg/L.

CH_4 emissions associated with wastewater disposal are estimated to be 11,615 tCO_2e in 2018-19. Table 8 presents the GHG emission from different pathways for domestic wastewater treatment and disposal in Narayanganj.

Table 8: GHG Emission from different treatment/discharge pathways for Wastewater Treatment and disposal

Treatment/discharge pathway or system	GHG Emission from Domestic Wastewater (in tCO_2e)				
	2014-15	2015-16	2016-17	2017-18	2018-19
Uncollected wastewater discharged to water bodies	3,838	4,665	5,078	5,322	5,445
Septic Systems-Uncollected	3,838	4,665	5,078	5,322	5,445
Latrines - Uncollected	512	622	677	710	726
Total	**8,188**	**9,952**	**10,834**	**11,354**	**11,615**

[5] Refer Annexure.

The trend of emissions from wastewater generation has been portrayed in Figure 31. The emissions have witnessed growth annually from 2014-15 to 2018-19. Discharge of untreated waste into water bodies without any treatment and uncollected septic-systems show a similar trend and have a higher contribution to the emissions than uncollected latrines.

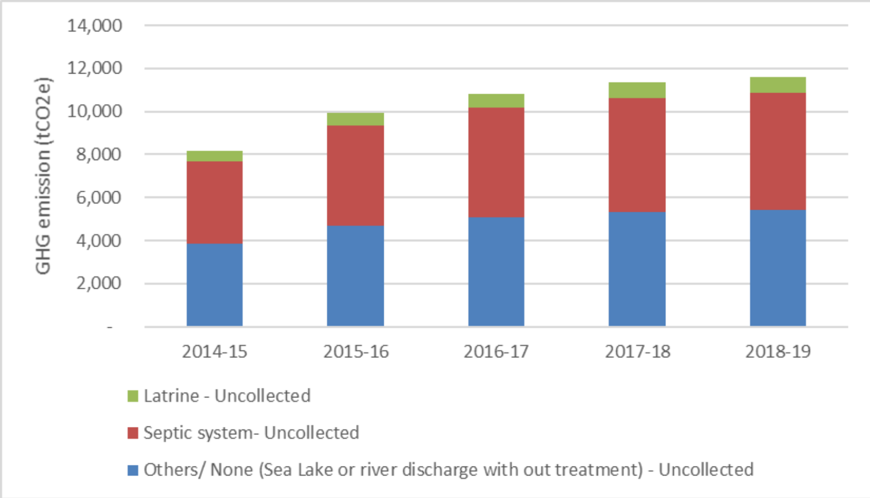


Figure 31: Trend of GHG Emission from Wastewater Treatment and disposal

In addition, N_2O emission occurs from the degradation of the nitrogen present in domestic wastewater, which mainly results from human protein consumption. The degradation of nitrogen occurs on the disposal of domestic wastewater into waterways, lakes or sea. N_2O emissions from domestic wastewater in Narayanganj are estimated to amount to 14, 151 tCO_2e in 2018-19. The N_2O emissions have increased with rise in population from 2014-15 to 2018-19.

Thereby total GHG emissions, including CH_4 and N_2O emissions, from domestic wastewater in Narayanganj city stood at 25,766 tCO_2e in 2018-19.

2.1.9 Emissions from Municipal operations and facilities

2.1.9.1 Sector wise Energy Consumption and GHG Emissions from Municipal Buildings and Facilities

NCC's energy consumption for its municipal services rendered to the city residents amounted to 13,872 GJ in 2018-19. Table 9 presents the energy consumption data of municipal buildings, services provided and transport.

Table 9: Energy Use in Municipal Operations

Sector	Energy Source/Activity	Energy Consumption (GJ)				
		2014-15	2015-16	2016-17	2017-18	2018-19
Buildings	Electricity	176	198	230	274	302
	Diesel	0.92	0.77	0.81	0.19	0.19
Facilities	Water Supply (Electricity)	2,304	2,484	2,916	3,312	3,960
	Street Lighting (Electricity)	1,852	2,362	3,013	3,272	5,418
Transport	Diesel	316	434	731	786	1,078
	Octane	1,309	2,202	2,368	2,586	3,114
Total		**5,959**	**7,681**	**9,260**	**10,230**	**13,872**

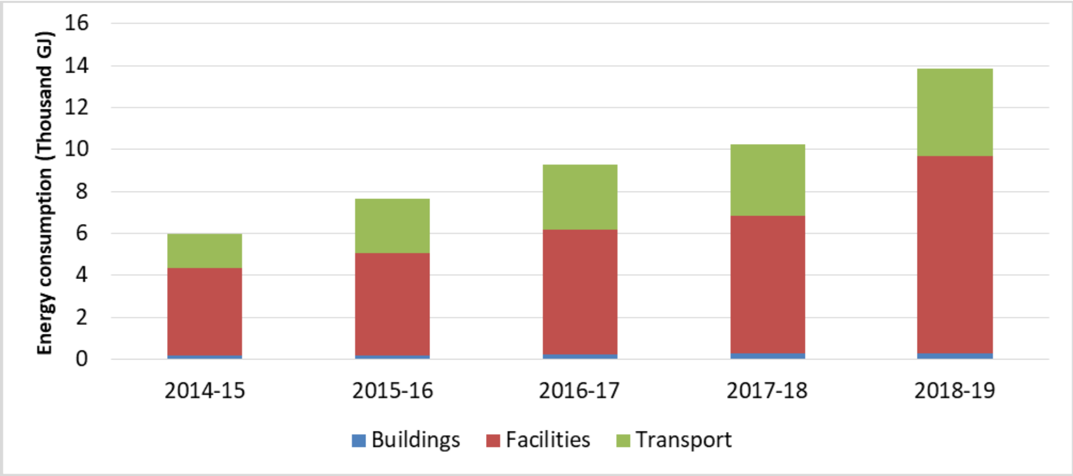
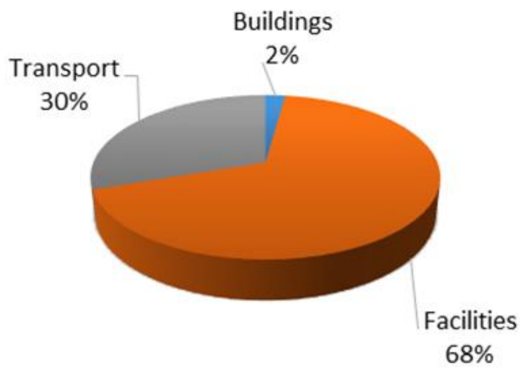


Figure 32: Trend of energy use by municipal buildings and services

From Figure 32 it can be noted that the total energy consumption of the city government has increased throughout the study period. A significant increased can be observed in energy consumption by the municipal facilities. This is because the electricity consumption for water supply has increased in recent years. Also, with the installation of new street-lighting fixtures, the energy consumption by street-lights have increased despite, LED retrofitting of the previously used HID lamps.

Energy consumption by municipal, buildings can also be observed to increase despite diesel consumption declining in the sector. This decline in consumption could be due to the NCC's shift toward adopting cleaner alternatives of power for its buildings.



Consumption in Municipal Buildings and Services, 2017-18

The major share of the energy consumed in the municipal government is from facilities, constituting water supply service and street-lighting. From Figure 33, it is evident that municipal facilities alone contribute to 68% of the municipal government's energy use. This could be due to the operation of energy-intensive water pumps to transport water against heads for supply and storage and the installation of new street-lighting fixtures in the city. Municipal facilities is followed by municipal transport which contributes about 30%, and municipal buildings which contribute the remaining 2% of the energy use.

The total GHG emissions from local government operations were estimated to be 2,049 tCO_2e in 2017-18. Table 10 gives the GHG emission contribution from each municipal service/facility in Narayanganj. Figure 34 depicts the trend of emissions from municipal services. The trends are similar to that in energy consumption and a significant increase can be observed in the emissions from all three sectors.

Table 10: GHG emission from Municipal Operations

Sector	Energy Source/Activity	GHG Emissions (tCO_2e)				
		2014-15	2015-16	2016-17	2017-18	2018-19
Buildings	Electricity	31.8	35.6	41.5	49.2	54.4
	Diesel	0.1	0.1	0.1	0.01	0.01
Facilities	Water Supply (Electricity)	414.7	447.1	524.9	596.2	712.8
	Street Lighting (Electricity)	333.4	425.2	542.4	589.0	975.2
Transport	Diesel	22.0	30.2	50.8	54.6	74.9
	Octane	97.3	163.7	176.1	192.2	231.5
Total		**899**	**1,102**	**1,336**	**1,481**	**2,049**

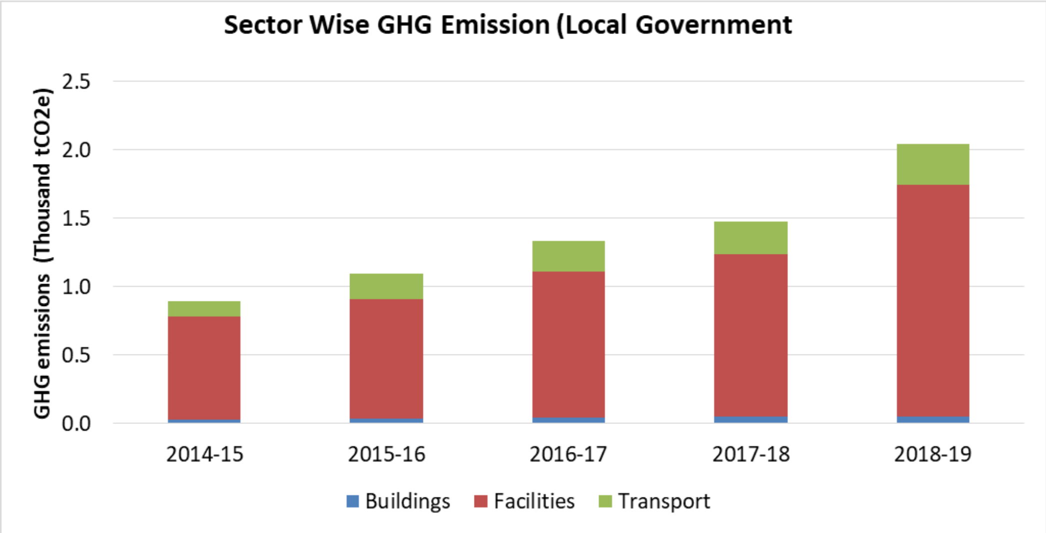


Figure 34: Trend of GHG emission from Municipal Operations

From Figure 35, it is evident that municipal facilities are the major contributor to emissions, a corollary of it being the major energy-consuming service in the city. It is followed by the transport sector which contributes around 15% of the emissions. Municipal Buildings contribute 3% of the emissions, which is quite paltry in comparison to the other two sectors.

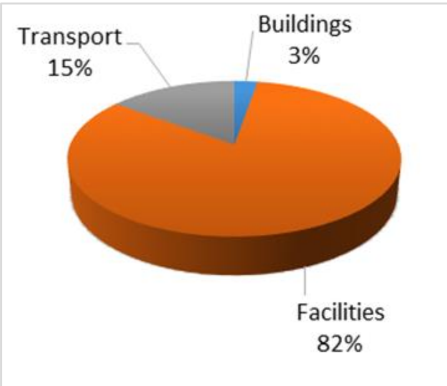


Figure 35: Share of GHG emission by Municipal Buildings, Facilities, and Transport, 2017-18

2.1.9.2 Electricity Consumption by Municipal Buildings and Facilities

NCC consumes grid electricity for providing municipal services like water supply, street lighting etc. and for its buildings lighting requirements. The annual electricity consumption by NCC was reported to be 2.69 million kWh in 2018-19. Figure 36 represents the trend of electricity consumption by the local government with respect to different services and facilities it provides to the city population.

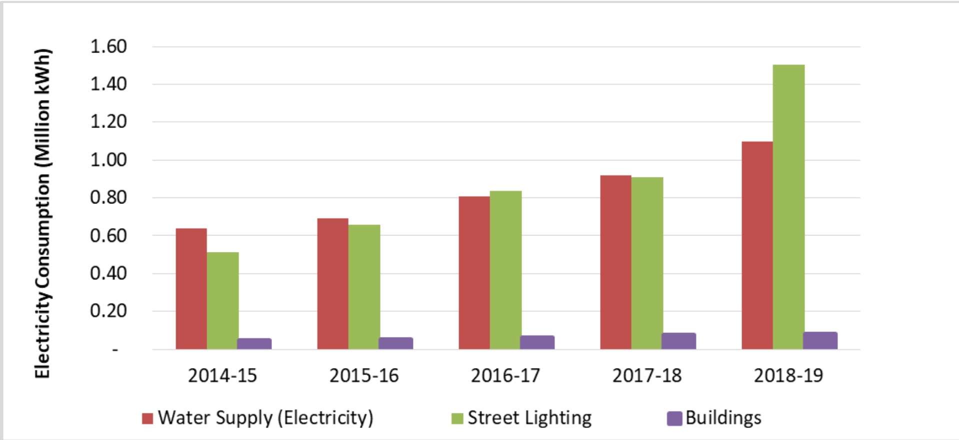


Figure 36: Trend of Electricity consumption by Municipal services

Electricity consumption by NCC after 2014-15 is increasing. The NCC launched an initiative to replace conventional street-lights with LED street-lights. However, despite this initiative, electricity use has increased, since new street lights have been installed in areas where there was no street lighting.

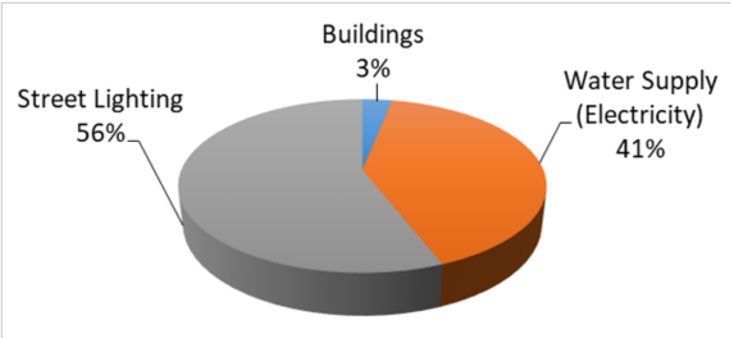


Figure 37: Share of Electricity Consumption in Municipal Buildings and Facilities, 2018-19

Figure 37 clearly shows that the electricity consumed by the Street-lighting serve is the highest with a share of 56%. It is followed by water supply services with a share of 41%. Electricity government buildings have a share of just 3%.

2.1.9.3 Fuel Consumption by Municipal Buildings and Facilities

NCC consumes fuels such as diesel and octane for its municipal vehicle fleet and for power generators used for back-up power generation in the buildings. The NCC as of 2017-18 total owns around 84 vehicles. The fleet includes vehicles such as cars and jeeps for picking-up or dropping officers from the office to their home and vice-versa, trucks for taking waste from transfer station to disposal site, mini fire tanker, boat, ambulance, various machinery etc. Diesel is the highest consumed fuel, mainly because the heavy machinery and vehicles use diesel for their operation and in DG sets in municipal buildings, while petrol is used by just cars. Figure 38 represents the trend of fuel consumption by the local government.

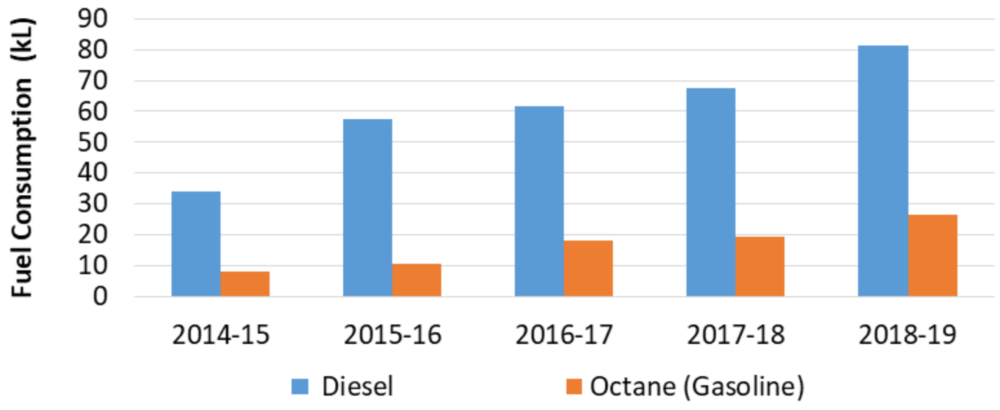


Figure 38: Trend of Fuel Consumption by Municipal Services and Vehicles

As can be seen from the figure, the trend of fuel consumption has increased over the study period. The reason for this trend is the expansion of vehicles fleet by NCC, especially heavy machinery and trucks.

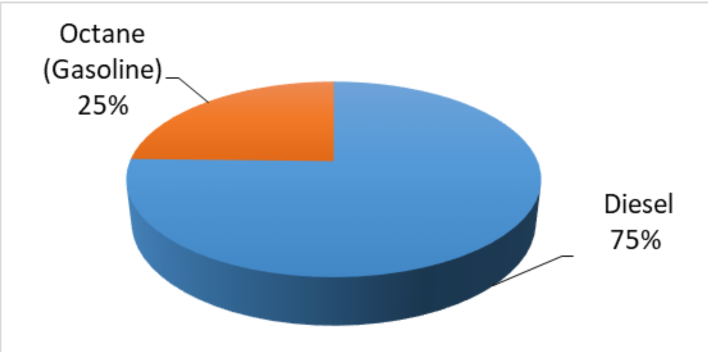


Figure 39: Fuel Wise Share of Consumption in Municipal Vehicles, 2018-19

Figure 39 exhibits the share of fuels in the total fuel consumption by municipal vehicles. As anticipated diesel alone has a share of 75% of the total fuel use. Petrol, on the other hand, has a share of just 25%.

2.1.10 Key Sustainability indicators for Narayanganj City

The key sustainability indicators for Narayanganj have been provided in Table 11 below. These indicators can enable comparison of Narayanganj City with the other cities of Bangladesh as well as the cities around the globe. However, such comparison should be done with due caution since results may vary across cities, even amongst those located in the same country, on account of the different local context (in terms of socio-economic conditions and drivers), data availability and data management practices followed in the cities, and the overall methodology adopted for developing GHG inventory.

Table 11: Key Sustainability Indicators for Narayanganj

Sustainability Indicator	Unit of Measure	Narayanganj (2018 -19)
Per Capita Energy Consumption	GJ/capita	10.81
Per Capita GHG Emission	tCO_2e/capita	1.19
Per Household Energy Consumption	GJ/HH	46.25
Per Household GHG Emission	tCO_2e/HH	5.09
Per sq. km of Area Energy Consumption	GJ/sq. km	133,077.84

Sustainability Indicator	Unit of Measure	Narayanganj (2018 -19)
Per sq. km of Area GHG Emission	tCO_2e/sq. km	14,654.27
Per Capita Electricity Consumption	kWh/capita	1,066
Per Household Electricity Consumption	kWh/HH	4,562

3 GHG emissions inventory summary reporting output

City Information		Data Source
Official name of local government	Narayanganj City Corporation	N/A
Country	Bangladesh	N/A
Region	South Asia	N/A
Inventory year (specify months covered)	2018-19	N/A
Description of boundary and map	City boundary representing jurisdiction of Narayanganj City Corporation	
Resident population	709,336	Population Statistics from Bangladesh Bereau of Statistics 2011

Inventory Setup	
GWP (IPCC AR version used)	IPCC 2006
Types of emissions factors (IPCC or LCA)	IPCC

Emission Sources and Emissions

Sector	Sub-Sector	*Direct (fuel combustion) or Indirect (grid energy) or Other (in separate rows)*	Total tCO_2e or Notation Key	ETS or non-ETS (in separate rows)	Type of Energy	Activity data			Emissions (CO_2 Gas)			Emissions (CH4 Gas)			Emissions (N20 Gas)			Notation keys (if no data to report)	
						Amount	Unit	Data source	Amount	Unit	Method	Amount	Unit	Method	Amount	Unit	Method	Notation key	Explanation
Stationary Energy	Residential	Indirect	240,310.80	-	Electricity	370.85	Million kWh	Electricity provider	240,310.80	tonnes of CO_2e	Location-based using consumption and national grid emission factor	0.00	tonnes of CO_2e	Location-based using consumption and national grid emission factor	0.00	tonnes of CO_2e	Location-based using consumption and national grid emission factor		
		Direct	971.07	-	LPG	325.00	tonnes	Fuel/Oil supply companies	970.23	tonnes of CO_2e	Fuel consumption	0.38	tonnes of CO_2e	Fuel consumption	0.458	tonnes of CO_2e	Fuel consumption		
		Direct	1,565.29	-	PNG	829,600	cubic metre	Natural Gas Supply Companies	1,563.76	tonnes of CO_2e	Fuel consumption	0.70	tonnes of CO_2e	Fuel consumption	0.831	tonnes of CO_2e	Fuel consumption		
	Commercial	Indirect	76,956.48	-	Electricity	118.76	Million kWh	Electricity provider	76,956.48	tonnes of CO_2e	Location-based using consumption and national grid emission factor	0.00	tonnes of CO_2e	Location-based using consumption and national grid emission factor	0.00	tonnes of CO_2e	Location-based using consumption and national grid emission factor		
		Direct	642.40	-	LPG	215.00	tonnes	Fuel/Oil supply companies	641.84	tonnes of CO_2e	Fuel consumption	0.254	tonnes of CO_2e	Fuel consumption	0.303	tonnes of CO_2e	Fuel consumption		
		Direct	8,562.43	-	PNG	4,538,068.00	cubic metre	Natural Gas Supply Companies	8,554.08	tonnes of CO_2e	Fuel consumption	3.812	tonnes of CO_2e	Fuel consumption	4.54	tonnes of CO_2e	Fuel consumption		
	Institutional	IE																IE	Included under Commercial sector as no disaggregated data for this sub-sector
		IE																IE	Included under Commercial sector as no disaggregated data for this sub-sector
		IE																IE	Included under Commercial sector as no disaggregated data for this sub-sector
	Industry	Indirect	298,728.00	-	Electricity	461.00	Million kWh	Electricity provider	298,728.00	tonnes of CO_2e	Location-based using consumption and national grid emission factor	0.00	tonnes of CO_2e	Location-based using consumption and national grid emission factor	0.00	tonnes of CO_2e	Location-based using consumption and national grid emission factor		
		Direct	311,946.86	-	PNG	165,331,060	cubic metre	Natural Gas Supply Companies	311,642.43	tonnes of CO_2e	Fuel consumption	138.88	tonnes of CO_2e	Fuel consumption	165.54	tonnes of CO_2e	Fuel consumption		
	Agriculture	Indirect	NO															NO	No agriculture activity is occuring within the city boundary
		Direct	NO															NO	No agriculture activity is occuring within the city boundary
	Fugitive	Direct	NO															NO	Activities such as coal and oil extraction & processing leading to fugitive emissions are not occuring within the city limits

Emission Sources and Emissions																			
Sector	**Sub-Sector**	***Direct (fuel combustion) or Indirect (grid energy) or Other (in separate rows)***	**Total tCO_2e or Notation Key**	**ETS or non-ETS (in separate rows)**	**Type of Energy**	**Activity data**			**Emissions (CO_2 Gas)**			**Emissions (CH4 Gas)**			**Emissions (N20 Gas)**			**Notation keys (if no data to report)**	
						Amount	**Unit**	**Data source**	**Amount**	**Unit**	**Method**	**Amount**	**Unit**	**Method**	**Amount**	**Unit**	**Method**	**Notation key**	**Explanation**
Transportation	On-road	Indirect	NO	-														NO	No electric transport within the city, hence no significant indirect emissions.
		Direct	3,051.60	-	Octane	1,079.40	kiloliters	Fuel/Oil supply companies	3,041.556	tonnes of CO_2e	Fuel Sales method	2.19	tonnes of CO_2e	Fuel Sales method	7.85	tonnes of CO_2e	Fuel Sales method		
		Direct	12,918.58	-	Diesel	4,530.50	kiloliters	Fuel/Oil supply companies	12,874.48	tonnes of CO_2e	Fuel Sales method	13.03	tonnes of CO_2e	Fuel Sales method	31.07	tonnes of CO_2e	Fuel Sales method		
		Direct	13,387.08	-	CNG	6,386,118.00	cubic metre	Fuel/Oil supply companies	13,350.25	tonnes of CO_2e	Fuel Sales method	29.75	tonnes of CO_2e	Fuel Sales method	7.09	tonnes of CO_2e	Fuel Sales method		
	Rail	Indirect																NO	Rail transport in the city is not using electricity as diesle locomotives are used as prime movers
		Direct	91.28	-	Fuel (Diesel)	13,614,208	pass-km	Railway Department	91.28	tonnes of CO_2e	Passenger-km basis	0	tonnes of CO_2e	Passenger-km basis	0	tonnes of CO_2e	Passenger-km basis		
	Waterborne	Indirect	NO	-														NO	Electricity consumption in water transportation is not occurring as they use conventional combustion engines
		Direct	IE															IE	The watercraft and on-road vehicles in Narayanganj have the same refueling sources. Due to unavailability of reliable disaggregated fuel consumption data for water transport vehicles, given the existing recording practices, direct emissions from watreborne navigation are included in on-road transport
	Aviation	Indirect	NO	-														NO	Airport is outside the city limit
		Direct	NO															NO	Airport is outside the city limit
	Off-road	Indirect	NO															NO	Electricity consumption for off-road transport is not occurring as these are using conventional combustion engines
		Direct	IE															IE	Emissions are included in On-road transport, due to unavailability of reliable disaggregated fuel consumption data for off-road vehicles.
Waste	Solid waste disposal	Direct	65,259.04	N/A	N/A	121,363	tonnes	Solid waste department, Narayanganj City Corporation	0	tonnes of CO_2e	Methane Commitment method	65,259.04	tonnes of CO_2e	Methane Commitment method	0	tonnes of CO_2e	Methane Commitment method		
	Biological treatment	Direct	1,252.10	N/A	N/A	7,300	tonnes	Solid waste department, Narayanganj City Corporation	0	tonnes of CO_2e	Mass of waste composted, IPCC 2006	730.00	tonnes of CO_2e	Mass of waste composted, IPCC 2006	522.10	tonnes of CO_2e	Mass of waste composted, IPCC 2006		
	Incineration and open burning	Direct		N/A	N/A													NO	Negligible incineration and open burning within city the boundary
	Wastewater	Direct	25,765.63	N/A	N/A	6,913.67	tonnes of organics	Sewerage department, Narayanganj City Corporation	0	tonnes of CO_2e	Organic content based and population-based approach	11,614.97	tonnes of CO_2e	Organic content based and population-based approach	14,150.66	tonnes of CO_2e	Organic content based and population-based approach		
IPPU	Industrial process	Direct	NE	N/A	N/A													NE	Not estimated due to absence of data
	Product use	Direct	NE	N/A	N/A													NE	Not estimated due to absence of data
AFOLU	Livestock	Direct	NE	N/A	N/A													NE	Not estimated due to absence of data
	Land use	Direct	NE	N/A	N/A													NE	Not estimated due to absence of data
	Other AFOLU	Direct	NE	N/A	N/A													NE	Not estimated due to absence of data

Energy Generation																		
Sector	Inside or outside city boundary (in separate rows)	Total tCO2e	ETS or non-ETS (in separate rows)	Type of Energy	Activity data			Emissions (CO2 Gas)			Emissions (CH4 Gas)			Emissions (N20 Gas)			Notation keys (if no data to report)	
					Amount	Unit	Data source	Amount	Unit	Data source	Amount	Unit	Data source	Amount	Unit	Data source	Notation key	Explanation
Electricity-only generation	Inside city boundary	NE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NE	Reliable information on activity data not available
	Outside city boundary	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NO	No power generating facilities within the city boundary
CHP generation	Inside city boundary	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NO	No grid supplied CHP within city limits
	Outside city boundary	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NO	No grid supplied CHP within city limits
Heat/cold generation	Inside city boundary	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NO	No heating or cooling networks exists
	Outside city boundary	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NO	No heating or cooling networks exists
Local renewable energy generation	N/A	NE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	NE	Reliable information on activity data not available

Emission Credits																	
Category	Sold or purchased	Total tC2Oe or Notation Key	Allocation to sector	Sub- category	Date of sale/ purchase	Activity data			Emissions (CO2 Gas)			Emissions (CH4 Gas)			Emissions (N20 Gas)		
						Amount	Unit	Data source	Amount	Unit	Data source	Amount	Unit	Data source	Amount	Unit	Data source
Offset credits generated in the city	*Sold*	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Credits purchased from outside	*Purchased*	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Purchase of certified green electricity	*Purchased*	NO	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Annexure

- **Population Projection:**
  Narayanganj City Corporation (NCC) was established in 2011. Thus, only the 2011 - census data for the population is available. For sampling the population of previous decades, the growth rate of Dhaka has been used.

- **Electricity consumption –**
  Bangladesh's Grid emission factor i.e. 0.648 (tCO2/MWh), has been used for calculation emissions from electricity consumption.
  Source: https://www.adb.org/sites/default/files/institutional-document/296466/guidelines-estimating-ghg.pdf

- **Waste Sector –**
  For GHG emission calculation using Methane Commitment method as per GPC, following conditions and assumptions are considered:
  - Landfill type - Unmanaged shallow solid waste disposal site with depths of less than 5 meters and corresponding MCF value of 0.4 is used for emission calculations
  - Landfill condition - Wet (as average rainfall is 2004 mm per year. Source: Climate-Data.ORG, Available at https://en.climate-data.org/asia/bangladesh/dhaka-division/narayanganj-33722/).
  - Physical composition of waste – As discrepancies were observed in the information received on the physical composition of solid waste, hence secondary literature has been used. . All the fractions based on average composition for Narayanganj was used from: Bangladesh, Country Chapter, State of the 3Rs in Asia and the Pacific (ATM Nurul Amin, United Nations Centre for Regional Development, 2017; Weblink: https://www.iges.or.jp/en/pub/bangladesh-country-chapter-state-3rs-asia-and/en)

- **Waste Water Treatment –**
  As per the available information, there is no treatment facility in Narayanganj. Wastewater generated in the city is directly discharged in the river. The official figures on wastewater characteristics are not available in the public domain, therefore results from secondary literature has been used.
  - Three different studies have been considered for calculating the BOD level of wastewater in Narayanganj.

  # The first study
  https://www.researchgate.net/publication/315415694_Water_Quality_and_Resident_Perceptions_of_Declining_Ecosystem_Services_at_Shitalakkah_Wetland_in_Narayangonj_City delineate the water characteristics of Shitalakkah Wetland area. of the city. As per this study, the average BOD value of Shitalakkah Wetland area is 52.8 mg/L.

  # The second study
  https://www.researchgate.net/profile/Sazal_Kumar/publication/329808955_Characterization_of_wastewater_from_Jhenaidah_municipality_area_Bangladesh_A_combined_physico-chemical_and_statistical_approach/links/5c1b9ce6299bf12be38d1990/Characterization-of-wastewater-from-Jhenaidah-municipality-area-Bangladesh-A-combined-physico-chemical-and-statistical-approach.pdf delineate the comparisons between

Physico-chemical characteristics of different cities of Bangladesh. However, the figures presented Narayanganj in this study pertains to the city's industrial effluents, as the samples collected were from the city's industrial area. This research gives an average BOD value of 573.89 mg/L.

The third study
{Quality of water and sediment of different cottage industries water bodies: A case study. Yasmin, F., Khanom, S., & Ferdous, M. S. (2017); Weblink: https://www.banglajol.info/index.php/BJSR/article/view/32330} presents the effects of industrial effluents on the surface water and sediment around BSCIC industrial area, Narayanganj. According to this research, the BOD value in the BSCIC industrial area is around 143.71 mg/L.

As the city does not have any STP or CETPs, thus it is assumed that a mixture of industrial and domestic wastewater is discharged into the water bodies. Hence, the average of all the three BOD values i.e. 256.8 mg/L has been considered for the wastewater emission calculations.

For GHG emission estimation, the proportion of households/population using different discharge systems/pathways are used as below. Information used from secondary literature as official statistics are not available for Narayanganj city.
Septic Tanks (with soak pits): 15%
Pit latrines: 10%
Discharge to water body with treatment: 75%
Source: As per WaterAid Bangladesh (2018): SLD Lite Report - Narayanganj, Table 1 and page 3. Available at https://www.susana.org/_resources/documents/default/3-3562-7-1552914540.pdf

- **Data for CNG and PNG**

The data for CNG and PNG has been collected from the Titas Gas Transmission and Distribution Company. As Titas operated beyond the NCC boundary, hence NCC specific data for PNG and CNG was not available in the public domain.

Hence, the data used in the analysis is actually the scaled-down number of the total CNG and PNG sale figure (around 70-80 per cent) in the Narayanganj city. The numbers were scaled down by Titas based on their internal discussions.

- **Street-Lighting**:

Electricity consumption data for the period 2014-15 and 2015-16 has been back-calculated using the CAGR between 2016-17 and 2017-18.

- **Additional Comments**

    - **Emission Factors for Octane fuel:** Default values of Net Calorific values, carbon emission factor and oxidation factor from IPCC have been used to arrive at the final figure, which is at par with Diesel values in India.
    - **Energy Densities:** the values of energy densities for Natural Gas, Octane and FO were compiled from the third NATCOM of Bangladesh. The values have been appropriately adjusted w.r.t measuring units based on their respective specific gravity.