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Climate Resilient City Action Plan - Rajkot

31 July 2018

CapaCITIES

LOW CARBON • CLIMATE RESILIENT • CITY DEVELOPMENT

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1 Rajkot City Commitment to Climate Action

1.1 Brief Introduction

Fast-growing energy demand, increase in infrastructure demand due to rapid urbanization, scarce resources and dependence on imported energy are just some of the challenges and opportunities that call for decisive action and innovation in Rajkot. Rajkot is at the forefront among Indian cities preparing for a sustainable, low carbon and climate resilient future.

The Rajkot Municipal Corporation (RMC) has undertaken a number of initiatives towards implementing renewable energy, energy efficiency, sustainable transport and solid waste management initiatives, aiming to achieve low emissions development and city climate resilience over the past few years.

The Low Emission Development Strategies Action Plan for Rajkot City has been prepared under Urban LEDS project. The cumulative potential GHG emission reduction from the actions proposed across the various sectors for the Community and for Municipal operations stands at 4,51,825 tonnes of CO2e, aggregating to about 25% of Rajkot City's baseline annual GHG emissions in the year 2012-13. The proposed actions would reduce the city's GHG emission by 14.06% as compared to annual GHG emissions under the business as usual scenario in the year 2019-20.

Rajkot city council has approved Low Emission Development Strategies Action Plan and committed to reduce 25% GHG emission in year 2019-20 as compare to baseline year 2012-13. Administrative order has been passed by Municipal Commissioner for implementation of this plan by respective department of Rajkot Municipal Corporation. Rajkot city has already implemented actions/interventions proposed under Low Emission Development Strategies Action Plan through Municipal Budget and various State/National schemes.

Figure 1 Past and On-going Initiatives on Climate Change in Rajkot

Development of Solar City

- Rajkot was recognized by the Ministry of New and Renewable Energy, Government of India as a Solar City in the year 2008
- RMC has set a target of reducing the total energy demand, from 2008 values, by 10%, by the year 2013

Low Carbon Mobility Plan (LCMP)

- LCMP of Rajkot city has been prepared for the horizon year 2031 and within the horizon of 20 years
- LCMP focuses more on the reduction of Green House Gas (GHG) emissions without compromising the accessibility and mobility needs of people. Low Carbon Comprehensive Mobility Plans (LCMP) adds the additional indicators of inclusiveness and measures that would lead to lower carbon emissions from transport to the existing methodology of CMP to make urban transport inclusive and low carbon.

Smart Cities Mission

- Rajkot has been selected as one of the Smart Cities by the Ministry of Urban Development, Government of India's flagship Smart City mission in August 2015.

Swachh Bharat Mission

- Launched in December, 2014. The programme includes elimination of open defecation, conversion of unsanitary toilets to pour flush toilets, eradication of manual scavenging, municipal solid waste management and bringing about a behavioural change in people regarding healthy sanitation practices.

Urban Low Emission Development Strategies (Urban-LEDS)

- Rajkot was one of 2 model cities of Indian under the Promoting Low Emission Urban Development Strategies in Emerging Economy Countries (Urban-LEDS) project funded by the European Commission, and implemented by UN-Habitat and ICLEI, with an objective of enhancing the transition to low emission urban development by integrating low-carbon strategies across all urban sectors.
- GHG emission inventory for year 2012-13 and low emission development strategies action plan for year 2019-20 have been prepared under this project. ULEDS action plan of Rajkot city has been prepared for the horizon year 2019-20 and within the horizon of 5 years. City council has approved Low Emission Development Strategies Action Plan and committed to reduce 25% GHG emission in year 2019-20 as compare to baseline year 2012-13

CapaCITIES

- Rajkot is one of 4 model cities which will be participating in the CapaCITIES project, supported by the Swiss Agency for Development & Coordination, which seeks to technically support fast track implementation of mitigation actions and also develop climate resilience strategies for Rajkot, with a specific focus on water resilience. This project will build upon the progress achived by Rajkot under their previous programmes.

District Energy Systems (DES**)**

- "Renewable Energy and Energy Efficiency in Buildings and Cities: Assessing Potential for District Energy Systems in Indian Cities" project is undertaken by the United Nations Environment Programme's (UNEP) District Energy in Cities programme under the "Sustainable Energy 4 All" initiative.
- Rajkot is one of five selected project cities (Rajkot, Thane, Pune, Coimbatore and Bhopal) from India. The DES project aims to provide technical assistance and build capacities of local governments and stakeholders in India to develop replicable modern district energy systems, particularly focusing on district cooling, which can be further scaled up across the country.

The Urban Nexus

- The Regional GIZ Project "The Integrated Resource Management in Asian Cities: the urban Nexus" financed by the German Federal Ministry of Economic Cooperation & Development (BMZ) promotes the practical implementation of planning and management approaches for an integrated urban resource management for the sectors of energy, water and food security in selected Asian cities.
- Rajkot in India is one of the twelve selected cities. With the Nexus approach of cross sectorial planning, management and implementation of infrastructure projects in the context of a circular economy projection, a contribution is made to a more future-orientated and sustainable urban development.

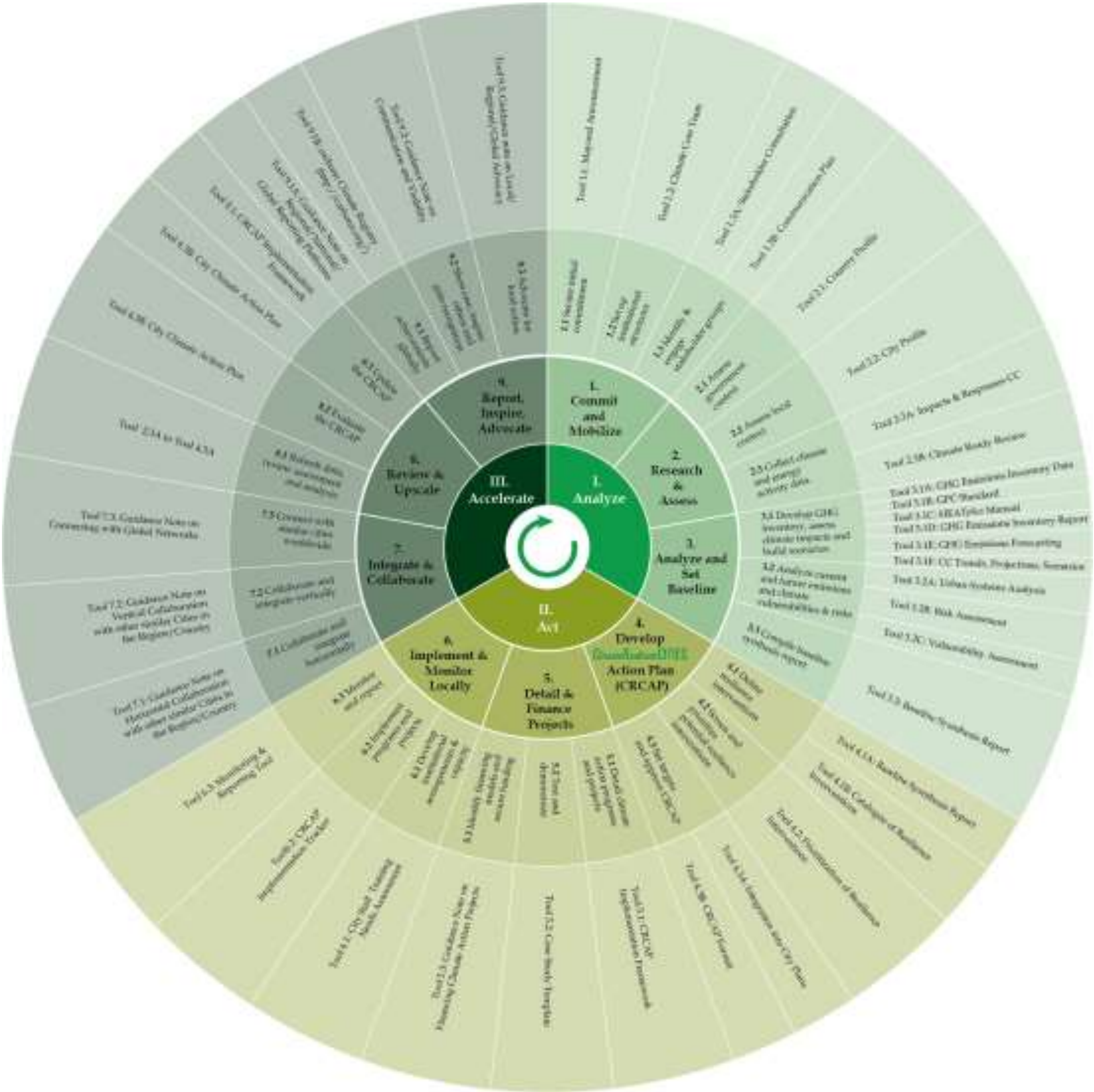
Building Efficiency Accelerator (BEA)

- Sustainable Energy for ALL (SE4ALL) Building Efficiency Accelerator (BEA) project, launched by UNEP to assist the sub-national governments in speeding up the process of adoption of best-practice policies and implementation of building efficiency projects. Rajkot has been selected as one of the six cities in the world for deeper engagement and receiving technical assistance in identifying building energy efficiency actions, developing work plans and implementing policies, projects and tracking methods to fulfil its BEA.

1.2 Methodology followed to prepare the Climate Resilience City Action Plan

The ClimateResilientCities methodology was followed to develop to the Climate Resilient City Action Plan for Rajkot. **The ClimateResilientCities Action Plan Process** is a 9-step process in 3 phases: ***Analyze Act and Accelerate -*** each unfolding into three steps - outlining how **climate fragility** can be assessed and **climate resilient options (to achieve low emissions development and climate adaptive development)** can be identified and integrated into urban development policies, plans and processes. It consists of a wide **range of tools and guidance notes** to support Local Governments to deliver effective Local Climate Action.

Figure 2 ClimateResilientCITIES Methodology



Rajkot City has adapted this methodology for preparing its Climate Resilient City Action Plan. The Climate Resilient City Action Plan is the result of implementing steps 1 to 4 in Rajkot City. The tools provided in the tool-kit have been adapted to suite the purposes of the City.

Step: 1 – Commit and mobilize

1.1 Secure initial commitment – It is very important to ensure senior political and local government buy-in to kick-start the process for climate resilient development in the community and provide clear leadership. As political, executive and administrative support are required for successful planning and implementation of climate action plans, A Mayoral Announcement has been made by using Tool 1.1 (Mayoral Announcement – See Section 1.1), which clearly states the intent of the Rajkot Municipal Corporation to address climate change through mitigation and adaptation measures.

1.2 Set up institutional structures - A Climate Core Team has been setup by Rajkot Municipal Corporation on 25th October, 2016 by using Tool 1.2 (Climate Core Team – See Annexure 1), which comprises of 41 nominated officers and officials from various relevant departments of Rajkot

Municipal Corporation including Mayor and Standing committee chairman, chaired by Municipal Commissioner (See Annexure 1). Climate Core Committee was involved in all steps of preparation of Climate Action Plan and support internal institutional capacity building to effectively fulfil the long-term climate resilience plan requirements by effective integration of planned initiatives into the city's developmental plans.

1.3 Identify and engage stakeholder groups - The Climate Action Planning Process should be supported by consultations with other groups in the city such as government agencies, local NGOs, community leaders, university partners and private sector organizations, to appropriately share responsibilities and ensure ownership. City level stakeholder committee was formed and notified by Rajkot Municipal Corporation by using Tool 1.3A (Stakeholder Committee – See Annexure 1) on 25th October, 2016 comprising of 43 members chaired by Municipal Commissioner for multi-way process of dialogue and deliberation within the Climate Core Team and with other stakeholders, as well as amongst stakeholders themselves.

A Communication Plan was prepared to communicate within the core team, with other departments of the Rajkot Municipal Corporation and with the external stakeholder committee and the community at large.

2 Research and Assess

2.2 Assess local context - It is very important to assess local policies, on-going projects, economic, social and environmental contexts at the local level, which would impact climate resilient development in the City. Local issues with respect to the environment and urban development (socio-economic status, demography, municipal services, energy consumption (electricity and fuel) within the city limit) are also identified and discussed with core team. A baseline assessment of the urban systems was conducted for assessment of climate change impacts and influences urban development activities, and to identify the kind of support required by the Rajkot Municipal Corporation to address such impacts. Based on information collected, city profile has been developed for an assessment of climate vulnerable urban systems and carbon intensive activities by using Tool 2.2 City Profile (See Chapter - 2).

3. Analyze and set baseline

3.3. Develop GHG inventory, assess climate impacts and build scenarios –

- Base data has been collected by using (Tool 3.1A Energy and GHG Emission Inventory – Data Format) for stationary fuel and electricity consumption by all community and government sectors. This necessitates relevant data collection from Rajkot Municipal Corporation and external agencies which have the required information (utilities), as well as determining data gaps. Rajkot Municipal Corporation 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 was therefore collected and analyzed.
- A GHG emissions inventory report is developed to determine sources of GHG emissions in Rajkot Municipal Corporation operations and the whole community using the HEAT+ GHG inventory online software tool and protocols by using (Tool 3.1B: Global Protocol for Community Scale GHG Emission Inventories, Tool 3.1C: HEAT+ Manual) (See Section– 3.1).

- The Community inventory includes emissions from community/city-wide activities within the Rajkot Municipal Corporation jurisdiction, including emissions from Rajkot Municipal Corporation activities and use. This includes emissions from sources and/or activities from stationary units (residential, commercial/institutional facilities, industrial and constructions, agricultural), mobile transportation units, waste. This is a useful planning tool in developing mitigation actions for the entire community.
- The Local Government operations inventory includes emissions from all of the operations that a Rajkot Municipal Corporation owns or controls. Sectors included in a local government operations inventory include Rajkot Municipal Corporation buildings, facilities such as street lighting and traffic lighting, water, waste and sewage facilities, municipal vehicle fleet.
- GHG emission inventory report was developed by using Tool 3.1D GHG Emissions Inventory Report,
- Energy consumption has been done for medium term (till 2025) and long term (for 2050) planning. Energy consumption from municipal services been forecasted based on population projections and municipal service delivery based on existing and future city planning. Based on a forecasting of the energy consumption, the corresponding GHG emissions are calculated using the HEAT+ software by using Tool 3.1E - GHG emissions forecasting.

3.2 Identify fragile urban systems, climate vulnerabilities and risks

- Core and secondary urban systems are examined to identify fragile urban systems and to examine the impact of climate change on these fragile urban systems by using *Tool 3.2A: Urban Systems Analysis (See section 3.2).* For each fragile urban system, key vulnerable areas (geographical areas) and the vulnerable population for each system are assessed and identified. Both the qualitative information gathered from stakeholder group through SLD and quantitative information from the city was assessed to assess vulnerability by using Tool 3.2C: Vulnerability Assessment (See section 3.4). The adaptive capacities of the urban systems are also assessed after close consultations with stakeholders. Risk for all critical fragile urban systems has been assessed after close consultation with stake holder committee and climate core team based on likelihood and consequences. Some of the qualitative attributes of the fragile sectors have been analysed to identify climate risk for Rajkot city by using Tool 3.2B Risk Assessment (See section 3.3).

4. Develop Climate Resilient Cities Action Plan

4.1 Define resilience interventions

- Various mitigation and adaptation interventions have been identified for Rajkot based on GHG emission inventory and urban system analysis in line with existing city planning. Mitigation and adaptation potential for each intervention along with financial aspect and implementation mode have been identified in line with on-going projects and future planning of Rajkot Municipal Corporation by using Tool 4.1A Resilience Interventions (See Chapter 4).

4.2 Screen and prioritize potential resilience interventions

Prioritization of Resilience Interventions has been done based on feasibility and impact assessment by using Tool 4.2 Prioritization of Resilience Interventions

4.3 Set targets and approve CRCAP

- The resilience interventions has been linked to existing/ongoing/planned initiatives within the city to assess possibilities of leveraging existing funding opportunities to implement the action plan (Tool 4.3 A Integration into city plans). Targets are set to move towards outcomes under climate action plan, which can relate to GHG "avoidance" or "reduction" and/or achievement of adaptation measures and also to socio-economic indicators.
- A formal Council approval is pending, which offers an opportunity for political review, recommendations and adoption of the Action Plan.

1.3 Mayoral Announcement

Dr. Jaiman Upadhyay
Mayor
Rajkot Municipal Corporation

Date: 15th January, 2018

DR. JAIMAN UPADHYAY, RAJKOT MUNICIPAL CORPORATION COMMITS TO DEVELOPMENT OF A CLIMATE ACTION PLAN FOR THE CITY OF RAJKOT

Today, Mayor Dr. JaimanUpadhyay committed to taking action to address climate change by planning for and implementing actions to reduce greenhouse gas (GHG) emissions and increase resilience of communities to impacts of climate change and regularly report progress publicly.

The Mayor Dr. JaimanUpadhyay will reinforce his commitment to climate action by compiling an inventory of greenhouse emissions, reporting on the current impacts of climate change on the city, creating an action plan including clear and ambitious GHG reduction and climate adaptation targets, and implementing a common system of measuring those emissions and monitoring climate risks.

With this commitment, the city will continue to work to make Rajkot city a community where people want to live, where businesses want to invest and where other cities look to for leadership on climate change. Taking stronger local action will improve the quality and livability of Rajkot city, and we proudly join fellow cities around the world to foster a global climate impact and help successfully implement the Paris Agreement.

Dr. JaimanUpadhyay,
Rajkot Municipal Corporation
Rajkot, Gujarat
India

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Figure 3 Mayoral Announcement

1.4 Climate Core Committee of the City

Climate Action Planning is not just linked to the environment so an effective Core Team was formed from a range of departments of Rajkot Municipal Corporation. City level climate core team has been formalized and notified by Rajkot Municipal Corporation on 25th October, 2016 comprises of 41 nominated officers and officials from various relevant departments of Rajkot Municipal Corporation including Mayor and Standing committee chairman, chaired by Municipal Commissioner (See Annexure 1). The climate core committee comprises of representatives from departments that have responsibilities for, or an impact on, energy use, pollution, waste, food security, resilience in water sector and water security, public health, drainage and sanitation, local economic development, infrastructure, mitigation actions in transportation, and development planning. Climate Core Committee was involved in all steps of preparation of Climate Action Plan and support internal institutional capacity building to effectively fulfill the long-term climate resilience plan requirements by effective integration of planned initiatives into the city's developmental plans.

1.5 Stakeholder Committee for Climate Action

The Climate Action Planning Process should be supported by consultations with other groups in the city such as government agencies, local NGOs, community leaders, university partners and private sector organizations, to appropriately share responsibilities and ensure ownership. City level stakeholder committee was formed and notified by Rajkot Municipal Corporation on 25th October, 2016 comprising of 43 members chaired by Municipal Commissioner for multi-way process of dialogue and deliberation within the Climate Core Team and with other stakeholders, as well as amongst stakeholders themselves (See Annexure 1). The 'Stakeholder's Committee' includes key decision makers and administrators from Rajkot Municipal Corporation as well as representatives from Builder's Association, Architect Association, Industrial Association, Rajkot Chamber of Commerce & Industries (RCCI), Association of Consulting Civil Engineers (ACCE), various educational institutions, Regional Transportation Office, and Various NGOs. Stakeholder concerns and feedback were considered through series of consultation. Valuable information from various stakeholders has improved the design and outcome of the project in Rajkot city.

1.6 Communication Plan for Climate Action

Launch workshop

Information on City Level Dialogues

2 Background Research

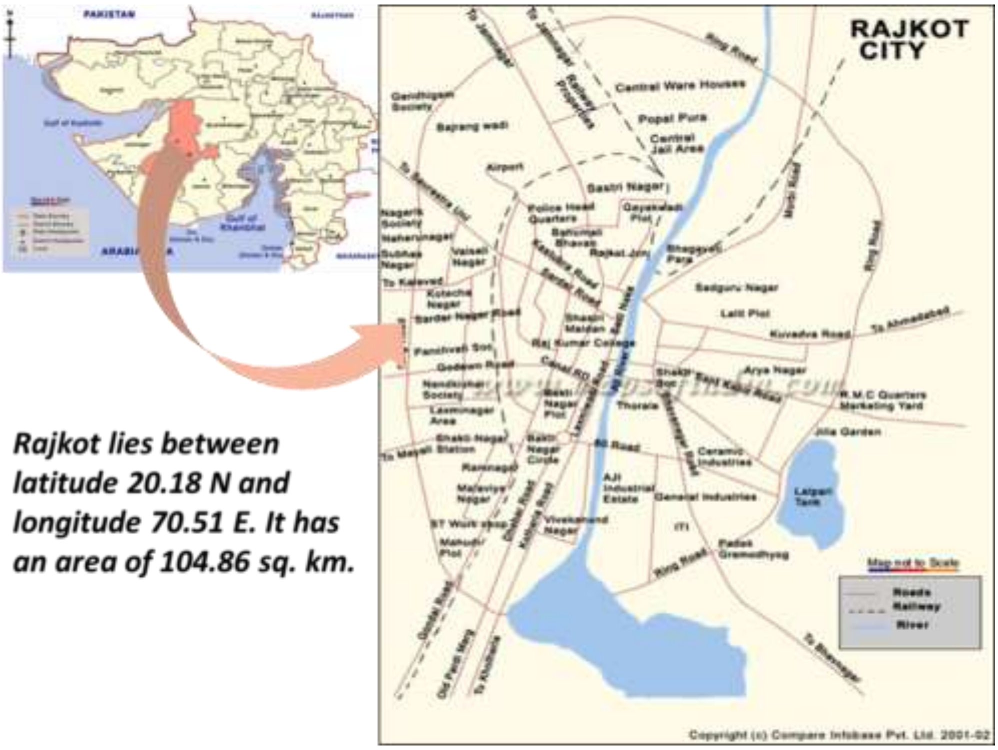
2.1 City Profile

2.1.1 Location

Rajkot is the fourth largest city in the state of Gujarat after Ahmedabad, Vadodara and Surat. Rajkot has a population of nearly 1.3 million as of 2011 and is ranked 22nd in the list of global fastest growing cities and urban areas from 2006 to 2020. It is located at 245 km from the state capital Gandhinagar, at the center of peninsular Saurashtra region in the central plains of Gujarat state, in the Western part of India at a height of 138 m above mean sea level and located on the banks of the Aji River and Nyari River. It lies between latitude 20.18 N and longitude 70.51 E.

The development of the city has been historically driven by industrial activity. With increasing industrial, trade and commerce activity, there has been tremendous growth in the population of the city. Rajkot is the biggest city in terms of population in Saurashtra-Kutch region, throbbing with commercial activities, spurted by globalized economic and industrial policy. The city area has grown up in area from 104.86 sq. km in the year 2011 to 129.21 sq. km in year 2015.

Figure 4 Location of Rajkot City



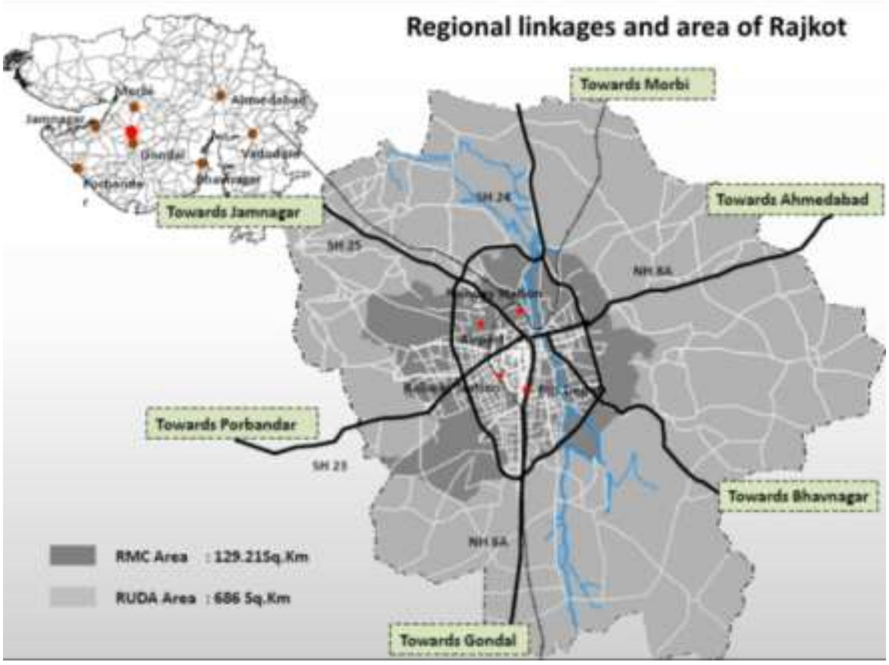
2.1.2 Connectivity

By Air: Rajkot has a domestic airport which is just 2.5 km away from the core of the city and 2km from the Railway station. The two airlines which operate daily connect Rajkot directly with Mumbai, Ahmedabad and Bhavnagar.

By Rail: The city is also connected by broad gauge railway lines to Delhi and Mumbai, the national and commercial capital cities of India.

By Road: Rajkot is well connected with the whole of Saurashtra-Kutch Region and other parts of the States through National and State Highways. It has one national highway (NH-8) connecting Ahmedabad and Gondal to Rajkot whereas three state highways i.e. SH -23, 24 & 25 connect Jamnagar, Porbandar and Morbi to the city. Regional linkages and area of Rajkot city are shown in Figure 5 below.

Figure 5 Regional linkages and area of Rajkot City



(Source: Low Carbon Mobility Plan-Rajkot, 2011-2031)

West zone area is a fast developing area, especially along the BRTS route, given the thrust on transit oriented development. Over the past decades, the city of Rajkot has expanded rapidly in almost all directions from its core areas. The radial arterials have attracted a significant amount of this growth and development while the Ring roads have improved the connectivity and ease of movement between them.

2.1.3 Demography

The population of Rajkot city is 1,288,599 (total 672,357 males and 613,237 females) as per census 2011. The population has grown at an average decadal growth rate of 28.31% since 2001. The population growth in the previous decade was influenced largely the expansion of the city area i.e. the area governed by the Rajkot Municipal Corporation. The population density of Rajkot city is 12,289 persons per sq. km as per Census 2011.

Table 1 Wardwise number of population and density

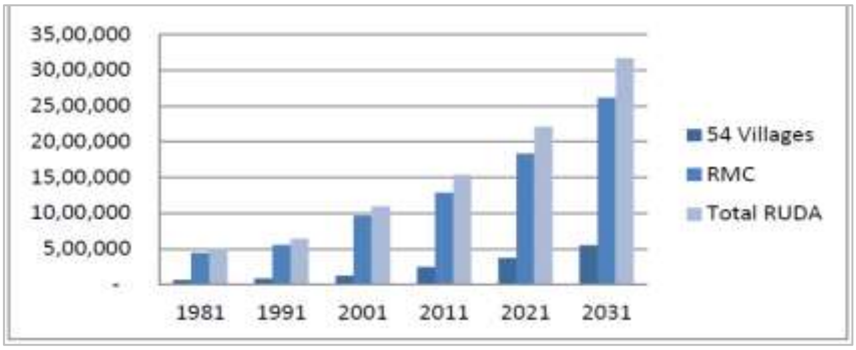
Wards	Population (2011)	Slum Population (2011)
Ward no - 1	74,290	18,500
Ward no – 2	70,143	4,098
Ward no – 3	74,335	10,316
Ward no – 4	72,287	48,300
Ward no – 5	70,583	21,175
Ward no – 6	69,239	30,000
Ward no – 7	80,016	7,736
Ward no – 8	78,000	3,000
Ward no – 9	76,270	3,450
Ward no – 10	73,297	2,950
Ward no – 11	73,297	2,950

Wards	Population (2011)	Slum Population (2011)
Ward no -12	74,000	16,800
Ward no – 13	80,570	3,482
Ward no – 14	77,625	2,321
Ward no – 15	67,857	53,445
Ward no – 16	74,701	20,573
Ward no – 17	78,739	7,503
Ward no – 18	78,658	19,150

(Source – Election Department, Rajkot Municipal Corporation 2016)

The projected population for Rajkot city in 2031 (based on 2011 population) is estimated to be 26 lakhs. Figure 6 shows the population growth and projections for Rajkot city area and its surrounding areas within the urban agglomeration (54 villages), which are both expected to increase rapidly. Population within RMC and RUDA limit will increase service and utility demand, change in land use, increase in use of vacant land and land for agricultural purpose on periphery of city for development.

Figure 6 Population Growth and Projection for Rajkot city and Urban Agglomeration



(Source: Rajkot Draft Comprehensive Development Plan 2031 (second revised))

2.1.4 Land Use

The Second Revised Draft Development Plan, 2031 has been prepared considering the demand of projected population for the next two decades for the entire area of 686 sq. km. under the Rajkot Urban Development Authority (RUDA), including the Rajkot city area. Proposed land use of RMC and RUDA area is shown in the Tables below.

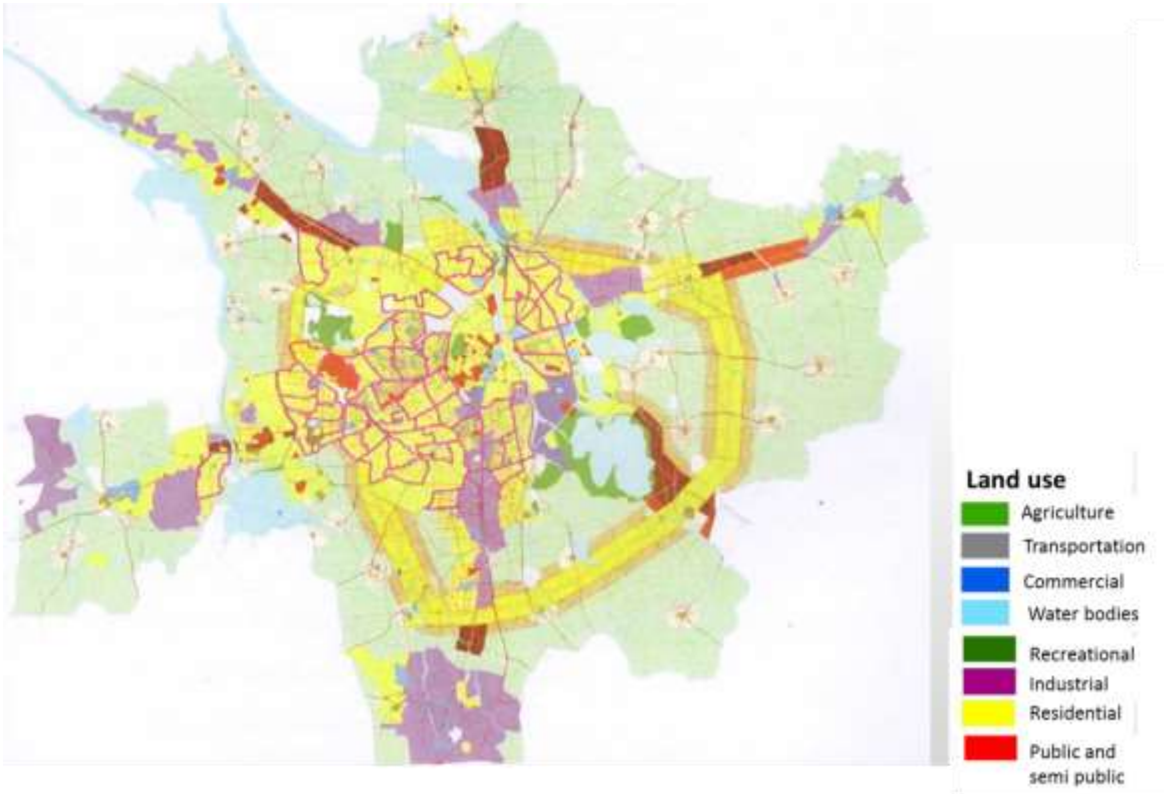
Total RMC area in year 2001 was 105 sq. km, the total area remained same for year 2011 but land use of particular zone has been changed. Based on existing land use analysis, it has been noted that there is no vacant land available within RMC limit in year 2011, which was ~15.1 sq. km in year 2001. All available vacant land and some agricultural land within city limit was utilised for Residential purpose followed by recreational spaces, traffic and transportation (construction of new roads), industrial, public and semi-public purposes and commercial establishment.

Typically, the outward growth is also fuelled by availability of developable non agriculture land in the outer areas at lower price and high rate of return upon development of this land. However, such developments have also caused significant amount of low density sprawl and loss of farmlands. However the city boundary is extending, it has been noted that the percentage of the water body area remained same from past few years as Lalpari lake and Randarda lake were added as part of new city boundary.

With the expansion of city, the peripheral agricultural land is continuously under pressure for urbanization. The land under double cropping is more fertile and well irrigated, which occupies a major part of land within the surrounding areas of city in RUDA limit as indicated in the Figure 7. Many of these peri-urban fertile lands however stands threatened by the encroachment of urban land use resulting in the decrease in agricultural production.

To preserve the ecological balance and boost agriculture activities, the developable zone is restricted till 2nd ring road. It is also proposed certain pocket between RMC and 2nd ring road as agriculture zone. Also, along with agricultural activities, development of agro-based industries and processing units are allowed in order to support activities like farming, livestock etc. in conjunction with the development regulations.

Figure 7 Proposed Development Plan, 2031



(Source: Rajkot Draft Comprehensive Development Plan 2031 (second revised))

Table 2 Existing and proposed Land Use for Rajkot City

Land Use for RMC limit (Rajkot City)	2001		2011		2031	
	Area in hectare	Share of each category (%)	Area in hectare	Share of each category (%)	Area in hectare	Share of each category (%)
Residential	4,247	40.5	5,502	52.4	6,228.2	59.4
Commercial	209	2	279	2.6	221.7	2.1

Land Use for RMC limit (Rajkot City)	2001		2011		2031	
	Area in hectare	Share of each category (%)	Area in hectare	Share of each category (%)	Area in hectare	Share of each category (%)
Industrial	628	5.9	738	7.1	635.2	6.1
Traffic and Transportation	1,400	13.3	1,650	15.7	NA	NA
Public and semi public	149	1.4	249	2.3	305.3	2.9
Recreational Space	123	1.2	523	4.9	517.1	4.9
Agriculture	995	9.5	800	7.6	69.3	0.7
Water bodies	236	2.3	236	2.3	236	2.3
Vacant lands	1,510	14.4	-	-	-	-
Other	988	9.4	508	4.8	2,307.5	22.01

(Source: Rajkot Draft Comprehensive Development Plan 2031 (second revised))

Table 3 Existing and proposed Land Use for RUDA area

Land Use for RUDA area	2001		2011		2031	
	Area in hectare	Share of each category (%)	Area in hectare	Share of each category (%)	Area in hectare	Share of each category (%)
Residential	5,744	8.4	12,528	18.3	13,075.29	19.1
Commercial	543	0.8	827	1.2	624.7	0.9
Industrial	3,388	4.9	5,205	7.5	4,938.89	7.2
Traffic and Transportation	1,697	2.5	2,453	3.5	NA	NA
Public and semi public	633	0.9	591	0.8	487.7	0.7
Recreational Space	379	0.55	1,053	1.53	1,133.5	1.6
Vacant lands, agriculture and other	55,926	81.8	45,974	66.9	36,962.47	55

(Source: Rajkot Draft Comprehensive Development Plan 2031 (second revised))

2.1.5 Economic Activities

Rajkot is an industrial town. The major industries in Rajkot are foundry, metal based, and machine tools. There are a number of small-scale industries within and around the city. Besides industrial development, Rajkot is a trade center for the region. It is also a center for selling agriculture produce. There are two main industrial estates in the city, viz., the Aji Industrial Estate and the Bhaktinagar Industrial Estate. The major industry types in Rajkot are given below.

- Oil Engine & Machine Tools
- Foundry industry
- Engineering and automobile industries
- Castor oil industries
- Gold and silver jewellery
- Handicrafts

In addition, the spices industries, viz., turmeric, coriander, fenugreek, black pepper, cardamom, dry ginger and chilli powder, etc. are also developing at an eye-catching rate.

Due to major industrial hubs with in and around the city limit i.e. Aji industrial estate, Bhaktinagar industrial estate, Shapar-veraval GIDC, and Metoda GIDC, number of migrating labors are staying at out skirt area of the city because of low land price. Some of the areas in city periphery are rapidly growing areas i.e. Kothariya and Vavdi.

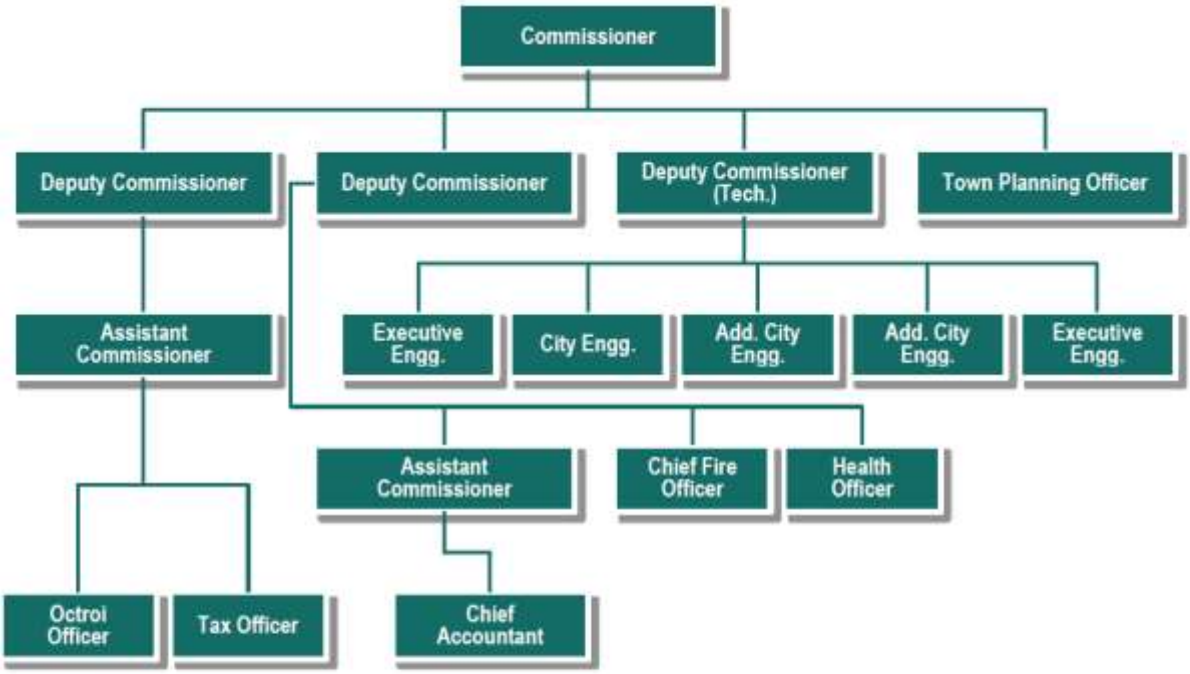
2.1.6 Local Government Body

There are two governing bodies within the Rajkot urban agglomeration area, the Rajkot Municipal Corporation (RMC) and the Rajkot Urban Development Authority (RUDA). RMC administers an area of 129 sq. km, includes 18 wards and RUDA governs the development and planning of the 54 villages located in the vicinity of RMC, covering a total area of 686 sq. km (including RMC area).

The local body of Rajkot city got the status of municipal corporation in 1973.It is being governed through the Bombay Provincial Municipal Corporation Act of 1949. Rajkot Municipal Corporation (RMC) is responsible for the provision and maintenance of the city's civic infrastructure and its administration.

The governing structure of RMC consists of political and administrative wings. The political wing is an elected body of councilors headed by a Mayor. RMC is headed by the Mayor – chief of the elected wing. The Commissioner from the IAS cadre heads the administrative wing and is responsible for strategic decisions, operational planning, and management of the Corporation. The Commissioner takes decisions on behalf of the Board or the Standing Committee, formed from the elected councilors to perform the duties of the Corporation. The structure of the administrative wing of the Rajkot Municipal Corporation is presented below.

Figure 8 Administrative Structure of Rajkot Municipal Corporation



Source: www.rmc.gov.in

Some of the important services provided by the Rajkot Municipal Corporation are water treatment and supply, sewage treatment and disposal, garbage disposal and public hygiene, solid waste management, disaster management, construction and maintenance of roads, streets and flyovers, street lighting, maintenance of parks and open spaces, cemeteries and crematoria , registering of births and deaths, conservation of heritage sites, disease control, including immunization, running of public municipal schools

The Rajkot Urban Development Authority (RUDA) was constituted under Section 22 of the Gujarat Town Planning & Urban Development Act (GTPUDA), 1976 on 1st February 1978. RUDA encompasses the RMC area and 54 villages on the periphery of RMC; with the total area covered under RUDA being 686 sq. km (including RMC area). The important functions of RUDA include the preparation of a physical plan for the development of the Rajkot Urban Agglomeration; preparation of draft town planning schemes; implementation of the revised town planning schemes; and monitoring and controlling of the development activities in accordance with the revised Development Plan.

2.1.7 Major Urban Systems

2.1.7.1 Water Supply

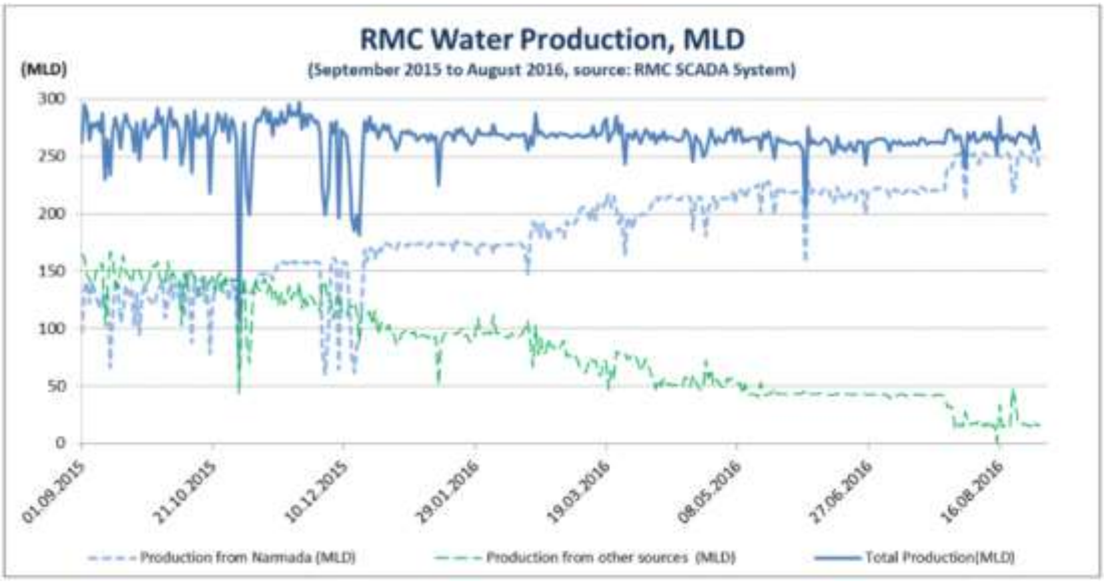
Rajkot lies in an arid zone, with irregular and erratic monsoons. The average annual rainfall is 500mm. The city falls under an arid zone; monsoons in Rajkot are irregular and erratic. The soil stratum in the Rajkot region is made of hard rock. Moreover, confined aquifer is thin. Hence, the availability of ground water for potable use in Rajkot is limited. Also, ground water level is below 1,000 feet.

Only in the monsoons water is available for extraction, due to rainfall in the upstream catchment areas of River Aji. Rajkot is largely dependent on surface water sources such as the Narmada River and the Bhadar River. Considerable variation in per capita availability of water has been observed due to inadequate availability of water.

2.1.7.1.1 Water Sources

Potable piped water supply in Rajkot city was made available with its first water scheme Aji-I developed by the Saurashtra Government in 1955. This water supply scheme is still functional. With the city's growth, the population increased and Aji-I reservoir became insufficient for supplying water to Rajkot. In 1975, Nyari-I scheme was developed by the Rajkot Municipal Corporation (RMC) to serve the western part of the city. After this, in 1988, the Bhadar scheme was developed by RMC. In 1998, with the expansion of limits, RMC developed another water supply scheme based on the Nyari-II reservoir. Moreover, RMC has upgraded Aji1 reservoir under "Sauni Yojana Scheme" and also sourcing water from the Narmada canal from the Maliya-Jamnagar section at Aji1 reservoir.. Water is sourced from the local water sources post-monsoon, during the months of August, September and October i.e. Aji Dam, Nyari dam, Bhadar dam, Lalpari lake and Randarda lake. This water is considered less expensive because transport distances are shorter, but treatment effort is high. RMC is also planning to interlink all local reservoirs and sources in future. Rajkot depends on ground water and Narmada canal to meet the water requirements in the dry months of beginning from November till month of July. Total water treatment capacity is 300MLD against total requirement of 240MLD. Rajkot has an agreement with Gujarat Water Infrastructure Limited for sourcing Narmada water at INR 6/KL upto 75MLD limit and at INR 12/KL after 75MLD limit. However, this supply does not ensure 24 x 7 water supply and water will be supplied only for 20mins per day. The share of the Narmada source increases over the course of the year and reaches more than 90% as can be seen from the historic SCADA records provided by RMC (see Figure 9). Presently, RMC is sourcing average 130MLD to 150MLD water from Narmada source, which increases up to 230MLD to 250MLD during dry periods.

Figure 9 RMC Water Production 2015-16



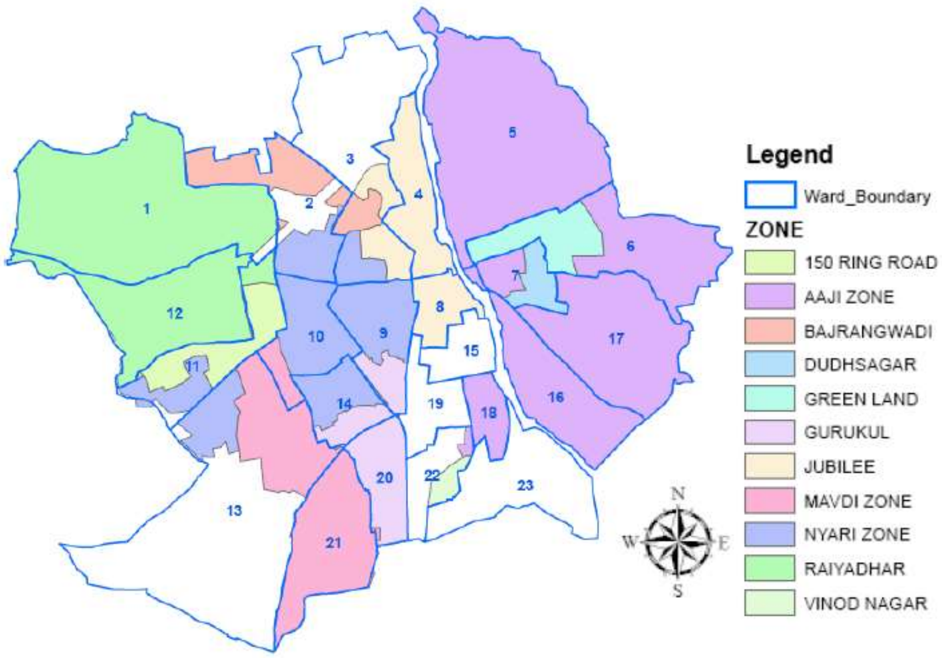
(Source: Analysis of historic SCADA records provided by RMC under Integrated Resource Management in Asian Cities: The Urban Nexus by GIZ)

Table 4 Water Sources and Capacity

Water Source	Type of source	Distance from city	2010 (Source capacity in MLD)	2015 (Source capacity in MLD)
Aji-1 + Narmada at Aji	Dam+Canal	0	110	110
Lalpari-Randarda	Lake	0	6	6
Bhadar-1	Dam	65	50	50
Nyari-1	Dam	18	35	35
Nyari-2	Dam	24	7.5	7.5
Narmada at Raiyadhar WTP	Canal	6	35	35
Total			243.5	243.5

(Source – Rajkot Municipal Corporation)

Figure 10 Water Supply Zone map



(Source – Rajkot Municipal Corporation)

2.1.7.1.2

2.1.7.1.3 Details of Pumping stations

Details of various pumping stations are as below. There are 10 to 15 years old pumping machineries in some of the pumping stations. RMC has recently replaced old pumping machineries with energy efficient pumps in few pumping stations i.e. Aji. RMC is also planning to replace all old pumps with new energy efficient pumps with support from EESL.

Sr. No.	Name of Pumping station	Zone	GSR Capacity (ML)	ESR Capacity (ML)	No. of pumps
1	Raiyadhar	West	20.00	3.00	5
2	Nyari-I	West	18.60	2.30	4

Sr. No.	Name of Pumping station	Zone	GSR Capacity (ML)	ESR Capacity (ML)	No. of pumps
3	Mavdi	West	8.00	2.50	6
4	150' Ring Road	West	2.50	1.25	2
5	Bajrangwadi	West	5.00	0.50	3
6	Sojitra Nagar	West	3.00	1.40	2
7	Nyari-II (Ghateshwar)	West	4.00	-	3
8	Chandresh Nagar	West	6.25	2.50	6
9	Aji	East	35.60	-	8
10	Doodhsagar	East	7.00	1.00	4
11	Marketing Yard	East	0.80	0.20	1
12	Kothariya	East	1.50	0.23	2
13	Greenland	East	10.00	3.00	6
14	Vinod Nagar	East	10.00	3.00	8
15	Ribda	Central	24.50	-	2
16	Gurukul	Central	5.40	4.74	5
17	Jubili	Central	6.00	5.40	5
18	Lalbahadur	Central	4.00	1.35	4
19	Popat Para (WIP)	Central	8.00	2.00	

(Source – Rajkot Municipal Corporation)

2.1.7.1.4 Water Network

The water supply network is not mapped in recent times. Network data that was available dates back to 2004, accordingly the information presented in the following is indicative only and by no means complete. The total length of documented assets is 1,757 kilometers of different diameters.

Diameter (mm)	Distribution (m)	Lateral (m)	Main (m)
100 to 150	11,866	236,071	0
150 to 200	0	793	125,488
200 to 400	0	0	166,428
400 to 1000	0	0	114,615
More than 1000	0	0	11,708

The material composition of the network is given in the database. It shows that the predominant material in use is Asbestos Cement (AC) with 85% followed by Mild Steel (MS) with 14%. In recent years AC-pipes are no longer utilised and more appropriate material is employed. DI piping is proposed to be used in the upcoming network expansion.

Pipe material	Length (km)
Ductile Iron (DI)	2.2
Asbestos Cement (AC)	1,495.9
Mild Steel (MS)	251.7
Reinforced Concrete (RCC)	2.7
(Material unknown)	4.7
Total	1,757.3

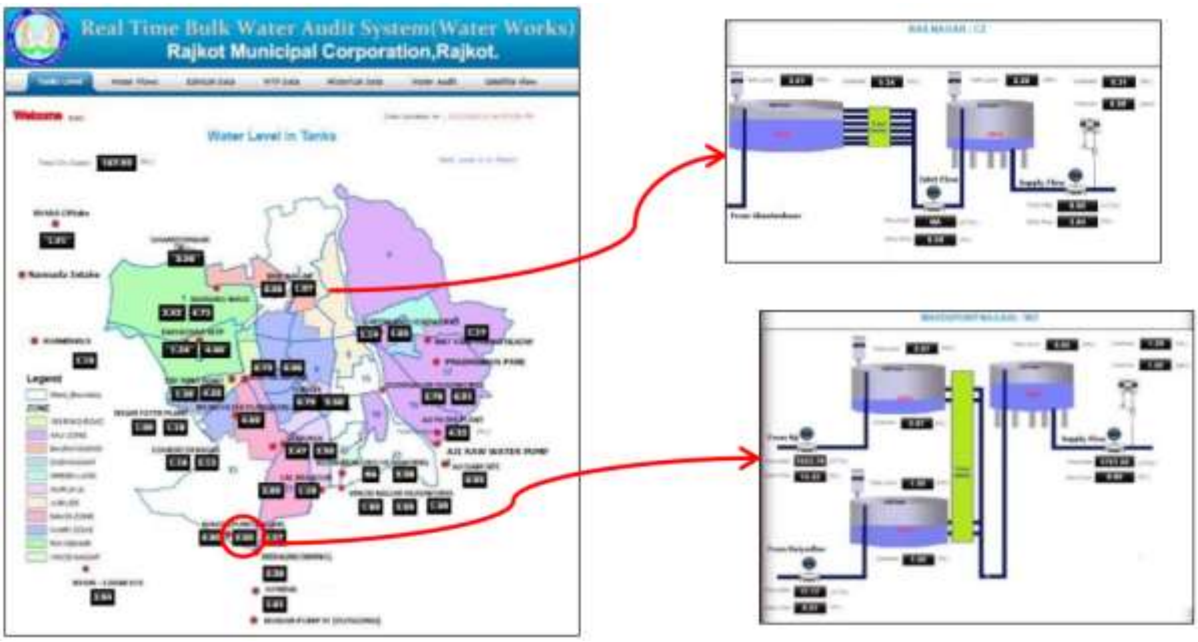
RMC operates the head-works and the corresponding distribution networks with the support of contractors. The contractors are in charge of network operation and maintenance. More than 100 valve operators (patrollers) make sure the sub-distribution zones receive water for precisely 20 minutes per day. Water distribution system in Rajkot was designed below 1m to 1.5m depth from level of beneficiary's tap, so that distribution system remains full with water after 20 minutes per day supply in sub distribution zone. This ensured that the beneficiary is able to receive water precisely 20 minutes during the next day. Since last few years, many households have constructed underground water storage tanks and have made illegal water connections below the level of the water distribution system. Water network of sub-distribution zones remains empty due to such illegal connections. This also enhances issues of water pressure drop during subsequent supply. Illegal connections in Rajkot are a major concern.

Leakage identification is a problem as only visual leaks are identified because the water operators have no possibility to proceed systematically with leak detection and repair. Leakages are visible only during the 20 minute of supply. During this short period of time the network doesn't show a normal hydraulic behavior; flow velocities are extremely high, which results in large friction losses and pressure drop. Many leaks also remain unnoticed because the leaked water doesn't surface and percolates into the underground instead. Proposed new water supply network consists of DI pipeline with household level water meters; which will reduce the scope for illegal connections.

2.1.7.1.5 Supervisory Control and Data Acquisition (SCADA) for water supply

A Supervisory Control and Data Acquisition (SCADA) system consists of two parts; the Data Acquisition part including monitoring and processing in addition to the Supervisory Control part that allows remote steering.

Figure 11 Website of RMC Real Time Bulk Meter Audit System (left), Railnagar (right top) and Mavdi Headwork (right bottom)



RMC is currently generating a solid data base to monitor the performance at the Primary Headwork Level (see Figure 11 above). The data is then deployed for decision making and development of Performance Indicators (PI). The system provides access to the data from any given point through a desktop computer or a mobile (Android). Real-time data can be checked or historic data may be aggregated. In terms of water quality, the residual chlorine is being measured for each ESR and GSR. The collected data reveals important information concerning the varying water sources as well as water distribution and water quality on the level of the Primary Distribution Network, the Headwork level.

2.1.7.1.6 Water taxes

Due to lack of metering of water connections, the cost recovery in water supply services is very low. Water taxes for residential connection and non-residential connection of 15mm diameter are 840 INR per year and 1680 INR per year respectively. There is proposal to increase water taxes for non-residential consumer of 15mm diameter from 1680 INR per year to 2400 INR per year in budget 2017-18. New houses, commercial, industrial and other establishments are paying one time connection fee based on the diameter of the connection pipe and usage. Water tariff structure of RMC is shown in table 5.

Table 5 Water tariff structure, RMC

Size of Connection (mm)	Domestic Tariff (INR/ Month)	Non Domestic Tariff (INR/ Month)
15 mm	70	140
25 mm	840	6720
40 mm	2100	16800
65 mm	5040	40320
100 mm	12600	100800
200 mm	25200	201600
300 mm	33600	268800

(Source: Final White Paper, Preparation of Second Generation City Development Plan for RMC as well as RUDA – June, 2012)

2.1.7.1.7 Service level information - Water Supply

Particulars	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Unit
Coverage of water supply connections	89.4	88.79	94	90	95	98	%
Per capita supply of water	106.2	85.7	110.5	120	120	120	lpcd
Existing total water supply				230	230	240	MLD
Existing water treatment plant capacity	250	250	250	250	250	300	MLD
Extent of metering of water connections	-	-	-	-	-		%
Extent of non-revenue water (NRW)	36.7	34.9	35.6	25	25	28	%
Continuity of water supply				20min/ day	20min/ day	20min/ day	Time

Particulars	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Unit
Efficiency in redress of customer complaints			Very good	Very good	Very good	Very good	
Quality of water supplied			Good	Good	Good	Good	
Cost recovery in water supply services							
Efficiency in collection of water supply - related charges							

2.1.7.1.8 Upcoming new water projects and plans

Project Name	Budget Allocation through state or central government scheme	Existing status	Expected start and end date
50MLD Bedi Filter Plant		Completed	
Household level water meters (around 15,000 HHs) at Chandresh Nagar water supply zone, ward 8 of west zone	AMRUT	Tendering is in progress for Feasibility study	
New water distribution system for Kothariya and Vavdi area	1,050 million INR - AMRUT	Work in progress	
24*7 water supply with new DI network and water meters in ward number 1,8,9,10,11, and 12 under ADB project (Around 45,000 HHs)	3,000 million INR - ADB	Feasibility study in progress	
Upgradation of Aji-1 dam under "Sauni Yojna"		Completed	
Renewal of seven water head works at the intake point	360 million INR – AMRUT Scheme	In Progress	
New water filter plant of 30 MLD capacity at Raiyadhar	200 million INR – Swarnim Jayanti Mukhyamantri Shaheri Vikas Yojna (SJMMSVY)	Work in progress	
SCADA phase 3	45 million INR - SJMMSVY	Proposed	
Assessment of potential for augmenting local water resources (groundwater recharge, rainwater harvesting and waste water reuse) in Rajkot city under CapaCITIES project	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project	On-going	

2.1.7.2 Sewerage

The total length of the sewerage network is 1435.55 km, which covers 80% of the road length as of 2010-11. In RMC, 98% of households have access to a toilet and remaining 2% use community toilets. About 75% of households are connected to the underground sewer line. Total sewage generation in city is 190MLD against treatment capacity of 95MLD as of 2015-16. Untreated sewage is discharged into the Aji River. Rajkot lies within the watershed expansion of Aji river basin and it is a network of 19 natural drainage courses, locally known as vokdas. Unfortunately, these natural drains are being used for sewage disposal resulting in the pollution of water of the Aji River in the downstream of Aji dam.

One STP of 44.50 MLD capacity is located at Madhapar and the other STP of 51 MLD capacity is located at Raiya, which do not comply with the recently revised national standards (10mg/L BOD level in treated waste water). Rajkot Municipal Corporation has recently demolished the Madhapar STP of 44.50 MLD which was not comply with new CPCB standards and constructed one new STP plant of 44.5 MLD based on Activated Sludge Process (ASP) along with 51MLD at Raiyadhar based on Sequential Batch Reactor (SBR) and 15MLD at Kothariya based on Activated Sludge Process (ASP) technology. It is also proposed to construct two new plants of 80 MLD at Madhapar and 70MLD at Gauridhar based on Sequential Batch Reactor (SBR). Total capacity of existing sewage treatment plant as of 2017 is 162.5MLD. Excess Un-treated waste water is bypassed from pumping stations and allowed to flow to the natural drains and river directly, polluting the environment and contaminating the groundwater. This is a common phenomenon during the rainy season due to combined sewer overflows. Sludge from STPs is dried and used by farmers.

2.1.7.2.1 Service level information- Sewerage

Particulars	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Unit
Coverage of toilets	96.4	97.6	96.5	97	98	98	%
Coverage of sewage network services		61.2	59.3	65	75	75	%
Collection efficiency of sewage network	62	64	65	67	80	80	%
Total sewage generation	173	175	180	190	190	190	MLD
Existing sewage treatment capacity	95.5	95.5	95.5	95.5	95.5	166.5	MLD
Adequacy of sewage treatment capacity	55	54	53	50	50	75	%
Quality of sewage treatment	96.2	95.5	95.5	95.5	95.5	95.5	%
Extent of reuse and recycling of sewage	NIL	NIL	NIL	NIL	NIL	NIL	%
Extent of cost recovery in sewage management					100		%
Efficiency in redress of customer	94.7	95.9	96	96	96	96	%

Particulars	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Unit
complaints							
Efficiency in collection of sewage charges	51.8	61.5	61.5	62	65	65	%
Total recovery of wastewater tax					148,119,000 INR		

2.1.7.2.2 Upcoming new drainage projects and plans

Project Name	Budget Allocation through state or central government scheme	Existing status	Expected start and end date
Madhapar Sewage Treatment Plant (STP) – 80MLD based on SBR technology	AMRUT Construction cost – 457,500,000 INR O&M for 5 years – 60,000,000	Construction in progress	Start Date – 1st January, 2017 End date – December, 2018
Gauridhar Sewage Treatment Plant (STP) – 70 MLD based on SBR technology	JnNURM	Under trial run	Start - 2014 End date – February 2018
Raiyadhar Sewage Treatment Plant (STP) – 51 MLD based on SBR technology	SJMMSVY	Construction work – Completed	Plant is operational
Tertiary treatment plant at Raiyadhar STP premises – 25 MLD	AMRUT	Detailed Project Report is completed	
Extending drainage network to uncovered area including 5 pumping stations	AMRUT	Prefeasibility study is under progress.	Work in progress
Assessment of biogas digester of 51MLD Raiya Sewage Treatment Plant in Rajkot city to stop direct methane emission under CapaCITIES project	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project	On-going	

2.1.7.3 Solid Waste Management

The Solid Waste Management Department of RMC is managing municipal solid waste from source to final disposal, under the supervision of an environment engineer. Rajkot generates 450 Metric Tonnes of municipal solid waste daily as of year 2014-15. Total solid waste generation in Rajkot

Municipal Corporation is 477[1] Metric Tonnes as per waste quantification and characteristic study done under CapaCITIES project in December 2017. A 300 TPD compost & RDF facility was shut down after 2012-13. Waste is transported from the transfer station to the disposal yard by private agencies. About 100% of the total waste generated is collected from various points and transferred to the disposal yard. The transportation of unattended waste from open plots and slums is done manually and/or mechanically through variety of vehicles as these areas are not covered while street sweeping. Presently all municipal waste is being dumped at a dump site. Segregation of waste is a major challenge in Rajkot. Unsegregated waste reduces treatment/processing efficiency and increases treatment/processing costs.

Various SWM initiatives are already proposed by RMC at centralized and decentralized level i.e. 600 TPD waste to energy plant, 5 TPD capacity waste to composting plants in 18 wards (3 are already constructed, 5 are is in tendering phase). 3 decentralized waste management facilities exist in the City, with a total capacity of 10.5 MT per day, but do not receive sufficient quantum of segregated waste. This is critical since these plants process only biodegradable waste. RMC also proposes to issue a notification to citizens in residential and commercial areas, urging them to segregate dry waste, wet waste and hazardous waste in three different dustbins.

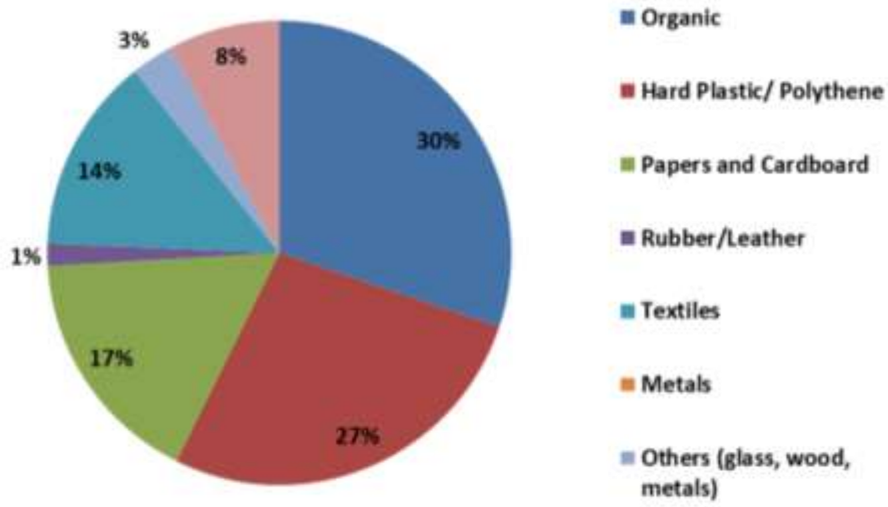
2.1.7.3.1 Composition of waste

Waste characterisation and quantification study was conducted under the project Capacity Building for Low Carbon and Climate Resilient City Development (CapaCITIES) supported by Swiss Agency for Development and Cooperation (SDC). Reconnaissance survey was undertaken and the location of the sampling points was identified with the help of municipal officials from Rajkot Municipal Corporation to represent different waste generation sources such as residential (LIG, MIG and HIG), institutional areas, commercial establishments, hotels, vegetable market, transfer stations and finally at the dumpsite. The study was conducted for seven days (21st to 28th January, 2017) wherein samples from different waste generation points were collected and sent to MoEF recognized and NABL accredited laboratory for analysis. A total of 17 waste samples were collected and analysed from all the 3 zones in the city and the dumpsite. A detailed waste quantification and characterisation report is included in Annexure-2.

Waste characterisation from waste collected from both waste transfer stations (Raiyadhar and KSD transfer stations) is shown below (see figure 12). 30% of total waste is organic waste followed by hard plastic and polythene (27%), papers and cardboard (17%), textiles (14%),metals (8%), others (3%) and rubber and leather (1%).

[1] Total waste generation in year 2017 is 575 Metric Tonnes per day as per Rajkot Municipal Corporation without any study but detailed waste characterization and quantification study for Rajkot city was done under CapaCITIES project, which shows that actual waste generation from all sources is 477MT per day.

Figure 12 Waste Characteristics, Rajkot Municipal Corporation



(Source – Waste characteristics and quantification study conducted under CapaCITIES Project)

2.1.7.3.2 Source wise distribution of Solid Waste

Quantity and rate of waste generated in Rajkot was estimated under CapaCITIES project. The total municipal waste generated in the city of Rajkot 477.36 TPD. The table below shows the sources and quantity of waste generated in Rajkot. Residential sector is highest contributor in terms of solid waste generation followed by commercial, hotels, institutions and vegetable markets. Waste segregation at source has been identified as big issue in city.

Table 6: Sources and Quantity of Waste Generated

Sr. No.	Sources of Waste Generation	Number of Entities	Rate of Waste Generation (kg/capita/day)	Quantity (tonnes/ day)
1.	Residents	1,477,183	0.25	378.12
2.	Commercial	75,459	0.7	52.82
3.	Vegetable		1350	1.35
4.	Institutional	463	58.33	27
5.	Hotel	237	76.22	18.06
	Total			477.3

(*There might be difference in waste generation by 10-20% accounting waste being collected from offices, open dumping points, municipal solid waste from hospitals and floating population.)

2.1.7.3.3 Service Level Benchmark

Particulars	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Unit
Total waste generation	350	375	400	450	525	477[1]	TPD
Household level	82.8	91.6	98	99	99.5	99.5	%

Particulars	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	Unit
coverage of SWM services							
Efficiency of collection of municipal solid waste	93.6	98	98.6	99.5	99.5	99.5	%
Extent of segregation of municipal solid waste	28.1	15.7	8.4	30	35	30	%
Extent of solid waste recovered	100	96.1	95.9	86	10		%
Extent of scientific disposal of municipal solid waste	NA	100	100	60	0	0	%
Extent of cost recovery in SWM services	36.1	30.8	29.2	30	43	40	%
Efficiency in redress of customer complaints	95.3	96	97.4	99	99.6	99.6	%
Efficiency in collection of SWM charges	56.2	NA	96	97	43		%
HH level coverage of SWM services in slum settlements	98	95	NA	99	99	99	%

2.1.7.3.4 Upcoming new SWM projects and plans

Project Name	Budget Allocation through state or central government scheme	Existing status	Expected start and end date
Capping work for first cell of 55,000MT capacity at Nakrawadi landfill dumping site		Completed	
capping work for second cell of 400,000MT capacity at Nakrawadi landfill dumping site		Work in progress	
Construction of two leachate collection ponds at Nakrawadi dumping site	2 million INR		
Waste to energy plant at Nakrawadi dumping site – 600 TPD capacity (500TPD for fresh waste and 100TPD waste from landfill)	BOT model	Tendering in progress	
Waste to compost plant at Nakrawadi dumping site – 150 TPD capacity	PPP	Tendering in progress	
2 Decentralized waste to composting plant 1. 400kg per day capacity at Jubeli 2. 200kg per day capacity at Racecourse	Swachh Bharat	Completed	June, 2017
1 Decentralized waste to Bio-methanation plant at Ketal pol, Bhavnagar road (5 TPD)	Swachh Bharat	Completed	January, 2017
15 Decentralized waste to composting plant or Waste to bio-methanation plant (50 to 400kg capacity each) is proposed	Swatch Bharat	DPR is submitted 3 waste to composting plants are installed and 5 waste to composting plant is budgeted	
Construction and Demolition waste recycling plant - 100 TPD	PPP	Tendering is in progress	Start date – March, 2017 End date – 18 months from start date
Capping of old dumping site at Sukhda	Swachcha Bharat	Consultant for DPR preparation and tendering process is hired	
Procurement of Waste bins of 40 litres and 120 litres capacity	INR 5 million - Swachh Bharat Mission	Completed	

Project Name	Budget Allocation through state or central government scheme	Existing status	Expected start and end date
Procurement of 120,000 dustbins for source segregation	Swachh Bharat Mission		
Procurement of three truck mounted mobile organic waste converter	INR 13.5 million - Swachh Bharat Mission		
Procurement of new vehicles and machineries for waste collection	Swachh Bharat Mission		
Construction of semi-closed waste transfer station at Kothariya	Swachh Bharat Mission		
Notification by RMC to segregate dry waste, wet waste and hazardous waste in three different dustbins at source by residential and commercial area	solid waste management rules-2016		
Provide three different dustbins for SMART Societies	INR 18 million - Swachh Bharat Mission		
Preparation of holistic Solid Waste Management Action Plan for Rajkot under CapaCITIES project	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project	On-going	

2.1.7.4 Transportation

The city of Rajkot being a business hub of Gujarat has got a huge floating population travelling to and from Rajkot every day and it is public transportation that largely serves them. Along with National Highways and the State Highways, Rajkot also has an extensive and dense road network that connects each and every corner of Rajkot to interstate destinations and far beyond. Rajkot is connected to all major cities of India by road, rail and air. The inter-city bus service is operated by GSRTC. Regular buses, cars, trucks and other means of transport ply through these well maintained roads to connect with other regions. The intra city transportation consists of mainly private modes i.e. four-wheelers and two-wheelers and Para-transit modes i.e. auto-rickshaw and chhakdas. There are no dedicated free parking zones available in city so people park at will, which creates issue in city.

Rajkot doesn't have any traffic management plan. Traffic management at junctions is a major concern; lack of traffic signals in many of the junctions exacerbates this problem. Drivers and pedestrians are unaware of traffic rules and haphazard driving results in regular traffic chaos. City has various mobility plans i.e. 1) Low carbon comprehensive mobility plan 2011-31 prepared by CEPT University 2) Prefeasibility Study and Business Plan for Public Bicycle Sharing System in Rajkot City prepared under Urban LEDS.

Rajkot does not have pedestrian accentuated signals or traffic calming measures at intersections except the footpaths and streetlights. The footpath facilities are present along most arterial and sub-arterial roads, but these footpaths are either discontinuous, encroached (trees, parked vehicles and hawker) or very narrow. This forces the pedestrian to walk on the carriageway thus reducing the capacity for vehicular movement and exposing the pedestrians to greater risk.

Bicycles are majorly used by labourers working in industries and also by students for going to schools. Presently motorized vehicles and cars share common road space, creating potentially dangerous driving conditions for cyclists. Dedicated cycle tracks are built only along the BRT corridor in 2010.

Rajkot is an industrial hub and people commute to Rajkot city from nearby villages for their livelihood. Traffic congestion and industrial pollution lead to poor air quality; there are only two Ambient Air Quality Monitoring Stations (AAQMS), one located near Sardara Corporation and another at GPCB office, monitored and maintained by Gujarat Pollution Control Board (GPCB), which are not sufficient. Also, AAQMS locations are not appropriate.

RMC is preparing plan of action to provide last mile connectivity through all available modes of transportation to feed in public transportation system. RMC has also introduced cycle rental schemes to promote NMT in city. RMC has proposed to provide more cycling and pedestrian tracks for safe and secure NMT in city. Road infrastructure is sufficient at present but haphazard Parking and encroachments on existing footpaths and roads by informal vendors on major corridor is an issue, RMC has taken various initiatives to tackle this issue i.e. effective implementation of vendor's policy, replaced registered vendors at identified vendor zones, proposed 6 additional pay and park facilities, penalizing illegal encroachment etc. RMC has implemented total 24 pay and park facilities and 100 hawker’s zones in city to reduce on-road parking and encroachment of road by hawkers and smooth management of traffic

2.1.7.4.1 Public Transport system

Public Transport is an important system for a city’s internal transportation as it mobilizes a group of people at the same time. Public Transport of the city includes City buses and the BRT buses for internal transportation. RMC has constructed a dedicated BRT corridor of 10kms. RMC has 100 public buses including RMTS (Rajkot Municipal Transportation Services) and BRTS running in various part of city. Among these 100 buses, 90 buses are running in various part of city and 10 buses are running on the BRTS track on the 150ft ring road. Ridership of city bus service and BRTS is more than 40,000 per day. These diesel buses ply over 180kms daily in the city area. Lack of last mile connectivity also restricts the usage of public transport. Shorter trips and inadequate frequency of available public transportation leads to increase in number of private vehicles. Auto-rickshaws is preferred mode for public transportation due to frequent availability (more than 30000 auto rickshaws are plying on roads and 1500 auto-rickshaws registers in Rajkot every year), apart from being illegal, add to problems such as unorganized operations, traffic congestion, unsafe mode of travel due to overloading, poor services, and pollution due to inefficient fuel usage with in city limit.

The total network length of 63.5 km for BRTS is planned with 3 corridors namely Blue - 29 km, Green – 16.5 km and Red - 18 km will be developed phase wise. About 10.7 Km of the 1st Phase of Blue corridor has been completed in west zone connecting Madhapar chowk in the N-W to Gondal chowk in S-W making the new development on the west connected to BRTS.

RMC has taken an initiative of cycle rental scheme to move towards NMT. RMC has set up 4 cycle rental stations as a pilot project. RMC has encouraged hotel associations to provide cycles to their guests at no cost. RMC has also set up 18 cycle rental stations on all BRTS stations. After such successful efforts, Rajkot now has 22 cycle rental stations (including 18 BRT stations). Additionally, 25 hotels have put cycles in their hotel to promote NMT in city.

2.1.7.4.2 Infrastructure for Private Motorized Vehicles

Roads are majorly classified as highways, arterials, sub-arterials, collector & local and outer RMC roads. There is a National Highway-8 connecting Rajkot with Ahmedabad and three State highways going towards Jamnagar, Bhavnagar and Morbi passing through the study area. The ring road and major roads connects the highway with the arterials of the city. These arterials further branch out into sub-arterials leading to inner land pockets by collector and local streets. The collector and local roads also form a grid like pattern making it an intensive network. The national and state highways form 4 % of the road network. The arterial and sub-arterial roads form 12% whereas collector & local roads form 63% of road network. The roads outside the RMC area are 21% of the total network in the study area.

The road hierarchy is not only formed by the width of the road but also by the function of the road in terms of its connectivity in the city. All the roads have different characteristics and are differentiated in terms of width of the road, length or its coverage in the city, type of road and the speeds allowed on that particular road. All these characteristics are summarized for this road hierarchy in the table 7 below.

Table 7 Road type and length

Road type	ROW (m)	Length(km)	% of length	Avg. Lanes	% of Metalled roads	Avg. Speeds Km/Hr.
Highways	22	121	4.51%	3	18%	40
Arterial	18	68	2.53%	3	70%	18
Sub arterial	12.5	237	8.81%	2	73%	14
Collector & Local	7.5	1704	63.3%	1	60%	10
Outer Roads	10	560	20.8%	1	27%	16
Total	14	2690	100%		62%	

(Source: Speed and delay survey, 2012 – Low Carbon Mobility Plan, Rajkot)

2.1.7.4.3 Registered vehicles in city by vehicle type

Vehicular information has been collected from Regional Transportation Office, Rajkot (RTO).

Sr. No	Type of Vehicle	2010 to 11	2011 to 12	2012 to 13	2013 to 14	2014-15	2015-16
Goods Vehicle							
1	Truck/ Lorries	932	1,952	1,104	785	923	1,098
2	Tanker	63	38	6	16	7	12
3	Three wheeler Vehicles	1,463	1,813	1,380	1,248	1,320	1,458
4	Other Light	1,053	1,846	2,151	2,044	2,234	2,064

Sr. No	Type of Vehicle	2010 to 11	2011 to 12	2012 to 13	2013 to 14	2014-15	2015-16
	Vehicles						
Passenger Vehicle							
5	Buses	154	97	132	140	67	56
6	Maxi Cab	229	168	263	119	210	178
7	Cars/ Station Wagon	15,845	19,525	16,020	14,430	15,543	16,343
8	Taxi cab	309	178	187	182	230	198
9	School Bus		35	150	93	54	34
10	Ambulance		11	27	28	21	11
11	Private service vehicles			39	12	23	
12	Jeep				25		
13	Three wheeler Auto Rickshaw	2,054	2,639	2,189	1,450	1,624	2,125
Two Wheeler							
14	Motorcycle	70,634	91,193	68,186	54,076	62,122	87,243
15	Scooter/Mopeds	10,048	14,071	17,415	30,396	35,764	27,863
Tractor							
16	Tractor	3,294	4,494	1,923	2,137	1,876	1,675
Trailer							
17	Trailer	2,064	2,320	674	288	176	187
Others							
18	JCB, Crane, Tractor, Loader etc.	854	1,097	726	796	690	564
Total		108,996	141,477	112,572	108,265	122,884	141,109

2.1.7.4.4 Registered vehicles by fuel type

Total numbers of fuel wise registered vehicles in city is as below. It was noted that sales of vehicle decreased in year 2013. Surprisingly, use of CNG vehicles in city is decreasing in city with respect to total vehicle population. It has been noted that use of LPG vehicles in city is decreasing rapidly. Numbers of petrol and diesel vehicle is increasing in city, leads to air pollution.

Fuel Type	Year				
	2010	2011	2012	2013	2014
Petrol	74396	105699	95025	86856	106137
Diesel	6842	10894	14353	13560	16044
Petrol/ CNG	5355	6886	4789	3107	3518
Petrol/ LPG	448	575	233	56	70

2.1.7.4.5 Upcoming new Transportation projects and plans

Project Name	Budget Allocation through state or central government scheme	Existing status
Combined ticketing for BRT and RMTS with automated fare collection system is proposed	RMC budget 2017-18	Planned
10 new cycle sharing stations	RMC budget 2017-18	Planned
Construction of Multilevel car parking	BOT	Planned
Development of new dedicated cycle track and walk way to promote NMT in city	RMC budget 2017-18	Planned
Free cycle parking facility at cycle stations for people using public transportation	RMC budget 2017-18	Planned
Foot over bridge for three traffic junction	RMC budget 2017-18	Planned
Procurement of battery operated vehicles for RMC officers for office work	RMC budget 2017-18	Planned
Construct cycle track and hawkers zone in an open drain (vokda in local language) from Jankalyan society to Sarveshwar chowk	RMC budget 2017-18	Planned
Assess the potential for last mile connectivity and electrification of BRTS corridor under CapaCITIES project	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project	On-going

2.1.7.5 Public Housing

There are 124 slums in the city with approximately 20% of the households residing in it. RMC has taken initiative to provide affordable housing projects under various government schemes i.e. Basic Service for Urban Poor (BSUP) under JnNURM, Rajiv Awas Yojana (RAY), Mukhya Mantri Awas Yojana (MMGY), Affordable Housing in Partnership (AHP), Safai Kamdar Awas Yojana (SKAY) and Pradhan Mantri Awas Yojana (PMAY) under Housing for All. Rajkot Municipal Corporation is taking care of building design and environment friendly infrastructure i.e. rain water harvesting, use of solar lights, maximum use of day light in their affordable housing schemes. Rajkot Municipal Corporation received support under Swiss agency for Development and Cooperation funded “Building Energy Efficiency Project” to make affordable housing more green and energy efficient through change in design and orientation. Design Charette was organized under this project for "SMART Ghar-3"; all suggested intervention was taken into consideration by Rajkot Municipal Corporation.

2.1.7.5.1 Overall Planning

Total 11,965 dwelling units are under construction and 3,693 dwelling units are under planning by Rajkot Municipal Corporation. Rajkot Municipal Corporation has proposed ~10000 more additional units by 2020 (See table 8).

Table 8 Total Number of dwelling units under various state and central government schemes

Name of Scheme	Total number of Housing units	
	Under Progress	Under Planning
Rajiv Awas Yojana (RAY)	631	
Basic Service for Urban Poor (BSUP)	1,512	
Safai Kamdar Awas Yojana (SKAY)	512	
Mukhya Mantri Awas Yojana (MMGY)	2,142	
RAY Affordable Housing in Partnership (AHP)	2,546	
Pradhan Mantri Awas Yojana (PMAY) Affordable Housing in Partnership (AHP)	3,410	1,808
Public Private Partnership (PPP)	1,212	1,677
Gujarat Redevelopment Public Housing Policy on PPP Basis-2016		208
Total	11,965	3,693

(Source – Housing Department, Rajkot Municipal Corporation)

2.1.7.5.2 Current status of affordable housing scheme

Rajkot Municipal Corporation has proposed various in-site redevelopment and relocation projects under various state and central government schemes as mentioned below (See tables 9 and 10).

Table 9 Number of dwelling units and type of projects proposed by affordable housing department

Type of project	Name of Scheme	Number of DUs
In-situ Redevelopment	RAY	887
Redevelopment project	BSUP III	1512
Relocation projects	PMAY-AHP	3600
In-situ Redevelopment	PPP (RMC land+Gov. land)	1777
Proposed projects	PPP-PMAY	905

(Source – Housing Department, Rajkot Municipal Corporation)

Table 10 Project sites and proposed dwelling units by Affordable housing department

Sr. No.	Housing Scheme	Project Site	DUs Planned	Project status
1	Ray	Natrajnagar	252	Completed
2	Ray	Gokul Nagar	335	Work in Progress
3	Ray	Kittipara	300	Completed
4	BSUP III	Popatpara, Raiyadhar	1512	Work in Progress
5	MMGY	EWS Units	2540	Half Completed
6	MMGY	LIG Units	2142	Work in Progress
7	SRS-PPP under PMAY	Raiyadhar, Bharatnagar, Bishop house	442	Work in Progress
8	PMAY-AHP	TP28, FP49/A, Mavdi, Ward 13	352	Proposal sent to Standing committee

9	PMAY_AHP	EWS housing	1266	Work in Progress
Total			9141	

(Source – Housing Department, Rajkot Municipal Corporation)

2.1.7.6 Electricity

Paschim Gujarat Vij Company Ltd. (PGVCL) is the distribution utility responsible for distribution of electricity in the Western parts of the State of Gujarat and supplies electricity to Rajkot city. The electricity consumption for Rajkot has been growing at an annual rate of 6.1%, with a total consumption of 1,508 Million kWh in the year 2015.

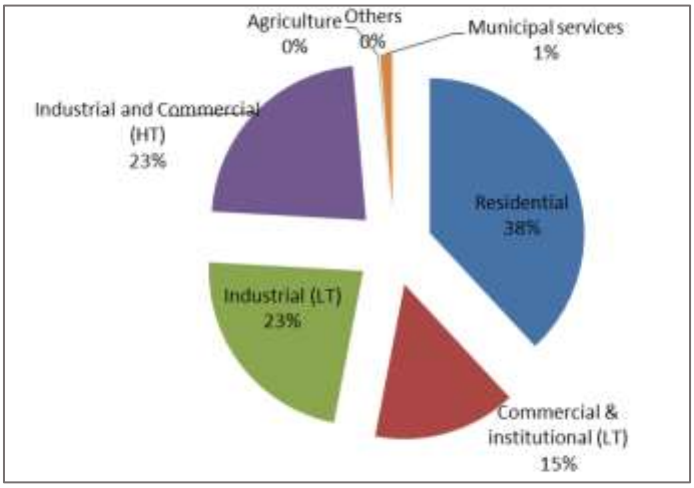
Table 11 Year-wise Total Electricity Consumption for Rajkot City

Year	2011	2012	2013	2014	2015	Average Annual Growth Rate (%)
Total Annual Electricity Consumption (Million kWh)	1,211	1,262	1,322	1,464	1,508	6.1%

(Source: PGVCL, Regional Office - Rajkot)

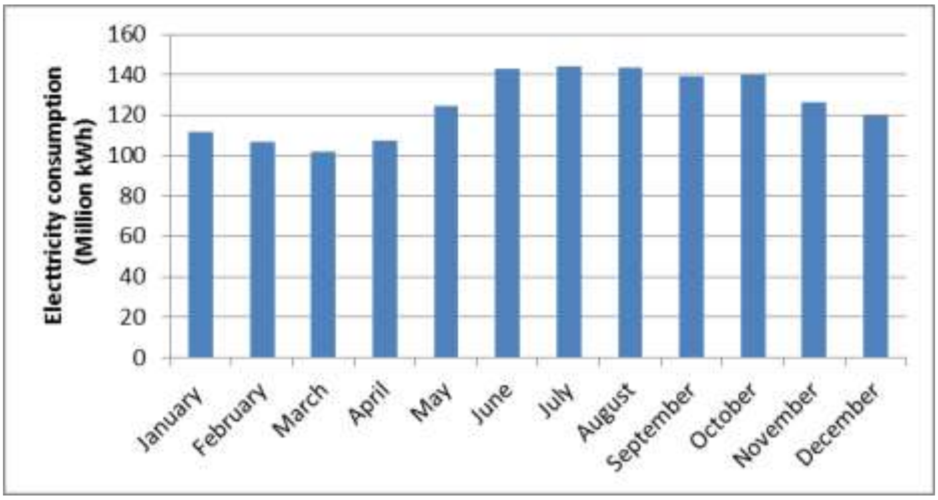
The Residential sector is the largest end-use consumer accounting for 38% of the total electricity consumption, followed by the Industrial Low tension consumers (23%), High Tension consumers (23%), and Commercial and Institutional consumers (15%).

Figure 13 Share of Electricity Consumption by End-Use Consumers for Rajkot City (2015)



Monthly energy consumption is useful in understanding minimum and peak consumption in city and the seasonal variations therein. The monthly power consumption indicates that energy consumption is increasing from March till October, with the highest electricity consumption of 144 Million kWh taking place in the month of July, a rise of about 40% compared to the electricity consumption in March due to increase in cooling demand due to high temperature and humidity.

Figure 14 Month-wise Electricity Consumption for Rajkot City (2015)



(Source: Analysis based on data from PGVCL, Regional Office - Rajkot)

3 Baseline Assessment

3.1 GHG Emissions Inventory Report

GHG emission inventory for year 2011 to 2015 was prepared under CapaCITIES project. The emissions inventory comprises of two parallel analyses, one for the local government operations and one for all the emissions within the community determined by the geographical boundaries of the Municipality's jurisdiction.

Community-level inventories include emissions from community activities within the local government's jurisdiction. This includes emissions from sources and/or activities from stationary units (residential, commercial/institutional facilities, industrial, agricultural), mobile transportation units, waste, industrial processes and product use, and agriculture, forestry and land-use. A community-wide inventory is a useful planning tool in developing mitigation actions for the entire community.

Local Government operations inventories include emissions from all of the operations that a local government owns or controls. Sectors included in a local government operations inventory include local government buildings, facilities such as street lighting and traffic lighting, water, waste and sewage facilities, municipal vehicle fleet. Based on the baseline inventory, the local government can demonstrate leadership by pursuing mitigation efforts that illustrate the possibilities of mitigation actions to the community.

The majority of emissions from local government operations are usually a subset of the community emissions. The GHG inventory of a city is not simply the sum of GHG emissions from its community and those from local government operations. Many a times, the community inventory data already accounts for data pertaining to local municipal operations and due care should be taken to avoid double counting by adding such data to the community inventory again.

For example, community-wide electricity consumption data may already include electricity consumption in municipal facilities for water supply, sewage treatment and street lighting under relevant customer/end-user categories as prescribed under the electricity distribution and tariff arrangements. Adding electricity consumption data in such facilities, obtained from the respective departments within the local government, to the community-wide data again will result in double counting.

It must however be acknowledged that analyzing community-scale emissions presents its own challenges as the natural flow of energy and materials is typically most accurate at the national level. Reducing the spatial area of an analysis, from national to sub-national level results in a lower level of accuracy in reflecting the energy flows. Therefore, analyzing GHG emissions at a local community level 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 are situated within the municipal boundary of Rajkot and are therefore contributing to the Municipality's carbon footprint, as well as to the local air pollution.

3.1.1 Harmonized Emission Analysis Tool plus (HEAT+)

In an effort to develop a comprehensive energy and carbon inventory, understand the city activities, measure the emissions, and provide options of mitigation measures best suited for the local government's development plans, an ICLEI emissions accounting software package was used to assist with the analysis. Harmonized Emission Analysis Tool Plus (HEAT+) 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 the tool used for GHG emissions.

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 on-line 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.

3.1.2 Data Sources and Collection

The baseline year for this study was the financial year of 2015-16 (i.e. April 2015-March 2016**)**. 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 due to limited data availability.

A full GHG inventory includes emissions from energy, waste, agriculture, forestry and land-use change, the direct emissions from agriculture, land-use change and forestry sectors have not been included in the analysis as it is not happening with in city boundary.

ICLEI South Asia and Rajkot Municipal Corporation 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 was therefore collected and analyzed.

Supply-side refers to the classification of both primary and secondary energy types that are distributed to the demand-side for use; these include liquid and solid fuels, electricity and renewables. Demand-side energy refers to the energy end user, i.e. the sectors like residential, commercial, industrial users of energy within and urban jurisdiction. The various sources of energy & other relevant data used in the report are elaborated in table 12.

Table 12 Supply and demand side Data Sources

Fuel Type	Sector	Source of Data
Electricity	Residential	Paschim Gujarat Vij Company Limited (PGVCL)
	Commercial/Institutional	Paschim Gujarat Vij Company Limited (PGVCL)
	Manufacturing Industry and Construction	Paschim Gujarat Vij Company Limited (PGVCL)
	Municipal Buildings	Various departments of RMC – i.e. Lighting department, Accounts department, Gardening department, Drainage department, SWM department, Municipal budget (2015-16)
	Water works department – Water treatment plant and pumping stations	Water works department, RMC and Municipal Budget (2015-26)
	Drainage department – drainage pumping stations and sewage treatment plants	Drainage department, RMC and Municipal Budget (2015-26)
	Street lights	Lighting department, RMC
	Solid waste management – waste transfer stations	SWM department, RMC and Municipal Budget (2015-26)
Diesel	Community Transport	IOCL- Rajkot; HPCL-Rajkot, BPCL- Rajkot, Essar Rajkot, reliance – Rajkot, Shell – Rajkot
	Manufacturing Industry and Construction	IOCL- Rajkot; HPCL-Rajkot, BPCL- Rajkot, Essar Rajkot, reliance – Rajkot, Shell - Rajkot

Fuel Type	Sector	Source of Data
	Municipal Vehicles	SWM & Fire brigade Department RMC, Workshop of RMC, Public transport department of RMC, Annual Budget of RMC (2015-16)
	DG sets at water pumping stations and water treatment plants	Water works department, RMC
	DG sets at drainage pumping stations and Sewage treatment plants	Drainage department, RMC
Petrol	Community Transport	IOCL- Rajkot; HPCL-Rajkot, BPCL- Rajkot, Essar Rajkot, reliance – Rajkot, Shell - Rajkot
	Manufacturing Industry and Construction	IOCL- Rajkot; HPCL-Rajkot, BPCL- Rajkot, Essar Rajkot, reliance – Rajkot, Shell - Rajkot
	Municipal Vehicles	SWM & Fire brigade Department RMC, Workshop of RMC, Public transport department of RMC, Annual Budget of RMC (2015-16)
LPG	Residential	Indane Gas- Rajkot; Bharat Gas-Rajkot; Hindustan Gas – Rajkot
	Commercial/Institutional	Indane Gas- Rajkot; Bharat Gas-Rajkot; Hindustan Gas – Rajkot
	Auto LPG – Transportation	Indane Gas- Rajkot; Bharat Gas-Rajkot; Hindustan Gas – Rajkot
Kerosene	Residential	IOCL- Rajkot; HPCL-Rajkot; BPCL- Rajkot
Coal	Manufacturing Industry and Construction	Gujarat Pollution Control Board (GPCB)-Rajkot
Furnace Oil	Manufacturing Industry and Construction	IOCL-Rajkot; HPCL-Rajkot; BPCL- Rajkot; Essar Rajkot; reliance – Rajkot; Shell – Rajkot
Light Diesel Oil	Manufacturing Industry and Construction	IOCL-Rajkot; HPCL-Rajkot; BPCL- Rajkot; Essar Rajkot; Reliance – Rajkot; Shell – Rajkot
CNG	Community Transport	GSPC Gas Company Limited-Rajkot
PNG	Residential	GSPC Gas Company Limited-Rajkot
	Commercial/Institutional	GSPC Gas Company Limited-Rajkot
	Manufacturing Industry and Construction	GSPC Gas Company Limited-Rajkot
Transport Sector		Regional Transport Office (RTO) - Rajkot

Fuel Type	Sector	Source of Data
Solid Waste Management in Rajkot		SWM Department, RMC; Annual Budget of RMC (2015-16)
Municipal Water Supply		WW Department, RMC; Annual Budget of RMC (2015-16)
Municipal STP		Drainage Department; Annual Budget of RMC (2015-16)
Municipal Street Lighting		Lighting Department, RMC
Municipal Vehicle Fleet		Central Workshop Department, RMC

3.1.3 Summary of Economy wide Energy Consumption and GHG Emission Baseline

Overall sector wide Energy consumption trend has been shown in Figure 15. Trend of energy consumption is linearly increasing with annual average growth rate of 4% from 2011-12 to 2015-16. Annual average growth rate is highest in commercial and institutional sector with 6.7%, followed by transportation sector (5.2%), residential buildings (3.2%) and manufacturing industries and construction (1.4%). The total GHG emission for Rajkot city was 1,887,684 tonnes of carbon dioxide equivalent (CO_2e) in the year 2015-16. Taking this into consideration, the average per capita GHG emission for the year 2015-16 for the Rajkot city area was 1.33 tonnes of CO_2e, which is less than India's per capita GHG emission 1.56 tCO_2e for the year 2010[2]. Sector-wise trend of Energy use and GHG emission has been shown in Table 13 and 14.

Table 13 Sector-wise trend of energy use (GJ) per year

Sector	Energy Consumption (GJ)				
	2011-12	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Residential Buildings	4,107,895.8	4,224,655.2	4,170,781.0	4,292,779.9	4,759,044.3
Commercial and Institutional buildings/facilities	754,682.1	653,096.8	798,063.1	910,512.9	1,008,827.3
Manufacturing Industries and Construction	2,146,739.0	2,548,903.7	2,622,177.2	2,586,607.8	2,298,594.8
Transport	6,066,655.9	6,474,645.7	6,557,883.0	6,933,354.6	7,649,868.1
Total	**13,075,972.6**	**13,901,301.4**	**14,148,904.2**	**14,723,255.2**	**15,716,334.5**

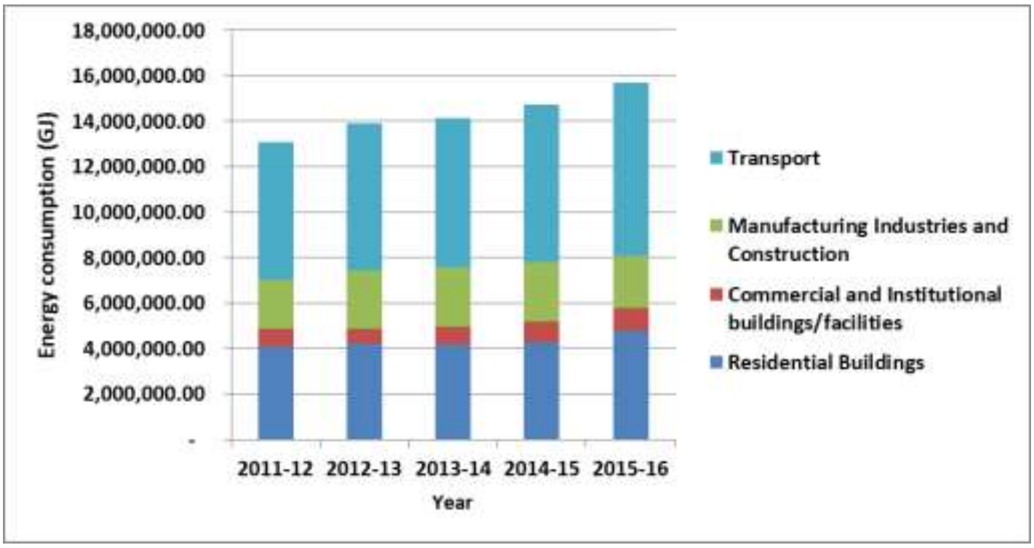
Table 14 Sector-wise trend of GHG emission (tCO2e) per year

Sector	GHG Emissions (tonnes of CO2e)

[2] India: First Biennial Update Report to the United Nations Framework Convention on Climate Change (2016), http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=7828#beg

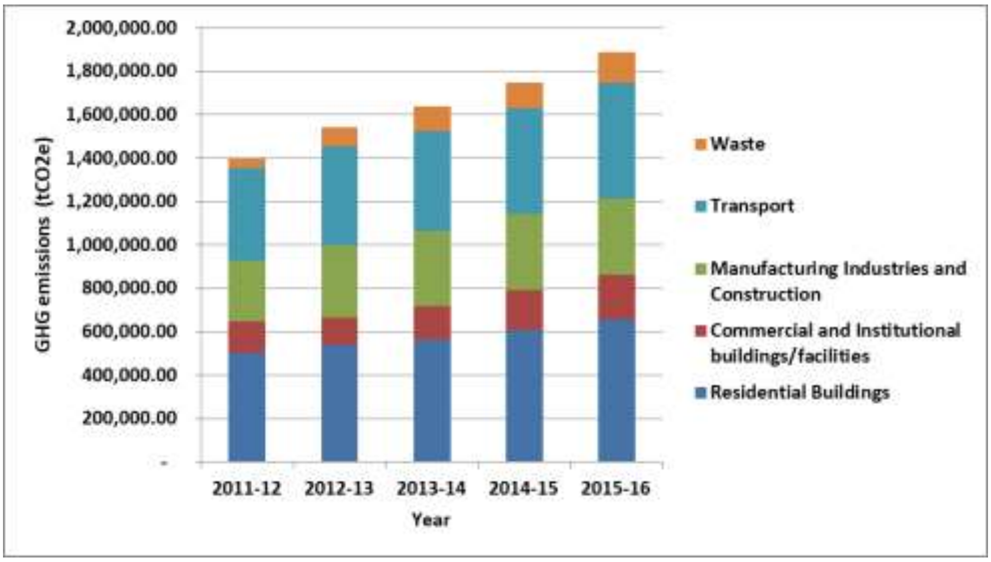
	2011-12	2012-13	2013-14	2014-15	2015-16
Residential Buildings	504,855.8	538,815.2	563,349.7	608,609.6	655,578.2
Commercial and Institutional buildings/facilities	143,484.3	127,747.7	157,286.2	183,066.5	207,597.4
Manufacturing Industries and Construction	279,959.4	334,210.9	346,275.5	352,243.0	349,362.2
Transport	426,015.6	454,380.4	460,191.0	485,277.9	534,818.2
Waste	44,826.6	86,872.6	112,469.7	119,778.2	140,329.0
Total	**1,399,141.8**	**1,542,026.7**	**1,639,572.0**	**1,748,975.3**	**1,887,684.9**

Figure 15 Sector wide trend of Energy Consumption from 2011 to 2015



Overall sector wide trend of GHG emission has been shown in Figure 16. Trend of GHG emission is linearly increasing from 2011 to 2015. Trend of energy consumption is linearly increasing with annual average growth rate of 7% from 2011-12 to 2015-16. Annual average growth rate is highest in waste sector with 42.6%, followed by commercial and institution sector (8.9%), residential buildings (6%), transportation sector (5.1%) and manufacturing industries and construction (5%).

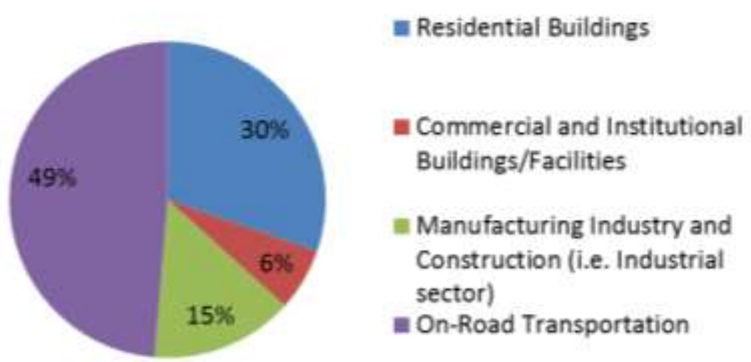
Figure 16: Sector wide trend of GHG emissions from 2011 to 2015



3.1.4 Energy consumption and GHG emission baseline

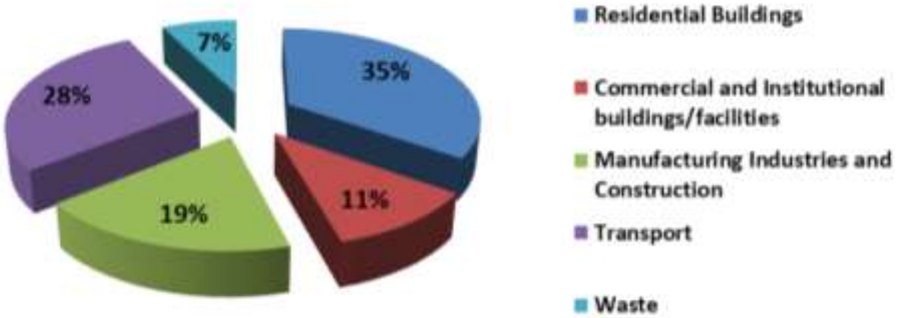
2015-2016 is considered as the baseline for the Climate Resilient City Action Plan in Rajkot. Figure 17 gives a summary of the energy baseline in 2015-16. On-road Transportation is the largest consumer of energy in Rajkot, accounting for 49% of the energy use (see figure 17). This is followed by energy use in Residential Buildings sector which accounts for 30% of the energy consumption. Energy use in Manufacturing Industry and Construction is also noteworthy.

Figure 17 Share of Energy Consumption by Sector in Rajkot, 2015-16



In line with the trends of energy demand, the major contributors to GHG emission are Residential buildings and On-road Transportation sector, followed by Manufacturing Industry and Construction (see figure 18). Residential building energy use contributes to 35% of the total GHG emission while On-road Transportation accounts for 28% of the emission. Percentage share of Manufacturing Industry and Construction sector, waste sector, and Commercial/Institutional sector is 19%, 11%, and 7% respectively. It has been noted that GHG emission from Residential sector is higher as use of thermal electricity is higher in sector.

Figure 18 Share of GHG Emission by Sector in Rajkot, 2015-16



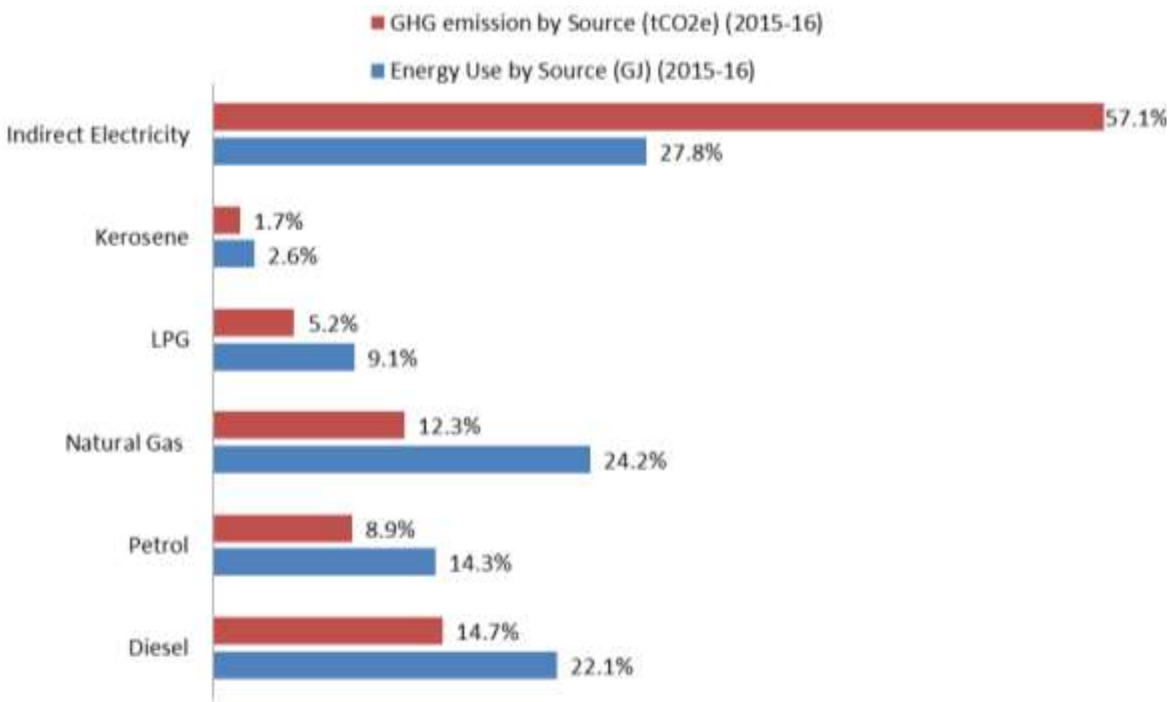
3.1.5 Supply Side Energy and Emissions

Supply-side refers to the classification of both primary and secondary energy types that are distributed to the demand-side sectors for use; these include liquid, solid and gaseous fuels, electricity and renewables.

Grid electricity is the dominant energy type, typically associated with consumption in residential, commercial/institutional and industrial sectors. Petroleum products are the second dominant fuel type consumed, typically used for community transportation in the city as well as in the industrial sector

Electricity is the predominant energy type in Rajkot city and makes up 27.4% of the energy mix, being used prominently in all sectors (See figure 19) Electricity is followed by natural gas, diesel, petrol, LPG and kerosene. It is interesting to note that although electricity accounts for 27.8% of the energy mix it contributes to 57.1% of the GHG emission in Rajkot, largely due to India's GHG intensive thermal power based generation system.

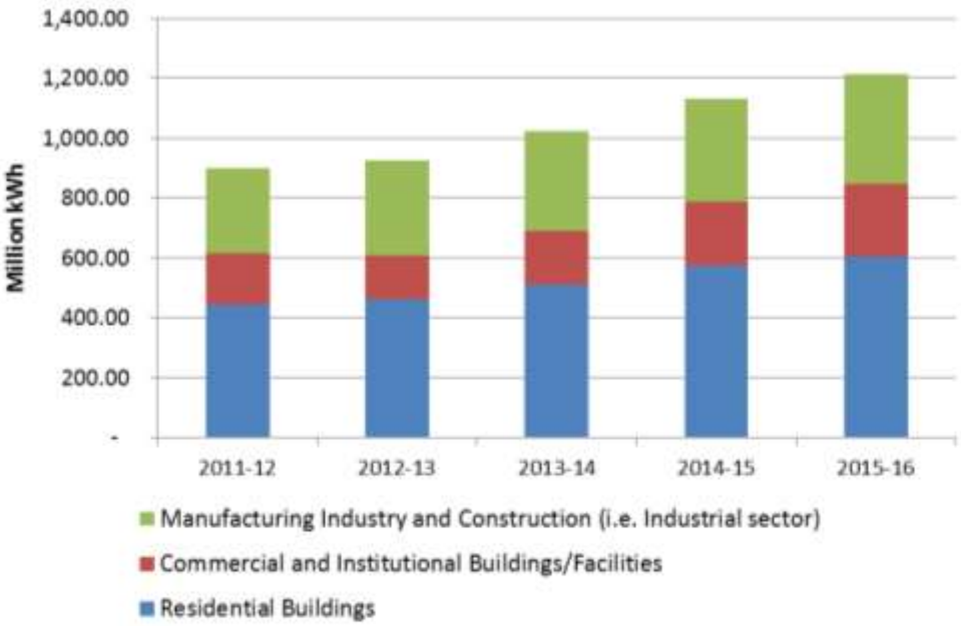
Figure 19 Share of Energy Consumption and GHG Emission by Energy Source



3.1.6 Energy Indirect Emissions from Grid Electricity at the Community Level

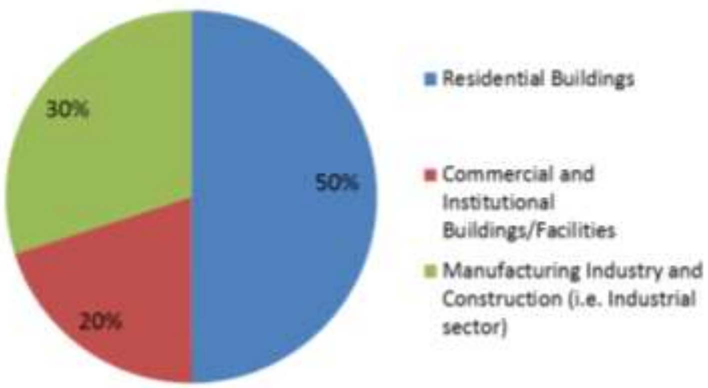
The pattern of electricity use within the city has undergone significant changes in the last few years; the consumption grew by over 311 million kWh in the period of 2011-12 to 2015-16 (903 million kWh in 2011-12 to 1,213 million kWh in 2015–16). Owing to the higher demands, a significant amount of the load of electricity used by commercial consumes has been shifted to the high tension (HT) distribution network after 2011–12. The shift of electricity consumption from low to high tension electricity distribution has taken place between2010–11 and 2012–13 (see figure 20).

Figure 20 Trend of Electricity Consumption by Sectors



The Residential Buildings sector is the largest end user of electricity accounting for almost half of the city-wide consumption. This is followed by Manufacturing Industry and Construction and the Commercial/Institutional Sectors, which consume 30% and 20% respectively. (See figure 21). Electricity consumption of year 2012-13 shows slightly decreased in commercial consumption and increase in industrial consumption, as some of the big commercial units shifted as small scale industrial units.

Figure 21 Share of Electricity Consumption by sector in 2015-16



3.1.6.1 GHG Emissions from Electricity Consumption

The total GHG emission from electricity use in the year 2015-16 in Rajkot was 931,664 tCO_2e. 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 consumption of electricity. The residential sector is the largest contributor, emitting 498,591 tCO_2e. Manufacturing Industry and Construction and Commercial/ Institutional sectors emit 299,164 tCO_2e and 200,397 tCO_2e respectively (See figure 22 and 23).

Figure 22 Sector-wise trend of GHG Emission from Electricity Consumption in Rajkot

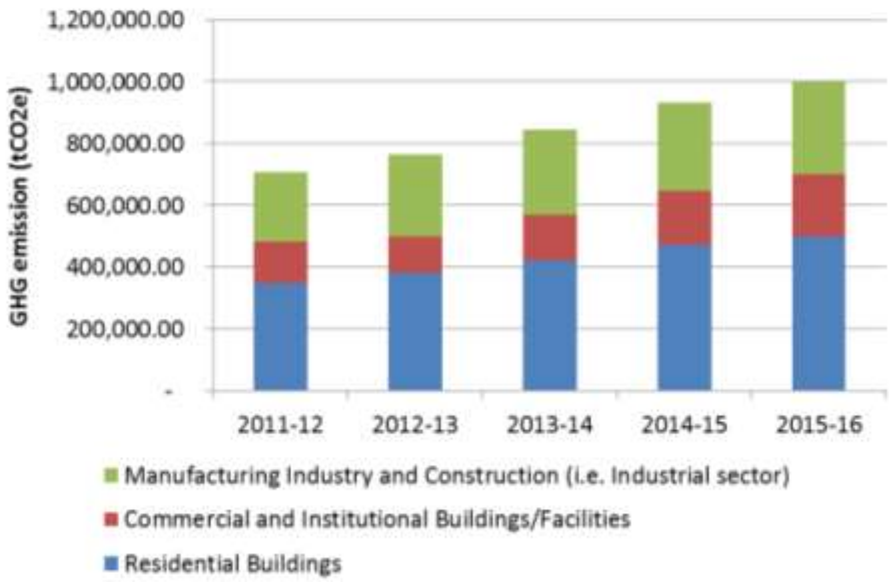
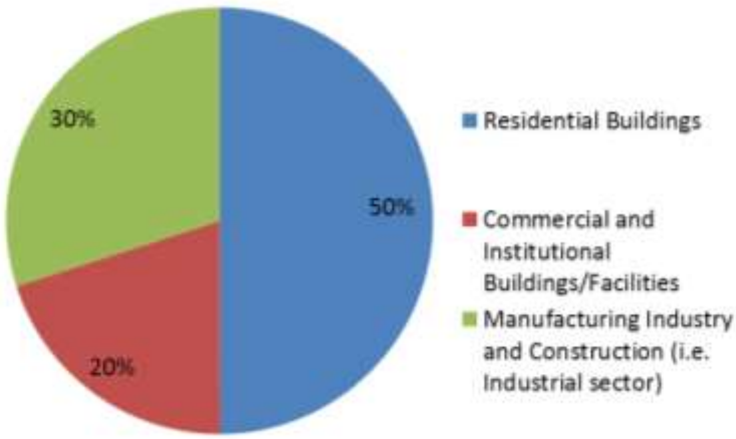


Figure 23 Share of GHG emission by sector from electricity in 2015-16



3.1.7 Direct Emission from Stationary Combustion at the Community Level

Stationary combustion refers to the fuel use for all purposes other than transportation (e.g. burning of kerosene and LPG for residential use, furnace oil used for industrial purposes). The direct GHG emissions are driven by the volume and type of fuels used for stationary combustion across sectors such as residential, commercial/institutional and industrial. The direct emissions are estimated by multiplying the fuel consumption by the specific GHG emission factor for the fuel.

3.1.7.1 Residential Buildings Sector

The fuels used to meet cooking and heating requirements in the Residential Buildings sector in the city are kerosene, LPG and PNG. LPG is retailed by the Indane, Hindustan Gas and Bharat Gas and PNG is supplied by GSPC through the pipeline network within Rajkot. Subsidized kerosene is distributed through the Public Distribution System (PDS) and plays an important role in meeting energy demands, particularly for low income households. Trend of PNG consumption is increasing while kerosene and LPG consumption is decreasing (see figures 24 and 25).

Figure 24 Trend of Fuel (Kerosene, LPG and PNG) Consumption by Residential Buildings Sector

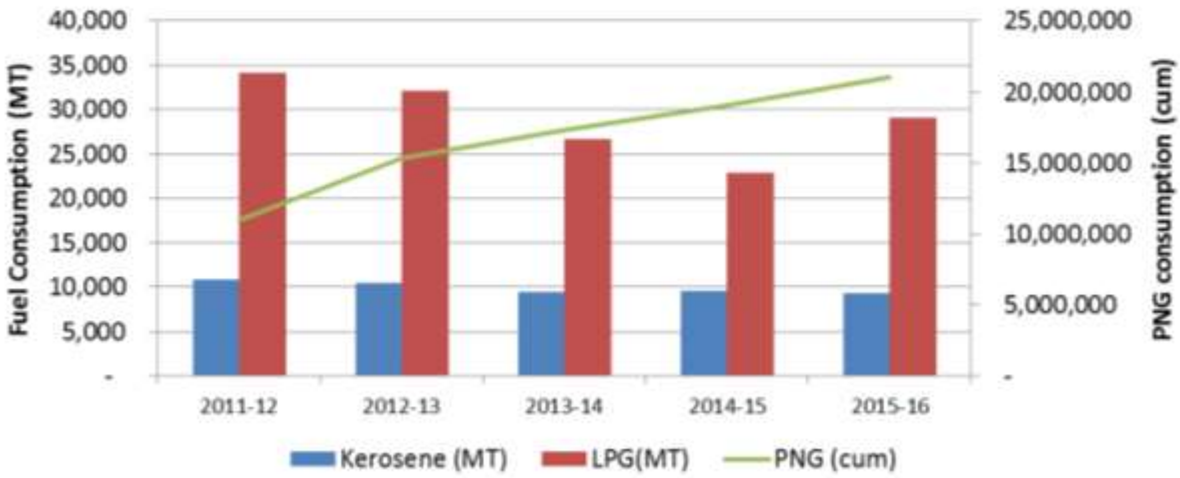
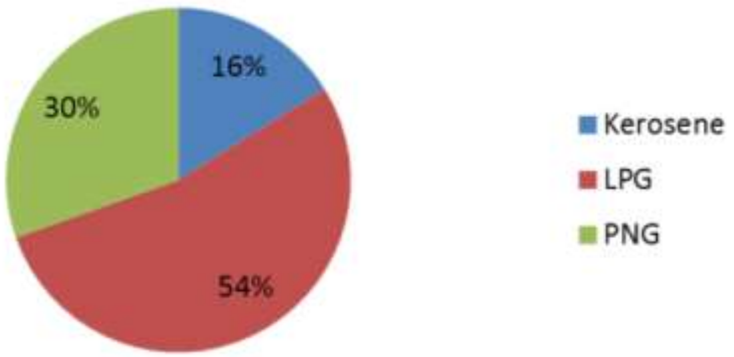


Figure 25 Share of Stationary Energy Use by Fuel in the Residential Buildings Sector, 2015-16



3.1.7.1.1 GHG Emissions from Stationary Fuel-use in Residential Buildings Sector

In the last five years, there has been a marginal decrease in the overall level of emissions generated from stationary fuel use in Rajkot. The CO_2 emissions from stationary fuel use fell from 158,334 tCO_2 in 2011-12 to 156,989 tCO_2 in 2015-16. This marginal decrease can be attributed to the decrease in consumption of LPG and increase in consumption of PNG. This trend has been demonstrated in figure 24.

Figure 26 Trend of GHG emissions by Stationary Fuel in the Residential Buildings Sector

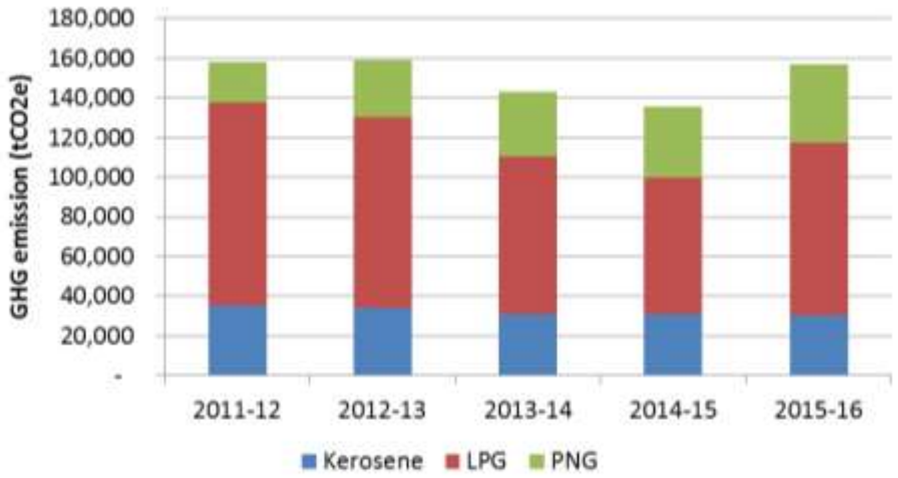
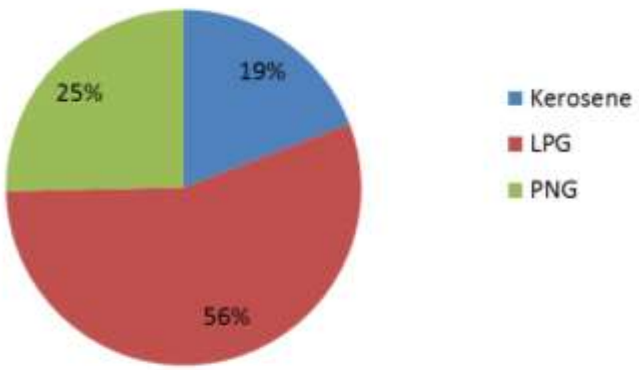


Figure 27 Share of GHG emissions by Stationary Fuel in the Residential Buildings Sector, 2015-16



3.1.7.2 Commercial and Institutional Buildings/Facilities Sector

The primary fuels used by commercial end users in Rajkot such as hotels, shops, malls, educational institutes, private office buildings etc. are piped natural gas (PNG) and liquefied petroleum gas (LPG), combusted mainly to meet energy requirements for cooking and water heating purposes. Bharat Gas, Hindustan Gas and Indane are the companies supplying LPG to commercial/institutional and residential sectors in Rajkot city, through a network of dealers. PNG is supplied by GSPC through its gas distribution pipeline network.

Figure 28 Trend of fuel Consumption in the Commercial/Institutional Sector

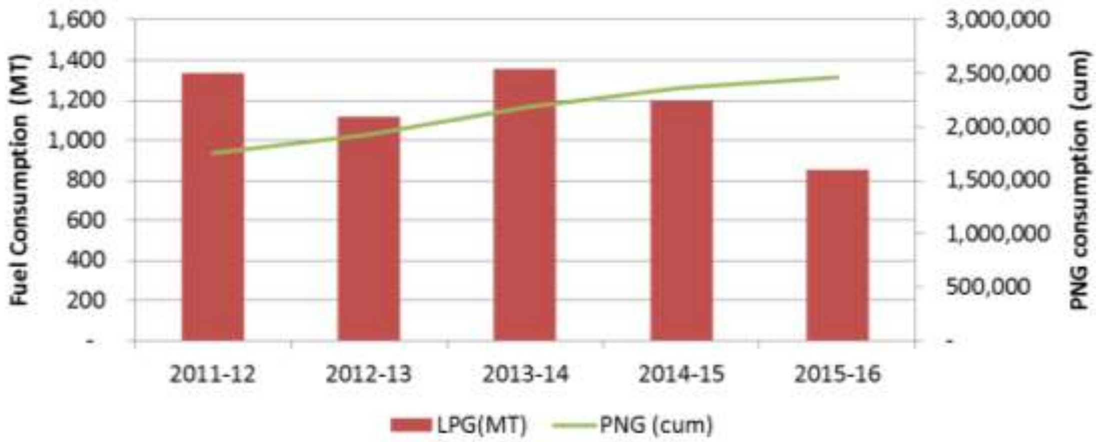
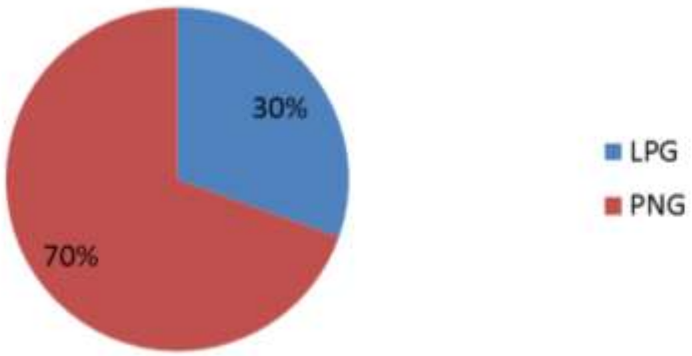


Figure 29 Share of fuel Consumption in the Commercial/Institutional Sector, 2015-16



3.1.7.2.1 GHG Emissions from Stationary Fuel-use in Commercial/Institutional Sector

In the last five years, there has been a significant decrease in the overall level of emissions generated from stationary fuel use in Commercial/Institutional sector in Rajkot. The CO_2 emissions from stationary fuel use decreased from 7,304 tCO_2 in 2011-12 to 7,200 tCO_2 in 2015-16 due to shift to PNG from LPG. This trend has been demonstrated in figure 28.

Figure 30 Trend of GHG emissions from Commercial/Institutional Sector

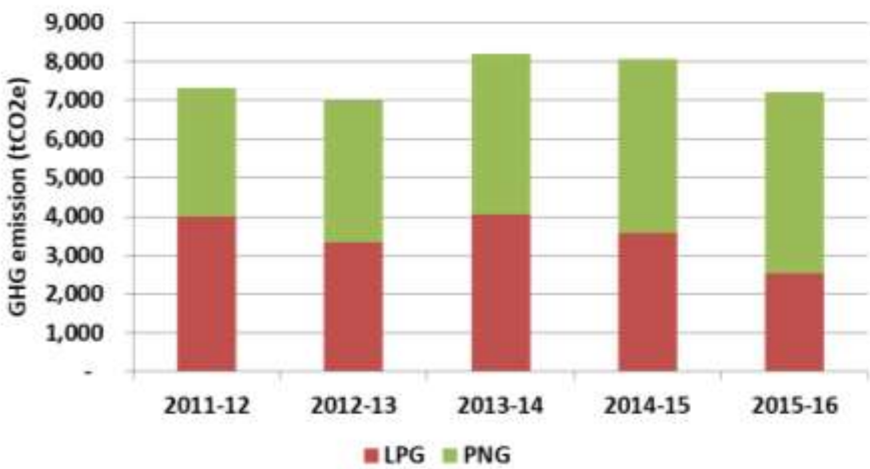
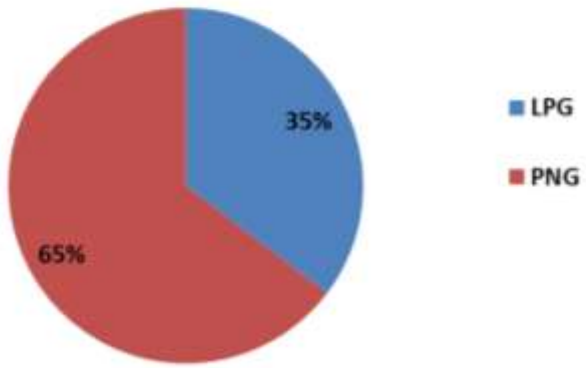


Figure 31 Share of GHG emissions from Commercial/Institutional Sector, 2015-16



3.1.7.3 Manufacturing Industries and Construction Sector

Rajkot is an industrial town. Rajkot is one of the biggest centers for the engineering industry. This is because a great number of foundry, automobiles, diesel engines, machine tools and bearing units are manufactured in Rajkot.

The major fuels consumed to meet industrial energy demand in the city are PNG and furnace oil. PNG is supplied directly to the industrial premises by GSPC through its distribution pipeline network. One industry has demanded for furnace oil in year 2014-15, which has shifted to PNG now. Some of the fuel intensive industrial units were closed or shifted out of city periphery during year 2014 and 2015.

Figure 32 Trend of Fuel Consumption in Manufacturing Industries and Construction Sector

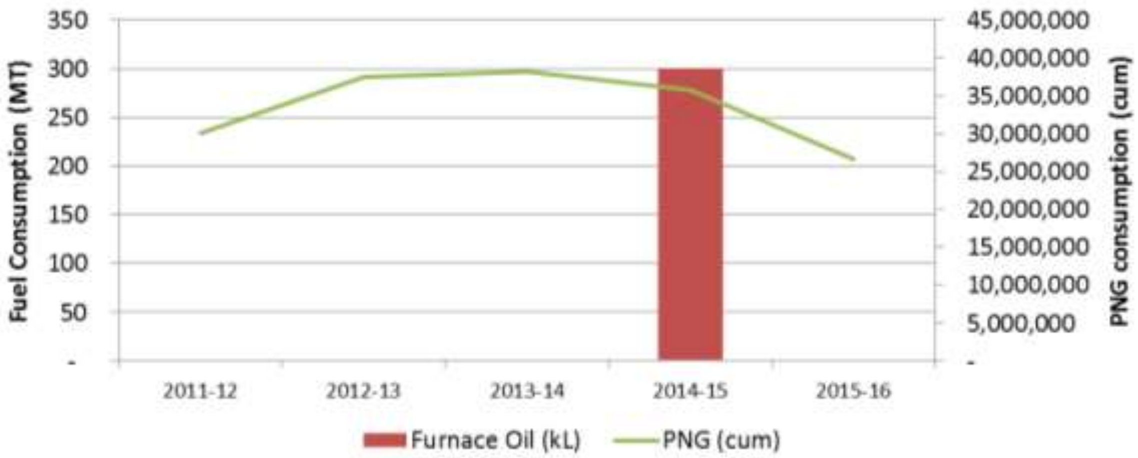
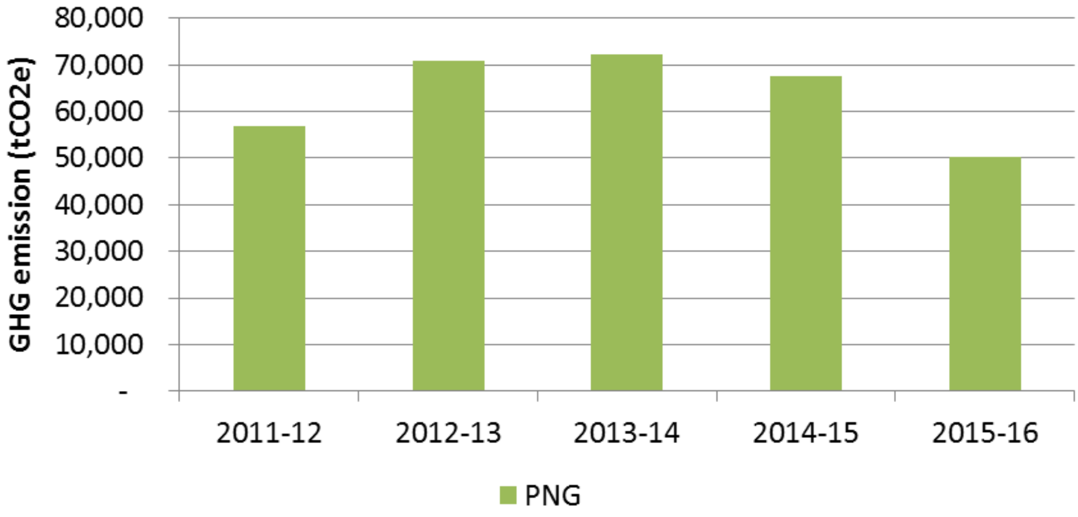


Figure 33 Trend of GHG Emission from Stationary Fuel Use in Manufacturing Industry and Construction Sector



3.1.7.4 On-road Transportation

The major fuels used for transportation in Rajkot are diesel, petrol and CNG. Bharat Petroleum Corporation Limited (BPCL), Hindustan Petroleum Corporation Limited (HPCL), Indian Oil Corporation Limited (IOCL), Essar, Reliance, Shell and GSPC are the oil and gas companies retailing these fuels across petrol pumps and gas stations in the city.

It has been noted that instead of decrease in registered CNG vehicles in city, CNG consumption is increasing as many of petrol or diesel vehicles have installed CNG kit in vehicles and shifted to CNG, which will not reflect in vehicle registration information.

Figure 34 Trend of Fuel Consumption for Road Transportation

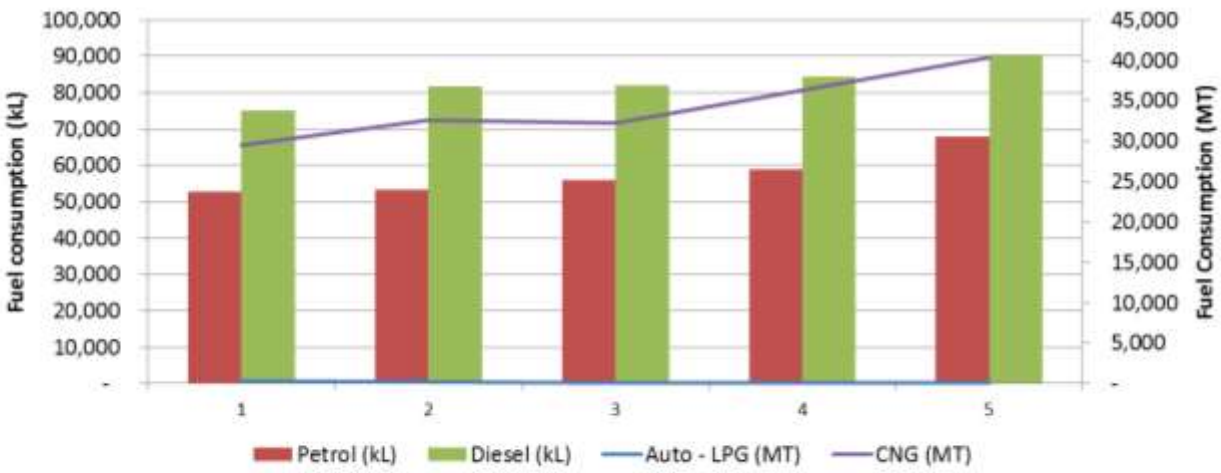


Figure 35 Share of stationary Energy Use by fuel in the road transportation, 2015-16

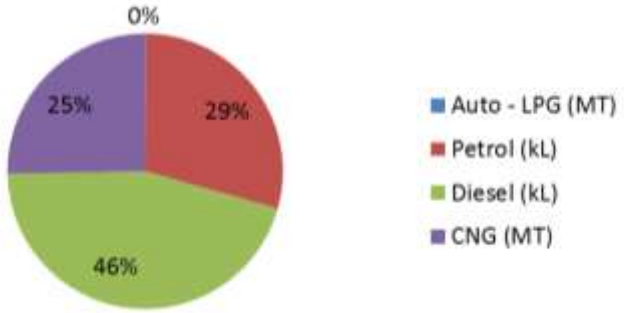
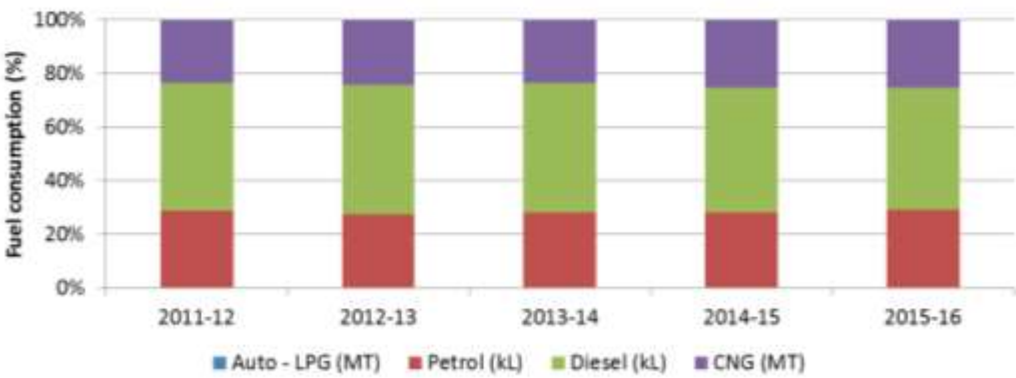


Figure 36 Share of Energy Use by Type of Fuel in the Transport Sector



3.1.7.4.1 GHG Emissions from On-road Mobile Sources

Figure 37 Trend of GHG emissions from On-road Mobile Sources

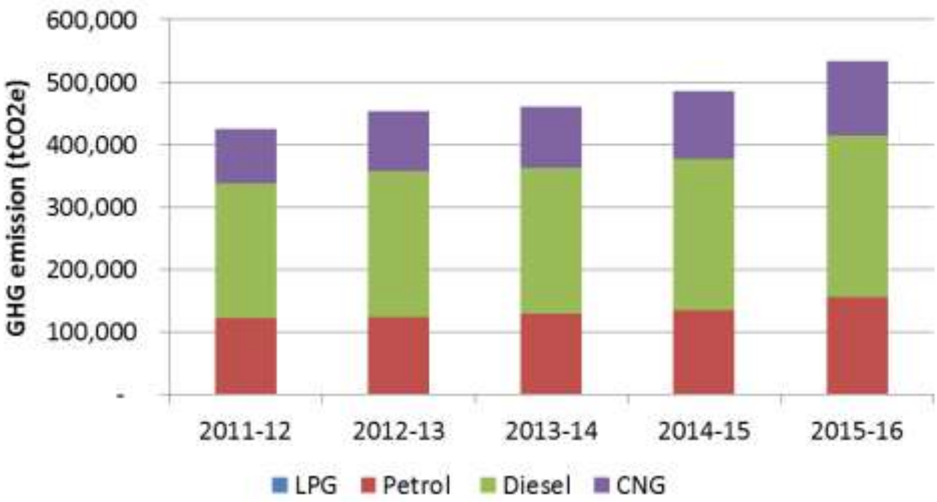
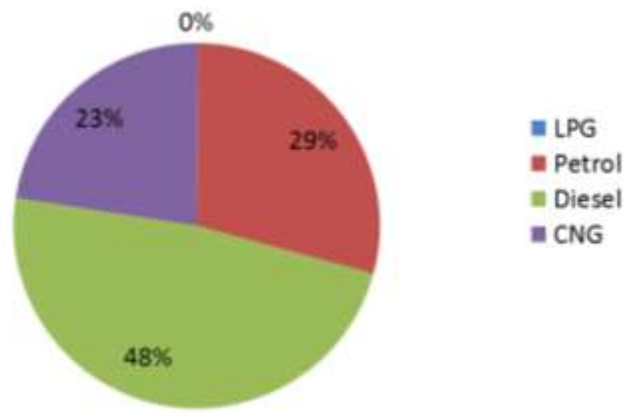


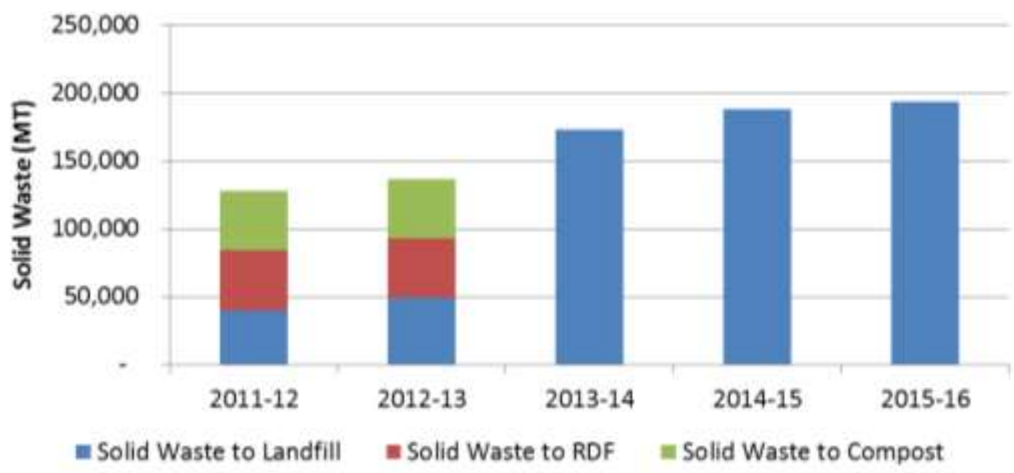
Figure 38 Share of GHG emissions from On-road Mobile Sources, 2015-16



3.1.7.5 Solid Waste Treatment and Disposal at the community level

Municipal solid waste (MSW) generally includes degradable matter (such as paper, textiles, food waste, straw and yard waste), partially degradable matter (such as wood, disposable napkins, sludge) and non-degradable materials (such as leather, plastics, rubbers, metals, glass, ash from fuel burning like coal, briquettes or woods, dust and electronic waste)[3]. Anaerobic decomposition of bio-degradable matter present in MSW generates GHG emission. CH_4 emissions from solid waste disposal sites are the largest source of GHG emission in the Waste Sector[4]. The direct GHG emissions from solid waste can be estimated based on parameters such as the solid waste generation, its composition and management of the landfill site. In Rajkot, waste to composting and waste to RDF plant was operated and maintained by Hanzer bio-tech, which was closed after 2012-13 so all waste is being dumped in open dump site, leads to increase in GHG emission.

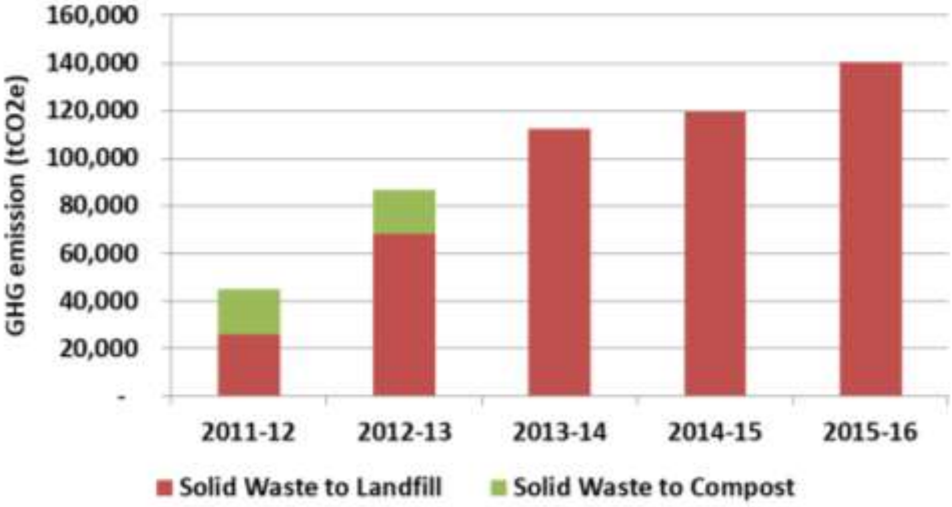
Figure 39 Trend of Generation and Processing of Solid Waste in Rajkot



[3] Jha, A.K. et al., Greenhouse gas emissions from municipal solid waste management in Indian mega-cities: A case study of Chennai landfill sites, Chemosphere (2007)

[4] IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Waste. Prepared by the National Greenhouse Gas Inventories Programme. Available online at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

Figure 40 Trend of GHG emission from Solid Waste Management in Rajkot



3.1.8 Emissions from Municipal Operations and Facilities

3.1.8.1 Energy Indirect emission from Municipal Facilities and Buildings

RMC consumed a total of 63.35 million kWh in its municipal facilities and buildings in 2015-16. Water works facilities consumes highest electricity, which is 38.36 million kWh followed by street lighting 14.99 million kWh. Waste water treatment, building use and Solid waste management transfer stations are consuming 6.66 million kWh, 3.20 million kWh and 0.14 million kWh respectively. Trend of energy use (GJ) per year for Local Government Operations and GHG emission has been shown in Table 15 and 16.

Table 15 Trend of energy use (GJ) per year for Local Government Operations (Municipal Buildings and Facilities)

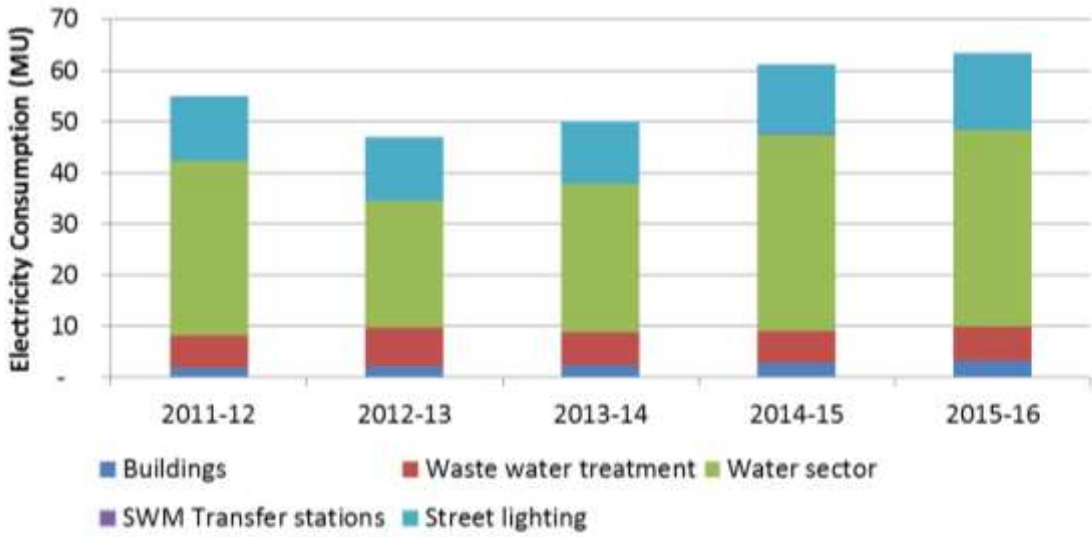
Sector	Energy Consumption (GJ)				
	2011-12	**2012-13**	**2013-14**	**2014-15**	**2015-16**
Buildings	7,031.84	7,685.26	8,790.41	10,282.68	11,516.55
Waste Water Treatment	22,138.65	27,611.63	23,312.66	22,535.00	24,042.89
Water Supply	125,805.72	91,182.23	107,106.98	141,122.80	140,054.92
SWM	153.37	195.29	278.63	345.21	493.15
Street Lighting	45,252.00	45,036.00	43,749.13	48,900.82	53,959.54
Transport	16,767.80	18,821.59	26,063.84	35,400.00	37,760.00
Total	**217,149.37**	**190,532.00**	**209,301.65**	**258,586.51**	**267,827.05**

Table 16 Trend of GHG emission (tCO2e) per year for Local Government Operations (Municipal Buildings and Facilities)

Sector	GHG Emissions (tonnes of CO2e)				
	2011-12	**2012-13**	**2013-14**	**2014-15**	**2015-16**

Buildings	1,529.00	1,756.48	2,009.06	2,350.12	2,632.12
Waste Water Treatment	4,805.60	6,301.98	5,319.80	5,141.88	5,486.46
Water Supply	26,964.33	20,467.89	24,060.39	31,777.98	31,710.31
SWM	33.35	44.63	63.68	78.90	112.71
Street Lighting	9,839.60	10,293.03	9,998.92	11,176.34	12,332.52
Transport	1,246.33	1,398.99	1,937.29	2,631.24	2,806.66
Total	**44,418.21**	**40,262.99**	**43,389.14**	**53,156.47**	**55,080.77**

Figure 41 Trend of Electricity Consumption in Municipal Buildings and Facilities



Water supply accounts for 61% of the total municipal electricity consumption. This is followed by street lighting, sewerage treatment plants and municipal building, which consume 24%, 10% and 5% respectively. (See figure 42)

Figure 42 Share of Electricity Consumption in Municipal Buildings and Facilities, 2015-16

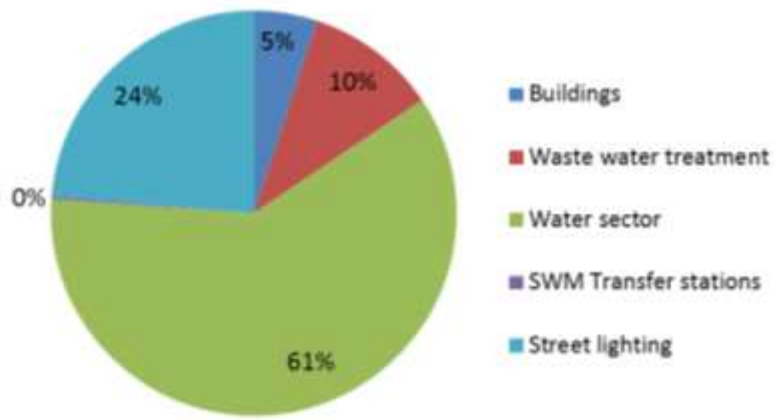


Figure 43 Share of stationary fuel use in Municipal Buildings and Facilities, 2015-16

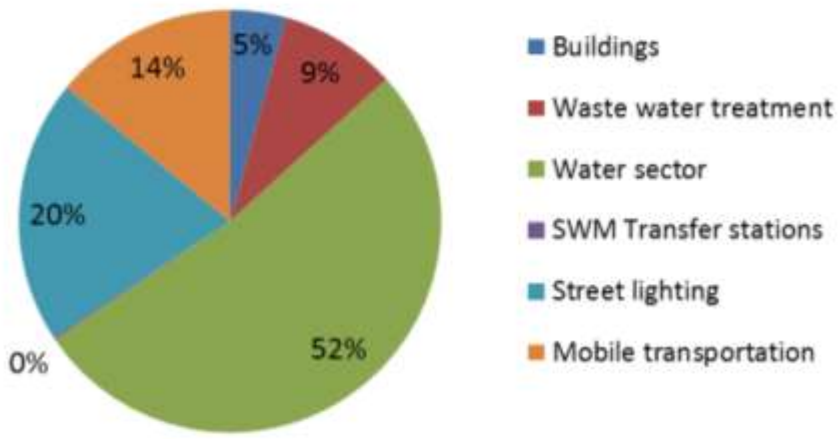
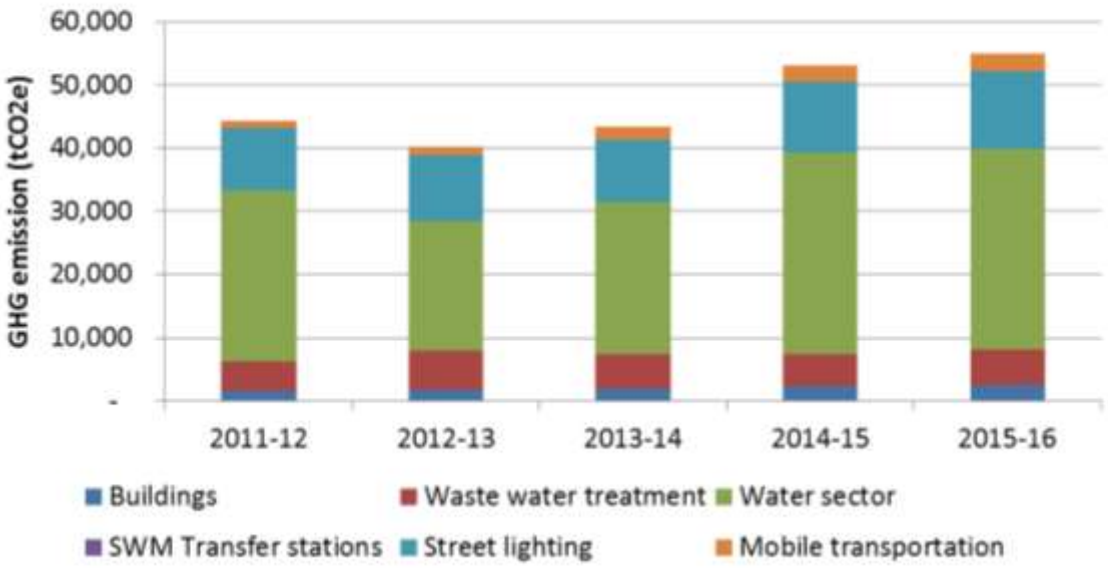


Figure 44 Trend of GHG emission from Municipal Building and facilities



3.1.9 Key sustainability indicator for Rajkot city

The key sustainability indicators for Rajkot city have been provided in table 17. These indicators can enable comparison with the other Indian cities as well as 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 differing 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 17 Key Sustainability Indicators for Rajkot City

Sustainability Indicator	Unit of Measure	Rajkot (2015-16)
Energy consumption per capita	GJ/capita	11.10
GHG emission per capita	tCO_2e/capita	1.33
Energy consumption per household	GJ/HH	49.95

GHG emission per household	tCO_2e/HH	6.00
Energy consumption per unit area	GJ/sq. km	121,634.04
GHG emission per unit area	tCO_2e/sq. km	14,609.43

3.2 Energy and GHG Emissions Projections

Climate Resilient Cities Action Plan is prepared for 5 years, with a long term vision for 20-30 years that is determined by the local authority. Energy consumption and GHG emissions are projected by using Tool 3.1E: GHG Emissions Forecasting for medium term (yearly from 2016-17 to 2025-26) and long term scenario (every 5 years from 2026-27 to 2049-50) (See Annexure 4).

Stationary fuel and electricity consumptions have been projected by using Geometric mean of past four years for community sectors. Energy consumption from utility services/ facilities (i.e. water supply, drainage and solid waste management) has been projected based on population growth (by taking average of population projection by arithmetical increase method, geometrical increase method and incremental increase method) and future planning of Rajkot Municipal Corporation (See Annexure 3). Based on a forecast of the energy consumption, the corresponding GHG emissions are calculated using the HEAT+ software (See Annexure 4).

3.2.1 Assumptions for forecasting and projections

Sector	Assumption
Water Supply	Based on existing city planning, below assumptions have been taken into consideration. • 128LPCD water supply with 28% NRW has been considered until 2018 based on baseline situation • It is assumed to reduce NRW from 28% to 25% due to implementation of DI network in phase-wise manner by year 2019 with 128LPCD of water supply from year 2019 until 2021 • It is assumed to have 128 LPCD water supply as 2021 and reduce in NRW from 25 to 23% by 2022-23 due to further implementation of DI pipeline from year 2022 until 2027 • It is assumed to reduce NRW from 23% to 20% in year 2028, with 135LPCD water supply and 100% water connection coverage by 2028
Waste water	• 80% of total water supply has been considered for respective years
Solid Waste Management	• Based on waste quantification and characteristic report, 0.3kg per capita of solid waste generation has been taken into consideration • Annual increase of 1.5% is assumed due to life style changes • Proposed waste treatment plants (i.e. waste to composting plant, bio methanation plant, and mobi trash, waste to energy plant) has been considered for GHG emission forecast and waste going to landfill
Street lights	• Future projection for streetlights has been done based on road length, pole to pole distance is assumed to be 33.5m based on existing situation (by using number of streetlights in exiting road network for year 2012 and 2015) • Road length has been arrived from past trend - Road network lengths for year 2005 (considered from Comprehensive Mobility Plan of Rajkot 2005), year 2009 (considered from Basic Road

	Transport Statistics of GOG 2009), year 2015 (considered from DP2031 of RUDA) and analysed further to project road length for year 2051 • Average increase in road length in Rajkot city area has been assumed to be 72.16kms each year based on regression analysis. • Considered retrofitting of all HPSV lights with LED lights in year 2017 done by RMC, which has reduced energy consumption by 50% from this sector.

Projected energy usage as per business as usual scenario for year 2050-51 is 462,667,923 Giga Joule, which is 25 times higher as compared with baseline of 15,716,334 Giga Joule in year 2015-16. Projected GHG emission based on projected energy consumption as per business as usual scenario for year 2050-51 is 69,026,032 tCO2e, which is 36 times higher as compared with baseline of 1,887,685 tCO2e in year 2015-16 (See figure 48). Increase in GHG emission by 36 times in next 35 years shows the need to prepare Climate Resilient City Action Plan for Rajkot to mitigate GHG emission cause and impact within city limit. Projected energy consumption and GHG emission trend has been shown in Figure 45 and 46

Figure 45: Projected Energy Consumption (GJ), 2016-17 to 2050-51

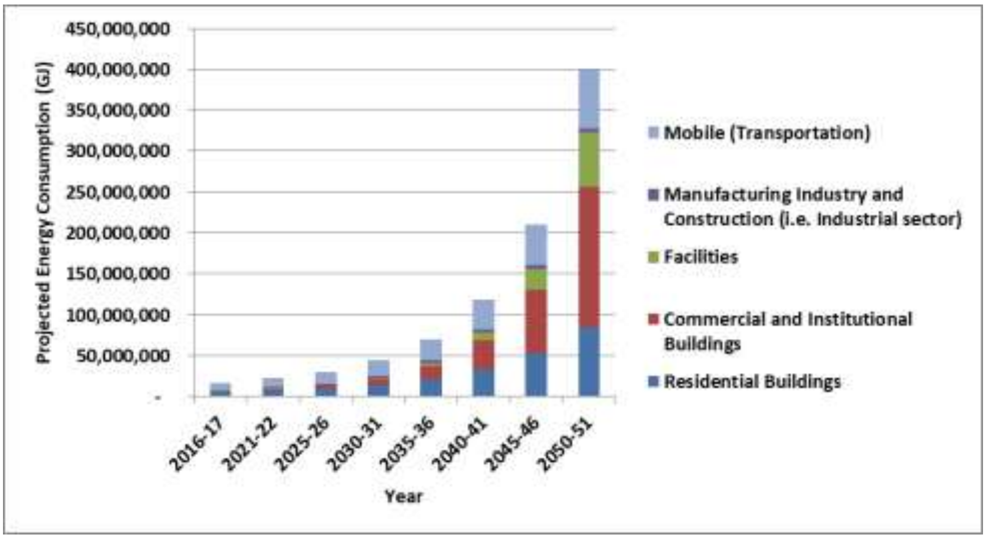
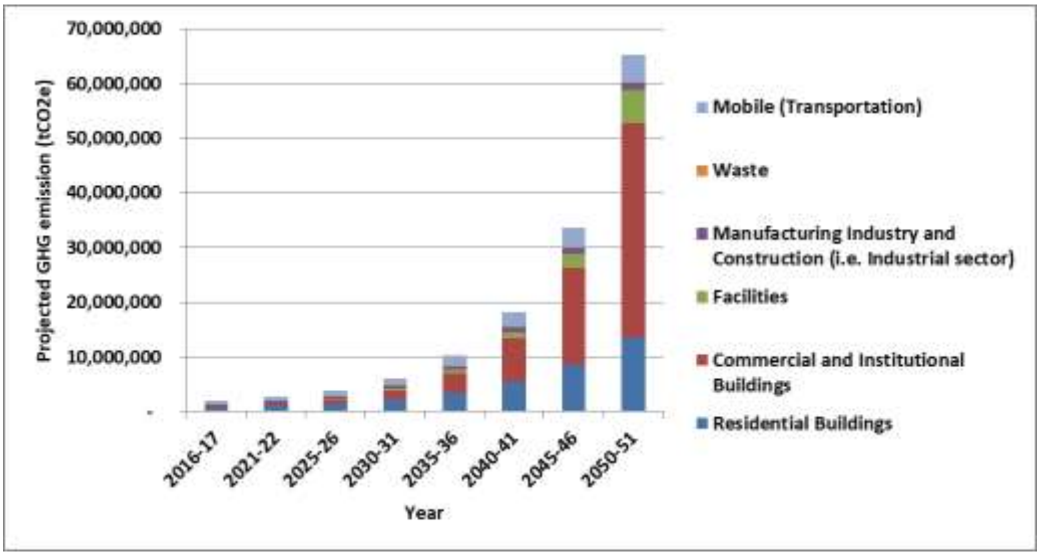


Figure 46: Projected GHG emission (tCO2e), 2016-17 to 2050-51



Forecasting trend shows that energy consumption in commercial and institutional building sector is rapidly increasing followed by Residential Buildings, mobile units (Transport sector), municipal facilities and manufacturing industry and construction sector (See table 47). Though use of conventional electricity consumption is increasing in all sectors, trend of increase in electricity consumption is highest in commercial and institutional building sector followed by Residential building and manufacturing industry and construction industrial sector. Trend of fuel consumption across the all sectors shows increase in use of petrol in transport sector will increase by 17 times in year 2050 as compared to baseline year 2015. These sectors require prior attention with long term and short term strategies. Increasing trend of PNG consumption in residential and commercial sector, and CNG consumption in transport sector shows people are slowly moving towards clean fuel.

Figure 47 Projected medium and long term GHG emission scenario

Sectors	Energy Source/Activity	GHG emission scenario (tCO2e)						
		Baseline	Projected (Medium Term scenario)			Projected (LongTerm scenario)		
		2015-16	2020-21	2022-23	2025-26	2030-31	2040-41	2050-51
Residential Buildings	Electricity	498,591	785,800	942,626	1,238,455	1,951,857	4,848,237	12,042,584
	Kerosene	30,067	24,360	22,394	19,738	15,992	10,498	6,892
	LPG	87,157	73,876	69,149	62,619	53,077	38,134	27,398
	PNG	39,765	67,433	83,296	114,353	193,921	557,672	1,603,734
Commercial and Institutional Buildings	Electricity	148,272	328,645	451,851	728,444	1,614,601	7,932,375	38,970,974
	LPG	2,544	1,618	1,350	1,029	654	265	107
	PNG	4,656	6,986	8,216	10,481	15,724	35,393	79,665
Facilities	Electricity	52,126	56,334	60,087	67,786	86,310	161,057	402,349
	Diesel	2,955	9,120	14,416	28,765	91,424	929,204	9,460,651
Manufacturing Industry and Construction (i.e. Industrial sector)	Electricity	299,164	369,948	402,747	457,478	565,719	865,091	1,322,885
	PNG	50,198	28,274	22,473	15,925	8,970	2,846	903
Waste	Solid Waste to Landfill	140,329					27,743	94,661
	Solid Waste to energy		100,022	107,294	119,521	131,582	151,904	151,904
	Solid Waste to Compost		15,025	15,025	15,025	15,025	15,025	15,025
Mobile (Transportation)	LPG	499	39	19	6	1	0	0
	Petrol	155,865	232,704	273,165	347,421	518,693	1,156,158	2,577,059
	Diesel	254,811	299,728	319,839	352,564	414,712	573,808	793,937
	CNG	120,687	172,049	198,267	245,272	349,661	710,628	1,444,235
Total	-	**1,887,685.31**	2,571,961	2,992,213	3,824,884	6,027,925	18,016,038	68,994,963

3.3 Analysis of Fragile Urban Systems

Fragile Urban Systems have been identified by using tool 3.2B in Rajkot city, to identify systems which are already failing or are under great pressure and contributing significantly to city's total energy consumption and Greenhouse Gases (GHGs) emission based on stakeholder consultation and GHG emission inventory prepared under CapaCITIES project.

Climate impact assessment of urban systems helps to assess their fragilities with respect to the climate impacts identified. In Rajkot, the major urban systems that have been identified as fragile and that have been assessed include:

A. Health
B. Transportation (Public Transportation)
C. Transportation (Road infrastructure)
D. Water
E. Sewerage
F. Storm water drainage
G. Solid Waste Management

The risks associated with the fragilities of these systems were identified through the qualitative information gathered from stakeholder group and core team during SLD and quantitative information collected from city and analysed. The Urban Systems Analysis is attached in Annexure 5.

3.3.1.1 Health

There are total 1522 private and government clinics and hospitals in city, having total capacity of 5518 beds in city, but the critical medical services are available in only 5 government hospitals, therefore access to critical medical care is very expensive and less accessible to the low income population. Apart from these clinics and hospitals, Health department of Rajkot Municipal Corporation is operating and maintaining 21 Public Urban Health Centres, which are not advanced.

Incidence of vector borne, water borne diseases increases with increase in temperatures and flooding issues in city. Around 7,119 water borne disease and vector borne morbidity cases (around 90,000 cases have noted symptoms of water borne and vector borne diseases) were registered in Public Health Centres last year. 52% of total population residing in slums and LIG households are highly dependent on Primary Public Health Centres. Given the preponderance of vector borne diseases and the paucity in affordable advanced health care, this system is considered fragile.

Although RMC has in place emergency response procedures for disease outbreaks, which includes monsoon preparedness, city-wide health monitoring system, identification of vulnerable hotspots, shifting people from vulnerable places to safe places during emergency situations, door to door monitoring for mosquito breeding, fogging, provide drinking water through tankers, awareness campaign for preventive measures, provide basic primary treatment etc. Preventive mechanisms such as drain cleaning and monsoon preparedness activities are also undertaken. However during an epidemic break out, affordable pubic health care facilities are insufficient and inadequate, since public hospitals with advanced facilities for treatment are limited.

Due to paucity of affordable critical health care services, during an epidemic outbreak, population in the lower income group may not have access to adequate health care facilities.

Fragility Statement:

Extended summer season, increasing temperatures, flooding due to higher intensity rainfall contribute to an increase in disease outbreak. Limited capacity of public health care system renders the lower income group population especially vulnerable.

Climate Fragility Statement:

1. Existing primary public health care infrastructure is adequate but needs improvements to address increasing health impacts, resulting from rising temperatures, and increase in the duration of the summer season and flooding conditions resulting from high intensity and short duration rainfall.
2. Preventive health measures are rendered inadequate during periods of excessive heat and flooding

3.3.1.2 Transportation (Public Transportation)

Public transportation in city includes Rajkot Mass Transportation Services (RMTS), Bus Rapid Transportation Services (BRTS), Public Cycle Rental System operated and maintained by Rajkot Rajpath Limited (RRL), Rajkot Municipal Corporation. Public transport in city includes 90 Rajkot Mass Transportation System (RMTS) and 11 Bus Rapid Transportation System (BRTS), with ~40,000 people commuting per day against total capacity of 60000 per day (33% underutilized). This is due to intermittent services and services do not cover all areas in Rajkot. Total 1684 kiloliters of diesel is consumed by public transportation system which leads to 4548 tCO2e GHG emission per year.

First and Last mile connectivity is big challenge for public transportation in city, which leads to increase in private vehicles on road and increase in air pollution and GHG emission . Shorter trips and inadequate frequency of available public transportation, auto-rickshaws is preferred mode for public transportation due to frequent availability, apart from being illegal, add to problems such as unorganized operations, traffic congestion, unsafe mode of travel due to overloading, poor services, and pollution due to inefficient fuel usage with in city limit.

Public transport buses are not plying on all roads at a fixed frequency and affordable and regulated last mile connectivity to the public bus system is an issue. Although RMC has taken various initiatives to maximize use of public transportation i.e. concession for students, elderly people, e-ticketing, mobile based application for RMTS and BRTS. However, availability of reliable public transport, first and last mile connectivity is making system fragile.

Fragility Statement:

Existing public transit system is inadequate to cater to the mobility needs of the city

Climate Fragility Statement:

1. During periods of water logging and increasing temperatures, use of public transport is limited due to inadequate public transport services and limited last-mile connectivity
2. Air pollution in the city is exacerbated due to increase in private vehicles, and resultant traffic congestion

3.3.1.3 Transportation (Road infrastructure)

Traffic and transportation is managed by state traffic and transportation department. At present, the traffic situation in city is getting more and more congested due to increasing private vehicle usage and absence of reliable public transport options. Traffic congestion due to erratic vehicle movement and absence of traffic lights at junctions and absence of planned traffic movement is a common phenomenon. Lack of parking facilities and encroachment of roads by vendors are contributing to the congestion in city.

Fragility Statement:

Poor enforcement of the traffic management system, inadequate parking facilities, encroachments on footpaths and cycle lanes, and makeshift vehicles with no pollution control mechanisms impact the functionality of the existing road infrastructure

Climate Fragility Statement:

During periods of intense rainfall, roads get water logged, which further exacerbates road congestion and affects connectivity and mobility

3.3.1.4 Water

The water supply system in Rajkot is managed by water works department of the RMC. Water scarcity is a major issue in Rajkot due to limited local water resources, irregular and erratic rainfall, and limited natural water percolation due to rocky soil strata. Current ground water level is below 1000ft and water table declines drastically in the event of low rainfall. Also, Faecal and biological contamination has been found in ground water in few samples, may create serious health issues. Illegal encroachment of natural water drains is also creating flooding issues. This increases the fragility of system.

Rajkot has connected Aji-1 dam with the Narmada Canal under state government's "Sauni Yojana" scheme to ensure availability of water during dry periods (period of supply from month of November till month of July each year). City is highly dependent on Narmada water, which not only leads to high energy consumption but also create major issue in case of any major fault in between Narmada pipeline network during dry period. Gujarat Water Infrastructure Limited (GWIL) is responsible for sourcing Narmada water in city.

Non-Revenue Water is also major problem in city as 85% of total water supply network is old and of asbestos cement (AC) pressure pipe, prone to leakage and loss of pressure, owing to breakages and unauthorized direct pumping from the pipe line in certain instances. City has taken various initiatives to solve this problem i.e. SCADA implementation for water supply monitoring, replacing existing old pipelines with DI pipeline, regularization or cut of illegal connections, panelizing direct pumping etc. Rain water harvesting is mandatory for all new buildings as per General Development Control Regulation (GDCR), but scientific technology needs to be assessed.

Policy changes required for protection of water sources, regulation of water use and reduce NRW, illegal encroachments of natural drains, scientific rainwater harvesting systems. Augmentation of local water resources through ground water/ aquifer recharge, rain water harvesting, and waste water reuse are needed.

Fragility Statement:

Availability of local surface and ground water and ground water is limited against the existing demand of the city. Combined with contamination of piped water and poor ground water quality, this sector is considered to be fragile

Climate Fragility Statement:

1. Exposure of the community to poor quality ground water increases due to increased demand for water during periods of increased temperature, as treated piped water supply is limited.
2. Increased flooding during periods of high intensity rainfall increases chances for potential contamination of surface water supply with untreated sewage due to compromised water distribution and sewage collection networks

3.3.1.5 Sewerage

Sewerage is managed by drainage department of Rajkot Municipal Corporation. Total Sewage Treatment plant capacity is 166.5MLD with 70% adequacy against total sewage generation of 190MLD in the city with existing sewerage network coverage of 85% of total households in city, which is insufficient. Excess untreated waste water is bypassed from pumping stations and allowed to flow to the natural drains and river directly, polluting the environment and contaminating the groundwater. This is a common phenomenon during the rainy season due to combined sewer overflows. Direct methane emission from STP and direct usage of Sludge from STPs by farmers increases fragility of the system.

Although Rajkot Municipal Corporation has planned to implement new STPs with 100% coverage of sewerage network, policy level changes needs to be made for reuse of water and dual plumbing system at household level.

Fragility Statement:

1. Excess untreated sewage that is discharged in the Aji river and natural drains due to inadequate Sewage Treatment capacity and due to combined sewer overflows during rainy season pollutes the environment.
2. Direct use of dry sludge as manure without proper treatment, and direct methane emission from gas digester chamber cause environmental pollution has global warming impacts and may cause severe health issues in city.

Climate Fragility Statement:

1. High Mixed sewer overflow volumes, in times of high intensity rainfall, render sewage treatment systems ineffective; consequent untreated sewage flows pollute the vokdas and the Aji River
2. Direct use of dry sludge as manure for food crops, without proper treatment, t may cause significant health impacts.

3.3.1.6 Storm Water Drainage

Storm water drainage is managed by drainage department of Rajkot Municipal Corporation. There is no storm water drainage network in city as such in city, which leads to flooding in various part of city. Also, degraded conditions of the natural drains due to disposal of untreated sewage solid waste lead to flooding during high intensity of rainfall, communities living on the banks of such natural drains are most vulnerable to floods. Such condition leads to health and hygiene issues for communities living along the natural drains, which increases the fragility of the system.

However, Rajkot Municipal Corporation has made Rain Water Harvesting mandatory for residential and individual households, area based ground water recharge has good potential to reduce the flooding issues.

Fragility Statement:

Absence of storm drains leads to urban water logging and flooding and also environmental pollution and water supply contamination from mixed sewer overflows

Climate Fragility Statement:

Runoff from high intensity rainfall, in the absence of a storm sewer system, drains through the sewer network, causing backflow of sewage into households, posing a health risk and mixed sewer overflows pollute the environment and the water supply network

3.3.1.7 Solid Waste Management

Solid waste is managed by solid waste management department of Rajkot Municipal Corporation. Rajkot Municipal Corporation has planned to treat solid waste at centralised and decentralised level, however segregation of waste has been identify as an issue in city. Illegal waste dumping on streets and natural drains chock ups the sewage lines leading to stagnation, health and hygiene issues, which increases fragility of the system.

RMC also proposes to issue a notification to citizens in residential and commercial areas, urging them to segregate dry waste, wet waste and hazardous waste in three different dustbins. Holistic Integrated Solid Waste Management Action Plan will be helpful of city.

Fragility Statement:

Unsegregated Municipal Solid Waste is collected and disposed in an open dumpsite, causing deleterious environmental and health impacts and also renders the decentralized waste management plants (compost and bio-methanation) ineffective

Climate Fragility Statement:

1. Increasing temperatures accelerate decomposition rates and also create potentially hazardous conditions in open dumpsites by increasing the probability of landfill fires.
2. Disposal of untreated municipal solid waste results in direct methane emissions, contributing to global warming and impacting health of residents.
3. Solid waste littered in streets is washed into drains and open sewer manholes, during periods of high intensity rainfall, blocking outflow and resulting in stagnation, leading to public health impacts.

3.4 Climate Risk Assessment

Risk for all critical fragile urban systems has been assessed after close consultation with stake holder committee and climate core team based on likelihood and consequences. Some of the qualitative attributes of the fragile sectors have been analysed to identify climate risk for Rajkot city.

Table 18 Risk Assessment, Rajkot by using Tool 3.2C

Urban Systems	Climate fragility statement	Likelihood	Consequence	Risk Score	Risk Status
Health	Existing primary public health care infrastructure is adequate but needs improvements to address increasing health impacts, resulting from rising temperatures, increase in the duration of the summer season and flooding conditions resulting from high intensity and short duration rainfall	3	4	12	High
	Preventive health measures are rendered inadequate during periods of excessive heat and flooding	3	3	9	Medium
Transportation (Public Transportation)	During periods of water logging and increasing temperatures, use of public transport is limited due to inadequate public transport services and limited last-mile connectivity	3	3	9	Medium
	Air pollution in the city is exacerbated due to increase in private vehicles, and resultant traffic congestion	4	3	12	High
Transportation (Road Infrastructure)	During periods of intense rainfall, roads get water logged, which further exacerbates road congestion and affects connectivity and mobility	3	3	9	medium
Water	Exposure of the community to poor quality ground water increases due to increased demand for water during periods of increased temperature, as treated piped water supply is limited	3	3	9	Medium
	Increased flooding during periods of high intensity rainfall increases chances for potential contamination of surface water supply with untreated sewage due to compromised water distribution and sewage collection networks	4	4	16	High
Sewerage	High Mixed sewer overflow volumes , in times of high intensity rainfall, render sewage treatment systems ineffective; consequent untreated sewage flows pollute the vokdas and the Aji River	3	3	9	Medium

Urban Systems	Climate fragility statement	Likelihood	Consequence	Risk Score	Risk Status
	Direct use of dry sludge as manure for food crops, without proper treatment may cause significant health impacts.	3	4	12	High
	Direct methane emissions into the atmosphere from the compromised gas digesters not only contribute to global warming, but also render the 50 MLD plant STP at Raiya ineffective	2	5	10	high
Storm water drainage	Runoff from high intensity rainfall, in the absence of a storm sewer system, drains through the sewer network, causing backflow of sewage into households, posing a health risk and mixed sewer overflows pollute the environment and the water supply network	3	3	9	Medium
SWM	Increasing temperatures accelerate decomposition rates and also create potentially hazardous conditions in open dumpsites by increasing the probability of landfill fires	3	2	6	Medium
	Disposal of untreated municipal solid waste results in direct methane emissions, contributing to global warming and impacting health of residents	4	3	12	High
	Solid waste littered in streets is washed into drains and open sewer manholes, during periods of high intensity rainfall, blocking outflow and resulting in stagnation, leading to public health impacts	3	3	9	Medium

Based on this risk assessment of all seven fragile urban systems; Water, Sewerage, health, Solid Waste Management, and Transportation show high risk which require urgent attention.

3.5 Climate Vulnerability Assessment

Climate vulnerability assessment for fragile urban systems has been done after close consultation with stake holder committee and climate core team and identified critical areas from city by using tool 3.2D. Both qualitative and quantitative information from the city was assessed for this purpose. Data was sourced related to several parameters and from multiple sources i.e. public grievance system for all critical sectors, flood prone areas based on fire department information, number of morbidity and mortality cases. Actor analysis has been done by using tool 3.2D (See annexure 6)

Vulnerability assessment consists of identification of vulnerable areas and actors for all the prioritized fragile urban systems and analysis of their adaptive capacities. The following elements are considered:

1) Identification of Vulnerable Places: Sector-wise issues have been identified based on SLD and quantitative information available with different departments. Highly vulnerable areas in context of identified issues and fragile urban system of the city were identified and mapped to arrive at vulnerable hotspots affected by maximum number of issues and fragile urban systems.
2) Identification of Vulnerable actors and their adaptive capacity: In each of the vulnerable areas, the actors that play a critical role towards building urban resilience were identified and assessed in terms of their capacity to organize and respond to threat or disruption, access to resources necessary for response (manpower, technology, funds) and access to information necessary to develop effective plans and actions and to improve responses to disruptions. These determine the adaptive capacity/resilience of the identified actors for a particular fragile system.

The sections below identify the vulnerable areas, vulnerable actors and adaptive capacity of the fragile urban systems using the Climate Fragility Statements developed and in consultation with the stakeholder group.

3.5.1 Identification of Vulnerable areas of Fragile Urban Systems

3.5.1.1 Health

The vulnerable areas in Rajkot for health as per the broad consensus in the SLD and analysis of quantitative information gathered from department were identified as follows:

Climate Fragility Statements	Issues identified for sector	Highly impacted Area/ward
1) Existing primary public health care infrastructure is adequate but needs improvements to address increasing health impacts, resulting from rising temperatures, increase in the duration of the summer season and flooding conditions resulting from high intensity and short duration rainfall **2)** Preventive health measures are rendered inadequate during periods of excessive heat and flooding	With rise in temperature, increase in health issues due to heat waves	Ward numbers – 1, 2, 5, 7, 8, 9, 10, 11, 14, 17
	With rise in rainfall intensity and degraded conditions of River and Natural drains which increase in incidences of vector-borne and other diseases	Ward numbers – 1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18
	Lack of awareness and availability of affordable treatment in city for severity of vector-borne and other epidemics	Ward numbers – 1, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18

Figure 48 Wards impacted with rise in temperature, increase in health issues due to heat waves

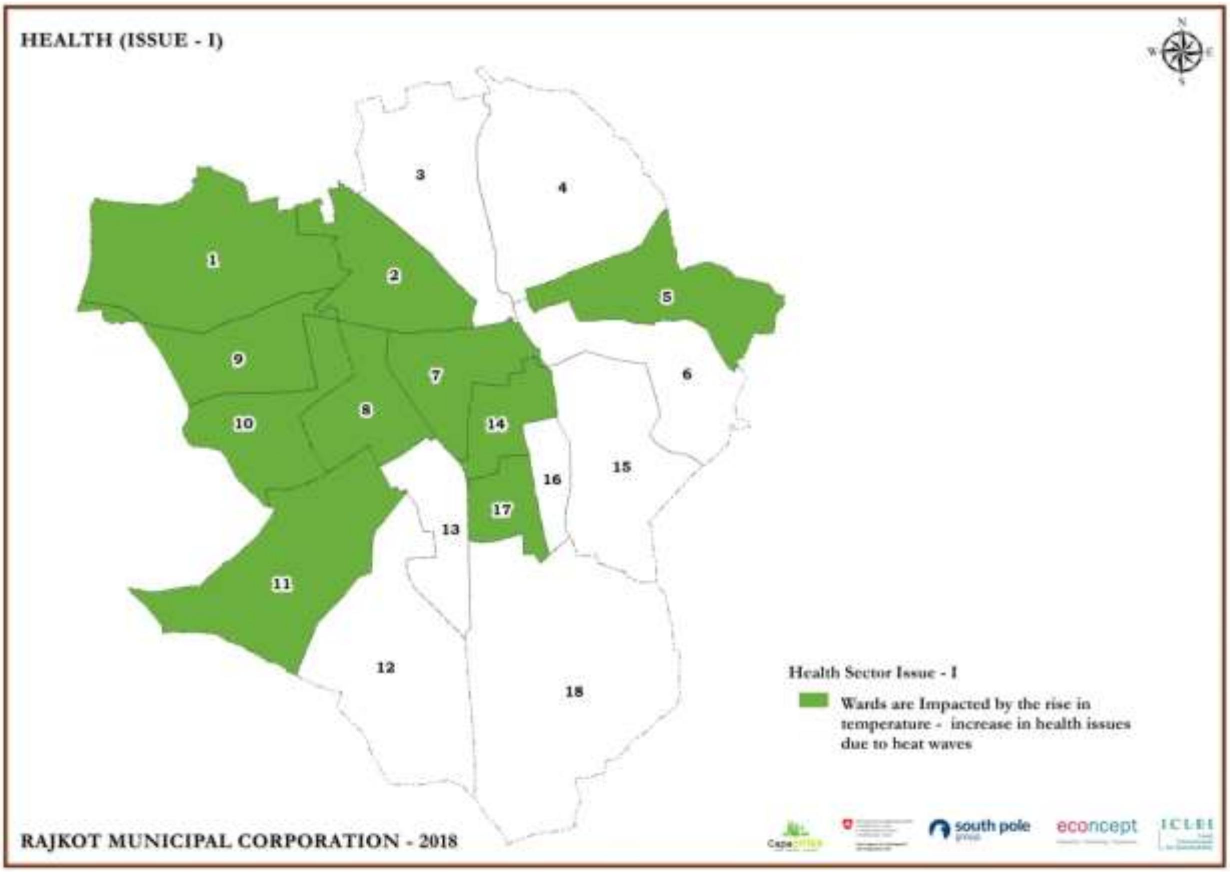


Figure 49 Wards impacted with rise in rainfall intensity and degraded conditions of River and Natural drains which increase in incidences of vector-borne and other diseases

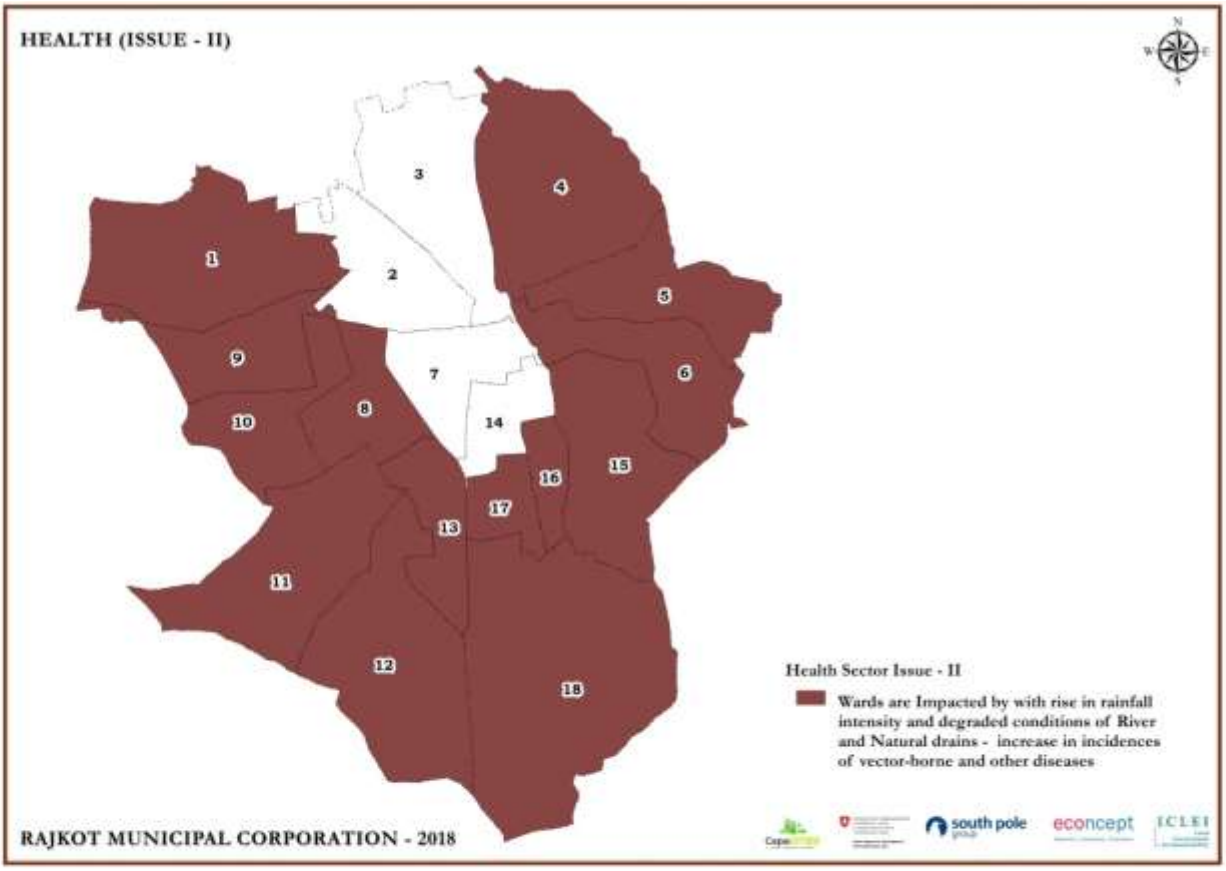


Figure 50 Wards impacted due to lack of awareness and availability of affordable treatment in city for severity of vector-borne and other epidemics

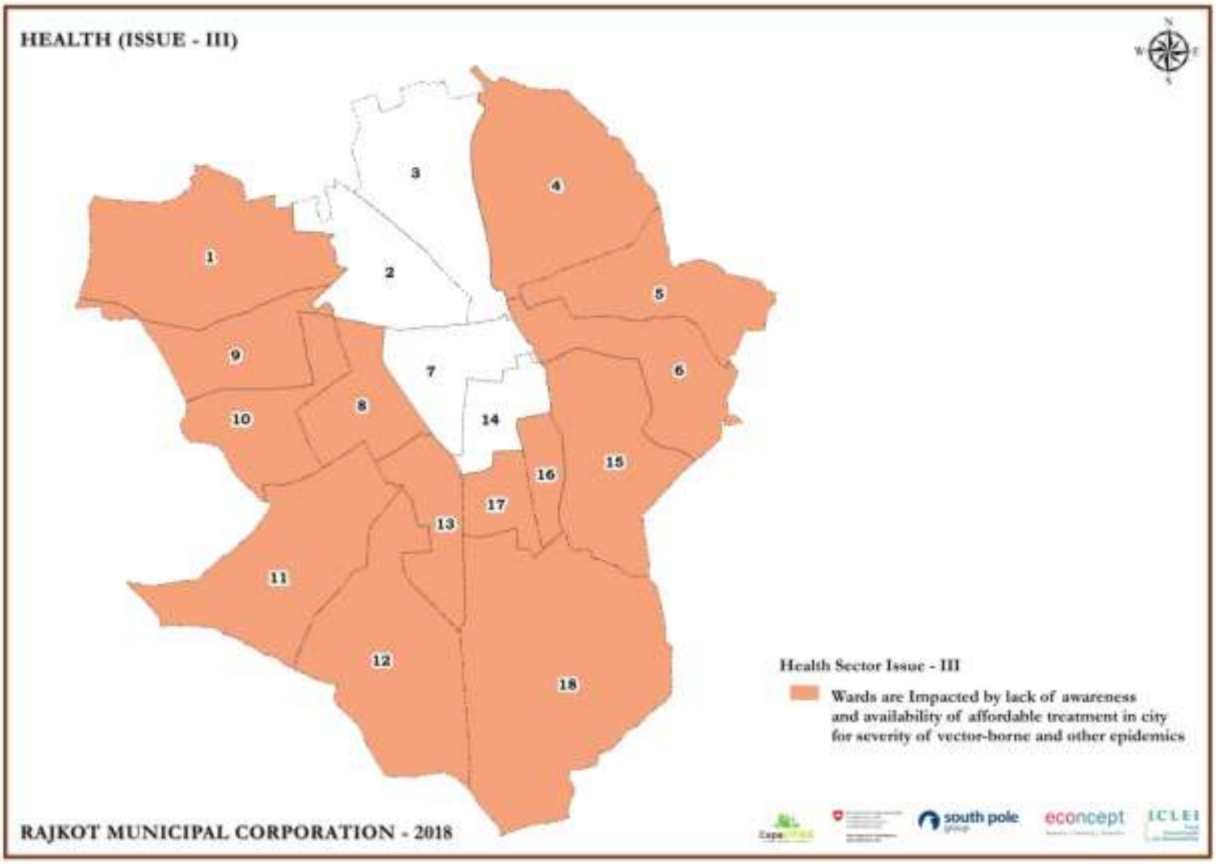
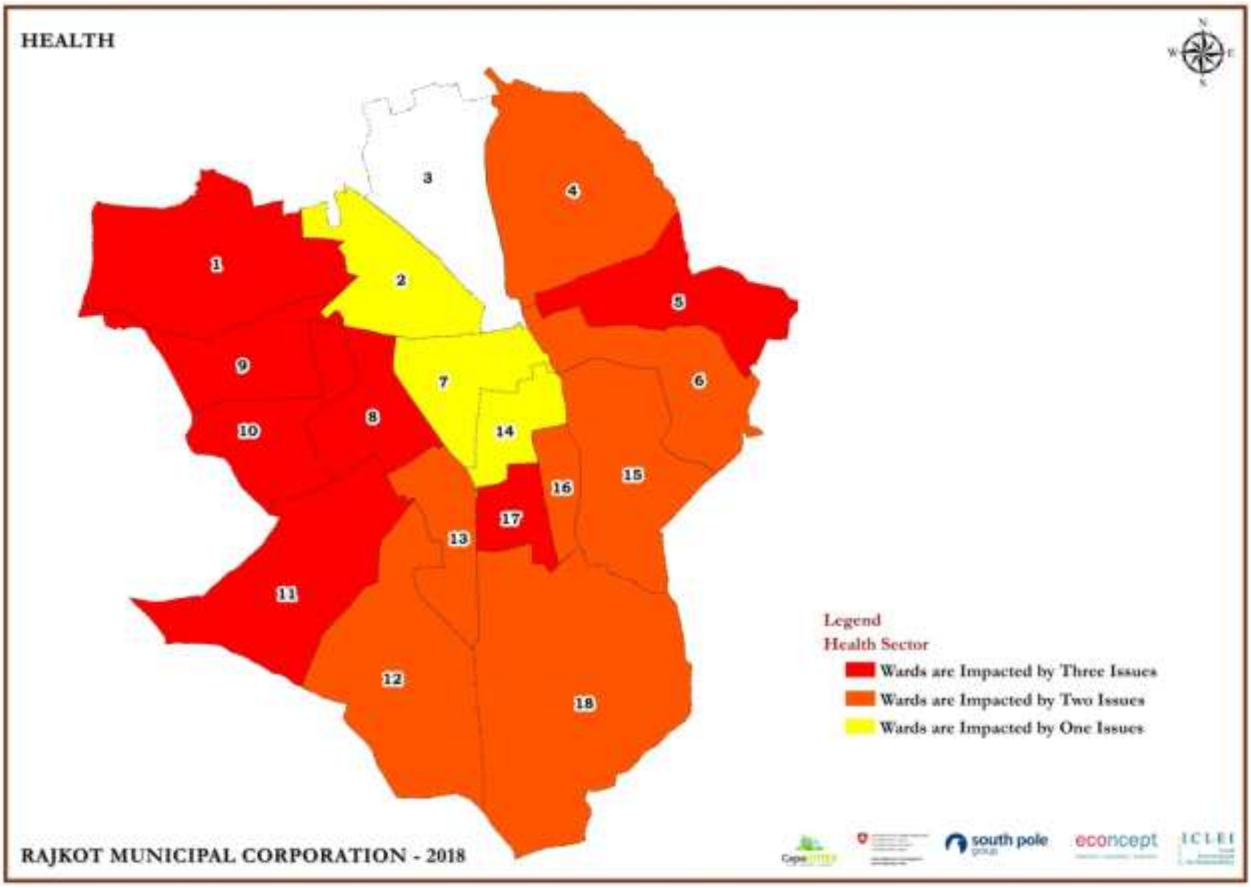


Figure 51 Wards most vulnerable to climate risks due to various issues in the context of Health in Rajkot



3.5.2 Transportation

The vulnerable areas in Rajkot for transportation as per the broad consensus in the SLD and analysis of quantitative information gathered from department were identified as follows:

Climate Fragility Statements	Issues identified for sector	Highly impacted Area/ward
1) During periods of water logging and increasing temperatures, use of public transport is limited due to inadequate public transport services and limited last-mile connectivity **2)** Air pollution in the city is exacerbated due to increase in private vehicles, and resultant traffic congestion **3)** During periods of intense rainfall, roads get water logged, which further exacerbates road congestion and affects connectivity and mobility	With increase in Temperature, road infrastructure may suffer damage and leads to more congestion and air pollution	Wards – 2, 3,4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 16, 17
	With increase in vehicles and lack of public transportation due to last-mile connectivity leads to traffic congestion and Air pollution	Wards – 2, 3, 4, 7, 8, 9, 10, 11, 13, 14
	With increase in Rainfall, increase an issue of water logging and traffic congestion	Wards – 2, 7, 8, 9, 10, 11, 12, 13, 15, 18

Figure 52 Wards impacted with increase in Temperature - Road infrastructure may suffer damage and leads to more congestion and air pollution

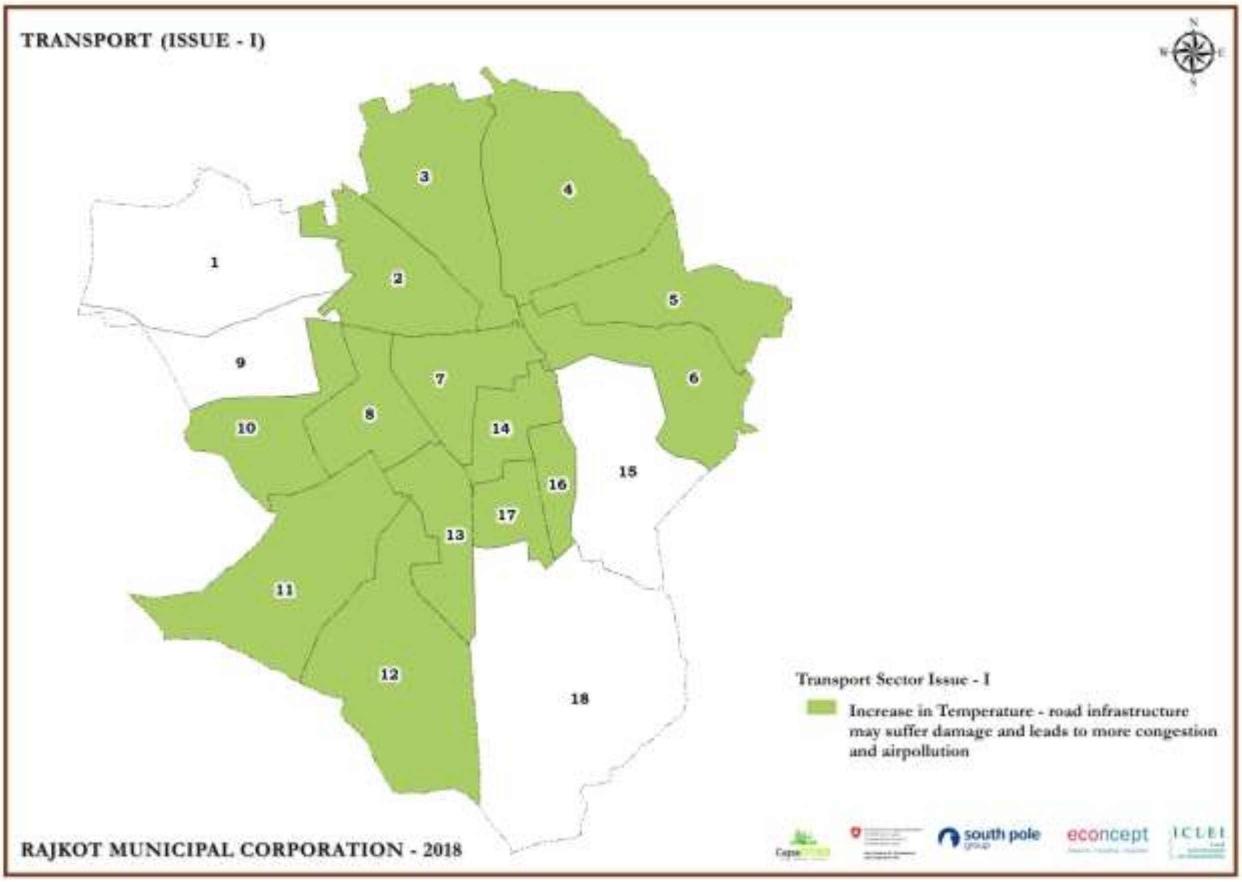


Figure 53 Wards impacted with increase in vehicles and lack of public transportation due to last-mile connectivity leads to traffic congestion and Air pollution

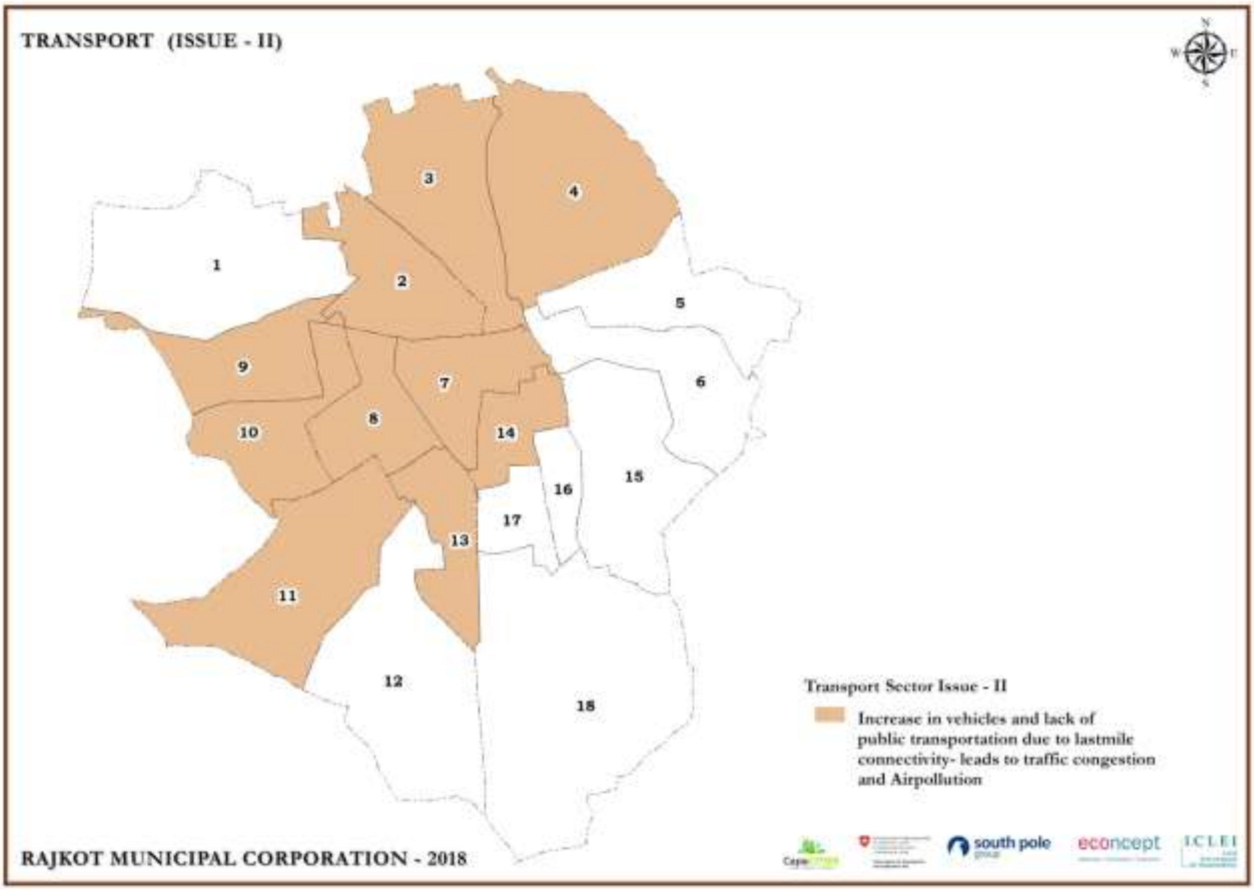


Figure 54 Wards impacted with increase in Rainfall, increase an issue of water logging and traffic congestion

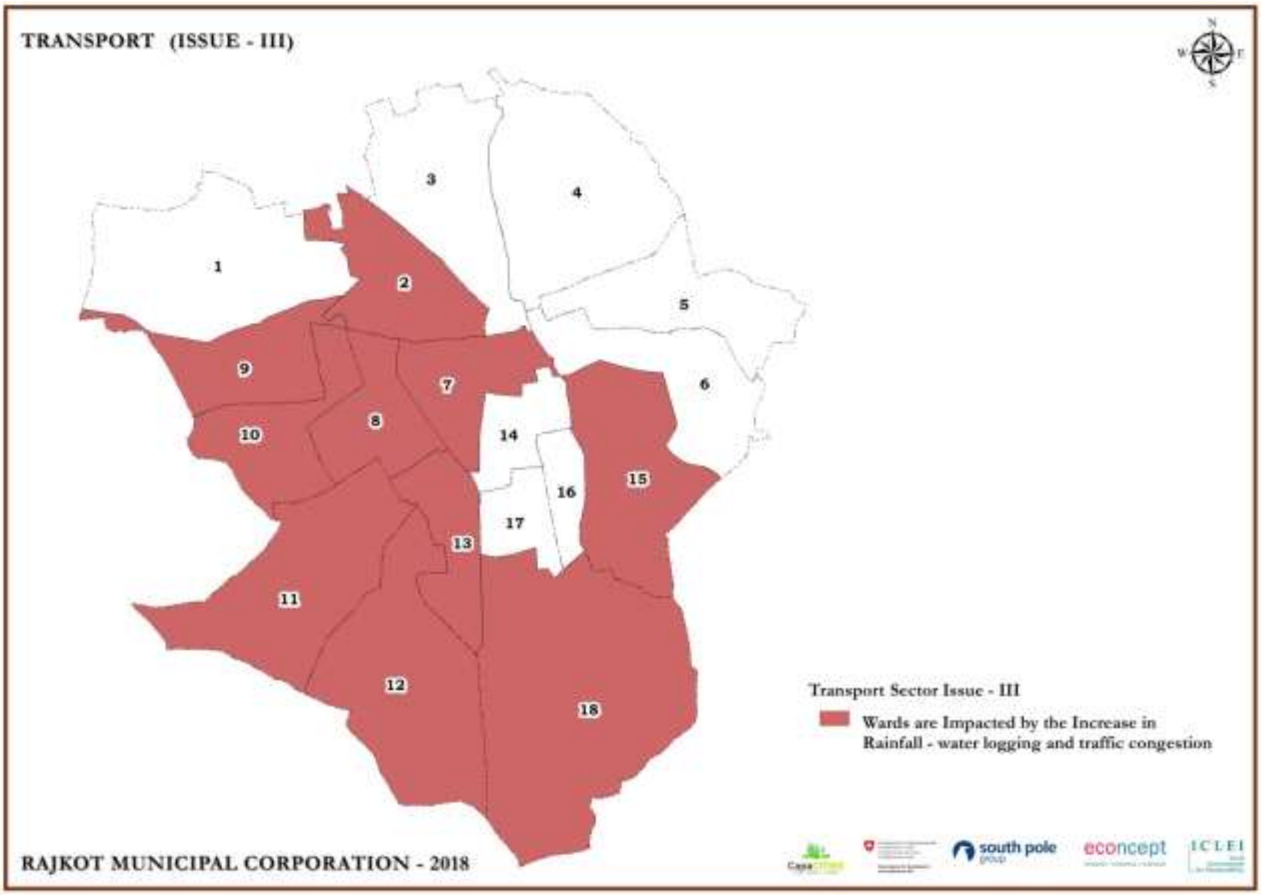
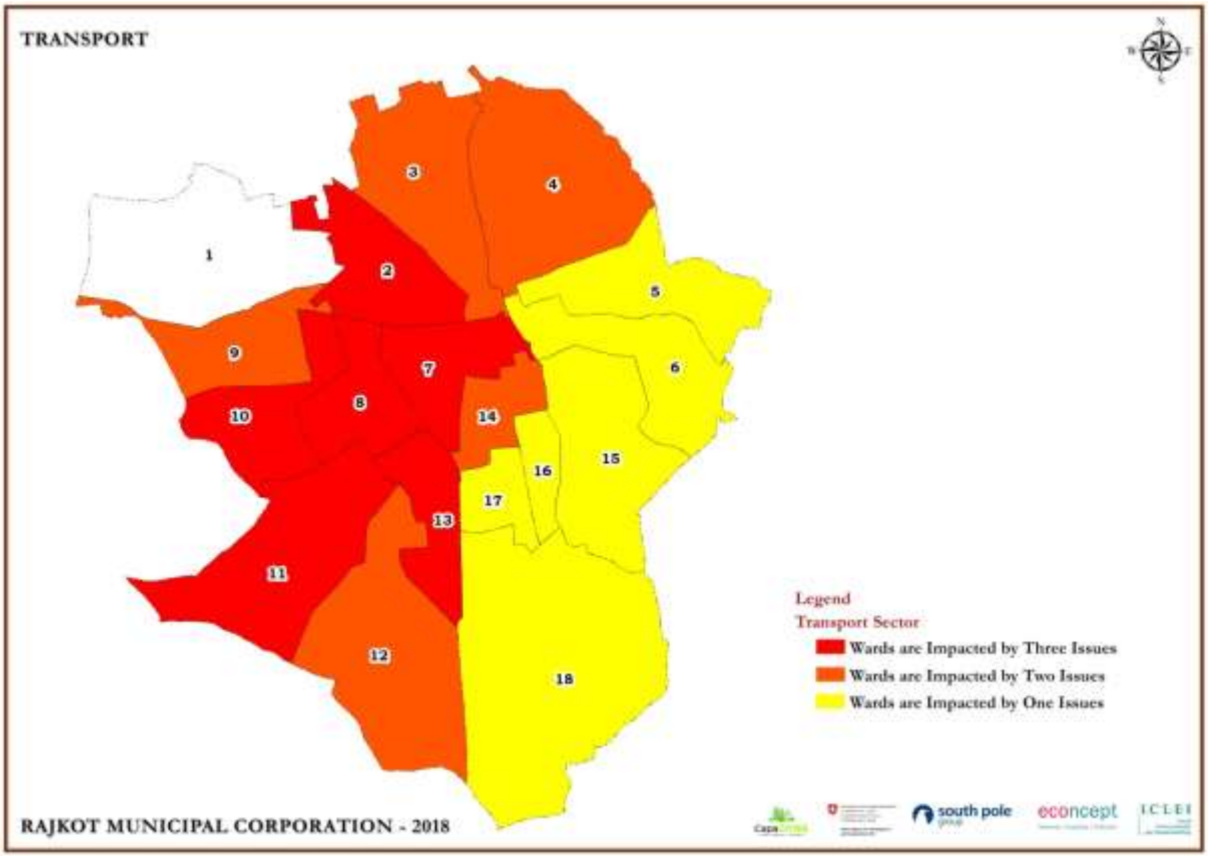


Figure 55 Wards most vulnerable to climate risks due to various issues in the context of Transportation in Rajkot



3.5.3 Water Supply

The vulnerable areas in Rajkot for water supply as per the broad consensus in the SLD and analysis of quantitative information gathered from department were identified as follows:

Climate Fragility Statements	Issues identified for sector	Highly impacted Area/ward
1) Exposure of the community to poor quality ground water increases due to increased demand for water during periods of increased temperature, as treated piped water supply is limited	With increase in temperature and humidity, the water demand will rise against the limited capacity of surface water supply - increase the use of bore well water, lead to adverse impacts on health.	Wards – 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 14, 15, 16, 18
2) Increased flooding during periods of high intensity rainfall increases chances for potential contamination of surface water supply with untreated sewage due to compromised water distribution and sewage collection networks	With increase in high intensity rainfall in absence of storm water drainage network and low maintenance of natural drains -high chances of contamination of the water and flooding in various part of city - may adversely impact health of citizens	Wards – 1, 7, 8, 9, 10, 11, 13, 14, 15, 16

Figure 56 Wards impacted with increase in temperature and humidity, the water demand will rise against the limited capacity of surface water supply - increase the use of bore well water, lead to adverse impacts on health

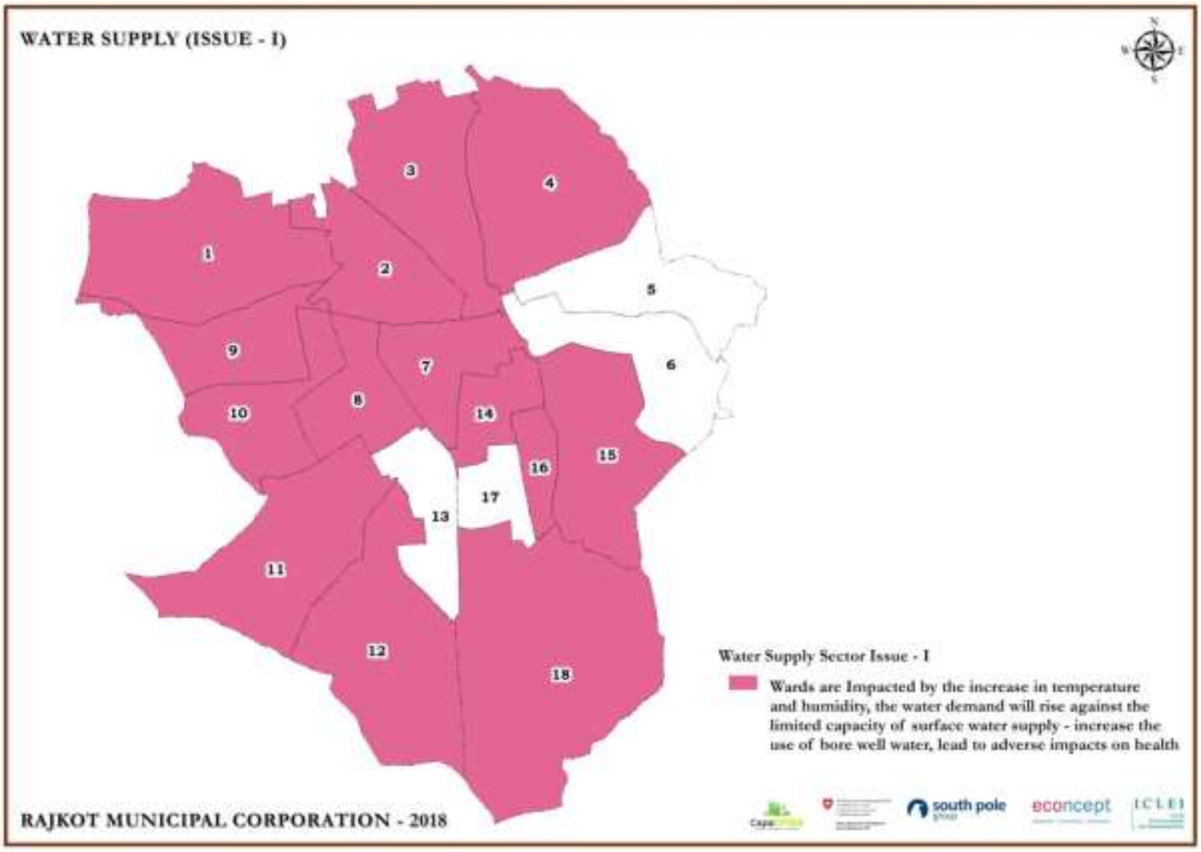


Figure 57 Wiards impacted with increase in high intensity rainfall in absence of storm water drainage network and low maintenance of natural drains -high chances of contamination of the water and flooding in various part of city - may adversely impact health of c

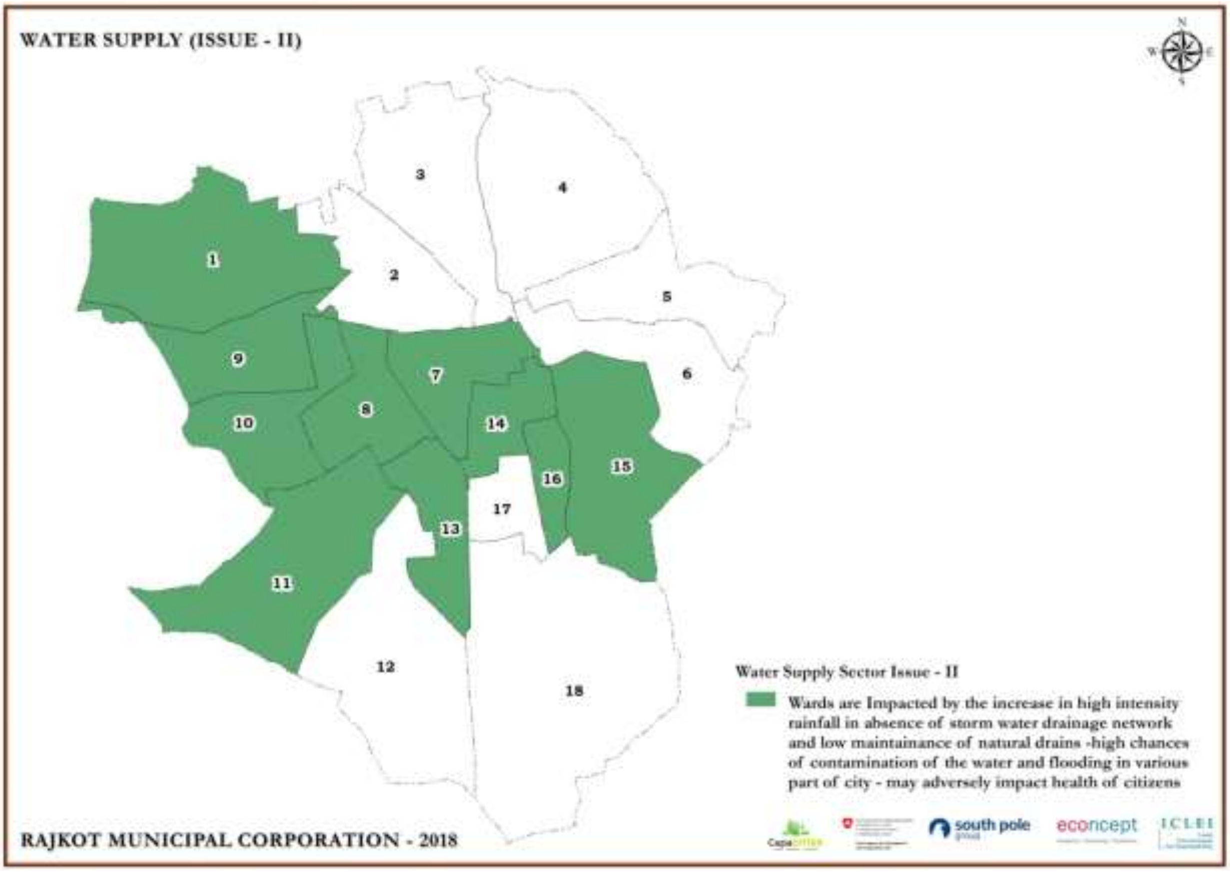
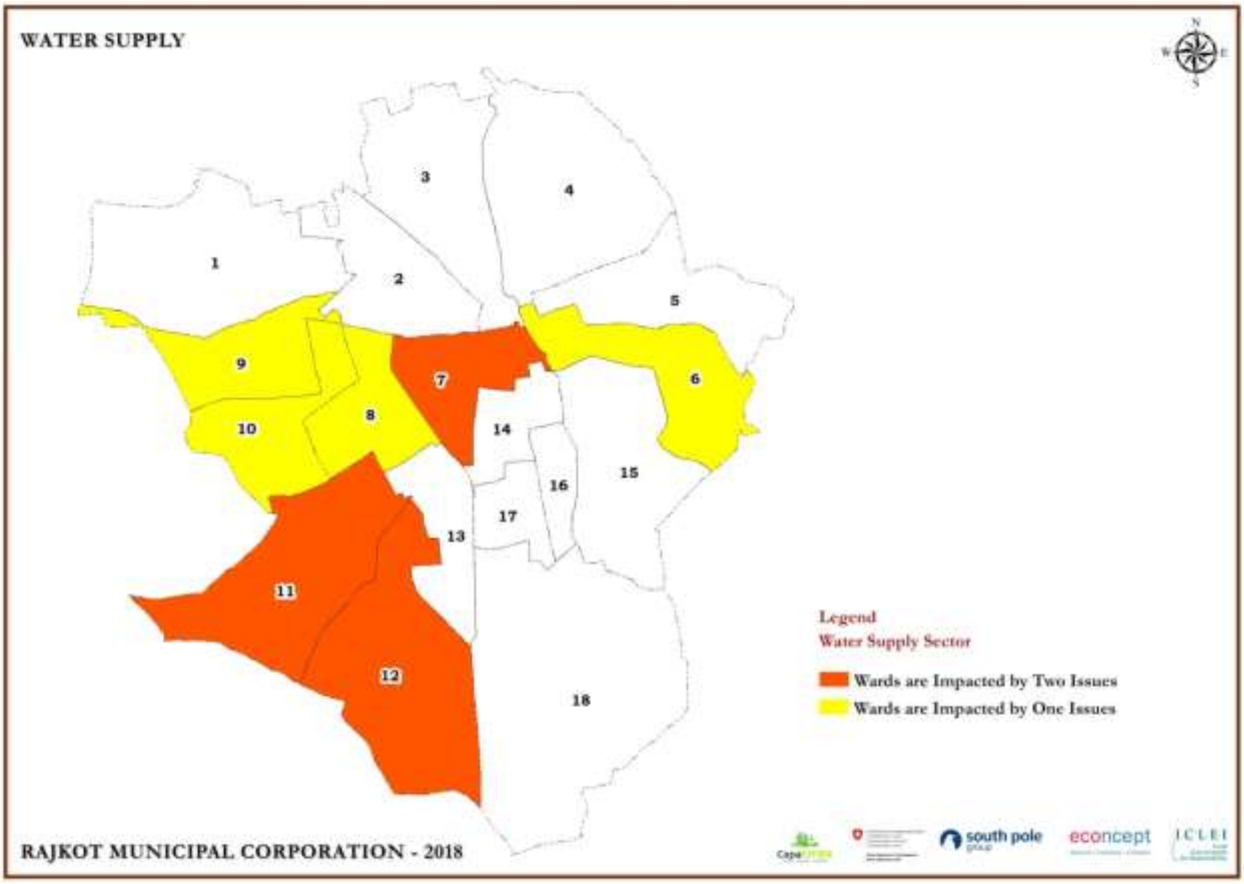


Figure 58 Wards most vulnerable to climate risks due to various issues in the context of Water Supply in Rajkot



3.5.4 Sewerage/ Drainage

The vulnerable areas in Rajkot for Sewerage/ Drainage as per the broad consensus in the SLD and analysis of quantitative information gathered from department were identified as follows:

Climate Fragility Statements	Issues identified for sector	Highly impacted Area/ward
1) High Mixed sewer overflow volumes , in times of high intensity rainfall, render sewage treatment systems ineffective; consequent untreated sewage flows pollute the vokdas and the Aji River **2)** Direct methane emission due to leakage of gas digester chamber and direct use of dry sludge as manure may lead to increase in pollution and severe health issues in city	Bypassing sewage without proper treatment in natural drains and inefficient way of saptage management in city - may increase in pollution level and severe health and hygiene issues	Wards – 1, 2, 3, 7, 8, 14, 16
	Direct methane emission due to leakage of gas digester chamber and direct use of dry sludge as manure may lead to increase in pollution and severe health issues in city	Wards – 1, 2, 3, 9

Figure 59 Wards impacted due to bypassing sewage without proper treatment in natural drains and inefficient way of saptage management in city - may increase in pollution level and severe health and hygiene issues

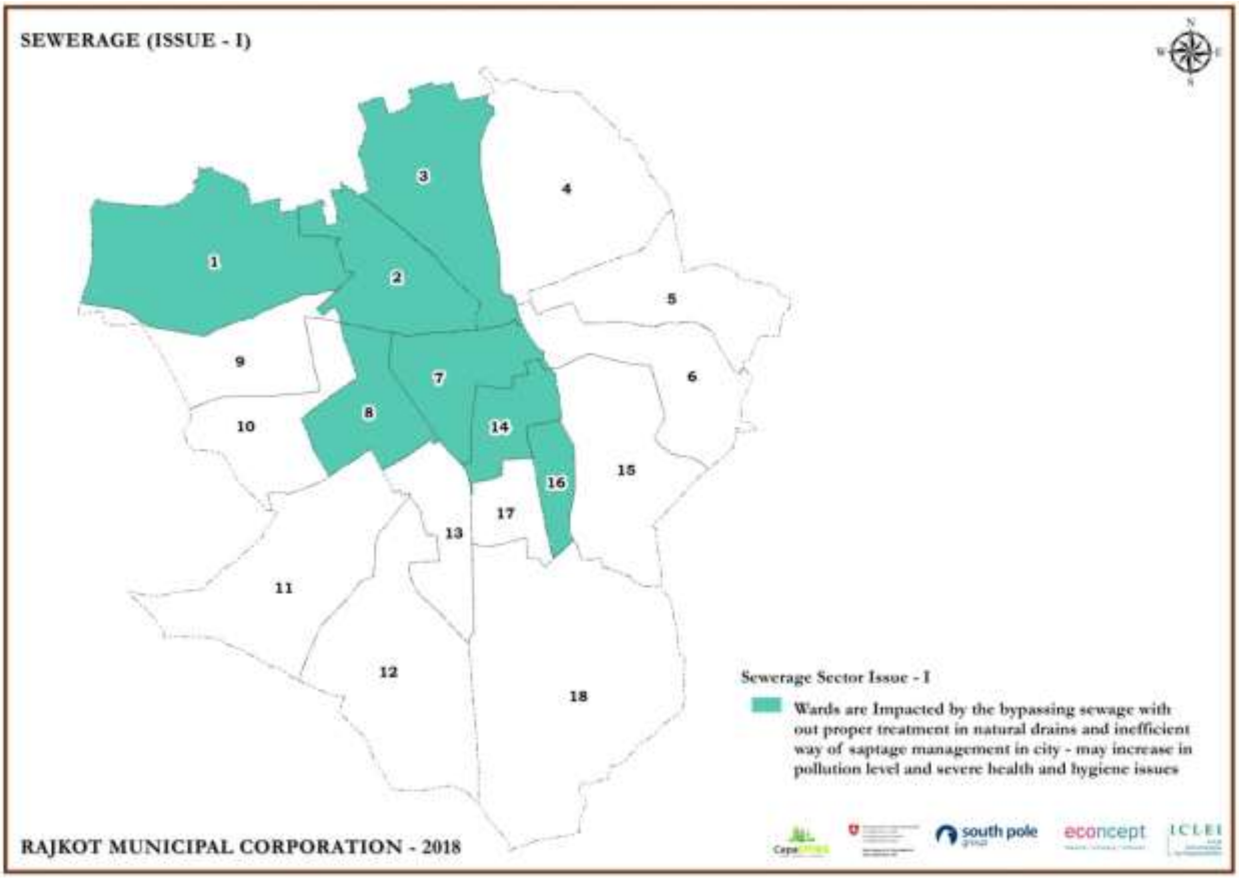


Figure 60 Wards impacted due to direct methane emission due to leakage of gas digester chamber and direct use of dry sludge as manure may lead to increase in pollution and severe health issues in city

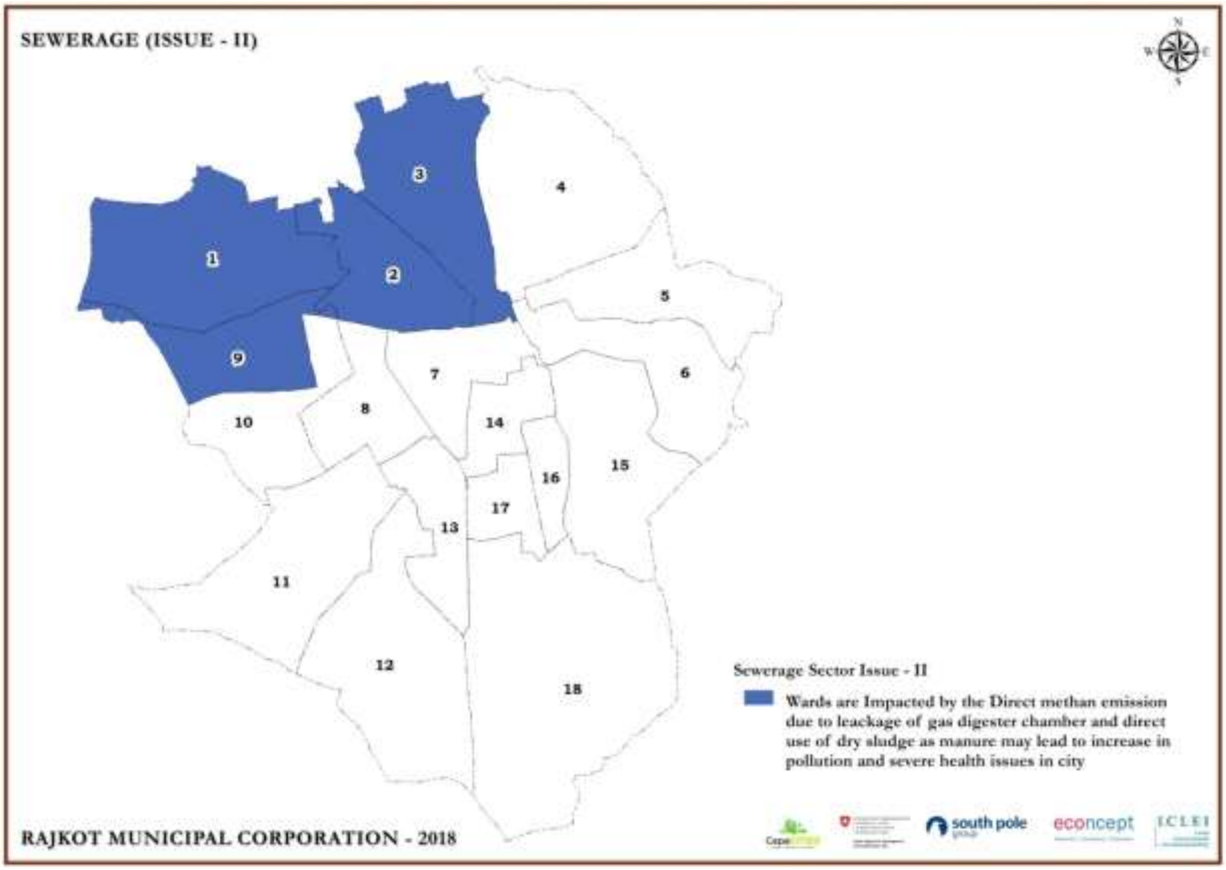
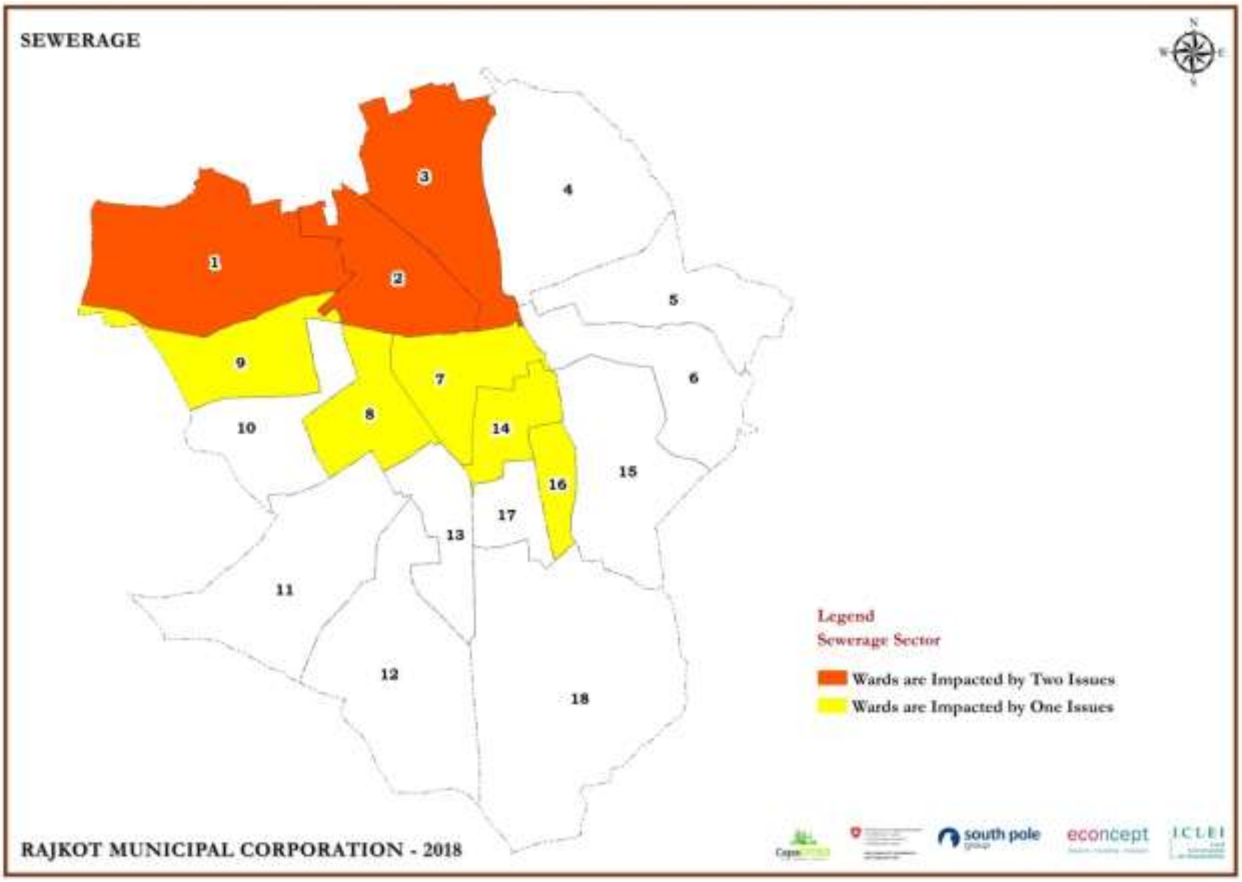


Figure 61 Wards most vulnerable to climate risks due to various issues in the context of Sewerage/ Drainage in Rajkot



3.5.5 Solid Waste Management

The vulnerable areas in Rajkot for Solid Waste Management as per the broad consensus in the SLD and analysis of quantitative information gathered from department were identified as follows:

Climate Fragility Statements	Issues identified for sector	Highly impacted Area/ward
1) Increasing temperatures accelerate decomposition rates and also create potentially hazardous conditions in open dumpsites by increasing the probability of landfill fires **2)** Solid waste littered in streets is washed into drains and open sewer manholes, during periods of high intensity rainfall, blocking outflow and resulting in stagnation, leading to public health impacts.	With increasing temperature, the rates of decomposition of waste changes, can encourage vectors of diseases and impact health	Wards – 2, 3, 4, 7, 8, 9, 10, 13, 14
	Increased rainfall can lead to blockages of drains due to solid waste and lead to water borne diseases and public health issues.	Wards – 2, 3, 4, 7, 8, 9, 10, 13, 14

Figure 62 Wards impacted with increasing temperature - the rates of decomposition of waste changes, can encourage vectors of diseases and impact health

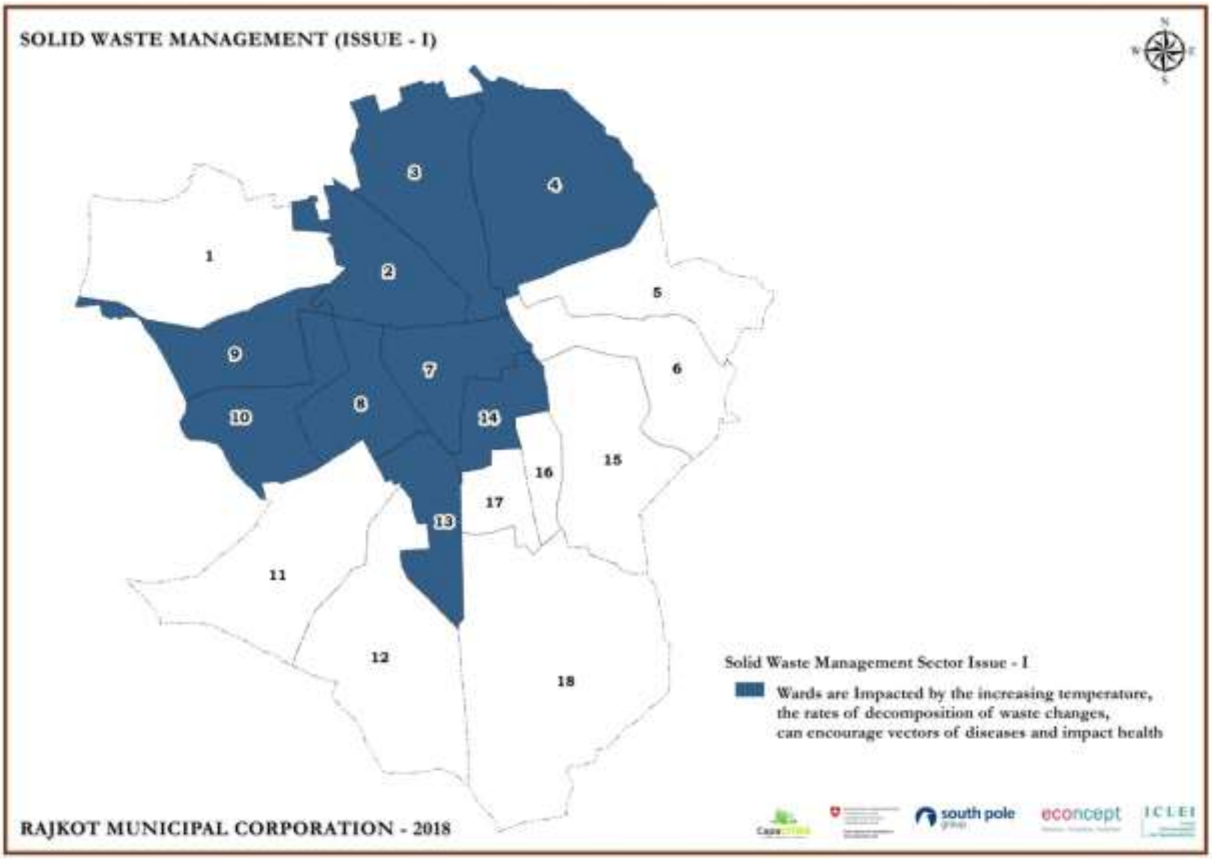


Figure 63 Wards impacted with increased rainfall - lead to blockages of drains due to solid waste and lead to water borne diseases and public health issues

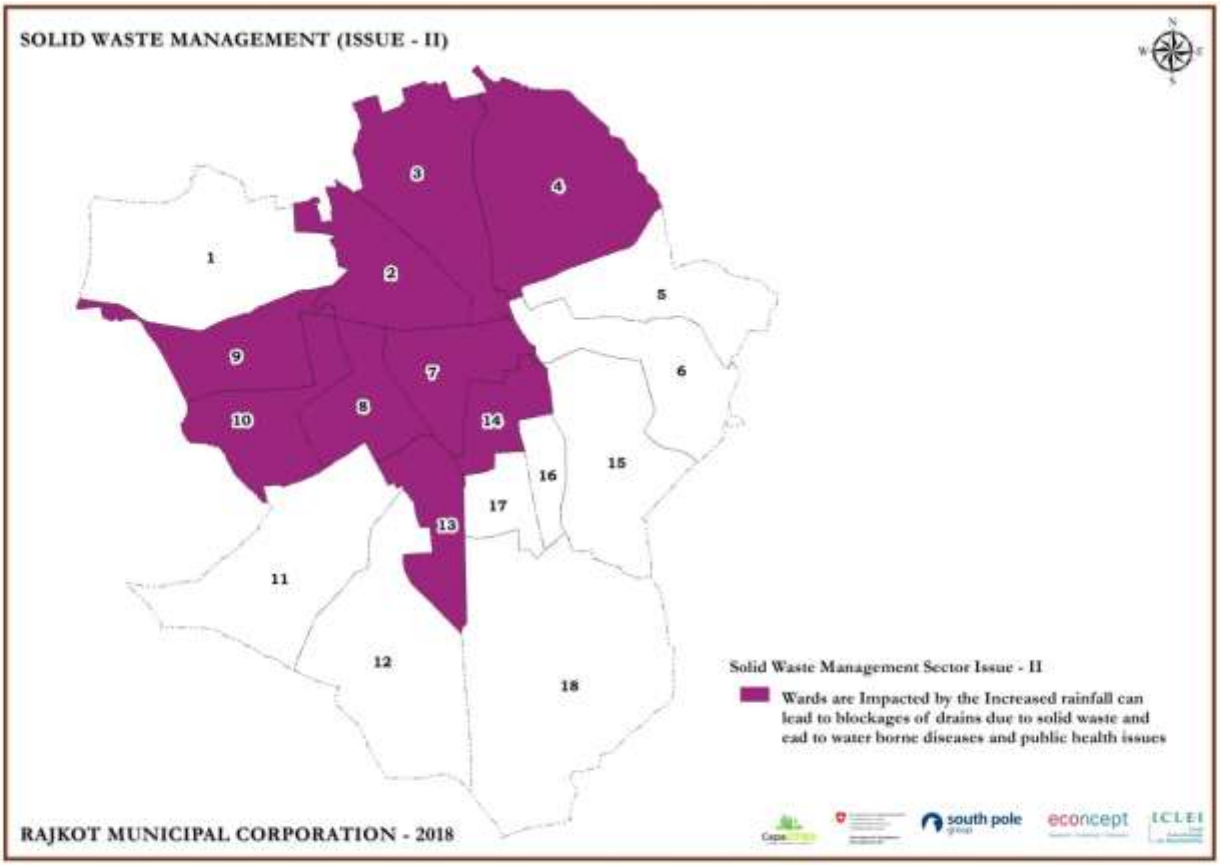
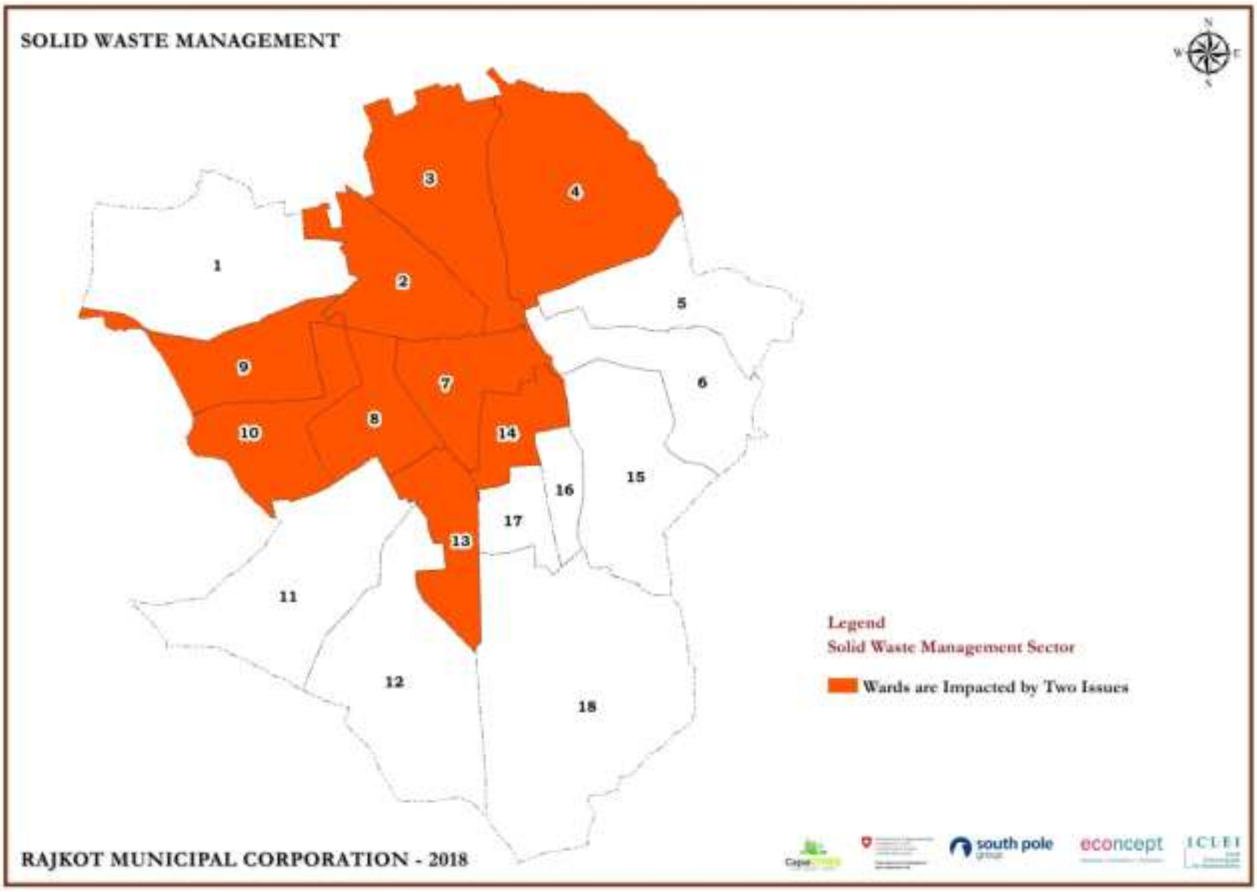


Figure 64 Wards most vulnerable to climate risks due to various issues in the context of Solid Waste Management in Rajkot

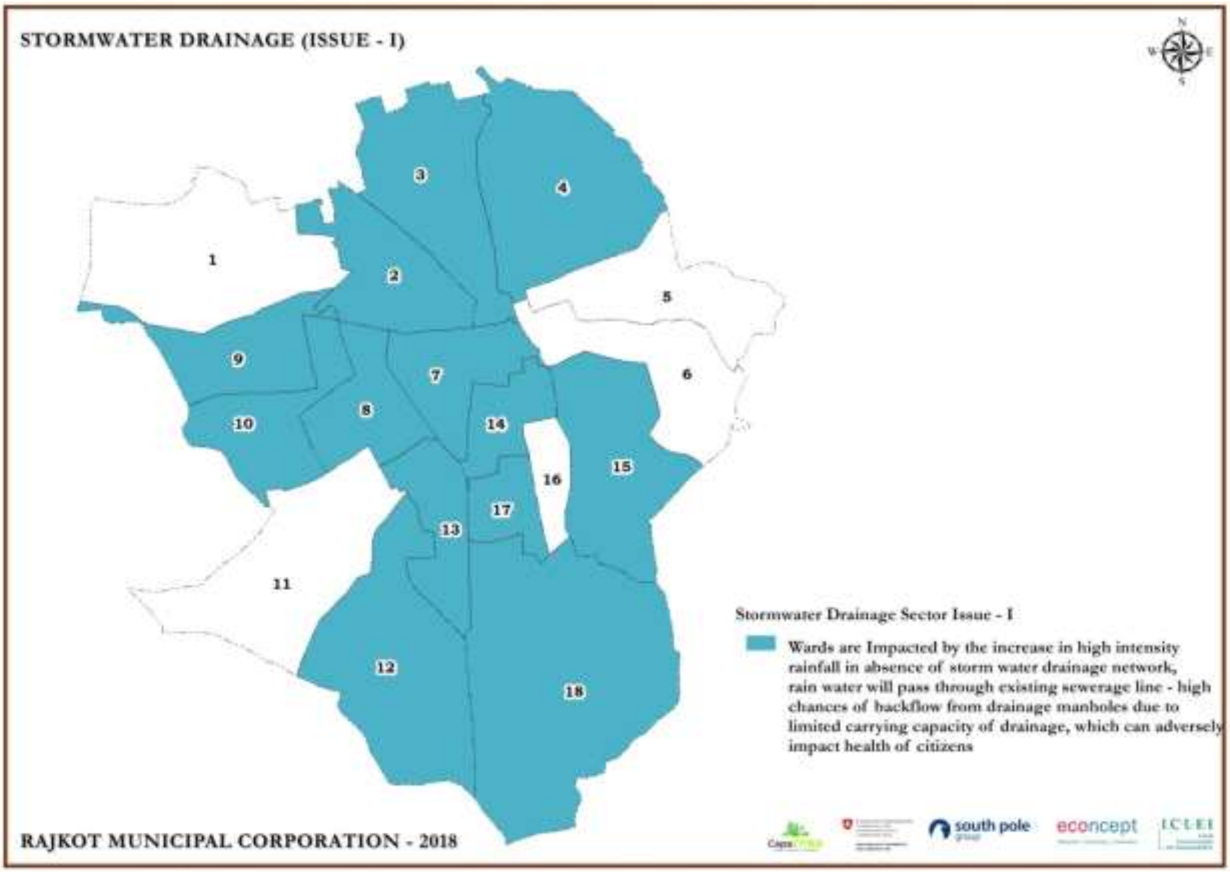


3.5.6 Storm Water Drainage

The vulnerable areas in Rajkot for Storm Water Drainage as per the broad consensus in the SLD and analysis of quantitative information gathered from department were identified as follows:

Climate Fragility Statements	Highly impacted Area/ward
With increase in high intensity rainfall in absence of storm water drainage network, rain water will pass through existing sewerage line, which has limited carrying capacity; there may be high chances of backflow from drainage manholes, which can adversely impact health of citizens.	Wards – 2, 3, 4, 7, 8, 9, 10, 12, 13, 14, 15, 17, 18

Figure 65 Wards impacted with increase in high intensity rainfall in absence of storm water drainage network, rain water will pass through existing sewerage line, which has limited carrying capacity; there may be high chances of backflow from drainage manholes, w



The sector specific vulnerability hotspot map (Figure 65) and issue specific vulnerability hotspot map (Figure 66) identifies ward numbers 2,7, 8, 9, 14 as the most vulnerable wards followed by ward numbers 3, 4, 10, 13 with regard to climate impacts in the city and faces the impacts on six and five urban system respectively out of the six fragile urban systems that have been analysed in this process. These wards are situated close to the natural drains and Aji river bank. These must be immediately focused on to build resilience through resource mobilization in light of the interventions that are identified in the following stages.

In addition, almost 65% of the remaining wards are impacted by multiple climate impacts as well. As such, interventions need to be identified for the fragile systems that can cover a majority of the area in the city as well.

Figure 66 Consolidated Sector Specific Vulnerable Hotspots for Rajkot

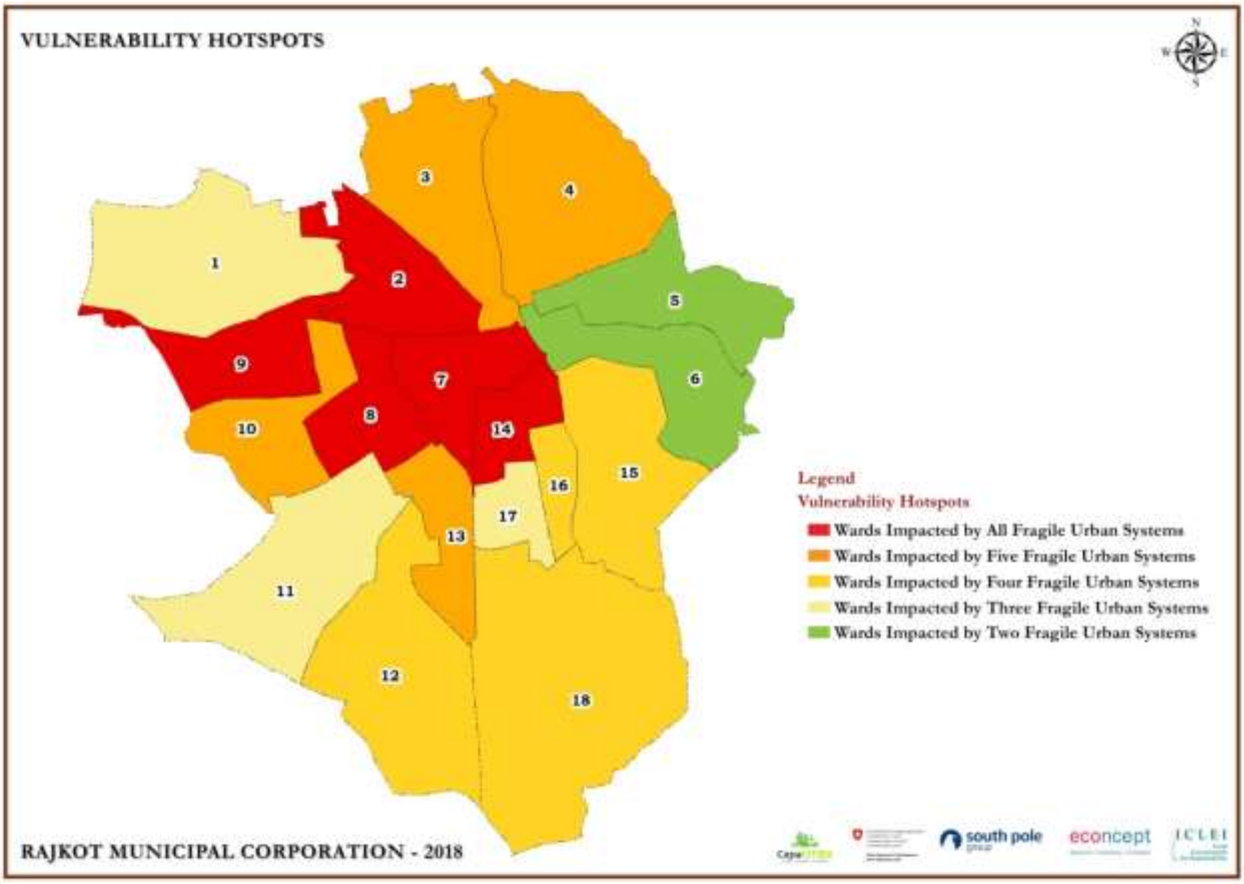
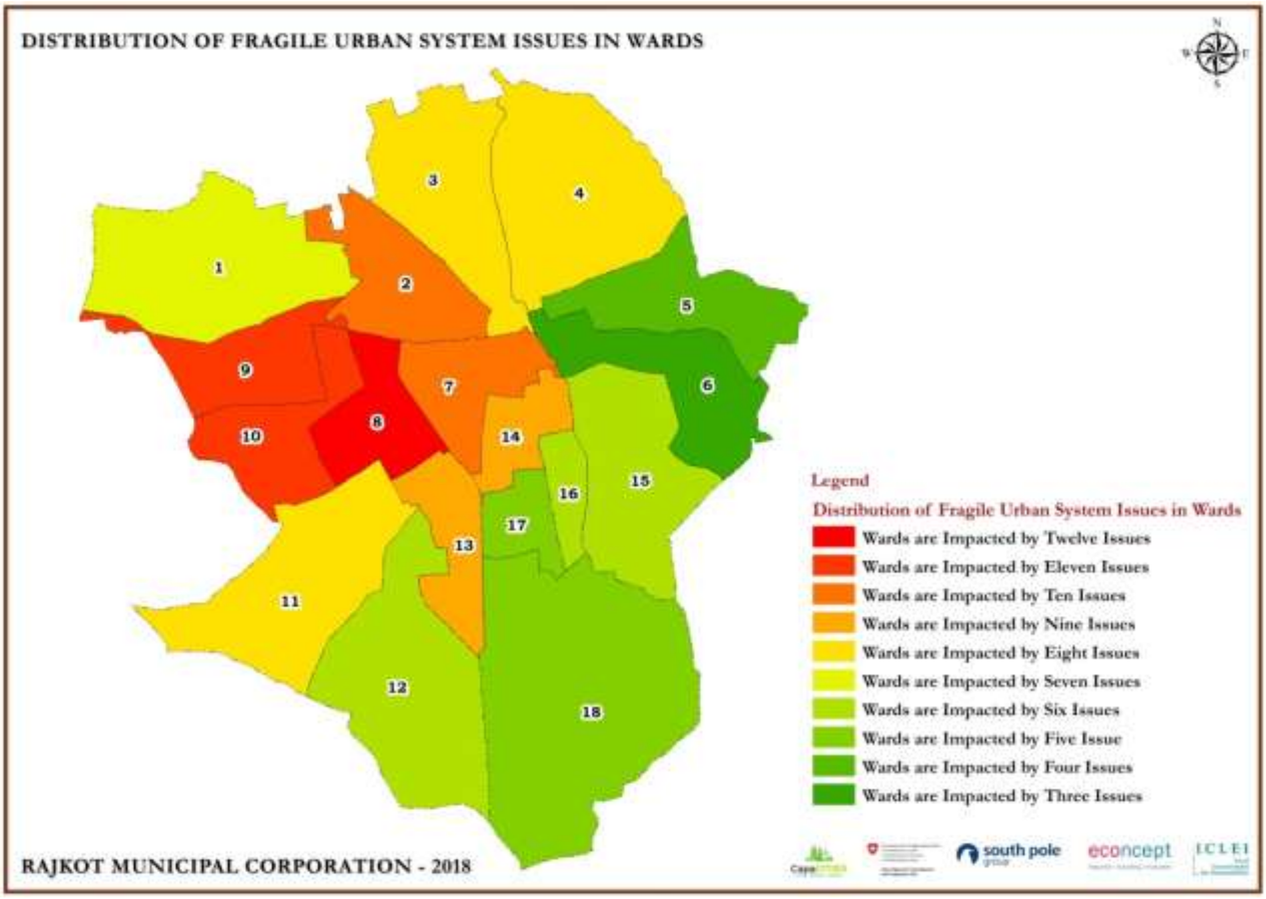


Figure 67 Distribution of fragile urban system issues in wards



3.6 Actor Analysis

In addition to the wards, for each fragile urban system, the relevant actors were identified by using tool 3.2D as shown in Table 16.

Table 19 Vulnerable places and Actors, Rajkot by using Tool 3.2D

Urban Systems	Climate fragility statement	Area	Actors
Health	Existing primary public health care infrastructure is adequate but needs improvements to address increasing health impacts, resulting from rising temperatures, increase in the duration of the summer season and flooding conditions resulting from high intensity and short duration rainfall	**Based on SLD** Impacted Areas - Areas on bank of Laludi vokda, Areas on bank of Aji river, Parshana Nagar main, Canal road vokda, vokda between Sant Kabir road and Pedak road Ward no. - 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16 **Based on Analysis** **Highly impacted wards -** 1,4,5,6,8,9,10,11,12,13,15,16,17,18 **Moderately impacted wards -** 2,3,7,14	1. Rajkot Municipal Corporation 2. Residential Societies 3. Slum People 4. NGOs 5. Hospitals (UHC/ hospitals/ private hospital) 6. Vulnerable people (Women, Children, elderly people) 9. Non- government organizations 10. Street vendors 11. Safai Kamdar of RMC 12. Health workers, Asha workers and Anganwadi workers 13. Public Relation Office, RMC
	Preventive health measures are rendered inadequate during periods of excessive heat and flooding	Ward no. - 1,2, 5, 7, 8,9,10,11, 12, 14, 17	1. Rajkot Municipal Corporation 2. Residential Societies 3. Slum People 4. NGOs 5. Hospitals (UHC/ Medical Colleges, hospitals/ private hospital) 6. Vulnerable people (Women, Children, elderly people 7. Drivers of two wheeler vehicles 8. Non- government organizations

Urban Systems	Climate fragility statement	Area	Actors
			9. Street vendors 10. Health workers, Asha workers and Anganwadi workers 11. Public Relation Office, RMC
Transportation (Public Transportation)	During periods of water logging and increasing temperatures, use of public transport is limited due to inadequate public transport services and limited last-mile connectivity.	**As per SLD** Highly impacted Areas - BRTS track, Kalawad Road, Madhapar, Raiya, Kalawad under bridge, near Chodhari school, Raiya, Nana Mava, 150ft ring road, Rail Nagar under bridge, Ghanshyam Nagar, Kothariya road, Mavdi, Ashapura Nagar, Jamnagar road, Amin Marg, Yagnik road, Bajarangwadi , Farsana Nagar, Popat Para nala, Near Nanda hall, Panchvati society, Hemu Gadhvi hall Wards - 1,2, 7, 8,9,10,11,12,13, 14 **Based on Analysis** Critical Wards - 2,7,8,9,10,11,12,13,15,17	1. Fire and Safety Department, Rajkot Municipal Corporation 2. Traffic and transport department, RMC 3. For public transportation - Rajkot Rajpath LTD, RMC 2. Traffic and city police department 3. Road side vendors 4. Vulnerable people (pedestrian and cyclists, women, elderly people and children) 5. Hospitals (UHC/ hospitals/ private hospital) 6. Slum areas 7. Residential housing societies 8.Local NGOs i.e. Bolbala charitable trust , Ramakrishna mission trust, Nav Bharat Mission
	Air pollution in the city is exacerbated due to increase in private vehicles, and resultant traffic congestion	Highly impacted wards - 2,3,4,7,8,9,10,11,13,14 Moderately impacted wards - 1,5,15,17	
Transportation (Road Infrastructure)	During periods of intense rainfall, roads get water logged, which further exacerbates road congestion and affects	Critical wards - 2,3,4,5,6,7,8,10,11,12,13,14,16,17	1. Fire and Safety Department, Rajkot Municipal Corporation 2. Traffic and transport department, RMC 3. For public transportation - Rajkot Rajpath LTD, RMC

Urban Systems	Climate fragility statement	Area	Actors
	connectivity and mobility. Connectivity between central zone and west zone is mostly through underpasses, which is affected during intense rain		2. Traffic and city police department 3. Road side vendors 4. Vulnerable people (pedestrian and cyclists, women, elderly people and children) 5. Hospitals (UHC/ hospitals/ private hospital) 6. Slum areas 7. Residential housing societies 8.Local NGOs i.e. Bolbala charitable trust , Ramakrishna Mission Trust, Nav Bharat Mission
Water supply	Exposure of the community to poor quality ground water increases due to increased demand for water during periods of increased temperature, as treated piped water supply is limited	**Based on SLD** Areas - 150ft ring road, Kalawad road, Yagnik road, Bajarangwadi, Raiya, Mavdi, Gondal chowk Highly impacted wards - 2,3, 7,8,9, 10,11,12, 14 **Based on Analysis** Highly impacted wards - 1,2,3,4,7,8,9,10,11,12, 14,15,16,18 Moderately impacted wards - 5,6,13,17	1. Hand pump and bore well department - Rajkot Municipal Corporation 2. Gujarat Water Supply and Sewerage Board (GWSSB) 2. Narmada water supply - Gujarat Water Infrastructure Limited (GWIL) 3. Ground Water Management in city Limit - Gujarat Water Resources Development Corporation (GWRDC) 4. Hospitals (UHC/ hospitals/ private hospital) 5. Agencies registered for water supply through tankers 4. Vulnerable people (Women, Children, elderly people) 5. Slum areas and people residing on bank of Natural drains and Aji river 6. Residential housing societies
	Increased flooding during periods of high intensity	**Based on SLD** Highly Impacted Areas due to flooding - Kalawad	1. Fire and safety Department, Water works and drainage departments, Rajkot Municipal

Urban Systems	Climate fragility statement	Area	Actors
	rainfall increases chances for potential contamination of surface water supply with untreated sewage due to compromised water distribution and sewage collection networks	Road, Kalawad under bridge, near Chodhari school, Raiya, Nana Mava, 150ft ring road, Rail Nagar under bridge, Ghanshyam Nagar, Kothariya road, Mavdi, Ashapura Nagar, Jamnagar road, Amin Marg, Yagnik road, Bajarangwadi , Farsana Nagar Highly Impacted areas due to contamination - Lodheshwar society, Green land chowkdi, Bhagvati Para, Parshana nagar, Ramnagar, Kubaliya Para, Shrinagar main road, Madhuram chowk, Rukhadiya Para, Balkrishna society Highly Impacted Wards- 1, 2, 4, 7, 8, 10, 12, 13, 14, 15, 16 **Based on Analysis** Highly impacted wards - 1,7,8,9,10,11,13,14,15,16 Moderately impacted wards - 2,3,4,12,17,18	Corporation 2. Hospitals (UHC/ hospitals/ private hospital) 3. Various Non-governmental Organizations 4. Vulnerable people (Women, Children, elderly people) 5. Community residing on bank of natural drains 6. Residential housing societies 7. Bolbala charitable trust 8. Ramakrishna Mission Trust 9. Nav Bharat Mission
Sewerage/ Drainage	High Mixed sewer overflow volumes , in times of high intensity rainfall, render sewage treatment systems ineffective; consequent untreated sewage flows pollute the vokdas and the Aji River	**Based on SLD** Areas - Bedipara, Laludi Vokdi, Madhapar, low lying areas on Aji river bank and natural drains Wards - 2,3,7,8,10,11,13,14 **Based on Analysis** Highly impacted wards - 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 17	1. Rajkot Municipal Corporation 2. Various Non-governmental organization 3. Gujarat Water Supply and Sewerage Board (GWSSB) 3. Hospitals (UHC/ hospitals/ private hospital) 4. Vulnerable people (Women, Children, elderly people) 5. People residing in low lying area/ on bank of vokda and Aji river

Urban Systems	Climate fragility statement	Area	Actors
		Moderately impacted wards - 4, 15, 16 Less impacted wards - 1, 5, 6, 18	6. Slums 7. Residential housing societies 8. Agencies registered for maintaining drainage line 9. Gujarat Pollution Control Boards 8. Private contractors registered for septage management 9. Private contractor operating and maintaining STP plants
	Direct methane emission due to leakage of gas digester chamber and direct use of dry sludge as manure may lead to increase in pollution and severe health issues in city	Ward no. 1 , 2, 3, 9	1. Rajkot Municipal Corporation 2. Various Non-governmental organizations 3. People residing near STP plant 4. Vulnerable people (Women, Children, elderly people) 5. Farmers using sludge as manure 6. Slums 7. Residential housing societies 8. Agencies registered for construction and maintaining STP 9. Gujarat Pollution Control Boards
Solid Waste Management	Increasing temperatures accelerate decomposition rates and also create potentially hazardous conditions in open dumpsites by increasing the probability of landfill fires	Areas on bank of river and natural drains Ward numbers - 1, 2, 3, 4, 7, 8, 10, 12, 13, 14, 15, 16	1. Rajkot Municipal Corporation 2. Various Non-governmental organizations 3. People residing near Natural Drains 4. Vulnerable people (Women, Children, elderly people) 5. Slums 6. Rajkot SMART societies 7. Rag pickers

Urban Systems	Climate fragility statement	Area	Actors
	Solid waste littered in streets is washed into drains and open sewer manholes, during periods of high intensity rainfall, blocking outflow and resulting in stagnation, leading to public health impacts.	Areas on bank of river and natural drains Ward numbers - 1, 2, 3, 4, 7, 8, 10, 12, 13, 14, 15, 16	
Storm water drainage	With increase in high intensity rainfall in absence of storm water drainage network, rain water will pass through existing sewerage line, which has limited carrying capacity; there may be high chances of backflow from drainage manholes, which can adversely impact health of citizens. .	Highly impacted wards - 2, 3, 5, 6, 7, 8, 9, 13, 14, 16 Moderately impacted wards - 10, 11, 12, 17 Less impacted wards - 1,4, 5, 6, 15, 18	1. Rajkot Municipal Corporation 2. Various Non-governmental organizations 3. Hospitals (UHC/ hospitals/ private hospital) 4. Vulnerable people (Women, Children, elderly people) 5. Slum areas 6. Residential housing societies 7. Agencies registered for maintaining drainage line 8. Bolbala charitable trust 9. Ramakrishna Mission Trust 10. Nav Bharat Mission

An analysis of the actors within the wards identified as vulnerable revealed that they had relatively good levels of adaptive capacities. This should be taken advantage of while implementing the resilience interventions that are identified in later stages. Table 16 below shows the adaptive capacities of the actors based on capacity to respond, capacity to access the information and resources available for each fragile urban system (Annexure 6 gives the details of the Actor Analysis). It has been noted that slum people, road side vendors, and people residing on bank of natural drains and river are most vulnerable people with very low adaptive capacity.

Table 20 Analysis of the adaptive capacities of local actors identified

Actors	Adaptive capacity score	Adaptive Capacity
Rajkot Municipal Corporation	18	High
Traffic and city police department	12	Medium
Regional Transport Office	4	Low
Road side vendors	1	Low
Private vehicle owners	2	Low
Vulnerable people (Cyclist, pedestrian, women, children, elderly people)	2	Low
Migrant labours	1	Low
Hospitals (Government and private hospitals, UHC, medical colleges)	12	Medium
Slum areas	1	Low
Community residing on bank of natural drains and Aji River	1	Low
Residential Housing Societies	2	Low
Rajkot Smart Societies	6	Low
Local NGOs i.e. Bolbala charitable trust , Ram krushna mission trust, Nav Bharat Mission	12	Medium
Health workers, Asha workers and Anganwadi workers	12	Medium
Public Relation Office, RMC	8	Medium
Safai Kamdar of RMC	2	Low

Actors	Adaptive capacity score	Adaptive Capacity
Gujarat Water Supply and Sewerage Board (GWSSB)	18	High
Narmada water supply - Gujarat Water Infrastructure Limited (GWIL)	18	High
Ground Water Management in city Limit - Gujarat Water Resources Development Corporation (GWRDC)	18	High
Agencies registered for water supply through tankers	12	Medium
Agencies registered for maintaining drainage line	8	Medium
Gujarat Pollution Control Boards	12	Medium
Private contractors registered for septage management	8	Medium
Private contractor operating and maintaining STP plants	8	Medium
People residing near STP plant	1	Low
Farmers using sludge as manure	1	Low
Rag pickers and local pastiwalas	1	Low

4 City Climate Action Plan

4.1 Identification & Prioritization of Resilience Interventions

Various mitigation and adaptation interventions have been identified for Rajkot based on GHG emission inventory and urban system analysis in line with existing city planning. Mitigation and adaptation potential for each intervention along with financial aspect and implementation mode have been identified under Climate Action Plant. Prioritization of Resilience Interventions, feasibility and impact assessment has been done by using tool 4.2 (See annexure 7 and 8).

Table 21 Resilience Interventions proposed under Climate Action Plan, Rajkot

Resilience Interventions	**Annual Mitigation Potential (2022-23)**			**Adaptation Impact**	**Cost of interventions (Million INR)**	**Implementation mode**
	Potential Energy Saving (Million kWh)	**Potential Fuel Saving (KL)**	**Potential GHG emission reduction (tCO2e)**			
Residential Building Sector Baseline (2015-16) Total Energy consumption – 4,759,044 Giga Joule (Total Electricity consumption – 605 Million kWh) Total GHG emission – 655,578 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 173.61 Million kWh Total GHG emission mitigation potential – 142,844.25 tCO2e						
Energy Efficient star rated appliance retrofits	7.95	NA	6,541.56	NA	-	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Replacement of CFL lights with LED bulbs in Residential HHs Under UJALA Scheme	87.38	NA	71,896.02	NA	52.04	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Replacement of CFL lights with LED tube lights in Residential HHs Under UJALA Scheme	16.62	NA	13,675.87	NA	39.03	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Replacement of existing fans with EE fans under UJALA Scheme	8.55	NA	7,033.31	NA	139.40	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Use of Solar water heater in place of conventional geyser	37.50	NA	30,854.25	NA	450.00	

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Rooftop Solar PV in Residential buildings	14.44	NA	11,884.44	NA	674.07	Gujarat Solar Policy 2015; State and Central Government subsidy scheme
Rooftop Solar PV in Affordable housing (proposed under CapaCITIES)	0.06	NA	49.37	NA	3.60	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project
Replacement existing fans with super EE fans in Affordable housing schemes (proposed under CapaCITIES)	0.02	NA	15.56	NA	0.44	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project
Rooftop Solar PV for common utilities in Affordable housing (proposed in Smart Ghar 3)	0.51	NA	420.85	NA	23.87	Rajkot Municipal Corporation
Rooftop Solar PV for common utilities in Affordable housing	-		-		-	Rajkot Municipal Corporation
Green building designs for SMART Ghar 3 (proposed)	0.18	NA	145.13	NA	-	Rajkot Municipal Corporation
Installation of EE appliances in Smart Ghar 1	0.23	NA	192.12	NA	2.38	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project – Proposal by RMC

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Rooftop PV installation on 11A and 14A affordable housing schemes for common utilities	0.17	NA	135.76	NA	7.70	Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project – Proposal by RMC
Replacement of Existing common lighting with LED lighting in 3 Mukhya Mantri Gruh Vikas Yojana (MMGVY) schemes by RMC (38A, 5C, 2D) [5]						Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project – Proposal by RMC
Total (1)	**173.61**		**142,844.25**		**1,392.54**	
Commercial and Institutional Buildings/Facilities Baseline (2015-16) Total Energy consumption – 1,008,827 Giga Joule (Total Electricity consumption – 243.56 Million kWh) Total GHG emission – 207,597 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 44.37 Million kWh Total GHG emission mitigation potential – 36,503.47 tCO2e						
Energy Efficient star rated Air Conditioners retrofits	8.90		7,319.50		-	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme

[5] Details and Information from RMC is pending for this intervention

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Replacement of CFL lights with LED bulbs in commercial units Under UJALA Scheme	23.19		19,078.96		13.81	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Replacement of CFL lights with LED tube lights in commercial units Under UJALA Scheme	4.41		3,629.15		10.36	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Replacement of existing fans with EE fans in commercial units under UJALA Scheme	2.90		2,384.59		47.26	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Use of Solar water heater in place of conventional geyser for hotels and hospitals	1.88		1,542.71		22.50	
Rooftop Solar PV in institutions	1.84		1,511.86		85.75	Gujarat Solar Policy 2015; State and Central Government subsidy scheme
Rooftop Solar PV in commercial units	1.26		1,036.70		58.80	Gujarat Solar Policy 2015; State and Central Government subsidy scheme
Total (2)	**44.37**		**36,503.47**		**238.48**	

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Manufacturing Industry and Construction (i.e. Industrial sector) Baseline (2015-16) Total Energy consumption – 2,298,595 Giga Joule (Total Electricity consumption – 363.60 Million kWh) Total GHG emission – 349,363 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 4.61 Million kWh Total GHG emission mitigation potential – 3,790.40 tCO2e						
Energy Efficient star rated appliance retrofits	2.66		2,185.98		-	"Unnat Jyoti by Affordable LEDs for All (UJALA)" – Central Government Scheme
Rooftop Solar PV in various industries	1.95		1,604.42		91.00	Gujarat Solar Policy 2015; State and Central Government subsidy scheme
Total (3)	**4.61**		**3,790.40**		**91.00**	
Municipal Services						
Water Supply Baseline (2015-16) Total Energy consumption – 140,055 Giga Joule (Total Electricity consumption – 38.36 Million kWh) Total GHG emission – 31,549 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 20.47 Million kWh Total GHG emission mitigation potential – 16,840.41 tCO2e						

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
NRW reduction from 28% to 22% (Proposed)	2.26		1,859.41	**Responsiveness** - The intervention will result in an overall reduction in demand for water supply	-	Rajkot Municipal Corporation with ADB funding
Rooftop Solar PV installation on Ribda water treatment plant (Proposed)	0.04		30.85		1.75	Rajkot Municipal Corporation budget 2018
Rooftop Solar PV installation on pumping stations and water treatment plant	0.6		493.66		28.00	Rajkot Municipal Corporation budget 2018
Reuse of water for gardening and green cover	3.78		3,114.11		-	Rajkot Municipal Corporation
EE implementation based on Energy Audits	13.79		11,342.38		-	Rajkot Municipal Corporation with EESL based on ESCo model

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Implementation of Rain water harvesting system and policy for ground water abstraction and guideline for recharge			--	**Redundancy -** Intervention will support a higher degree of self-sufficiency at the household level. **Flexibility -** Rain water is not utilised in absence of required infrastructure, intervention will allow for water to be utilised on site or channelized towards recharging groundwater as well **Responsiveness -** In case of shutdown of the city's water supply system, households have stored rainwater for use		• It is already mandatory as per General Development Control Regulation to implement rainwater harvesting system for certain kind of buildings • RMC has already implemented rain water harvesting in more than 16 affordable housing schemes

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Strengthen and strict implementation of dual plumbing system (including residential buildings) and strict monitoring			Due to potential of treatment at decentralised level, Energy consumption from waste water pumping from site till sewage treatment plant will reduce and hence GHG emission	**Redundancy -** Rajkot is in water scares region, reuse and recycling of waste water for non-portable use has good potential to reduce consumption of fresh water for the purpose **Flexibility -** As grey and black water collected separately has great potential of effective treatment on site or nearby, which will reduce load and dependency on existing sewerage network **Responsiveness -** as dual plumbing system has potential to treat waste in decentralised manner, which will reduce use of electricity for pumping - Fresh water usage can be reduce for non-portable purposes		Mandatory as per GDCR for certain building types and area – It can be mandatory for residential construction as well It is already mandatory as per General Development Control Regulation to implement such interventions for some kind of buildings. i.e. hospitals and hospitalities (>5000 sq.m. construction); hostels, education institutions, community centres, commercial and industries (> 10000 sq.m. construction)

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Compulsion of water meters for all buildings with socially acceptable water metering pricing policy				**Redundancy -** Intervention has potential to change usage habits among public, which will reduce waste of fresh water. **Flexibility -** Intervention will reduce wastage of freshwater will lead to availability of freshwater for various purposes **Access to information -** It will be possible for city to get information on actual water requirement and if there is any water leakages. Improve efficiency of water collection charges		AMRUT Mission RMC has already proposed to install water meters for 15000 households in city on pilot bases, city is planning to replicate project based on this pilot implementation Policy – As This intervention requires to develop socially acceptable water prices, which may lead to social issues (strong political will is needed to prepare socially acceptable policy)

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Assessment of potential for augmenting local water resources (groundwater recharge, rainwater harvesting, and waste water reuse) under CapaCITIES project Best practices of lakes and catchment area management			Water is pumped over a distance of around 700 Km, requiring a total of 143million kWh electricity consumption for pumping leads to 117,540 tCO2e of GHG emission per year. Intervention will help to reduce emission.	**Redundancy -** Local aquifer recharge and an improvement in the ground water situation are desired outcomes along with reuse of treated wastewater, which will help to address water scarcity and pressure on the declining ground water resource **Flexibility -** Intervention will reduce city's dependency on Narmada water **Responsiveness -** In case of break down in Narmada water supply, city will have water stored in local water resources for use		Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Replacement of existing old pipelines with new DI pipeline with proper hydraulic design			Reduced NRW will lead to save electricity and related GHG emission	**Redundancy** -Supports city to reduce Non-revenue water due to leakages and illegal water connections **Flexibility -** Freshwater will be available for longer period due to reduction in NRW **Responsiveness -** It will be possible to reduce fresh water contamination and hence related health issues **Access to Information** - RMC can identify illegal connections and leakage		Funding - ADB • 15% of total water distribution network is replaced with DI pipeline • RMC has proposed to replace existing network with DI in phase wise manner in wards 1,8,9,10,11, and 12 by RMC
Legalise all illegal existing water connections and stop direct pumping			Reduced energy consumption with subsequent social benefit	**Redundancy -** Illegal water connections and direct pumping leads to water pressure drop during subsequent supply next day due to empty water supply network **Flexibility -** Beneficiary will be able to receive sufficient water as per designed pressure levels within 20minutes water supply		Rajkot Municipal Corporation City has regularized 21697 illegal water connections, issued notice to 1259 direct pumping cases, cut 5874 illegal water connections and issued notice to 549 HHs wasting water

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO_2e)			
Sewerage Baseline (2015-16) Total Energy consumption – 24,043 Giga Joule (Total Electricity consumption – 6.66 Million kWh) Total GHG emission – 5,142 tCO_2e Climate Resilience Potential (2022-23) Total Electricity savings – 4.87 Million kWh Total GHG emission mitigation potential – 4,005.51 tCO_2e						
Energy efficiency in pumping and SCADA implementation	4.27		3,511.85		-	Rajkot Municipal Corporation with EESL based on ESCo model
Rooftop Solar PV for New Raiya Sewage Treatment plant	0.38		308.54		22.50	Rajkot Municipal Corporation budget 2018
Rooftop Solar PV for drainage pumping stations	0.23		185.12		13.50	Rajkot Municipal Corporation budget 2018

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Implementation of 100% Sewerage network in city, including peri-urban areas			Potential of GHG emission reduction due to direct waste water dumping and reduced BOD load after treatment	**Redundancy -** Around 15% of total households are using septic tanks, providing inefficient treatment, which may lead to additional soil and groundwater pollution and related health issues. **Flexibility -** All proposed STP has enough capacity to treat sewerage efficiently, linkage of all this areas with STP through this intervention has potential to reduce pollution and related health impacts **Responsiveness -** Proper treatment of wastewater will improve condition of natural drains and reduce water pollution in Aji river		Rajkot Municipal Corporation under AMRUT Scheme

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Improve treatment quality and adequacy of existing old STP plants			Potential GHG emission reduction due to direct waste water dumping with reduced BOD load after treatment and energy consumption of waste water pumping.	**Redundancy -** Existing STPs do not comply with the recently revised national standards (10mg/L BOD level in treated waste water) with 50% adequacy of treatment. Excess water is bypassed in natural drain causing pollution **Flexibility -** System will provide efficient treatment and hence reduce direct waste water dumping in natural drainage **Responsiveness -** Treated water flow in natural drains will lead to reduction in pollution and related health issues.		Rajkot Municipal Corporation under AMRUT Scheme Total 162MLD STPs are operational (51 MLD based on SBR and 110 MLD based on ASP technology) in city and construction of additional 150MLD STPs based on SBR technology is in progress by RMC (will be completed by 2019-20).

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Assessment of gas digester chamber at Raiya STP to stop direct methane emission			GHG emission reduction by stopping direct methane emissions from STP plant	**Redundancy** - Direct methane emissions from the structurally compromised gas digesters at the 50MLD STP plant at Raiya pollute the environment **Flexibility** - Energy can be produce by utilising methane gas generated from STP **Responsiveness** - Direct methane emission is more harm full for climate, intervention will help to stop this emission **Access to information** - Intervention will provide information on energy generation potential which may be utilise with in plant		Rajkot Municipal Corporation is receiving support form Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project for this intervention

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Stop direct usage of dry sludge without quality check and provide additional treatment if required				**Redundancy -** Using dry sludge without quality check may be harm full due to E-Coli and hard metals **Flexibility -** By providing additional required treatment, manure can be utilise by farmers, less harm full for agriculture **Responsiveness** – Stop direct usage of dry sludge, which may be harm full for agricultural issues and lead to critical health issues **Access to information -** Land pollution by using without quality check		Rajkot Municipal Corporation

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Rejuvenation of existing natural drains				**Redundancy** - Natural drains are being used for waste water and solid waste dumping, degraded environmental condition leads to severe health issues **Flexibility** - Rejuvenated natural drains may be utilise for effective storm water management in city **Responsiveness** - Intervention has potential to reduce health hazards due to degraded environmental quality		Rajkot Municipal Corporation – Already sanctioned few projects Resurfacing of 13 main natural drains to river is proposed along with construction of 2 interceptor drains on either side of Aji River by end 2019.

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Implementation of storm water drainage				**Redundancy -** absence of storm water drainage, sanitary sewer network doubles up as a conveyance network during periods of intense rainfall. Channels leading to natural drains are built over causing water logging and flooding in the streets during intense, long duration rainfall **Flexibility -** Storm water may be utilise for various purpose if not mixed with sewerage line **Responsiveness -** Stop direct dumping of excess wastewater in natural drains		Rajkot Municipal Corporation – AMRUT Scheme
Street lighting Baseline (2015-16) Total Electricity consumption – 14.99 Million kWh Total GHG emission – 12,332.52 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 7.47 Million kWh Total GHG emission mitigation potential – 6,145.72 tCO2e						

Resilience Interventions	Annual Mitigation Potential (2022-23) Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)	Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
ESCo. Replacement of existing Street lighting with LED	7.47		6,145.72		-	Rajkot Municipal Corporation with EESL based on ESCo model
Transportation Baseline (2015-16) Total Energy consumption – 7,649,868 Giga Joule (Total Petrol consumption – 67,869.7 KL, Total Diesel Consumption – 90,428.02 KL) Total GHG emission – 534,818.17 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 1.36 Million kWh Total Diesel savings – 7,542.22 KL Total GHG emission mitigation potential – 14,796.07 tCO2e						
Rooftop SPV for renewable energy for electric buses	1.36		1,119.85		72.59	Rajkot Municipal Corporation
Replacement of all 11 BRTS diesel buses with electric buses		302.46	862.17		375.09	Rajkot Municipal Corporation budget 2018 and FAME scheme
Replace all diesel chakda with CNG goods vehicles		6,629.92	11,337.74			
Electric bikes for field officers – RMC office		35.42	100.96			Rajkot Municipal Corporation Budget 2018
Implementation of Public bicycle Sharing scheme		574.42	1375.36			Rajkot Municipal Corporation Budget 2018

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Study on the existing BRTS corridor for the last mile connectivity and pre-feasibility for potential of electrification of the corridor			Reduce GHG emission by using electric mobility and reduced private vehicles including auto rickshaws on road	**Redundancy -** Shorter trips and inadequate frequency of available public transportation leads to increase in number of private vehicles. Intervention will provide last mile connectivity which will reduce usage of private vehicles **Flexibility -** Reduced used of auto rickshaws will leads to safe and comfortable public transportation **Responsiveness** – Use of cleaner fuel		Swiss Agency for Development and Cooperation (SDC) under CapaCITIES project
Effective Traffic management and awareness				**Redundancy -** reduce traffic congestion and accidents in city **Flexibility -** Smooth mobilisation of traffic in case of any critical situation in city **Responsiveness -** Reduce intensity of air pollution due to traffic congestion		Capacity building of traffic officers/ officials by Traffic and transport department

Resilience Interventions	Annual Mitigation Potential (2022-23) Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)	Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
Providing NMT and pedestrian infrastructure			GHG emission reduction by using more NMT	**Redundancy -** providing safe and secure infra for vulnerable people (i.e. cyclist and pedestrians by providing dedicated infrastructure) in city **Responsiveness -** reduce rate of accidents on roads		Rajkot Municipal Corporation Some of the projects are already sanctioned by standing committee
Remove illegal encroachment by providing hawkers zone and effective pay and park facilities				**Responsiveness -** Provide more Right of Way to vehicular traffic will reduce congestion		Rajkot Municipal Corporation RMC has implemented total 24 pay and park facilities and 100 hawker's zones in city to reduce on-road parking and encroachment of road by hawkers and smooth management of traffic
Maximise use of clean fuel (electric mobility)			Reduce GHG emission from stationary fuels by providing electric mobility	**Redundancy -** maximise use of electric vehicles will reduce dependency on stationary fuel		Rajkot Municipal Corporation and Regional Transportation Department

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Solid waste management Baseline (2015-16) Total GHG emission – 140,329 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 41.88 Million kWh Total GHG emission mitigation potential – 29,769.87 tCO2e						
Waste management in Rajkot (Waste to Composting and Waste to energy)	41.88		29,769.87		1452 -	Rajkot Municipal Corporation on PPP model
Scientific capping of first and second cell of Nakrawadi landfill dumpsite			GHG emission reduction by utilising methane emission	**Redundancy** - reduce waste related issues during rainfall and temperature increase i.e. degradation and waste burning **Flexibility** - Reduce vector borne diseases and health related issues, Methane can be utilised **Responsiveness** - Effective management of waste will reduce direct methane emission and waste related issues		Rajkot Municipal Corporation – Swachh Bharat Mission Capping of first cell is completed; work is in progress for capping of second cell.

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Construction of leachate collection ponds at Nakrawadi landfill site				**Redundancy** - Provide effective treatment to leachate **Flexibility** - Stop GW contamination **Responsiveness** - Reduce water contamination and related health impacts		Rajkot Municipal Corporation – Swachh Bharat Mission Approved by standing committee, RMC - Currently leachate is being collected through pumping and sending to STP for treatment.
Zone wise solid waste material recovery facilities			GHG emission reduction due to reduced quantity of waste send to dumpsite	**Redundancy** - Effective treatment possible due to segregation **Flexibility** - **E**mployment generation for rag pickers **Responsiveness** - Quantity of waste being dump in dumpsite can reduce due to waste recovery on site		Rajkot Municipal Corporation – Swachh Bharat Mission Tendering in progress
Training on roof gardening and organic farming, link with waste composting in city			GHG emission reduction due to reduced cooling demand	**Redundancy** - 18 waste to composting plant is proposed in city, composting may be utilise **Flexibility** - Reduce direct heat from roof and hence cooling requirement		Capacity building is needed for community

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Notification by RMC to segregate dry waste, wet waste and hazardous waste in three different dustbins at source by residential and commercial area			GHG emission reduction by providing effective waste treatment and waste not dumped in dumping site	**Redundancy -** Segregated waste collection will lead to effective waste treatment **Flexibility - T**reatment efficiency will be enhanced due to waste quality		Rajkot Municipal Corporation Policy level intervention – Notification by RMC
Health						
Prepare detailed health inventory for city - including vector, water and air borne diseases, health risk maps for critical diseases, prepare disease surveillance plan and link with various service utilities for cross sectorial actions				**Redundancy -** Preventive measures can be taken based on inventory **Flexibility -** Cross sectorial actions can be taken based on disease surveillance **Responsiveness -** Reduce risk during critical events **Access to information -** Health indicator can be utilised for healthy and happy community		Rajkot Municipal Corporation

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Prepare emergency response plans for health facilities in case of extreme weather event management : which also includes development and implement effective risk communication strategy for the health issues in case of emergency				**Redundancy** - Prior communication regarding predictions on extreme weather event and related health issues my reduce health risk during critical events **Flexibility** - preventive measures can be planned during critical events **Responsiveness** - Health risk can be reduced by using prior communication strategy **Access to information** - Prior weather information and forecasting can be utilised for future planning		Rajkot Municipal Corporation Strong political and administrative support needed for preventive measures and communication strategies • Heat Action Plan is already prepared by RMC • RMC has already in place emergency response procedures for disease outbreaks

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Establish/strengthen and support research networks, within and across city				**Redundancy** - Integrate climate and health modules in existing curricula/ courses such as community medicine and public health may provide additional support during extreme events **Flexibility** - Additional support to existing health infrastructure, preparation of communication strategy and capacity building **Responsiveness** - Immediate actions can be taken and hence reduction in health risk **Access to information** - Facilitate access to meteorological and health data and develop capacity for conducting research on health impacts and effectiveness of adaptation measures.		Rajkot Municipal Corporation No additional cost needed Volunteers program can be started by RMC

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Reduce vulnerability of health care facilities by proper designing and location of health centres for accessibility during climatic hazards				**Redundancy** - Intervention will make health- care facilities resilient to climate change (by retrofitting to make them safe from various climatic hazards such as flooding, storms), which will Provide access to vulnerable people during epidemic break out **Flexibility** - Availability of affordable pubic health care facilities and public hospitals with advanced facilities for treatment will reduce health risk **Responsiveness** - Increase in accessibility during epidemic break out by siting urban health centres in safe areas which will be accessible for all and reduce health risk **Access to information** - provides information for future planning of urban health centres requirement and accessibility		Rajkot Municipal Corporation

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Develop coordinating platforms for climate change and health focal point to other climate-sensitive programmes and health-determining sectors (such as water, environment, drainage, energy)				**Redundancy** - Capacity building to focal point will improve departmental strength **Flexibility** - Capacity building of staff through various climate sensitive programmes will provide additional strength during epidemic events **Responsiveness** - Help in identifying cross sectorial interventions to reduce health risk		Rajkot Municipal Corporation
Vegetation (green cover) mapping , local biodiversity improvement and ward level surface analysis to reduce heat wave impact						Rajkot Municipal Corporation can encourage NGOs involvement for the study
Smart City						
Installation of rooftop SPV system in Smart City Area	9.60		7,898.50		576.00	Rajkot Municipal Corporation
Implementation of Green Building Policy			GHG emission reduction from reduced energy consumption	Reduce energy consumption from buildings by providing more comfortable hours with changing building design and material use		Rajkot Municipal Corporation

Resilience Interventions	Annual Mitigation Potential (2022-23)			Adaptation Impact	Cost of interventions (Million INR)	Implementation mode
	Potential Energy Saving (Million kWh)	Potential Fuel Saving (KL)	Potential GHG emission reduction (tCO2e)			
Total (4)	85.65	7,542.22	79,456.08		2,468.84	
Municipal corporation buildings Baseline (2015-16) Total Energy consumption – 3.2 Million kWh Total GHG emission – 2,632 tCO2e Climate Resilience Potential (2022-23) Total Electricity savings – 1.49 Million kWh Total GHG emission mitigation potential – 1,229.24 tCO2e						
Rooftop Solar PV in Municipal Building	0.75		617.07		7.56	Rajkot Municipal Corporation budget 2018
Rooftop Solar PV for e-bikes	0.14		116.56		35	Rajkot Municipal Corporation budget 2018
Replacement of all Fluorescent tube lights with LED in Zone offices (Proposed)	0.30		243.64		-	Rajkot Municipal Corporation budget 2018
Replacement of all existing fans with super EE fans in Zone offices (Proposed)	0.11		88.47		2.95	Rajkot Municipal Corporation budget 2018
Installation of AC energy savers in split Air conditioners (proposed)	0.02		14.11		0.30	Rajkot Municipal Corporation budget 2018
Reduction of heat ingress through adopting heat prevent measures cool roof to replace existing roofs in central zone office	0.18		149.39		1.50	Rajkot Municipal Corporation budget 2018
Total (5)	1.49		1,229.24		47.31	
Grand Total (Total 1+2+3+4+5)	309.73	7,542.22	263,823.45		4,238.17	

4.1.1 Potential and GHG Emission Mitigation Share of Proposed Mitigation Actions

The Climate Action Plan for Rajkot City has been prepared under the CapaCITIES project. As energy use and GHG emission forecasting trend shows that energy consumption in commercial and institutional building sector is rapidly increasing followed by Residential Buildings, mobile units (Transport sector), municipal facilities and manufacturing industry and construction sector (See table 47). Climate resilient interventions in this CRCAP are focused on critical sectors to reduce energy consumption and hence reduce GHG emissions. Sector-wise mitigation potential of interventions proposed in CRCAP as compared to baseline energy use and GHG emission is shown as below (see table 22).

Total GHG emission in baseline year 2015-16 is 1,887,684.9 tonnes of CO2e. Total GHG emission for year 2022-23 is estimated to be 2,988,053 tonnes of CO2e as per BAU scenario, which is around 1.6 times GHG emission in year 2015-16. The annual potential GHG emission reduction in 2022-23 from the actions proposed across the various sectors for the Community and for Municipal operations stands at 263,824tonnes of CO2e, aggregating to about 13.98% of Rajkot City's baseline annual GHG emissions in the year 2015-16.

Table 22 Potential of CRCAP as compared to baseline energy use and GHG emission

Sector	Baseline (2015-16)		CRCAP Potential (2022-23)	
	Energy Use (GJ)	GHG emission (tCO2e)	Energy Saving (GJ)	GHG emission reduction (tCO2e)
Residential Building Sector	4,759,044.0	655,578.2	625,002.9	142,844.3
Commercial and Institutional Buildings/Facilities	741,000.2	152,516.6	413,975.8	47,841.2
Manufacturing Industry and Construction (i.e. Industrial sector)	2,298,595.0	349,362.2	16,584.6	3,790.4
Water Supply	140,054.9	31,710.3	73,683.8	16,840.4
Sewerage	24,042.9	5,486.5	17,525.8	4,005.5
Street lighting	53,959.5	12,332.5	26,890.0	6,145.7
Transportation	7,687,628.0	537,624.8	38,528.6	3,357.4
Solid waste management	493.2	140,329.0	150,781.5	29,769.9
Smart City	-	-	34,560.0	7,898.5
Municipal corporation buildings	11,517.0	2,632.1	6,736.8	1,330.2
Total	**15,716,334.7**	**1,887,684**	**1,404,269.8**	**263,823.4**

A total of 310 Million kWh of electricity, 7,542 kilolitres of diesel will be saved by implementing proposed priority actions across different sectors, which will reduce 263,824tCO2e GHG emissions for the city. The total investment required for the proposed actions is INR 4,238 Million INR.

Mitigation potential of buildings (residential, commercial and industrial) sector (69%) is highest followed by solid waste management (11%), water (6%), transport (6%), smart city initiative (3%) street lighting (2%), sewerage (2%), and municipal buildings (1%) (See figure 69)

Figure 68 Total annual energy saving potential of CRCAP (Million kWh)

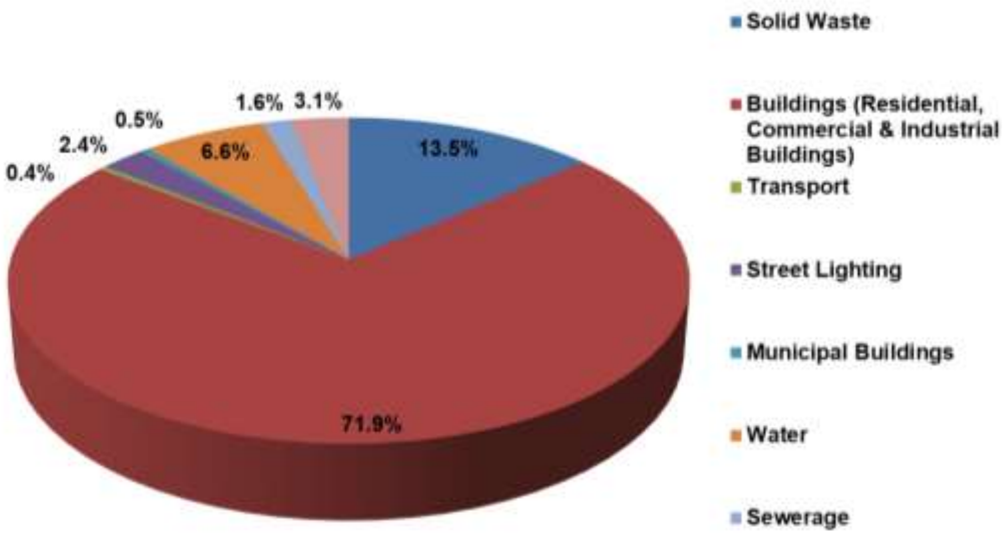
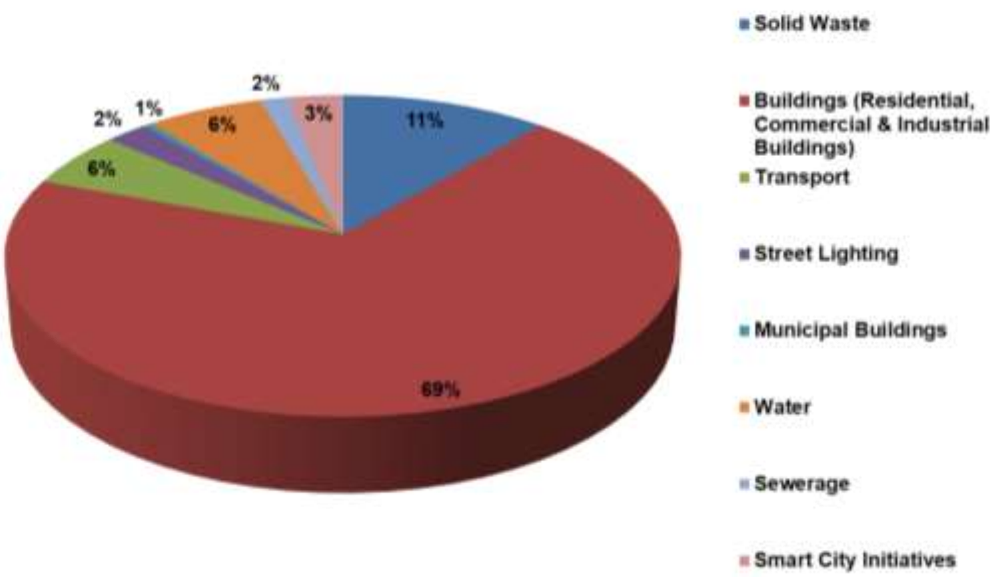
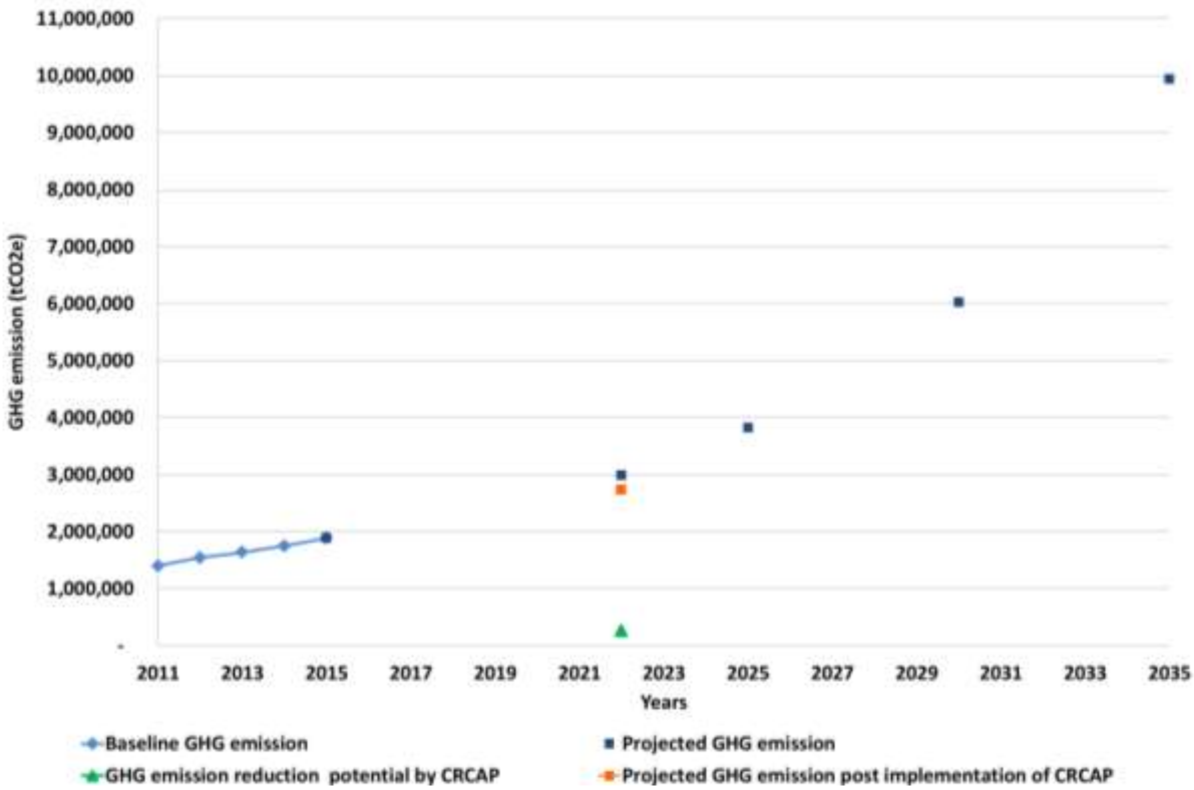


Figure 69: Total annual mitigation potential of CRCAP (tonnes CO2e)



Baseline GHG emission trend from year 2011 to 2015 and projected GHG emission for next 20 years shows that GHG emission in 2022-23 will be 2,992,213tCO2e as per business as usual scenario, implementation of Climate Resilient City Action Plan (CRCAP) has annual potential to mitigate 263,823tCO2e GHG emission in year 2022-23 (See figure 70). Projected number shows that GHG emission in year 2022-23 will be 2,728,390tCO2e after implementation of CRCAP as compared to 2,992,213tCO2e GHG emission as per business as usual scenario.

Figure 70 Baseline GHG emission (tCO2e), Projected GHG emission (tCO2e) and Impact of CRCAP



4.2 Way Forward

- Development of Implementation Plan/ timeline for Resilience Interventions in line with municipal budget and discussion with RMC officials
- Develop impact timeline based on implementation phase of all resilient interventions – short term (up to 2 years), medium term (3rd year), Long term (4th and 5th year)
- Adoption of Climate Action Plan in Municipal Council

It is anticipated that above mentioned task will be completed in year 2018

Annexure

Annexure 1 Stakeholder committee and climate core team under CapaCITIES project

Annexure 2 Detailed waste quantification and characterization report

Annexure 3 Energy consumption Projections (2016 to 2050)

Annexure 4 GHG emission Projections (2016 to 2050)

Annexure 5 Tool 3.2B Urban System Analysis

Annexure 6 Tool 3.2D Actors Analysis

Annexure 7 Tool 4.2 (Table1) Prioritization of Resilience Interventions

Annexure 8 Tool 4.2 (Table2) Feasibility and Impact assessment of resilience interventions

RAJKOT MUNICIPAL CORPORATION

Banchhanidhi Pani I.A.S.

COMMISSIONER

RMC/C 135

Date: 25th October, 2016

Rajkot Municipal Corporation with assistance from the Swiss Development Cooperation has initiated the Implementing the **"Capacity Building Project on Low Carbon and Climate Resilient City Development in India" (CapaCITIES) Project**, being implemented by ICLEI-Local Governments for Sustainability, South Asia (ICLEI South Asia), South Pole Group and econcept, with the goal to achieve lower greenhouse gas emissions growth path and increase resilience to climate change in select Indian cities.

In India, the project is being implemented in four cities, Coimbatore, Rajkot, Siliguri and Udaipur. The impact goal of the CapaCITIES project is that the "lower greenhouse gas emissions growth path achieved and resilience to climate change increased in select Indian cities". The project will strengthen the capacities of four Indian partner cities - Coimbatore, Rajkot, Siliguri and Udaipur - to identify, plan and implement measures for reducing greenhouse gas emissions and for enhancing resilience to climate change in an integrated manner. The first phase (2016-19) of the project shall focus on mainstreaming climate change mitigation and adaptation into development policies at the city level, support the city authorities in the formulation and implementation of integrated action plans and measures across priority sectors and share experiences with other cities in developing and emerging countries.

The project will result in enhanced capacities of city officials in the 4 cities to develop, institutionalize and update climate resilience and GHG reduction measures and plans. Climate change mitigation and adaptation will be mainstreamed into urban service delivery. New capacities will be developed to plan for inclusive and gender sensitive urban services. Institutional structures for MRV mechanisms and other evaluation mechanisms to assess impacts of deployed projects and bankable projects will be developed. City level policies and byelaws, which will subsequently ensure climate resilient planning and urban services, will be identified and developed. And finally benefits of climate resilient planning and implementation will be showcased to other stakeholders including other cities, state governments and national government.

A 'stakeholder Committee' and Rajkot Climate Core Team' are constituted under this project; these two bodies will play a key role in successful implementation of project activities in Rajkot City.

Stakeholder concerns and feedbacks are a valuable source of information that will improve the design and outcome of project in Rajkot city. The 'Stakeholder's Committee' in Rajkot includes key decision makers and administrators from Rajkot Municipal Corporation as well as representatives from Builder's Association, Architect Association, Industrial Association, Rajkot Chamber of Commerce & Industries (RCCI), Association of Consulting Civil Engineers (ACCE), various educational institutions, various government departments, RTO and Various NGOs,

Through the consultation process the stakeholders will get an opportunity to learn about the local government's planning process, international practices, discover potential connections to their own programs, planning and funding mechanisms, and contribute by raising issues and concerns, potentially helping to shape the strategy by making suggestions to the Climate Core Team.

Rajkot Climate Core Team is responsible for coordinating the Local Government's ongoing participation in the CapaCITIES project, and institutional structure to facilitate action well into the future beyond this project. Low Carbon development is much broader than just about the environment, so the Climate Core team has drawn on staff from a range of departments and engages different points of view and areas of expertise. The core team comprises of representatives from departments that have responsibilities for, or an impact on, energy use, pollution, waste, food security, resilience in water sector and water security, public health, drainage and sanitation, local economic development, infrastructure, mitigation actions in transportation, and development planning. In this way, the team is essential for communicating the goals of the municipal's low emission projects or program to all staff, and ensuring that resulting actions are incorporated into all areas of the local government's functions.

Stakeholder Committee formed in Rajkot as part of CapaCITIES project initiated by the Swiss Development Cooperation and being implemented by ICLEI-Local Governments for Sustainability, South Asia (ICLEI South Asia), South Pole Group and econcept.

Sr. No	Name	Position	Organization/Body
1	Shri Jaiman Upadhyay	Hon'ble Mayor	Rajkot Municipal Corporation
2	Shri Banchhanidhi Pani, IAS	Hon'ble Municipal Commissioner	Rajkot Municipal Corporation
3	Shri Darshitaben Shah	Hon'ble Deputy Mayor	Rajkot Municipal Corporation
4	Shri Pushkarbhai Patel	Hon'ble Chairman	Standing Committee, RMC
5	Shri R.J. Halani	Deputy Commissioner	West Zone Office, RMC
6	Shri P.P. Vyas	Deputy Commissioner	East zone office, RMC
7	Shri C.K. Nandani	Deputy Commissioner	Accounts Department, RMC
8	Shri C.M. Pandya	City Engineer	Construction/Waterworks/Drainage/JNNURM Cell, Central zone, RMC

9	Shri M.R. Kamaliya	Add. City Engineer	Construction/Waterworks/Drainage/JNNURM Cell, East zone, RMC
10	Shri. B. U. Joshi	Add. City Engineer	Construction/Waterworks/Drainage/JNNURM Cell, west zone, RMC
11	Shri V.C. Rajyaguru	Executive Engineer	Water Works Department, RMC
12	Shri Alpana Mitra	City Engineer (Sp.)	Affordable Housing Department, RMC
13	Shri M.H. Ghoniya	Incharge City Engineer (Sp.)	Drainage Department, RMC
14	Shri M.D. Sagathiya	Town Planning Officer (I/C)	Town Planning Department, RMC
15	Shri K.D. Hapaliya	Director	Garden Department, RMC
16	Shri V.P. Pandya	Health Officer	Heath Department, RMC
17	Shri K.P. Dethariya	Add. City Engineer (I.C)	Lighting Department, RMC
20	Shri. N.R. Parmar	Environment Engineer	Solid Waste Department, RMC
21	Shri K.V. Ghela	Chief Fire Officer	Fire and Emergency Services, RMC
22	Shri Y. K. Goswami	DEE, Incharge General Manager	Rajkot Rajpath Ltd, RMC
23	Shri R.R. Raiyani	Deputy Executive Engineer	JNNURM Cell, RMC
24	Shri. R.M. Gameti	Assistant Manager	Tax Department, RMC
26	Shri B.L. Kathrotiya	Assistant Manager	Estate Department, RMC
27	Mr.Kothari	Superintendent Engineer	PGVCL
28	Mr. J.J.Gandhi	Additional Chief Engineer	PGVCL
29	Mr. J.N. Vaghela	Regional transport officer	RTO
30	Mr. H.P. Patel	Regional Officer	GPCB
31	Shri. Pravinbhai Godasana	President	Rajkot Civil Engineer's Association
32	Shri Mautikbhai Trivedi	President	Rajkot Architect Association
33	Shri Ghanshyambhai Patel	President	Rajkot Builder's Association

34	Shri Shivlalbhai Barasiya	President	Rajkot Chamber of Commerce & Industries (RCCI)
35	Shri Rajeshbhai Joshi	Chairman	JJ PV Solar
36	Dr. G. D. Acharya	Principal	Atmiya Institute of Technology & Science (AITS)
37	Dr. Sachin Parikh	Principal	VVP Engineering collage
38	Ms. Sonal Shah	Principal	Kadvibai School
39	Ms. Dimpal Mehta	Principal	Gardi Collage of engineering collage
40	Ms. Brinda Shah	Professor	Indubhai Parikh School of Architecture
41	Mr. Ankur Sanghvi	Architect	Sanghvi Architects
42	Mr. Devang Parekh	Principal	School of Architects, Rajkot
43	Mr. Parth Garg	Architect	Self employed

Rajkot Climate Core team formed as part of CapaCITIES project initiated by the Swiss Development Cooperation and being implemented by ICLEI-Local Governments for Sustainability, South Asia (ICLEI South Asia), South Pole Group and econcept. The Rajkot Municipal Commissioner will act as the chairperson of the Climate Core Team.

Sr. No	Name	Position	Organization/Body
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4	Shri. Pushkarbhai Patel	Hon'ble Chairman	Standing Committee, RMC
5	Shri. Arvindbhai Raiyani	Neta shri.	Shashak paksh, Rajkot Municipal Corporation
6	Shri. Vashrambhai Sagathiya	Neta shri.	Virodh paksh, Rajkot Municipal Corporation
7	Shri Rajubhai Aghera	Dandak shri.	Shashak paksh, Rajkot Municipal Corporation
8	Shri Mukeshbhai Radadiya	Chairman	Construction Committee, RMC
9	Shri Ashishbhai Vagadiya	Chairman	Sanitation Committee, RMC
10	Shri. Jaiminbhai Thakar	Chairman	Samaj Kalyan Committee, RMC
11	Shri. Manishbhai Radiya	Chairman	Health Committee, RMC
12	Shri. Ajaybhai Parmar	Chairman	Lighting Committee, RMC
13	Shri. Dalsukhbhai Jagani	Chairman	Water Works Committee, RMC
14	Shri. Ashwinbhai Bhoraniya	Chairman	Market Committee, RMC
15	Shri Anitaben Goswami	Chairman	Law Committee, RMC
16	Shri Varshaben Ranpara	Chairman	Planning Committee, RMC
17	Shri Kiranben Sorathiya	Chairman	Housing Committee, RMC
18	Shri Devrajbhai Makvana	Chairman	Drainage Committee, RMC

19	Shri Devuben Jadav	Chairman	Garden & Zoo Committee, RMC
20	Shri Jagrutiben Ghadiya	Chairman	Child welfare and firefighting committee, RMC
21	Shri Rupaben Shilu	Chairman	Education Committee, RMC
22	Shri Jayaben Dangar	Chairman	Real Estate Committee, RMC
23	Shri R.J. Halani	Deputy Commissioner	West Zone Office, RMC
24	Shri P.P. Vyas	Deputy Commissioner	East zone office, RMC
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35	Shri K.P. Dethariya	Add. City Engineer (I.C)	Lighting Department, RMC
36	Shri. N.R. Parmar	Environment Engineer	Solid Waste Department, RMC
37	Shri K.V. Ghela	Chief Fire Officer	Fire and Emergency Services, RMC
38	Shri Y. K. Goswami	DEE, Incharge General Manager	Rajkot Rajpath Ltd, RMC
39	Shri R.R. Raiyani	Deputy Executive Engineer	JNNURM Cell, RMC
40	Shri. R.M. Gameti	Assistant Manager	Tax Department, RMC
41	Shri B.L. Kathrotiya	Assistant Manager	Estate Department, RMC

Mr. Banchhanidhi Pani, IAS
Municipal Commissioner,
Rajkot Municipal Corporation

Municipal Solid Waste Quantification and Characterization for Rajkot, Gujarat

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1. City Profile

The city of Rajkot is located in the centre of the Saurashtra region of the state of Gujarat. With approximate 1.28 million inhabitants spread over 129 sq. kms, Rajkot is the fourth largest city in the State. The city is also the administrative headquarters of the Rajkot district. For the administrative purposes, city is divided into 3 zones and 18 administrative wards. Known for industrial development, Rajkot is also an important trade centre for the region. Due to vibrant economy, the city has witnessed high growth rate of 28.24% in the last decade.

Figure 1: Location of Rajkot

Table 1: City Profile for Rajkot

Location	**Western India**
District	Rajkot
State	Gujarat
Class of City	Tier II
Area of City	129 sq. kms
No. of Administrative Wards	18
Population (Census 2011)	12,86,678
Decadal Growth Rate	28.31%
Climate	Semi-Arid Climate

2. Present Scenario of MSWM in Rajkot

2.1 Waste Generation Quantity and its Composition

Rajkot Municipal Corporation with the support of ICLEI South Asia conducted an extensive study for assessing the quantity and quality of waste being generated from different sectors in the city. The study was conducted under the project Capacity Building for Low Carbon and Climate Resilient City Development (CapaCITIES) supported by Swiss Agency for Development and Cooperation (SDC).

Reconnaissance survey was undertaken and the location of the sampling points was identified with the help of municipal officials from Rajkot Municipal Corporation to represent different waste generation sources such as residential (LIG, MIG and HIG), institutional areas, commercial establishments, hotels, vegetable market, transfer stations and finally at the dumpsite. **The study was conducted for seven days (21st to 28th January, 2017)** wherein samples from different waste generation points were collected and sent to MoEF recognized and NABL accredited laboratory for analysis. A total of 17 waste samples were collected from all the 3 zones in the city and the dumpsite.

2.2 Sampling of Municipal Solid Waste

Waste samples were collected from all 3 zones of Rajkot city, Transfer Stations at Raiyadhar and KSD and Nakravadi landfill site; the general procedures followed for waste sampling are briefly discussed below:

- Identification of major sample collection points from all 3 zones representing diverse types of waste generation sources, such as residential, commercial, markets (vegetable market), hotels and institutional. The economic status of the areas, representing high, middle and low-income groups, was also taken into consideration during the selection of sampling locations. In addition, samples were also collected from the two transfer stations and Nakravadi landfill site.
- Almost 10 kg of waste were collected from each identified point and mixed thoroughly to get a homogenous sample. The quarter and coning method recommended in the Manual for Municipal Solid Waste Management, 20166 (CPHEEO) was used for sampling.
- The physical composition of MSW for residential areas was determined at the site itself for 3 days. The collected samples were separated into various major components, such as, paper, glass, plastics, etc. and weighed and expressed as a percentage of the original sample.

- Further, 5 kg of MSW samples were collected, packed, sealed and sent to the laboratory for physical and chemical analysis.

2.3 Residential Wastes

In order to ensure that the household samples represent all the socio-economic strata of the city viz. Lower Income Group (LIG), Middle Income Group (MIG), Higher Income Group (HIG), different wards in each zone was selected for the survey.

Following areas were selected for collecting samples from residential areas:

- LIG: Ward No 15 (Central Zone): Ramnagar Colony
- MIG: Ward No 14 (East Zone): Geeta Nagar
- HIG: Ward No 10 (West Zone): Prakash Society

Quantification of waste from approx. 40 households from each area was conducted for seven days including weekends. It was found that the rate of generation of waste varies substantially:

- LIG: 186 g/c/d
- MIG: 261 g/c/d
- HIG: 321 g/c/d

The variation in waste generation rate could be attributed to the difference in income, life style and household size. **Based on the waste generation rates above, the average rate of waste generation was calculated to be 256 g/c/d**. The survey sheets with daily quantum of waste generated is attached as an Annexure 1.

Physical Composition: The composition of waste collected from households from LIG, MIG and HIG are tabulated below. Organic waste constitutes the major portion of waste i.e. 60 percent which implies that exploring different types of composting/bio-methanation might be a feasible idea in the city. Segregation of waste is not complied in the entire city, with only few households segregating waste into wet and dry. Traces of bio-medical waste, hazardous waste (tubelights, batteries etc.) were found mixed in the waste. Also, since a lot of households in LIG use coals for heating water and other purposes, coal and ash were also found in the waste.

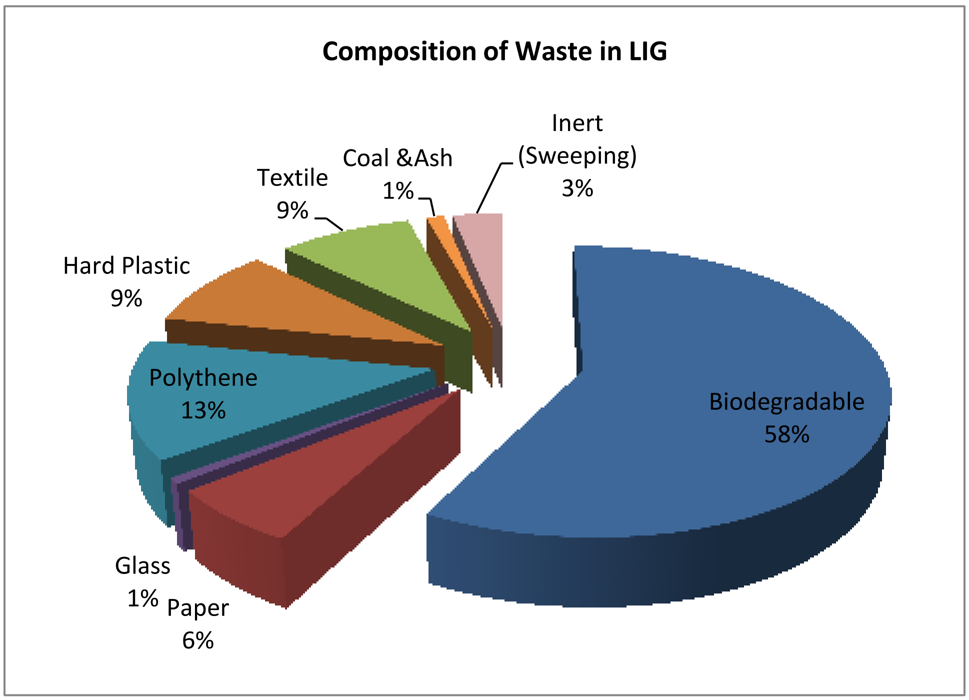
The physical characterization of households conducted for additional 3 days are attached as an Annexure 2.

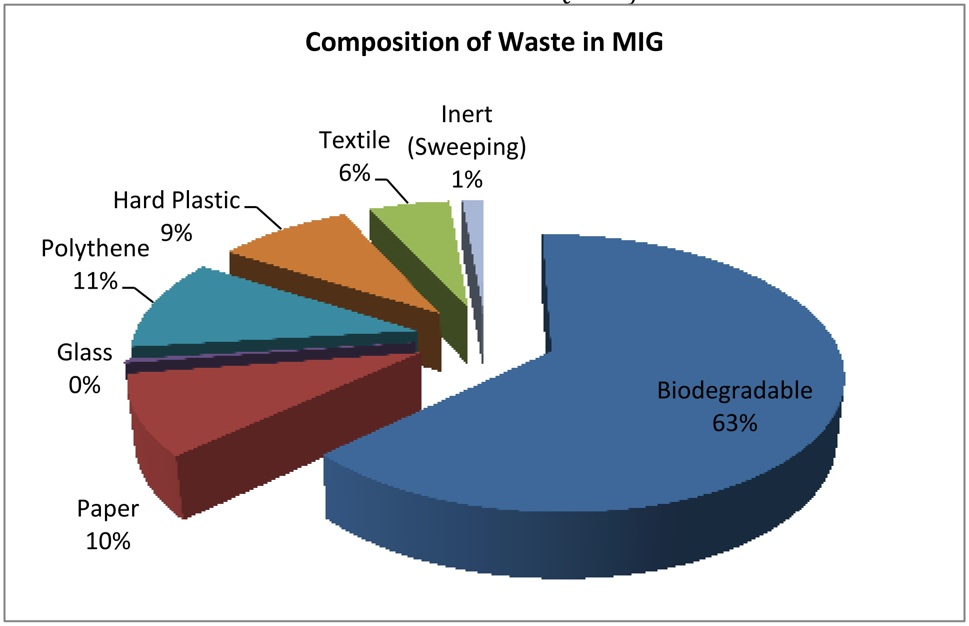
Table 2: Physical Composition of Waste from Households in Rajkot

Waste Type	LIG	MIG	HIG

Organic (%)	57.235	62.25	60.08
Recyclables (%)			
Hard Plastic	8.855	8.97	8.5
Polythene	13.13	10.86	14.11
Paper	6.235	9.33	6.86
Rubber/Leather	0.18	0.24	0.235
Textiles	8.34	5.395	6.21
Metals	0.135	0.14	0.16
Glass	0.675	0.45	0.45
Cardboard	0.175	0.135	0.135
Coal &Ash	1.105	0.235	0.5
Inert (C&D Waste) (%)	0.335	0.16	0.27
Inert (Sweeping) (%)	3.135	1.365	1.93

(Source: Survey Conducted by ICLEI South Asia, December 2017)





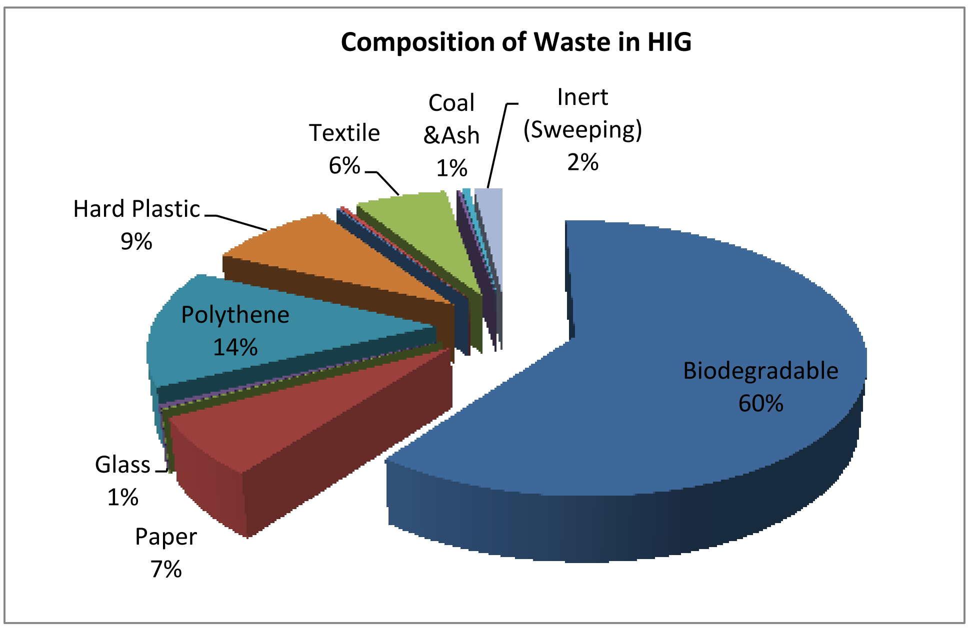


Figure 2: Composition of Waste in Residential Areas

Chemical Composition: Proximate and Ultimate Analysis of garb samples from households was conducted to derive chemical composition of waste and is tabulated below. High moisture content (almost 75%) and low calorific value of waste renders it suitable for composting and biomethanation.

Table 2: Chemical Composition of Waste Collected from Residential Areas

Parameters		Residential LIG	Residential MIG	Residential HIG
PROXIMATE ANALYSIS	Moisture (%)	73.75	77.635	75.57
	Volatile Combustible Matter (%)	21.18	18.42	20.5
	Fixed Carbon	1.545	1.11	1.05
	Ash (%)	3.525	2.835	2.875
ULTIMATE ANALYSIS	Carbon (%)	12.53	10.81	11.87
	Hydrogen (%)	5.38	5.13	5.67
	Oxygen (%)	30.79	34.545	31.31
	Nitrogen (%)	0.96	0.895	0.92
	Sulphur	0.395	0.34	0.37
	Ash	3.525	2.835	2.875
	Total Carbon Analysis	44.045	43.035	44.285
	Total Nitrogen (Kjeldahl Method)	1.15	1.1	1.15
	Gross Calorific Value (GCV)	1044	900.5	989.5
	C:N Ratio	1:13.05	1:12.1	1:12.9
	Phosphorous as P2O5 (%)	0.58	0.69	0.76
	Potassium as K2O (%)	0.635	0.685	0.78
	Chlorides (%)	0.011	0.0115	0.012

(Source: Survey Conducted by ICLEI South Asia, December 2017)

2.4 Commercial Areas

Quantification of waste collected from commercial areas like Sanganva Chowk, Dharmendra Road, Yagnik Road and Lkahaji Road was conducted by weighing the tipper trucks catering to these areas per day. Tippers serving in these areas were weighed for six days continuously to provide an average of waste being generated in the commercial areas. Approximate number of commercial entities present in these areas is 1200. **The rate of waste generation in the commercial areas was estimated to be 0.7 kg per capita per day.**

Table 3: Quantification of Waste from Commercial Area

Days	Weight (Kg)
Day 1 (21.12.2017)	1710
Day 2 (22.12.2017)	610
Day 3 (23.12.2017)	850
Day 4 (24.12.2017)	320

Day 5 (25.12.2017)	1260
Day 6 (26.12.2017)	290
Number of shops	1200
Per capita waste generation rate (kg/c/d)	**0.7**

(Source: Survey Conducted by ICLEI South Asia, December 2017)

Physical Composition: The physical composition of waste generated from the commercial areas is tabulated below. With no organic present in the waste and higher fraction of recyclables, the RMC should identify and involve potential recyclers to generate revenue. However, waste from commercial areas could also be used in future waste to energy plant.

Waste Type	Commercial Area
Organic (%)	-
Recyclables (%)	
Hard Plastic	26.99
Polythene	15.28
Paper	13.96
Rubber/Leather	2.16
Textiles	16.08
Metals	1.96
Glass	0.26
Wood	3.41
Cardboard	0.19
Coal &Ash	5.375
Inert (C&D Waste) (%)	9.885
Inert (Sweepings) (%)	3.445

(Source: Survey Conducted by ICLEI South Asia, December 2017)

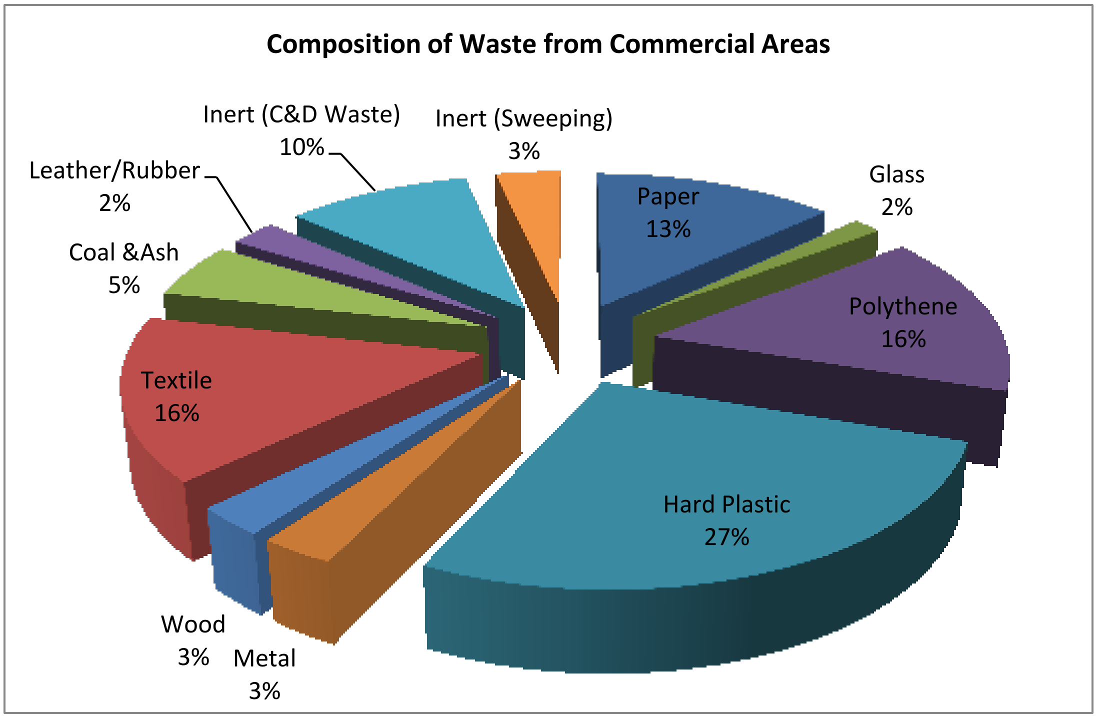


Figure 3: Composition of Waste from Commercial Areas

Chemical Composition: Proximate and Ultimate Analysis of garb samples from commercial areas was conducted to derive chemical composition of waste and is tabulated below. :

Parameters		Sanganva Chowk+Dharmendra Road+Yagnik Road	Lakhaji Road
PROXIMATE ANALYSIS	Moisture (%)	39.21	34.89
	Volatile Combustible Matter (%)	52.8	57.61
	Fixed Carbon	3.13	2.16
	Ash (%)	4.86	5.34
ULTIMATE ANALYSIS	Carbon (%)	29.83	32.45
	Hydrogen (%)	7.21	6.32
	Oxygen (%)	21.42	23.06
	Nitrogen (%)	0.92	0.99
	Sulphur	0.34	0.37
	Ash	4.86	5.34
	Total Carbon Analysis	32.47	28.64

	Total Nitrogen (Kjeldahl Method)	1.2	1.4
	Gross Calorific Value (GCV) (kCal/Kg)	2486	2704
	C:N Ratio	1:32.4	01:32.8
	Phosphorous as P2O5 (%)	0.84	0.69
	Potassium as K2O (%)	0.9	0.73
	Chlorides (%)	0.016	0.011

2.5 Vegetable Market

Quantification of waste from main vegetable market at Jubeeli Garden was arrived by weighing the tippers catering to the market. The tippers were weighed for five days continuously to be able to arrive at the average amount of vegetable waste generated in the city. **It was found that approximately 1350 kg of vegetable waste was being generated and collected in Rajkot**.

Table 4: Quantification of Waste from Vegetable Market

Days	**Weight (Kg)**
Day 1 (22.12.2017)	2365
Day 2 (23.12.2017)	1360
Day 3 (24.12.2017)	1010
Day 4 (25.12.2017)	1270
Day 5 (28.12.2017)	745
Average waste per day (kg/day)	**1350**

(Source: Survey Conducted by ICLEI South Asia, December 2017)

Physical Composition: The physical composition of waste generated from vegetable market is provided below. Very high value of organic fraction (as high as 88.16%) clearly indicates suitability of waste for composting/biomethanation. Presently, waste is being treated in organic waste convertor located nearby vegetable market.

Waste Type	**Vegetable Market**
Organic (%)	88.16

Recyclables (%)	
Hard Plastic	26.99
Polythene	4.89
Paper	6.87
Rubber/Leather	-
Textiles	-
Metals	-
Glass	-
Wood	-
Cardboard	-

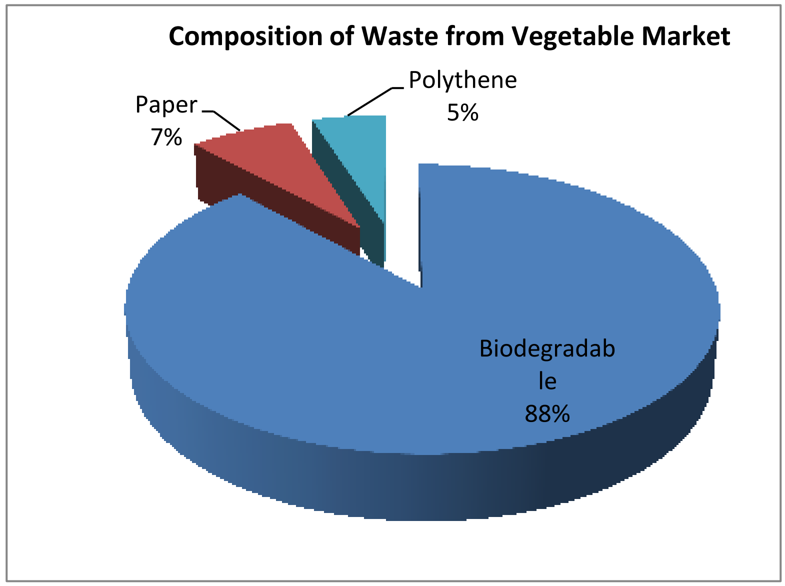


Figure 4: Composition of Waste from Vegetable Market

Chemical Composition: Proximate and Ultimate Analysis of garb samples of waste from vegetable market was conducted to derive chemical composition of waste and is tabulated below:

Parameters		**Vegetable Market**
PROXIMATE ANALYSIS	Moisture (%)	57.18
	Volatile Combustible Matter (%)	38.82
	Fixed Carbon	1.19
	Ash (%)	2.81
ULTIMATE ANALYSIS	Carbon (%)	16.34
	Hydrogen (%)	5.78
	Oxygen (%)	22.39
	Nitrogen (%)	1.50
	Sulphur	0.290
	Ash	2.81
	Total Carbon Analysis	47.62
	Total Nitrogen	1.80

	(Kjeldahl Method)	
	Gross Calorific Value (GCV) (kCal/Kg)	1382
	C:N Ratio	1:8.23
	Phosphorous as P2O5 (%)	0.71
	Potassium as K2O (%)	0.75
	Chlorides (%)	0.019

2.6 Institutional Areas

Tippers collecting waste from institutional areas were weighed to quantify waste being generated. Atmiya college, Mahila Arts College and St. Mary's School were covered during survey. **It was estimated that approximately 58.33 kg of waste per day is being generated from per institute**.

Table 5: Quantification of Waste from Institutions

Days	Weight (Kg)
Day 1 (21.12.2017)	230
Day 2 (22.12.2017)	210
Day 3 (23.12.2017)	100
Day 4 (25.12.2017)	100
Day 5 (26.12.2017)	235
Number of institutes covered	3
Average amount of waste collected per day	175
Approx. average weight per institution	**58.33**

(Source: Survey Conducted by ICLEI South Asia, December 2017)

Physical Composition: The physical composition of waste generated from institutional area constitutes mainly recyclables like paper, cardboard etc with no organic content.

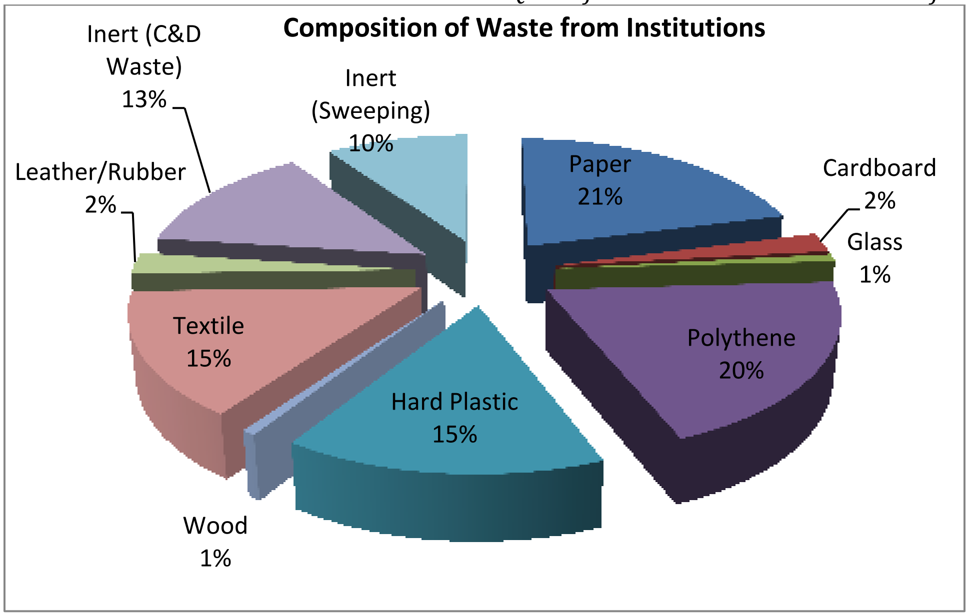


Figure 5: Composition of Waste from Institutes

Waste Type	**Vegetable Market**
Organic (%)	-
Recyclables (%)	
Paper	20.81
Cardboard	2.26
Glass	0.87
Polythene	19.81
Hard Plastic	15.04
Metal	0.34
Wood	0.67
Textile	14.62
Leather/Rubber	2.49
Inert (C&DWaste) (%)	13.24
Inert (Sweepings) (%)	9.54

Chemical Composition: Proximate and Ultimate Analysis of garb samples of waste from institutional areas was conducted to derive chemical composition of waste and is tabulated below. High calorific value and low moisture content makes this waste ideal for waste to energy plants.

Parameters		**Institutional Waste**
PROXIMATE	Moisture (%)	28.81

ANALYSIS	Volatile Combustible Matter (%)	62.78
	Fixed Carbon	2.49
	Ash (%)	5.92
ULTIMATE ANALYSIS	Carbon (%)	26.18
	Hydrogen (%)	6.28
	Oxygen (%)	21.87
	Nitrogen (%)	0.85
	Sulphur	0.31
	Ash	5.92
	Total Carbon Analysis	36.11
	Total Nitrogen (Kjeldahl Method)	1.10
	Gross Calorific Value (GCV) (kCal/Kg)	2182
	C:N Ratio	1:30.8
	Phosphorous as P2O5 (%)	0.66
	Potassium as K2O (%)	0.71
	Chlorides (%)	0.014

2.7 Hotel Waste

Similarly, waste generated from hotels was quantified using the tipper collecting waste from hotels. Presently, RMC is collecting waste from only 7 hotels/restaurants which include Hotel Silver Palace, Madhyahan Bhojan Yojna, Sahjanand Restaurant, Thakar Hotel, Lords Banquet, Temptation restaurant and Pankaj Restaurant. Tippers were weighed for seven days to provide an average estimation of waste being collected from hotels. **Almost 533.57 kg of waste is being generated from the above mentioned seven hotels and restaurants in Rajkot.**

Table 6: Quantification of Waste from Hotels

Days	Weight (Kg)
Day 1 (21.12.2017)	705
Day 2 (22.12.2017)	480
Day 3 (23.12.2017)	385
Day 4 (24.12.2017)	360
Day 5 (25.12.2017)	950

Day 6 (26.12.2017)	445
Day 7 (27.12.2017)	410
Average hotel waste collected per day (Kg/day)	533.57
Total number of hotels from waste collected	7.00

(Source: Survey Conducted by ICLEI South Asia, December 2017)

Physical Composition: Organic constitutes almost 80% of the waste from hotels which highlights the suitability of waste to be used for composting/bio-methanation purposes. Presently, waste from hotels is being processed at organic waste convertor in the city.

Waste Type	**Commercial Area**
Organic (%)	80.31
Recyclables (%)	
Hard Plastic	4.54
Polythene	4.96
Paper	4.89
Rubber/Leather	1.18
Textiles	2.18
Glass	1.92

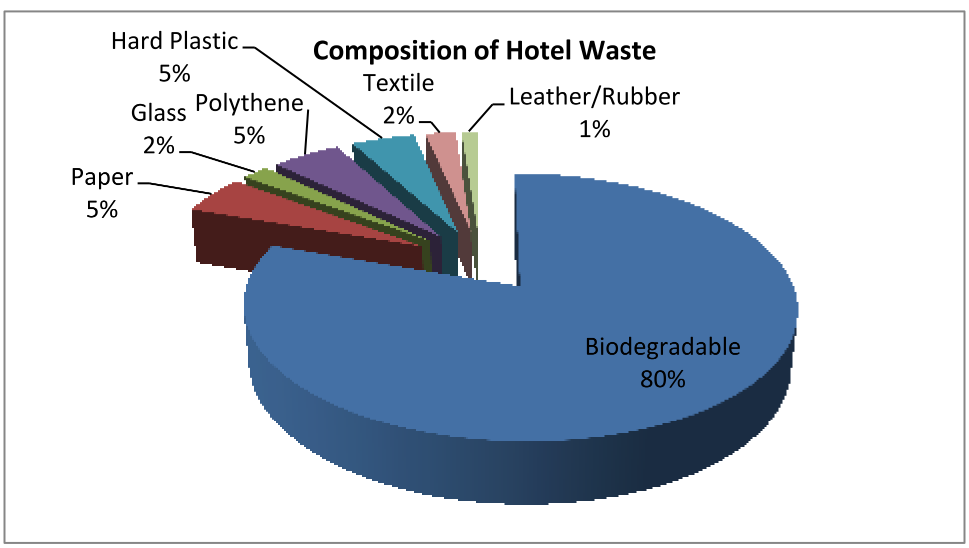


Figure 6: Composition of Waste from Hotels

Chemical Analysis: Proximate and Ultimate Analysis of garb samples of waste from institutional areas was conducted to derive chemical composition of waste and is tabulated below:

Parameters		Hotel Waste
PROXIMATE ANALYSIS	Moisture (%)	91.28
	Volatile	6.98
	Fixed Carbon	0.56
	Ash (%)	1.18
ULTIMATE ANALYSIS	Carbon (%)	8.29
	Hydrogen (%)	5.76
	Oxygen (%)	33.08
	Nitrogen (%)	1.34
	Sulphur	0.31
	Ash	1.18
	Total Carbon	46.92
	Total Nitrogen	1.4
	Gross Calorific	691
	C:N Ratio	01:06.2
	Phosphorous as	0.79
	Potassium as K2O	0.92
	Chlorides (%)	0.014

2.8 Waste at Transfer Station

There are two transfer stations in Rajkot, K.S. Diesel and Raiyadhar garbage transfer station, where the municipal solid waste from the city is aggregated and safely transported to the final disposal site at Nakravadi site.

Samples were collected from each of the transfer station for two consecutive days and analysed for their physical and chemical composition.

Physical Composition: Physical composition of waste accumulated at the two transfer stations is tabulated below depicting very low organic content and high recyclables.

Waste Type	Transfer Station at Raiyadhar	Transfer Station at KSD
Organic (%)	32.495	27.485
Recyclables (%)		
Hard Plastic	12.515	15.56
Polythene	13.66	12.305
Paper	16.51	13.76
Rubber/Leather	0.95	2.115
Textiles	13.775	13.395
Metals	0.65	1.055
Glass	0.93	1.03
Wood	0.83	1.395
Cardboard	1.775	1.35
Coal & Ash	0.085	0.355
Inert (C&D Waste) (%)	0.12	0.47
Inert (Sweepings) (%)	4.945	9.445

Chemical Analysis: Proximate and Ultimate Analysis of garb samples of waste from transfer stations are tabulated below:

Parameters		Transfer Station at Raiyadhar	Transfer Station at KSD
PROXIMATE ANALYSIS	Moisture (%)	50.68	44.33
	Volatile Combustible Matter (%)	45.26	51.5
	Fixed Carbon	0.6	0.675
	Ash (%)	3.38	3.495
ULTIMATE ANALYSIS	Carbon (%)	18.295	19.26
	Hydrogen (%)	6.1	6.28
	Oxygen (%)	24.315	26.125
	Nitrogen (%)	1.225	1.295
	Sulphur	0.335	0.365
	Ash	3.38	3.495
	Total Carbon Analysis	43.225	40.46
	Total Nitrogen (Kjeldahl Method)	1.5	1.56
	Gross Calorific Value (GCV)	1489	1627

	(kCal/Kg)		
	C:N Ratio	1:15	1:14.9
	Phosphorous as P2O5 (%)	0.785	0.56
	Potassium as K2O (%)	0.83	0.59
	Chlorides (%)	0.0155	0.016

2.9 Waste at Landfill Site

Most of the waste is not processed in the city. Waste from transfer station is transported to the dumping site at Nakravadi. Samples were collected from dumping site on two consecutive days to assess the waste characteristics.

Physical Composition: The physical composition of waste samples from dumping site is tabulated below:

Waste Type	Landfill Site
Organic (%)	24.83
Recyclables (%)	
Hard Plastic	17.875
Polythene	17.055
Paper	9.9
Rubber/Leather	2.665
Textiles	16.535
Metals	0.86
Glass	0.485
Wood	1.285
Cardboard	0.71
Coal & Ash	0.58
Inert (C&D Waste) (%)	0.83
Inert (Sweepings) (%)	6.305

Chemical Composition: Proximate and Ultimate Analysis of garb samples of waste from landfill site is tabulated below:

Parameters		Landfill Site
PROXIMATE ANALYSIS	Moisture (%)	24.59
	Volatile Combustible Matter (%)	65.15

	Fixed Carbon	3.72
	Ash (%)	6.54
ULTIMATE ANALYSIS	Carbon (%)	17.53
	Hydrogen (%)	7.02
	Oxygen (%)	28.74
	Nitrogen (%)	1.2
	Sulphur	0.36
	Ash	6.54
	Total Carbon Analysis	35.91
	Total Nitrogen (Kjeldahl Method)	1.45
	Gross Calorific Value (GCV) (kCal/Kg)	1461
	C:N Ratio	1:14.75
	Phosphorous as P2O5 (%)	0.605
	Potassium as K2O (%)	0.635
	Chlorides (%)	0.0155

3. Total Amount of Waste Generated in Rajkot

Quantifying the waste being generated from various sources, it was estimated that the total municipal waste generated in the city of Rajkot 477.36 TPD. The table below tabulates the sources and quantity of waste generated.

Table 7: Sources of Waste and Quantity of Waste Generated

S. No.	Sources of Waste Generation	Number of Entities	Rate of Waste Generation (kg/c/d)	Quantity (tonnes)
1.	Residents	1477183	0.256	378.12
2.	Commercial	75459	0.7	52.82
3.	Vegetable		1350	1.35
4.	Institutional	463	58.33	27.008
5.	Hotel	237	76.22	18.065
	Total			477.36

(*There might be difference in waste generation by 10-20% accounting waste being collected from offices, open dumping points, municipal solid waste from hospitals and floating population.)

ANNEXURE 1: Quantification at Household Level

	Lower Income Group (LIG)																	
	Ward No	15																
	Area	Ramnagar Colony																
			Weight (Kg)															
S. No	House Number	Family Size	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7			
			Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	**Average per capita waste generation (k/c/d)**	**Average per capita waste generation (g/c/d)**
1	Zoya	4	0.7	0.175	0.21	0.053	1.71	0.428	0.755	0.189	1.2	0.300	0.4	0.100	0.92	0.230	0.211	210.5
2	Anju Ben	7	0.68	0.097	0.77	0.110	2.48	0.354	1.515	0.216	1.05	0.150	0.49	0.070	0.655	0.094	0.156	155.9
3	Nazma	6	1.35	0.225	1.84	0.307	3.38	0.563	1.835	0.306	1.345	0.224	1.275	0.213	2.45	0.408	0.321	320.8
4	Bhikna Bhai	5	0.385	0.077	1.15	0.230	0.89	0.178	0.525	0.105	0.595	0.119	0.435	0.087	0.66	0.132	0.133	132.6
5	Vijay Bhai	3	0.2	0.067	0.19	0.063	0.48	0.160	1.29	0.430	0.095	0.032	0.08	0.027	0.74	0.247	0.146	146.4
6	Jayshukh Bhai	4	0.8	0.200	0.875	0.219	0.09	0.023	1.39	0.348	0.275	0.069	0.745	0.186	0.685	0.171	0.174	173.6
7	Sunita Ben	4	0.375	0.094	0.705	0.176	0.805	0.201	0.53	0.133	0.985	0.246	0.34	0.085	0.53	0.133	0.153	152.5
8	Kalabhai	5	0.095	0.019	1.27	0.254	0.5	0.100	1.655	0.331	0.83	0.166	1.215	0.243	0.95	0.190	0.186	186.1
9	Gauri Ben	6	0.875	0.146	0.835	0.139	0.37	0.062	0.795	0.133	1.555	0.259	0.58	0.097	0.595	0.099	0.133	133.5

10	Ramila Ben	4	3.81	0.953	1.14	0.285	2.44	0.610	1.48	0.370	1.69	0.423	0.87	0.218	1.34	0.335	0.456	456.1
11	Dharmesh Bhai	6	4.04	0.673	1.85	0.308	1.55	0.258	0.515	0.086	1.685	0.281	1.195	0.199	0	0.000	0.301	301.0
12	Mumtaz Ben	2	1.41	0.705	0.215	0.108	0.56	0.280	0.99	0.495	0.13	0.065	0	0.000	0.32	0.160	0.302	302.1
13	Dipak Bhai	12	1.705	0.142	1.655	0.138	2.67	0.223	0.445	0.037	1.29	0.108	0.485	0.040	1.06	0.088	0.111	110.8
14	Nazam parmar	4	0.63	0.158	0.11	0.028	1.32	0.330	1.89	0.473	0.29	0.073	0.865	0.216	0	0.000	0.213	212.7
15	Salim Bhai	7	2.895	0.414	1.745	0.249	2.17	0.310	4.695	0.671	2.225	0.318	0.865	0.124	4.49	0.641	0.389	389.5
16	Hari Bhai	9	0.445	0.049	0.93	0.103	0.37	0.041	0.6	0.067	0.835	0.093	0.65	0.072	0.236	0.026	0.065	64.5
17	Marine Ben	4	0.74	0.185	0.99	0.248	4.07	1.018	0.365	0.091	0.51	0.128	0.325	0.081	0.81	0.203	0.279	278.9
18	Rasina Ben	4	0.015	0.004	0.68	0.170	0.6	0.150	0.075	0.019	0.08	0.020	0.098	0.025	0.125	0.031	0.060	59.8
19	Nitin Bhai	6	0.88	0.147	1.2	0.200	2.18	0.363	1.325	0.221	0.945	0.158	1.82	0.303	0.33	0.055	0.207	206.7
20	Bharat Bhai	5	1.54	0.308	1.76	0.352	2.39	0.478	1.935	0.387	0.65	0.130	0.595	0.119	0	0.000	0.296	295.7
21	Karan Bhai	5	1.15	0.230	1.26	0.252	2.31	0.462	0.725	0.145	0.535	0.107	0	0.000	1.22	0.244	0.240	240.0
22	Ishwar Bhai	7	1.72	0.246	1.74	0.249	2.89	0.413	1.31	0.187	2.475	0.354	1.88	0.269	2.02	0.289	0.286	286.4
23	Rajesh Bhai	4	0.68	0.170	1.75	0.438	1.41	0.353	0	0.000	1.795	0.449	0.43	0.108	2.14	0.535	0.342	341.9
24	Hitesh Bhai	4	0.96	0.240	0.39	0.098	1.75	0.438	0.705	0.176	0.88	0.220	1.11	0.278	1.31	0.328	0.254	253.8
25	Aruna Ben	3	0.73	0.243	0.815	0.272	1.47	0.490	1.88	0.627	0.63	0.210	0.565	0.188	0.27	0.090	0.303	302.9
26	Bharat Bhai	4	0	0.000	0.645	0.161	0	0.000	1.24	0.310	2.54	0.635	0	0.000	0.395	0.099	0.301	301.3

27	Ramesh Bhai	6	0.26	0.043	0.45	0.075	0.38	0.063	0.075	0.013	0.2	0.033	0.35	0.058	0.415	0.069	0.051	50.7
28	Dilip Bhai	6	1.57	0.262	0.285	0.048	2.46	0.410	0.825	0.138	0.93	0.155	0.515	0.086	0.84	0.140	0.177	176.8
29	Jignabh Bhai	4	0.46	0.115	1.735	0.434	2.94	0.735	0.34	0.085	0.26	0.065	1.9	0.475	1.275	0.319	0.318	318.2
30	Mukta Ben	6	0.52	0.087	0.9	0.150	0.63	0.105	0.24	0.040	1.1	0.183	1.1	0.183	0.075	0.013	0.109	108.7
31	Raju Ben	6	0	0.000	0.63	0.105	0	0.000	0.53	0.088	0.33	0.055	0	0.000	0.74	0.123	0.093	92.9
32	Sharita Ben	5	0.69	0.138	0	0.000	1.52	0.304	0.715	0.143	0	0.000	0.44	0.088	0	0.000	0.168	168.3
33	Bharat Makwana	3	1.04	0.347	0.7	0.233	0.34	0.113	0.225	0.075	0.12	0.040	0.19	0.063	0.99	0.330	0.172	171.7
34	Sikhar Bhai	6	1.9	0.317	2.815	0.469	2.71	0.452	1.23	0.205	1.635	0.273	1.8	0.300	1.425	0.238	0.322	321.8
		176	35.25	0.200	34.235	0.195	51.835	0.295	34.645	0.197	31.69	0.180	23.608	0.1341364	30.011	0.170517	7.425	
																	0.185621216	**185.621216**

	Middle Income Group (MIG)																	
	Ward No: 14																	
	Area: Geeta Nagar																	
			Weight (Kg)															
S. No	House Number	Family Size	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7			
			Weight (Kg)	Per Capita Waste Generation	Weight (Kg)	Per Capita Waste Generation	Weight (Kg)	Per Capita Waste Generation	Weight (Kg)	Per Capita Waste Generation	Weight (Kg)	Per Capita Waste Generation	Weight (Kg)	Per Capita Waste Generation	Weight (Kg)	Per Capita Waste Generation	average per capita waste generation (k/c/d)	average per capita waste generation (g/c/d)
1	Mitesh Shah	4	0.485	0.121	1.73	0.433	0.77	0.193	0.15	0.038	0.405	0.101	0.405	0.101	0.3	0.075	0.152	151.6
2	Hemi Ben	4	2.77	0.693	1.16	0.290	1.78	0.445	0.785	0.196	0.865	0.216	1.2	0.300	1.405	0.351	0.356	355.9
3	JS Sidhpura	6	1.63	0.272	2.29	0.382	2.47	0.412	3.005	0.501	2.575	0.429	3.505	0.584	2.4	0.400	0.426	425.6
4	Charmi Ben	5	3.02	0.604	2.52	0.504	3.5	0.700	2.95	0.590	3.755	0.751	3.75	0.750	3.635	0.727	0.661	660.9
5	Lila Ben	6	0.865	0.144	1.05	0.175	1.1	0.183	1.685	0.281	1.575	0.263	4.375	0.729	0.98	0.163	0.277	276.9
6	Meena ben	4	0.425	0.106	0.425	0.106	0.235	0.059	0.29	0.073	0.380	0.095	0.21	0.053	0.17	0.043	0.076	76.3
7	Geeta Ben	3	0.445	0.148	0.445	0.148	1.25	0.417	0.49	0.163	0.320	0.107	0.14	0.047	0.17	0.057	0.155	155.2

8	Ramesh Bhai	3	4.2	1.400	4.2	1.400	1.5	0.500	1.93	0.643	2.080	0.693	5.115	1.705	0.95	0.317	0.951	951.2
9	Aarti Ben	7	1.6	0.229	1.6	0.229	2.13	0.304	1.875	0.268	1.110	0.159	2.315	0.331	2.375	0.339	0.265	265.4
10	Bhavesh Bhai	3	0.995	0.332	0.995	0.332	0.66	0.220	1.591	0.530	0.985	0.328	1.02	0.340	1.04	0.347	0.347	347.0
11	Rekha Ben	4	1.24	0.310	1.24	0.310	0.99	0.248	2.115	0.529	1.050	0.263	1.64	0.410	1	0.250	0.331	331.3
12	Viraj Ben	4	3.43	0.858	3.43	0.858	1.97	0.493	1.36	0.340	2.040	0.510	2.62	0.655	1.275	0.319	0.576	575.9
13	Sharoj Ben	3	0.11	0.037	0.11	0.037	0.92	0.307	0.605	0.202	0.655	0.218	1.195	0.398	0	0.000	0.200	199.7
14	Kishor Bhai	5	1.225	0.245	1.225	0.245	2.06	0.412	0.803	0.161	1.200	0.240	0.62	0.124	1.3	0.260	0.241	240.9
15	Bharat Bhai	3	0.87	0.290	0.87	0.290	0.21	0.070	0.94	0.313	0.900	0.300	0.51	0.170	0.97	0.323	0.251	251.0
16	Mahavir	5	0.29	0.058	0.29	0.058	0.43	0.086	0	0.000	0.280	0.056	1.115	0.223	1.1	0.220	0.117	116.8
17	Naina Ben	4	0	0.000	1.335	0.334	1.19	0.298	1.07	0.268	0.620	0.155	0.595	0.149	1.03	0.258	0.243	243.3
18	Neelkanth	5	0	0.000	1.5	0.300	0	0.000	0.833	0.167	0.810	0.162	0.72	0.144	1.15	0.230	0.201	200.5
19	Natwarlal	10	4.5	0.450	3.25	0.325	3.64	0.364	1.315	0.132	0.955	0.096	2.95	0.295	5.38	0.538	0.314	314.1
20	Pushpam	5	0.52	0.104	2.09	0.418	2.78	0.556	0.52	0.104	0.800	0.160	2.29	0.458	1.45	0.290	0.299	298.6
21	Paras Palace	10	3.32	0.332	4.64	0.464	6.47	0.647	6.785	0.679	1.890	0.189	3.535	0.354	3.5	0.350	0.431	430.6
22	KR Pandya	9	2.86	0.318	2.13	0.237	4.9	0.544	2.225	0.247	2.520	0.280	6.06	0.673	2.25	0.250	0.364	364.2
23	Atul	4	1.69	0.423	1.06	0.265	3.59	0.898	0.99	0.248	2.325	0.581	1.48	0.370	2.02	0.505	0.470	469.8
24	Radha Raman	8	3.29	0.411	1.91	0.239	1.66	0.208	1.48	0.185	1.160	0.145	1.835	0.229	2.68	0.335	0.250	250.3

25	Teja Bhai	5	2.61	0.522	2.16	0.432	0.79	0.158	0.53	0.106	0.350	0.070	0.75	0.150	1.88	0.376	0.259	259.1
26	Ashok Bhai	5	0.56	0.112	0.38	0.076	0.39	0.078	0.51	0.102	0.390	0.078	0.665	0.133	0.655	0.131	0.101	101.4
27	Tripda	5	1.72	0.344	2	0.400	0.61	0.122	0.435	0.087	1.570	0.314	0	0.000	1.44	0.288	0.259	259.2
28	Hanraj JJ Thakkar	4	1	0.250	0.92	0.230	1.85	0.463	1.405	0.351	1.635	0.409	1.17	0.293	1.39	0.348	0.335	334.6
29	Swati Kripa	3	3.54	1.180	0.77	0.257	0.81	0.270	0.845	0.282	0.980	0.327	0.055	0.018	0.615	0.205	0.363	362.6
30	Siresh Bhai	3	2.5	0.833	0.43	0.143	0.33	0.110	0.62	0.207	0.620	0.207	0.605	0.202	4.9	1.633	0.476	476.4
31	Shiv Kripa	4	2.65	0.663	1.13	0.283	2.83	0.708	0.32	0.080	1.615	0.404	1.87	0.468	1.35	0.338	0.420	420.2
32	Shiv Kripa FF	3	0.4	0.133	1.78	0.593	0.61	0.203	0.91	0.303	0.365	0.122	0.58	0.193	0.5	0.167	0.245	245.0
33	Jaydeep	3	1.64	0.547	1.96	0.653	2.3	0.767	2.475	0.825	0.000	0.000	0.99	0.330	2.25	0.750	0.645	645.3
34	Vishal Bhai	4	0.845	0.211	3.18	0.795	0.855	0.214	1.6	0.400	0.615	0.154	1.115	0.279	3.765	0.941	0.428	427.7
		163	57.245		56.205		57.58		45.442		39.395		57		57.275		11.484	11484.5
																	0.261	**261.0**

	Higher Income Group (HIG)																	
	Ward No: 10																	
	Area: Prakash Society																	
			Weight (Kg)															
S. No	House Number	Family Size	Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7			
			Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	Weight (Kg)	Per capita waste generation	average per capita waste generation (k/c/d)	average per capita waste generation (g/c/d)
1	Vinod	9	0	0.000	1.28	0.142	0.14	0.016	1.355	0.151	0.71	0.0789	0.96	0.107	0.66	0.073	0.095	94.5
2	Shivanand	4	0.77	0.193	0.99	0.248	0.8	0.200	0.48	0.120	0.58	0.1450	0.885	0.221	0.85	0.213	0.191	191.3
3	Radhe Krishnan	5	5.3	1.060	1.7	0.340	2.45	0.490	1.85	0.370	0.905	0.1810	2.03	0.406	3.32	0.664	0.502	501.6
4	ShriRam	6	2.72	0.453	0.88	0.147	3.75	0.625	1.535	0.256	2.225	0.3708	4.095	0.683	0.49	0.082	0.374	373.7
5	Manet	9	2.39	0.266	3.94	0.438	0.55	0.061	2.06	0.229	2.08	0.2311	1.495	0.166	2.08	0.231	0.232	231.7
6	Shiv Kripa	4	3.57	0.893	2.24	0.560	2.06	0.515	0.895	0.224	1.15	0.2875	0.61	0.153	0.93	0.233	0.409	409.1
7	Tanukar	2	0.695	0.348	1.415	0.708	1.53	0.765	1.865	0.933	1.14	0.5700	0.36	0.180	0.825	0.413	0.559	559.3

8	Anjali	4	0.96	0.240	2.31	0.578	0.77	0.193	0.705	0.176	1.85	0.4625	2.38	0.595	2.56	0.640	0.412	412.0
9	Ramesh	6	1.02	0.170	0.765	0.128	0.36	0.060	1.17	0.195	0.64	0.1067	0.35	0.058	1.035	0.173	0.127	127.1
10	Jay Navkar	4	0.74	0.185	1.04	0.260	0	0.000	0	0.000	0	0.0000	0	0.000	0	0.000	0.223	222.5
11	Vardhman	4	1.525	0.381	0.93	0.233	0.86	0.215	1.51	0.378	0.465	0.1163	1.15	0.288	1.24	0.310	0.274	274.3
12	Paritran	4	0.33	0.083	0.72	0.180	0.94	0.235	1.215	0.304	0.415	0.1038	0.795	0.199	1.28	0.320	0.203	203.4
13	Shiv Shankar	5	0.69	0.138	1.7	0.340	2.32	0.464	1.69	0.338	2.27	0.4540	1.39	0.278	1.28	0.256	0.324	324.0
14	Shri Ram	4	0.74	0.185	2.12	0.530	1.465	0.366	0.9	0.225	1.53	0.3825	1.66	0.415	8.42	2.105	0.601	601.3
15	Shivam	6	1.39	0.232	0.89	0.148	0.22	0.037	1.015	0.169	0.8	0.1333	0.845	0.141	1.68	0.280	0.163	162.9
16	Lin	5	1.375	0.275	1.58	0.316	0	0.000	0	0.000	0	0.0000	0.455	0.091	0.62	0.124	0.202	201.5
17	Bilipatra	3	0.75	0.250	1.35	0.450	0.75	0.250	1.185	0.395	0.5	0.1667	0.79	0.263	1.33	0.443	0.317	316.9
18	Parag	5	1.288	0.258	0	0.000	2.6	0.520	1.5	0.300	1.035	0.2070	0.65	0.130	0.87	0.174	0.265	264.8
19	Tara	4	0.63	0.158	1	0.250	1.08	0.270	1.315	0.329	1.965	0.4913	2.945	0.736	0.19	0.048	0.326	325.9
20	Shri Shakti	6	1.4	0.233	1.19	0.198	1.62	0.270	0.815	0.136	0.13	0.0217	0.895	0.149	1.4	0.233	0.177	177.4
21	Vaikunth GF	4	0.27	0.068	0.57	0.143	0.3	0.075	0.565	0.141	0.42	0.1050	0.915	0.229	0.91	0.228	0.141	141.1
22	Vaikunth FF	4	1.08	0.270	0.52	0.130	0.82	0.205	0.14	0.035	0.35	0.0875	0.82	0.205	0.225	0.056	0.141	141.3
23	Shnati Kunj	7	2.64	0.377	1.25	0.179	2.05	0.293	4.23	0.604	3.425	0.4893	3.285	0.469	1.33	0.190	0.372	371.6
24	Gurukripa	5	1.525	0.305	0.95	0.190	0.41	0.082	1.15	0.230	2.415	0.4830	1.055	0.211	1.38	0.276	0.254	253.9

25	yadunandan	6	3.33	0.555	3.13	0.522	2.91	0.485	3.01	0.502	1.76	0.2933	3.87	0.645	1.62	0.270	0.467	467.4
26	Gayatri Krupa	5	0.58	0.116	0.88	0.176	1.62	0.324	0.93	0.186	0.42	0.0840	0.93	0.186	0.91	0.182	0.179	179.1
27	Jaydwarkadhish	4	0	0.000	1.14	0.285	0.86	0.215	1.095	0.274	0.895	0.2238	0.945	0.236	1.15	0.288	0.254	253.5
28	Niraj	5	0	0.000	3.85	0.770	2.29	0.458	5.48	1.096	2.87	0.5740	1.8	0.360	2.545	0.509	0.628	627.8
29	Shubham	5	0	0.000	1.39	0.278	1.67	0.334	1.49	0.298	0.645	0.1290	0.595	0.119	0.92	0.184	0.224	223.7
30	Khushbu	4	0	0.000	0.73	0.183	0.28	0.070	0.185	0.046	0.875	0.2188	0.175	0.044	0.6	0.150	0.119	118.5
31	Vishal	3	0	0.000	2.02	0.673	0	0.000	2.475	0.825	1.345	0.4483	1.505	0.502	1.685	0.562	0.602	602.0
32	Krishna	8	0	0.000	0.31	0.039	0	0.000	0.17	0.021	0	0.0000	0.07	0.009	0	0.000	0.017	17.2
33	Prerna	4	2.9	0.725	3.73	0.933	1.23	0.308	4.25	1.063	3.365	0.8413	0	0.000	2.87	0.718	0.764	764.4
34	Navkar	2	0.39	0.195	2.09	1.045	3.36	1.680	1.83	0.915	0.585	0.2925	1.585	0.793	1.18	0.590	0.787	787.1
		165	40.998		50.6		42.065		50.06		39.76		42.29		48.385		10.924	
																	0.321	**321.3**

ANNEXURE 2

Physical Characterization of Waste from Households Conducted by Municipal Staff with Support from ICLEI South Asia

1. **Lower Income Group (LIG)**

Waste Types	Day 1	Day 2	Day 3	Average
	(%)	(%)	(%)	(%)
Biodegradable (Kitchen waste, egg shell etc.)	79.48	78.15	76.95	69.81
Polythene	2.73	2.49	3.53	7.00
Wrapper	4.32	3.19	1.05	2.85
Paper	5.22	1.79	2.44	4.38
Cardboard	1.99	1.94	1.64	1.18
Clothes/Rag	1.04	1.29		1.17
Glass	1.94	0.00	2.09	1.34
Inert	3.28	3.68	2.99	3.32
Inert (C&D)	0.00	7.07		3.53
Jute		0.40		0.40
Hazardous Waste			0.45	0.45
Hard Plastic			8.86	8.86
Total	100.00	100.00	100	100.00

2. Middle Income Group

Waste Types	Day 1	Day 2	Day 3	AVERAGE
	(%)	(%)	(%)	(%)
Biodegradable	60.85	69.86	71.91	67.54
Polythene	1.44	4.19	4.74	3.46
Wrapper	7.00	3.19	1.95	4.05
Hard Plastic	3.83	2.30	2.00	2.71
Paper	3.35	3.59	4.14	3.70
Yard Waste	4.70	0.00	4.34	3.01
Cardboard	4.70	2.89	3.59	3.73
Clothes/Rag	1.53	1.10	-	1.32
Thermocol	0.43	0.00	0.25	0.23
Medicines	0.34	0.40	-	0.37
Sanitary Waste	0.81	2.59	-	1.70
Rubber	3.07	6.59	-	4.83
Hazardsous Waste (battery,tubelight)	2.20	0.00	2.50	1.57
Coconut Husk	-	1.60	-	1.60
Others	2.87	0.00	-	1.44
Metal	0.00	0.60	1.60	0.73
Glass	0.00	1.10	-	0.55
Inert	2.87	0.00	2.99	1.96
Total	100	100.00	100.00	100.00

3. High Income Group

Waste Type	Day 1 (%)	Day 2 (%)	Day 3 (%)	Average (%)
Biodegradable	69.85	67.43	71.563	69.61
Yard Waste	-	-	1.780	1.78
Cocount Shell	0.00	2.19	-	1.09
Wood	0.00	6.86	-	3.43
Polythene	2.05	1.34	3.610	2.34
Wrapper	7.19	1.39	1.039	3.21
Hard Plastic	1.59	0.80	2.275	1.55
Plastic Bottles	2.62	1.59		2.11
Paper	9.19	8.55	4.698	7.48
Cardboard	0.98	1.99	5.242	2.74
Clothes/Rag	2.05	0.80	3.264	2.04
Medicines	0.82	0.00	0.544	0.46
Metal	0.00	0.90	-	0.45
Glass	-	-	3.017	3.02
Battery	-	0.70	-	0.35
Inert	3.65	5.47	2.967	4.03
Total	100.00	100.00	100.00	100.00

Annexure - 3

Quantification and Characterization of MSW in Rajkot along with community awareness regarding source segregation

Waste quantification in MIG Housing Society at Gitanagar, Ward No. 14

Awareness for Segregation at Source in MIG Housing Society at Gitanagar, Ward No. 14

Awareness for Segregation at Source in LIG Housing Society at Ramnagar, Ward No. 15

Awareness for Segregation at Source in HIG Housing at Prakash Society, Ward No. 10

TEST REPORT

Customer's Name and Address :

ICLEI - LOCAL GOVERNMENTS FOR SUSTAINABILITY SOUTH ASIA **GROUND FLOOR, NSIC-STP COMPLEX** **NSIC BHAWAN, OKHLA INDUSTRIAL ESTATE,** **NEW DELHI - 110020, INDIA.**	Test Report No.	: **PLPL/171225026 To PLPL/171225028**
	Issue Date	: **29/12/2017**
	Customer's Ref.	: **As Per Work Order**

Description of Sample	: **Solid Sample**	Quantity/No. of Samples	: **05 Kg/09**
Sampling By	: **As per Table**	Protocol (Purpose)	: **QC**
Sample Receipt Date	: **25/12/2017**	Lab ID	: **PLPL/171225026 To PLPL/171225028**
Packing/Seal	: **Sealed**	Test of Parameters	: **As Per Table**
Date of Starting of Test	: **25/12/2017**	Date of Completion	: **29/12/2017**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT		
			Residential: LIG/ Dt.23.12.17#	Residential:MIG/ Dt.23.12.17#	Residential: HIG/ Dt.23.12.17#
Physical Characterization					
1	Biodegradable	%	54.28	61.08	58.26
2	Paper	%	5.21	8.52	4.86
3	Carboard	%	0.16	0.10	0.12
4	Glass	%	0.48	0.21	0.18
5	Plastic Covers (Polythylene)	%	12.98	9.86	14.11
Hard Plastic					
6	PVC	%	2.89	1.92	1.92
7	HDPE	%	3.52	2.18	3.64
8	LDPE	%	2.61	4.08	3.09
9	Polypropylene	%	0.14	0.21	0.17
10	Polystyrene	%	0.11	0.18	0.09
11	Metal	%	0.13	0.11	0.16
12	Wood	%	0.17	0.22	0.31
13	Textile	%	10.81	8.81	9.32
14	Leather/Rubber	%	0.15	0.20	0.28
15	Inert (C&D Waste)	%	0.32	0.16	0.54
16	Inert (Sweeping)	%	4.21	1.42	1.88
16.1	Coal	%	1.06	0.31	0.70
16.2	Ash	%	0.41	0.16	0.30

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION **SOLID WASTE MANAGEMENT BRANCH**	Test Report No. : **PLPL/171225026 To PLPL/171225028** Issue Date : **29/12/2017** Customer's Ref. : **As Per Work Order**

RESULT TABLE

Proximate analysis					
17	Moisture	%	71.80	77.16	73.92
18	Volatile Combustible Matter	%	23.96	19.58	22.10
19	Fixed Carbon	%	0.35	0.28	0.32
20	Ash	%	3.89	2.98	3.66
Ultimate Analysis					
21	Carbon	%	13.78	10.90	12.80
22	Hydrogen	%	5.89	5.10	6.11
23	Oxygen	%	28.09	33.28	27.86
24	Nitrogen	%	0.95	0.89	0.93
25	Sulphur	%	0.43	0.37	0.41
26	Ash	%	3.89	2.98	3.66
27	Total Carbon Analysis	%	44.28	43.96	45.28
28	Total Nitrogen (Kjeldahl method)	%	1.20	1.10	1.20
29	GCV	Kcal/kg	1148	908	1067
30	C:N Ratio	--	1:14.50	1:12.25	1:13.76
31	Phosphorous as P_2O_5	%	0.790	0.770	0.910
32	Potassium as K_2O	%	0.690	0.640	0.830
33	Chlorides	%	0.012	0.010	0.011

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION **SOLID WASTE MANAGEMENT BRANCH**	Test Report No. : **PLPL/171225029 To PLPL/171225031** Issue Date : **29/12/2017** Customer's Ref. : **As Per Work Order**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT		
			Commercial Areas/ Dt.23.12.17#	Institutional Waste/ Dt.23.12.17#	Hotel Waste/ Dt.23.12.17#
Physical Characterization					
1	Biodegradable	%	--	--	80.31
2	Paper	%	11.92	20.81	4.89
3	Carboard	%	0.29	2.26	--
4	Glass	%	2.89	0.87	1.92
5	Plastic Covers (Polythylene)	%	15.69	19.81	4.96
Hard Plastic					
6	PVC	%	12.86	6.86	1.86
7	HDPE	%	4.62	3.96	1.21
8	LDPE	%	7.91	2.12	1.47
9	Polypropylene	%	0.87	1.14	--
10	Polystyrene	%	0.21	0.96	--
11	Metal	%	3.81	0.34	--
12	Wood	%	2.16	0.67	--
13	Textile	%	14.98	14.62	2.18
14	Leather/Rubber	%	2.96	2.49	1.18
15	Inert (C&D Waste)	%	10.19	13.24	--
16	Inert (Sweeping)	%	3.09	9.54	--
16.1	Coal	%	4.05	--	--
16.2	Ash	%	0.70	--	--
Proximate analysis					
17	Moisture	%	39.21	28.81	91.28
18	Volatile Combustible Matter	%	52.80	62.78	6.98
19	Fixed Carbon	%	3.13	2.49	0.560
20	Ash	%	4.86	5.92	1.18
Ultimate Analysis					
21	Carbon	%	29.83	26.18	8.29
22	Hydrogen	%	7.21	6.28	5.76
23	Oxygen	%	21.42	21.87	33.08
24	Nitrogen	%	0.92	0.85	1.34
25	Sulphur	%	0.34	0.31	0.31
26	Ash	%	4.86	5.92	1.18
27	Total Carbon Analysis	%	32.47	36.11	46.92
28	Total Nitrogen (Kjeldahl method)	%	1.20	1.10	1.40
29	GCV	Kcal/kg	2486	2182	691
30	C:N Ratio	--	1:32.42	1:30.8	1:6.19
31	Phosphorous as P_2O_5	%	0.84	0.66	0.790
32	Potassium as K_2O	%	0.90	0.71	0.920
33	Chlorides	%	0.016	0.014	0.014

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION **SOLID WASTE MANAGEMENT BRANCH**	Test Report No. : **PLPL/171225032 To PLPL/171225034** Issue Date : **29/12/2017** Customer's Ref. : **As Per Work Order**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT		
			Residential: LIG/ Dt.24.12.17#	Residential: MIG/ Dt.24.12.17#	Residential: HIG/ Dt.24.12.17#
Physical Characterization					
1	Biodegradable	%	60.19	63.42	61.90
2	Paper	%	7.26	10.14	8.86
3	Carboard	%	0.19	0.17	0.15
4	Glass	%	0.87	0.69	0.72
5	Plastic Covers (Polythylene)	%	13.28	11.86	14.11
Hard Plastic					
6	PVC	%	3.21	4.87	3.87
7	HDPE	%	1.96	2.16	1.98
8	LDPE	%	2.87	1.92	1.86
9	Polypropylene	%	0.21	0.19	0.17
10	Polystyrene	%	0.19	0.23	0.21
11	Metal	%	0.14	0.17	0.16
12	Wood	%	0.28	0.37	0.41
13	Textile	%	5.87	1.98	3.10
14	Leather/Rubber	%	0.21	0.28	0.19
15	Inert (C&D Waste)	%	0.35	0.16	0.00
16	Inert (Sweeping)	%	2.06	1.31	1.98
16.1	Coal	%	0.57	0.00	0.00
16.2	Ash	%	0.17	0.00	0.00
Proximate analysis					
17	Moisture	%	75.70	78.11	77.23
18	Volatile Combustible Matter	%	18.40	17.26	18.90
19	Fixed Carbon	%	2.74	1.94	1.78
20	Ash	%	3.16	2.69	2.09
Ultimate Analysis					
21	Carbon	%	11.28	10.72	10.94
22	Hydrogen	%	4.87	5.16	5.23
23	Oxygen	%	33.49	35.81	34.76
24	Nitrogen	%	0.97	0.90	0.91
25	Sulphur	%	0.36	0.31	0.33
26	Ash	%	3.16	2.69	2.09
27	Total Carbon Analysis	%	43.81	42.11	43.29
28	Total Nitrogen (Kjeldahl method)	%	1.10	1.10	1.10
29	GCV	Kcal/kg	940	893	912
30	C:N Ratio	--	1:11.62	1:12.02	1:12.02
31	Phosphorous as P_2O_5	%	0.370	0.61	0.61
32	Potassium as K_2O	%	0.580	0.73	0.73
33	Chlorides	%	0.011	0.013	0.013

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

QR/5.10/01

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION **SOLID WASTE MANAGEMENT BRANCH**	Test Report No. : **PLPL/171225035** Issue Date : **29/12/2017** Customer's Ref. : **As Per Work Order**

Description of Sample	: **Solid Sample**	Quantity/No. of Samples	: **05 Kg/08**
Sampling By	: **As per Table**	Protocol (Purpose)	: **QC**
Sample Receipt Date	: **25/12/2017**	Lab ID	: **PLPL/171225035**
Packing/Seal	: **Sealed**	Test of Parameters	: **As Per Table**
Date of Starting of Test	: **25/12/2017**	Date of Completion	: **29/12/2017**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT
			Vegetable Market/Dt.23.12.17#
Physical Characterization			
1	Biodegradable	%	88.16
2	Paper	%	6.87
3	Carboard	%	--
4	Glass	%	--
5	Plastic Covers (Polythylene)	%	4.89
Hard Plastic			
6	PVC	%	--
7	HDPE	%	--
8	LDPE	%	--
9	Polypropylene	%	--
10	Polystyrene	%	--
11	Metal	%	--
12	Wood	%	--
13	Textile	%	--
14	Leather/Rubber	%	--
15	Inert (C&D Waste)	%	--
16	Inert (Sweeping)	%	--
16.1	Coal	%	--
16.2	Ash	%	--

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION **SOLID WASTE MANAGEMENT BRANCH**	Test Report No. : **PLPL/171225035** Issue Date : **29/12/2017** Customer's Ref. : **As Per Work Order**

RESULT TABLE

Proximate analysis			
17	Moisture	%	57.18
18	Volatile Combustible Matter	%	38.82
19	Fixed Carbon	%	1.19
20	Ash	%	2.81
Ultimate Analysis			
21	Carbon	%	16.34
22	Hydrogen	%	5.78
23	Oxygen	%	22.39
24	Nitrogen	%	1.50
25	Sulphur	%	0.290
26	Ash	%	2.81
27	Total Carbon Analysis	%	47.62
28	Total Nitrogen (Kjeldahl method)	%	1.80
29	GCV	Kcal/kg	1382
30	C:N Ratio	--	1:8.23
31	Phosphorous as P_2O_5	%	0.71
32	Potassium as K_2O	%	0.75
33	Chlorides	%	0.019

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION	Test Report No. : **PLPL/171225036 & PLPL/171225037**
SOLID WASTE MANAGEMENT BRANCH	Issue Date : **29/12/2017**
	Customer's Ref. : **As Per Work Order**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT	
			Transportation/ Raiyadhar/Dt.23.12.17#	Transportation/Near K.S. Diesel/Dt.23.12.17#
Physical Characterization				
1	Biodegradable	%	30.81	24.86
2	Paper	%	16.81	14.92
3	Carboard	%	1.69	1.28
4	Glass	%	0.98	1.16
5	Plastic Covers (Polythylene)	%	12.46	10.99
Hard Plastic				
6	PVC	%	3.49	4.21
7	HDPE	%	2.87	2.47
8	LDPE	%	4.10	3.87
9	Polypropylene	%	1.90	0.98
10	Polystyrene	%	0.98	0.87
11	Metal	%	0.61	1.17
12	Wood	%	0.82	0.69
13	Textile	%	14.86	17.82
14	Leather/Rubber	%	1.96	2.81
15	Inert (C&D Waste)	%	0.12	0.27
16	Inert (Sweeping)	%	4.98	10.96
16.1	Coal	%	0.10	0.43
16.2	Ash	%	0.07	0.09
Proximate analysis				
17	Moisture	%	48.19	40.82
18	Volatile Combustible Matter	%	47.91	54.89
19	Fixed Carbon	%	0.76	0.62
20	Ash	%	3.14	3.67
Ultimate Analysis				
21	Carbon	%	18.63	19.61
22	Hydrogen	%	6.26	6.48
23	Oxygen	%	25.31	26.39
24	Nitrogen	%	1.26	1.37
25	Sulphur	%	0.34	0.39
26	Ash	%	3.14	3.67
27	Total Carbon Analysis	%	41.86	39.14
28	Total Nitrogen (Kjeldahl method)	%	1.50	1.72
29	GCV	Kcal/kg	1520	1612
30	C:N Ratio	--	1:14.78	1:14.31
31	Phosphorous as P_2O_5	%	0.810	0.590
32	Potassium as K_2O	%	0.880	0.630
33	Chlorides	%	0.017	0.016

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION **SOLID WASTE MANAGEMENT BRANCH**	Test Report No. : **PLPL/171225038 & PLPL/171225042** Issue Date : **29/12/2017** Customer's Ref. : **As Per Work Order**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT	
			Landfill Waste/Dt.23.12.17#	Landfill Waste/Dt.24.12.17#
Physical Characterization				
1	Biodegradable	%	26.81	22.85
2	Paper	%	10.62	9.18
3	Carboard	%	0.68	0.74
4	Glass	%	0.81	0.16
5	Plastic Covers (Polythylene)	%	17.89	16.22
Hard Plastic				
6	PVC	%	4.87	7.34
7	HDPE	%	5.92	2.80
8	LDPE	%	4.18	6.37
9	Polypropylene	%	1.21	1.10
10	Polystyrene	%	0.98	0.98
11	Metal	%	0.96	0.76
12	Wood	%	1.60	0.97
13	Textile	%	14.86	18.21
14	Leather/Rubber	%	2.19	3.14
15	Inert (C&D Waste)	%	0.39	1.27
16	Inert (Sweeping)	%	5.60	7.01
16.1	Coal	%	0.28	0.59
16.2	Ash	%	0.11	0.18
Proximate analysis				
17	Moisture	%	20.87	28.31
18	Volatile Combustible Matter	%	68.38	61.92
19	Fixed Carbon	%	3.59	3.85
20	Ash	%	7.16	5.92
Ultimate Analysis				
21	Carbon	%	18.31	16.75
22	Hydrogen	%	7.10	6.94
23	Oxygen	%	28.14	29.34
24	Nitrogen	%	1.10	1.30
25	Sulphur	%	0.38	0.34
26	Ash	%	7.16	5.92
27	Total Carbon Analysis	%	35.24	36.58
28	Total Nitrogen (Kjeldahl method)	%	1.30	1.60
29	GCV	Kcal/kg	1526	1396
30	C:N Ratio	--	1:16.64	1:12.88
31	Phosphorous as P_2O_5	%	0.610	0.600
32	Potassium as K_2O	%	0.650	0.620
33	Chlorides	%	0.017	0.014

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION **SOLID WASTE MANAGEMENT BRANCH**	Test Report No. : **PLPL/171225039 & PLPL/171225041** Issue Date : **29/12/2017** Customer's Ref. : **As Per Work Order**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT	
			Transportation/ Raiyadhar/Dt.24.12.17#	**Transportation/Near K.S. Diesel /Dt.24.12.17#**
Physical Characterization				
1	Biodegradable	%	34.18	30.11
2	Paper	%	16.21	12.60
3	Carboard	%	1.86	1.42
4	Glass	%	0.88	0.90
5	Plastic Covers (Polythylene)	%	14.86	13.62
Hard Plastic				
6	PVC	%	4.11	7.54
7	HDPE	%	2.86	3.91
8	LDPE	%	2.71	5.87
9	Polypropylene	%	1.14	0.87
10	Polystyrene	%	0.87	0.53
11	Metal	%	0.69	0.94
12	Wood	%	0.84	2.10
13	Textile	%	12.69	8.97
14	Leather/Rubber	%	0.94	1.42
15	Inert (C&D Waste)	%	0.12	0.67
16	Inert (Sweeping)	%	4.91	7.93
16.1	Coal	%	0.00	0.13
16.2	Ash	%	0.00	0.06
Proximate analysis				
17	Moisture	%	53.17	47.84
18	Volatile Combustible Matter	%	42.61	48.11
19	Fixed Carbon	%	0.600	0.73
20	Ash	%	3.62	3.32
Ultimate Analysis				
21	Carbon	%	17.96	18.91
22	Hydrogen	%	5.94	6.08
23	Oxygen	%	23.32	25.86
24	Nitrogen	%	1.19	1.22
25	Sulphur	%	0.330	0.34
26	Ash	%	3.62	3.32
27	Total Carbon Analysis	%	44.59	41.78
28	Total Nitrogen (Kjeldahl method)	%	1.50	1.40
29	GCV	Kcal/kg	1458	1642
30	C:N Ratio	--	1:15.09	1:15.55
31	Phosphorous as P_2O_5	%	0.760	0.530
32	Potassium as K_2O	%	0.780	0.550
33	Chlorides	%	0.014	0.016

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

TEST REPORT

Customer's Name and Address :

RAJKOT MUNICIPAL CORPORATION	Test Report No. : **PLPL/171225040**
SOLID WASTE MANAGEMENT BRANCH	Issue Date : **29/12/2017**
	Customer's Ref. : **As Per Work Order**

RESULT TABLE

SR. NO.	PARAMETERS	UNIT	RESULT
			Commercial/Dt.24.12.17#
Physical Characterization			
1	Biodegradable	%	--
2	Paper	%	13.96
3	Carboard	%	0.19
4	Glass	%	0.26
5	Plastic Covers (Polythylene)	%	15.28
Hard Plastic			
6	PVC	%	10.74
7	HDPE	%	6.89
8	LDPE	%	8.12
9	Polypropylene	%	0.92
10	Polystyrene	%	0.32
11	Metal	%	1.96
12	Wood	%	3.41
13	Textile	%	16.08
14	Leather/Rubber	%	2.16
15	Inert (C&D Waste)	%	9.58
16	Inert (Sweeping)	%	3.80
16.1	Coal	%	4.20
16.2	Ash	%	1.80
Proximate analysis			
17	Moisture	%	34.89
18	Volatile Combustible Matter	%	57.61
19	Fixed Carbon	%	2.16
20	Ash	%	5.34
Ultimate Analysis			
21	Carbon	%	32.45
22	Hydrogen	%	6.32
23	Oxygen	%	23.06
24	Nitrogen	%	0.99
25	Sulphur	%	0.37
26	Ash	%	5.34
27	Total Carbon Analysis	%	28.64
28	Total Nitrogen (Kjeldahl method)	%	1.40
29	GCV	Kcal/kg	2704
30	C:N Ratio	--	1:32.78
31	Phosphorous as P_2O_5	%	0.69
32	Potassium as K_2O	%	0.73
33	Chlorides	%	0.011

: Detail given by customer.

H.T. Shah
Lab Manager

Dr. Arun Bajpai
Lab Manager(Q)

Note: This report is subject to terms & conditions mentioned overleaf.

Annexure 3 - Energy Projections - 2016 to 2050

Community

Sectors	Energy Source/Activity	Baseline Activity Data						Projected Energy Use (Medium Term Scenario)										Projected Energy Use (Long Term Scenario)				
		Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2030-31	2035-36	2040-41	2045-46	2050-51
Residential Buildings	Electricity	MU	442.68	461.23	510.45	574.83	605.98	663.70	726.92	796.16	871.99	955.05	1,046.02	1,145.65	1,254.78	1,374.30	1,505.20	2,372.26	3,738.78	5,892.48	9,286.79	14,636.38
	Kerosene	kL	13,611.84	13,192.16	11,911.00	12,009.90	11,627.37	11,148.17	10,688.71	10,248.19	9,825.83	9,420.87	9,032.60	8,660.34	8,303.42	7,961.20	7,633.09	6,184.58	5,010.94	4,060.03	3,289.56	2,665.31
	LPG	tonnes	34,221.02	32,160.68	26,673.82	22,930.29	29,123.72	28,176.52	27,260.13	26,373.54	25,515.79	24,685.93	23,883.06	23,106.31	22,354.81	21,627.76	20,924.36	17,735.96	15,033.41	12,742.66	10,800.97	9,155.15
	PNG	cubic m	10,964,262.68	15,323,967.01	17,318,535.55	19,030,773.20	21,037,647.65	23,381,507.04	25,986,501.94	28,881,726.15	32,099,514.85	35,675,805.83	39,650,540.74	44,068,111.27	48,977,854.89	54,434,605.91	60,499,307.84	102,595,194.81	173,981,725.99	295,039,558.46	500,330,368.38	848,464,113.87
Commercial and Institutional Buildings	Electricity	MU	119.08	99.76	131.07	151.59	180.21	219.47	267.29	325.53	396.46	482.85	588.06	716.19	872.24	1,062.29	1,293.75	3,466.49	9,288.15	24,886.75	66,681.83	178,667.97
	LPG	tonnes	1,334.12	1,115.18	1,357.85	1,196.67	850.02	776.46	709.28	647.90	591.84	540.63	493.85	451.11	412.08	376.42	343.85	218.70	139.09	88.47	56.27	35.79
	PNG	cubic m	1,751,597.40	1,931,213.25	2,187,158.61	2,365,321.98	2,463,404.55	2,671,596.76	2,897,384.13	3,142,253.70	3,407,818.18	3,695,826.57	4,008,175.72	4,346,922.74	4,714,298.64	5,112,722.95	5,544,819.70	8,318,849.61	12,480,704.99	18,724,704.06	28,092,527.02	42,146,998.52
Facilities	Electricity	MU	54.89	47.01	50.13	61.12	63.35	69.98	77.29	85.37	94.30	104.16	115.05	127.08	140.36	155.04	171.25	281.55	462.90	761.07	1,251.28	2,057.25
	Diesel	KL	509.95	555.14	751.89	1,004.96	1,036.69	1,276.63	1,572.10	1,935.96	2,384.03	2,935.81	3,615.29	4,452.04	5,482.45	6,751.34	8,313.92	23,544.24	66,675.06	188,817.44	534,713.06	1,514,256.61
Manufacturing Industry and Construction (i.e. Industrial sector)	Electricity	MU	285.03	320.10	333.14	344.79	363.60	379.38	395.84	413.01	430.93	449.63	469.14	489.49	510.73	532.89	556.01	687.57	850.25	1,051.42	1,300.19	1,607.82
	Furnace Oil	KL	-	-	-	300.00	-															
	PNG	cubic m	30,072,749.04	37,477,020.30	38,183,585.59	35,793,073.34	26,557,395.76	23,676,943.04	21,108,908.30	18,819,406.24	16,778,226.81	14,958,436.59	13,336,023.39	11,889,579.43	10,600,018.82	9,450,325.78	8,425,330.07	4,745,561.91	2,672,934.78	1,505,528.85	847,988.18	477,628.82
Agriculture, forestry and fishing activities (i.e. mainly agriculture)	Electricity	MU																				
Waste	Solid Waste to Landfill	tonnes	40,150.00	49,275.00	173,375.00	187,975.00	193,450.00															
	Solid Waste to RDF	tonnes	43,800.00	43,800.00	-	-	-															
	Solid waste to Compost	tonnes	43,800.00	43,800.00	-	-	-															
Mobile (Transportation)	Auto - LPG	tonnes	720.00	511.00	289.00	182.00	167.00	115.03	79.23	54.58	37.59	25.89	17.84	12.29	8.46	5.83	4.02	0.62	0.10	0.01	0.00	0.00
	Petrol	kL	52,724.27	53,363.46	56,098.99	58,888.20	67,869.73	73,533.77	79,670.50	86,319.37	93,523.11	101,328.05	109,784.34	118,946.34	128,872.96	139,628.00	151,280.60	225,858.68	337,202.16	503,435.59	751,618.52	1,122,150.32
	Diesel	kL	74,683.75	81,094.16	81,288.81	83,449.44	89,391.34	92,341.59	95,389.22	98,537.44	101,789.55	105,149.00	108,619.32	112,204.18	115,907.35	119,732.74	123,684.39	145,487.14	171,133.22	201,300.13	236,784.78	278,524.57
	CNG	tonnes	29,535.69	32,581.70	32,273.47	36,321.66	40,306.25	43,268.51	46,448.48	49,862.16	53,526.72	57,460.61	61,683.61	66,216.98	71,083.52	76,307.72	81,915.87	116,779.29	166,480.61	237,334.82	338,344.61	482,344.22
Total	-	-																				

Local Government

Sectors	Energy Source/Activity	Activity Data						Projected Energy Use (Medium Term Scenario)										Projected Energy Use (Long Term Scenario)				
		Unit	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2030-31	2035-36	2040-41	2045-46	2050-51
Buildings	Electricity	MU	1.95	2.13	2.44	2.86	3.20	3.66	4.19	4.79	5.49	6.28	7.18	8.22	9.41	10.76	12.32	24.17	47.44	93.09	182.67	358.45
	Diesel	kL	-	-	-	-	-															
Facilities	Waste Water Treatment (Electricity)	MU	6.13	7.65	6.46	6.24	6.66	9.61	9.84	10.07	10.30	10.53	10.75	11.09	11.43	11.77	13.55	15.44	17.94	20.58	23.97	27.54
	Waste Water Treatment (Diesel)	KL	1.50	1.47	1.41	1.44	1.45	1.44	1.44	1.43	1.42	1.42	1.41	1.40	1.40	1.39	1.39	1.35	1.32	1.29	1.26	1.24
	Water Supply (Electricity)	MU	34.19	24.66	29.00	38.34	38.36	39.90	40.85	41.79	42.74	43.69	44.63	46.04	47.45	48.85	47.63	54.29	63.06	72.35	84.26	96.83
	Water Supply (Diesel)	KL	71.22	62.88	70.85	80.45	50.62	47.09	43.81	40.75	37.91	35.27	32.81	30.52	28.39	26.41	24.57	17.12	11.93	8.31	5.79	4.03
	Solid waste management (Transfer stations)	MU	0.04	0.05	0.08	0.10	0.14	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.15	0.17	0.19	0.22	0.26	0.30
	Street Lighting	MU	12.57	12.51	12.15	13.58	14.99	15.92	16.91	17.96	19.07	20.26	21.52	22.85	24.27	25.78	27.38	37.01	50.02	67.61	91.38	123.51
Mobile (Transportation) (Local Government vehicles)	Petrol	kL	0.00	0.00	0.00	0.00	0.00															
	Diesel	kL	437.23	490.78	679.63	923.08	984.62	1,241.82	1,566.21	1,975.34	2,491.35	3,142.14	3,962.94	4,998.16	6,303.79	7,950.49	10,027.34	31,999.63	102,118.51	325,884.67	1,039,976.17	3,318,813.50
	Auto-LPG	kL	0.00	0.00	0.00	0.00	0.00															
	CNG	tonnes	0.00	0.00	0.00	0.00	0.00															
Total	-	-	-	-	-		-															

Annexure 4 - GHG Emission Projections - 2016 to 2050

Community Inventory

Sectors	Energy Source/Activity	Baseline GHG Emission (tonnes of CO2e) (using HEAT+)					Projected GHG emission (Medium Term scenario)										Projected GHG emission (LongTerm scenario)				
		2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2030-31	2035-36	2040-41	2045-46	2050-51
Residential Buildings	Electricity	346,523	379,493	419,990	472,961	498,591	546,082.06	598,096.82	655,066.02	717,461.59	785,800.38	860,648.50	942,625.96	1,032,411.84	1,130,749.90	1,238,454.74	1,951,857.22	3,076,209.79	4,848,237.16	7,641,027.48	12,042,583.51
	Kerosene	35,199	34,114	30,801	31,056	30,067	28,826.93	27,638.87	26,499.78	25,407.63	24,360.49	23,356.51	22,393.90	21,470.97	20,586.08	19,737.65	15,992.08	12,957.30	10,498.42	8,506.16	6,891.96
	LPG	102,411	96,245	79,825	68,622	87,157	84,322.11	81,579.68	78,926.44	76,359.50	73,876.04	71,473.35	69,148.80	66,899.86	64,724.05	62,619.02	53,077.31	44,989.54	38,134.16	32,323.38	27,398.04
	PNG	20,724	28,965	32,735	35,971	39,765	44,194.82	49,118.68	54,591.12	60,673.26	67,433.03	74,945.92	83,295.84	92,576.04	102,890.18	114,353.45	193,921.46	328,853.52	557,672.35	945,705.09	1,603,734.02
Commercial and Institutional Buildings	Electricity	93,216	82,079	107,843	124,723	148,272	180,578.51	219,924.65	267,843.90	326,204.24	397,280.68	483,843.92	589,268.37	717,663.69	874,034.98	1,064,477.92	2,852,173.06	7,642,141.78	20,476,433.11	54,864,765.04	147,005,214.53
	LPG	3,993	3,337	4,064	3,581	2,544	2,323.67	2,122.61	1,938.94	1,771.16	1,617.90	1,477.90	1,350.02	1,233.20	1,126.49	1,029.02	654.48	416.26	264.75	168.39	107.10
	PNG	3,311	3,650	4,134	4,471	4,656	5,049.75	5,476.52	5,939.37	6,441.33	6,985.71	7,576.10	8,216.39	8,910.78	9,663.87	10,480.60	15,723.97	23,590.55	35,392.71	53,099.41	79,664.62
Facilities	Electricity	42,965	38,681	41,246	50,292	52,126	57,575.54	63,595.20	70,244.23	77,588.42	85,700.48	94,660.66	104,557.66	115,489.41	127,564.09	140,901.22	231,657.45	380,870.89	626,194.57	1,029,534.29	1,692,670.14
	Diesel	1,454	1,582	2,143	2,865	2,955	3,639.04	4,481.29	5,518.47	6,795.70	8,368.54	10,305.42	12,690.58	15,627.77	19,244.77	23,698.92	67,113.09	190,057.89	538,225.91	1,524,204.67	4,316,402.93
Manufacturing Industry and Construction (i.e. Industrial sector)	Electricity	223,117	263,373	274,102	283,688	299,164	312,144.71	325,688.22	339,819.36	354,563.63	369,947.63	385,999.12	402,747.06	420,221.67	438,454.48	457,478.39	565,719.20	699,570.12	865,090.58	1,069,773.70	1,322,885.48
	Furnace Oil																				
	PNG	56,842	70,838	72,173	67,655	50,198	44,753.24	39,899.24	35,571.71	31,713.55	28,273.86	25,207.24	22,473.22	20,035.75	17,862.64	15,925.23	8,969.88	5,052.28	2,845.69	1,602.83	902.80
Agriculture, forestry and fishing activities (i.e. mainly agriculture)	Electricity																				
Waste	Solid Waste to Landfill	26,046	68,092	112,470	119,778	140,329	133,150.40	130,236.50	125,804.40	113,477.40								10,718.90	43,445.03	85,401.07	129,664.60
	Solid Waste to energy										95,470.56	98,554.70	103,135.45	107,716.26	112,297.79	116,878.56	128,298.70	147,972.20	147,972.20	147,972.20	147,972.20
	Solid Waste to Compost	18,781	18,781					3,130.24	7,043.04	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10	15,025.10
Mobile (Transportation)	LPG	2,152	1,527	864	544	499	173.86	119.75	82.49	56.82	39.14	26.96	18.57	12.79	8.81	6.07	0.94	0.15	0.02	0.00	0.00
	Petrol	121,083	122,551	128,833	135,238	155,865	168,872.96	182,966.19	198,235.55	214,779.22	232,703.53	252,123.71	273,164.59	295,961.43	320,660.76	347,421.38	518,692.65	774,397.00	1,156,158.09	1,726,119.20	2,577,058.90
	Diesel	212,887	231,160	231,715	237,873	254,811	263,220.60	271,907.89	280,881.90	290,152.09	299,728.23	309,620.42	319,839.09	330,395.02	341,299.33	352,563.52	414,712.48	487,816.89	573,807.95	674,957.28	793,936.95
	CNG	88,437	97,558	96,635	108,756	120,687	129,554.59	139,076.05	149,297.29	160,269.72	172,048.56	184,693.07	198,266.87	212,838.27	228,480.58	245,272.49	349,660.56	498,476.24	710,627.92	1,013,071.44	1,444,235.05
Total	-	**1,399,139.96**	**1,542,025.81**	**1,639,571.99**	**1,748,073.77**	**1,887,685.31**	2,004,462.8	2,145,058.4	2,303,304.0	2,478,740.3	2,664,659.8	2,899,538.6	3,168,217.5	3,474,489.8	3,824,673.9	4,226,323.3	7,383,249.6	14,339,116.4	30,646,025.7	70,833,256.7	173,206,347.9

Local Govt Inventory

Sectors	Energy Source/Activity	Baseline GHG Emission (tonnes of CO2e) (using HEAT+)					Projected GHG emission (Medium Term scenario)										Projected GHG emission (LongTerm scenario)				
		2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	2024-25	2025-26	2030-31	2035-36	2040-41	2045-46	2050-51
Buildings	Electricity	1,526.00	1,753.00	2,008.00	2,353.00	2,633.00	3,012.04	3,446.79	3,944.30	4,513.61	5,165.10	5,910.62	6,763.76	7,740.03	8,857.21	10,135.65	19,889.53	39,029.90	76,589.70	150,294.56	294,928.10
	Diesel																				
Facilities	Waste Water Treatment (Electricity)	4,798.00	6,294.00	5,315.00	5,134.00	5,480.00	7,910.63	8,098.31	8,285.99	8,473.67	8,661.35	8,849.03	9,127.86	9,406.69	9,685.52	11,146.72	12,706.29	14,758.20	16,933.21	19,721.64	22,663.43
	Waste Water Treatment (Diesel)	4.28	4.19	4.02	4.10	4.13	4.11	4.10	4.08	4.06	4.04	4.02	4.00	3.98	3.97	3.95	3.86	3.77	3.69	3.60	3.52
	Water Supply (Electricity)	26,763.00	20,290.00	23,861.00	31,546.00	31,562.00	32,830.16	33,609.06	34,387.95	35,166.85	35,945.75	36,724.65	37,881.82	39,039.00	40,196.17	39,185.22	44,667.75	51,881.07	59,527.09	69,329.56	79,671.15
	Water Supply (Diesel)	204.00	180.00	203.00	230.00	145.00	134.24	124.88	116.17	108.07	100.53	93.52	87.00	80.93	75.29	70.04	48.79	33.99	23.68	16.50	11.49
	Solid waste management (Transfer stations)	31.00	41.00	66.00	82.00	115.00	95.30	97.56	99.83	102.09	104.35	106.61	109.97	113.33	116.69	120.05	136.84	158.94	182.36	212.39	244.08
	Street Lighting	9,840.00	10,293.00	9,997.00	11,173.00	12,334.00	13,098.49	13,912.04	14,776.11	15,693.86	16,668.60	17,703.89	18,803.47	19,971.36	21,211.78	22,529.24	30,450.46	41,156.77	55,627.39	75,185.83	101,620.98
Mobile (Transportation) (Local Government vehicles)	Petrol																				
	Diesel	1,246.00	1,399.00	1,937.00	2,631.00	2,807.00	3,539.82	4,464.50	5,630.73	7,101.61	8,956.71	11,296.41	14,247.29	17,969.01	22,662.93	28,583.02	91,215.26	291,089.78	928,937.35	2,964,462.00	9,460,309.59
	Auto-LPG																				
	CNG																				
TOTAL		**44,412.28**	**40,254.19**	**43,391.02**	**53,153.10**	**55,080.13**	**60,624.80**	**63,757.24**	**67,245.16**	**71,163.81**	**75,606.43**	**80,688.75**	**87,025.18**	**94,324.33**	**102,809.55**	**111,773.88**	**199,118.78**	**438,112.43**	**1,137,824.46**	**3,279,226.09**	**9,959,452.35**

Tool 3.2B: Urban System Analysis

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
Health	**Flexibility & Diversity:** • Incidence of vector borne, water borne diseases increases with increase in temperatures and flooding • ~7119 water borne disease and vector borne morbidity cases (~90,000 cases have noted symptoms of WB and VB diseases) are registered in Public Health Centres last year. • Total number of available Public Urban Health Centres is 21, which are adequate for the city population as per National Urban Health Mission (NUHM) • Total numbers of hospital beds available in public hospitals and private hospitals (1522 clinics and hospitals) together are 5518 in all. Total available beds per 1000 people is 3.9 as compared to standard provided by WHO (5 rooms/ 1000 people), which are inadequate. Given the preponderance of vector borne diseases and the paucity in affordable advanced health care, this system is considered fragile.	Due to paucity of affordable critical health care services, during an epidemic outbreak, population in the lower income group may not have access to adequate health care facilities	1. Urban Health Centres (UHC) - Health Department of Rajkot Municipal Corporation is completely responsible 2. Awareness generation with in city limit - Health Department, Rajkot Municipal Corporation 3. City level health related preventive initiatives - Health Department, Rajkot Municipal Corporation 4. Spreading Emergency/ disaster related information - District Disaster Management Cell, District Collector 5. Management of Government hospitals	Extended summer season, increasing temperatures, flooding due to higher intensity rainfall contribute to an increase in disease outbreak. Limited capacity of public health care system renders the lower income group population especially vulnerable.	Existing primary public health care infrastructure is adequate but needs improvements to address increasing health impacts, resulting from rising temperatures, increase in the duration of the summer season and flooding conditions resulting from high intensity and short duration

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
			within city and other hospitals outside city areas - District Collector and State Government		rainfall
	Energy Use and GHG Emissions: No Data Available				Preventive health measures are rendered inadequate during periods of excessive heat and flooding
	Redundancy: ~52% of total population residing in slums and LIG HHs, are highly dependent on Primary Public Health Centres. There are total 1522 private clinics and hospitals, but the critical medical services are available in only 5 government hospitals. Therefore access to critical medical care is very expensive and less accessible to the low income population.				
	Safe failure: • RMC has in place emergency response procedures for disease outbreaks, which includes monsoon preparedness, city-wide health monitoring system, identification of vulnerable hotspots, shifting people from vulnerable places to safe places during emergency situations, door to door monitoring for mosquito breeding, fogging, provide drinking water through tankers, awareness campaign for preventive measures, provide basic				

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	primary treatment etc. • Preventive mechanisms such as drain cleaning and monsoon preparedness activities are also undertaken. However during an epidemic break out, affordable pubic health care facilities are insufficient and inadequate, since public hospitals with advanced facilities for treatment are limited.				
Transportation (public transport)	**Flexibility & Diversity:** • Average trip length in Rajkot city is under 4kms Average 1.2lakhs new private vehicles per year registered in Rajkot city, with 40% decadal growth rate in city. • Public transport in city includes 90 Rajkot Mass Transportation System (RMTS) and 10 Bus Rapid Transportation System (BRTS), with ~40,000 people commuting per day against total capacity of 60000 per day (33% underutilized). This is due to intermittent services and services do not cover all areas in Rajkot.	1. Unorganized operations of auto-rickshaws (including 'Chakras'), is unsafe mode of travel due to overloading and poor services in city 2. Increase in Air pollution due to traffic congestion and inefficient use of fuel	1. Public transportation and NMT – Rajkot Rajpath Limited, RMC; Traffic and Transport department, RMC 2. Vehicle Passing and registration - Regional Transport Office	Existing public transit system is inadequate to cater to the mobility needs of the city	During periods of water logging and increasing temperatures, use of public transport is limited due to inadequate public transport services and limited last-mile connectivity
	Energy Use and GHG Emissions:				Air pollution

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	• On road transportation accounts for 49% of the total energy consumption and 28% of the total GHG emission during 2015-16, which are 7,649,868 Giga Joule and 534,818 tCO2e per year respectively. • RMC operates total 11 BRTS buses around 2,485 kilometres per day in Rajkot city. All BRTS buses consume around 425 kilolitres of diesel which leads to 958 tCO2e GHG emission per year. • RMC operates total 90 RMTS city buses around 15,340 kilometres per day in Rajkot city. All RMTS buses consume around 1259 kilolitres of diesel which leads to 3590 tCO2e • Public Transportation GHG emission per year. Total 1684 kilolitres of diesel is consumed by public transportation system which leads to 4548 tCO2e GHG emission per year				in the city is exacerbated due to increase in private vehicles, and resultant traffic congestion
	Redundancy: • Shorter trips and inadequate frequency of available public transportation leads to increase in number of private vehicles. • Auto-rickshaws is preferred mode for				

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	public transportation due to frequent availability (more than 30000 auto rickshaws are plying on roads and 1500 auto-rickshaws registers in Rajkot every year), apart from being illegal, add to problems such as unorganized operations, traffic congestion, unsafe mode of travel due to overloading, poor services, and pollution due to inefficient fuel usage with in city limit. **Safe failure:** • Public transport buses are not plying on all roads at a fixed frequency and affordable and regulated last mile connectivity to the public bus system is an issue • RMC has taken various initiatives to maximize use of public transportation i.e. concession for students, elderly people, e-ticketing, mobile based application for RMTS and BRTS. However, availability of reliable public transport				
Transport (Road Infrastructure)	**Flexibility & Diversity:** • Traffic congestion due to erratic vehicle movement and absence of traffic lights at junctions and absence of planned traffic movement is a common phenomenon.	1. Regular chaos on major corridors 2. Safety and security for	1. Encroachment Removal - Rajkot Municipal Corporation 2. Parking facility - Rajkot Municipal	Poor enforcement of the traffic management system,	During periods of intense rainfall, roads get water logged, which

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	Lack of parking facilities and encroachment of roads by vendors are contributing to the congestion.	cyclists and pedestrians is an issue due to lack of dedicated infrastructure for these travel modes	Corporation 3. Traffic management and enforcement - City and Traffic police	inadequate parking facilities, encroachments on footpaths and cycle lanes, and makeshift vehicles with no pollution control mechanisms impact the functionality of the existing road infrastructure	further exacerbates road congestion and affects connectivity and mobility
	Energy Consumption & GHG Emissions : No data available				
	Redundancy: Absence of traffic movement plan for high congestion areas is not in place, alternate routing of vehicles is therefore not practiced.				

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	Safe failure: • Damage of road infrastructure, water logging on roads and lack of traffic awareness and management systems lead to traffic congestion and air pollution • Roads are subject to congestion and water logging during peak hours and when there is high intensity rainfall; there are no anticipatory mechanisms in place to avoid such incidences				
Water	**Flexibility & Diversity:** **Water Supply:** • Rajkot lies in an arid zone, with irregular and erratic monsoons. The average annual rainfall is 500mm Water is sourced from the local water sources post-monsoon, during the months of August, September and October i.e. Aji Dam, Nyari dam, Bhadar dam, Lalpari lake and Randarda lake. • Rajkot depends on ground water and Narmada canal to meet the water requirements in the dry months of beginning from November till month of July. Total water treatment capacity is 300MLD against total requirement of	1. Water scarcity in the non-monsoon months 2. High dependency on Narmada water leads to high energy consumption for pumping 3. Non-availability of acceptable quality ground water	1. Water supply and water resource management with in city limit - Completely under water supply department, Rajkot Municipal Corporation 2. Narmada water supply - Shared with Gujarat Water Infrastructure Limited (GWIL) 3. Building usage permission after verifying rain water	Being in an arid zone with irregular and erratic monsoons and thin confined aquifer layer, availability of local surface and ground water and ground water is limited against the existing demand of the	Exposure of the community to poor quality ground water increases due to increased demand for water during periods of increased temperature, as treated piped water supply is

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	240MLD • Rajkot has an agreement with Gujarat Water Infrastructure Limited for sourcing Narmada water at INR 6/KL up to 75MLD limit and at INR 12/KL after 75MLD limit. However, this supply does not ensure 24 x 7 water supply and water will be supplied only for 20mins per day. **Water Distribution:** • 85% of total water supply network is old and of asbestos cement (AC) pressure pipe, prone to leakage and loss of pressure, owing to breakages and unauthorised direct pumping from the pipe line in certain instances	4. Contamination of water supply leads to severe health issues (biological contamination is noted in few sample and cases of kidney stones noted as per SLD) 5.Loss of water due to leakages 6. Promoting bore recharge without filtration through captured runoff from roofs/impervious surfaces may contaminate the water table/aquifer due to presence of oils and grease	harvesting infrastructure - Completely with Town Planning Department, Rajkot Municipal Corporation 4. Ground Water Management in city Limit - Gujarat Water Resources Development Corporation (GWRDC) 5. Maintenance of Natural drains - Completely under Solid waste management Department, Rajkot Municipal Corporation	city. Combined with contamination of piped water and poor ground water quality , this sector is considered to be fragile	limited.
	Energy Consumption & GHG Emissions: • Water is pumped over a distance of around 700 Km, requiring a total of 143million kWh electricity consumption for pumping leads to 117,540 tCO2e of GHG emission per year. • Overall water supply in city consumes total of 38.36 million kWh electricity and 50.62 kilolitres of diesel leads to 31,710 tCO2e GHG emission per year (which is				Increased flooding during periods of high intensity rainfall increases chances for potential contamination

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	not accounting consumption from water pumping from Narmada source) • Current level of Non-revenue water (28% of the total water supply) accounts for 3.07 million kWh electricity consumption leads to 2,525 tCO2e GHG emission per year as compared to Service Level Benchmark (20% of the total water supply)	and even faecal contamination			of surface water supply with untreated sewage due to compromised water distribution and sewage collection networks
	Redundancy: • Availability of water in local water sources is limited due to irregular and erratic rain fall. Poor surface water quality results in significant treatment effort Dependency on Narmada water is increasing over ~90% during dry months as per SCADA record Current ground water level is below 1000ft, water table declines drastically in the event of low rainfall • Faecal and biological contamination has been found in ground water in few samples, may create serious health issues				

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	Natural water percolation is limited due to rocky soil strata • Absence of suitable storage structures and suitable mechanisms for rainwater harvesting, much of rainwater is lost for any future use				
	Safe failure: • City has regularized 21697 illegal water connections, issued notice to 1259 direct pumping cases, cut 5874 illegal water connections and issued notice to 549 HHs wasting water. • Rajkot has implemented SCADA system for bulk water supply at every ESR/GSR and pumping stations to monitor water supply. • 15% of total water distribution network is replaced with DI pipeline, and proposed the same in phase wise manner Plans are afoot to install water meters and provide 24*7 water supply to 15000 HHs on pilot bases which will be replicate at city level • Rajkot is assessing potential for augmentation of local water resources through ground water/ aquifer recharge, rain water harvesting, and waste water				

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	reuse Rajkot has connected Aji-1 dam with the Narmada Canal under state government's "Sauni Yojana" scheme to ensure availability of water during dry periods (period of supply from month of November till month of July each year) • Rain water harvesting is mandatory for all new buildings as per General Development Control Regulation (GDCR), which may improve ground water level • Despite these measures, the City does not receive acceptable quality, 24 x 7 water supply				
Sewerage	**Flexibility & Diversity:** • Total Sewage Treatment plant capacity is 166.5MLD with 70% adequacy against total sewage generation of 190MLD - Total 4 sewage treatment plants cater to 3 zones (18 wards) in the city. • Although sewage treatment is 95.5%, some old plants do not comply with the recently revised national standards (10mg/L BOD level in treated waste water) • Excess untreated waste water is bypassed from pumping stations and allowed to	1. Environmental and ground water pollution due to combined sewer overflows during rainy season and due to by-passing of excess untreated wastewater 2. Environmental pollution and	1. Sewage management with in city limit - Completely under Drainage department, Rajkot Municipal Corporation 2. Periodic cleaning of Natural drains - Solid Waste Management Department, RMC	1. Excess untreated sewage that is discharged in the Aji river and natural drains due to inadequate Sewage Treatment capacity and due to	1. High Mixed sewer overflow volumes, in times of high intensity rainfall, render sewage treatment systems ineffective; consequent

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	flow to the natural drains and river directly, polluting the environment and contaminating the groundwater. This is a common phenomenon during the rainy season due to combined sewer overflows. Sludge from STPs is dried and used by farmers **Energy Consumption and GHG Emissions:** • Direct methane emissions from the structurally compromised gas digesters at the 50MLD STP plant at Raiya pollute the environment • Waste water pumping and treatment consumes total of 6.66 million kWh electricity and 1.45 kilolitres of diesel leads to 5,487 tCO2e GHG emission **Redundancy:** • The existing Sewerage network coverage is about 75% of total households in city, which is insufficient. Around 25% of total households are using septic tanks, providing inefficient treatment, which may lead to additional soil and groundwater pollution and related health issues.	health hazards due to direct methane emissions to the atmosphere because of leakage from gas digesters 4. Dry sludge from STPs is used by local farmers as manure without checking quality of sludge from sludge drying bed of STP plants, which may result in serious health issues.		combined sewer overflows during rainy season pollutes the environment. 2. Direct use of dry sludge as manure without proper treatment, and direct methane emission from gas digester chamber cause environmental pollution has global warming impacts and may cause severe health issues in city.	untreated sewage flows pollute the vokdas and the Aji River 2. Direct use of dry sludge as manure for food crops, without proper treatment, t may cause significant health impacts.

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	• In the absence of proper storm water drainage in city, rainwater runoff is conveyed through the sewer network, causing overflows from the manholes, leading to health and hygiene issues in city. Peri-urban areas within RMC jurisdiction are not connected to the sewer network.				
	Safe failure: • RMC has proposed additional sewage treatment plants with a total capacity of 150MLD by 2020. 25% of the unsaved areas will also be connected to the sewer network by 2020.				Direct methane emissions into the atmosphere from the compromised gas digesters not only contribute to global warming, but also render the 50 MLD plant STP at Raiya ineffective

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
Storm Water Drainage	**Flexibility & Diversity:** • No storm water drainage system, leads to flooding in various part of city. • Degraded conditions of natural drains leads to flooding and unhygienic conditions, especially since untreated sewage that is in excess of the treatment capacity is let out untreated into the drains and the Aji River • Rain Water Harvesting in residential areas, in individual households has been made mandatory in the Gujarat Development Control Regulations for Rajkot , allowing for percolation of rainwater and ensuring capture of at least a part of the runoff **Energy Consumption & GHG Emissions:** Data Not Available **Redundancy:** Storm sewer network is not present in Rajkot City and the sanitary sewer network doubles up as a conveyance network during periods of intense rainfall. Channels leading to natural drains are built over causing water logging and flooding in the streets during intense, long	• Degraded conditions of the natural drains (vokda) lead to flooding during high intensity of rainfall, communities living on the banks of such natural drains are most vulnerable to floods. • Discharge of untreated sewage into the natural drains poses significant health and hygiene issues for	1. Sewage management with in city limit - Completely under Drainage department, Rajkot Municipal Corporation 2. Periodic cleaning of Natural drains - Solid Waste Management Department, RMC	Absence of storm drains leads to urban water logging and flooding and also environmental pollution and water supply contamination from mixed sewer overflows	Runoff from high intensity rainfall, in the absence of a storm sewer system, drains through the sewer network, causing backflow of sewage into households, posing a health risk and mixed sewer overflows pollute the environment and the water supply network

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	duration rainfall **Safe Failure:** During periods of heavy rainfall, the runoff flows through the sanitary sewer network and also floods the streets, since the natural drainage channels have been built over. However, portable water pumps are operated to pump out the stagnant flood waters to the natural drains and/or the Aji River	communities living along the natural drains			
Solid Waste Management	**Flexibility & Diversity:** • Total solid waste generated in the city is ~470 tonnes/ day • Household level coverage of door to door collection of SW is 99% • Mixed waste is being collected from door to door, which impedes efficient waste treatment. Adequate vehicles and machinery are available for waste collection and dumping • A partially constructed sanitary landfill, which is unused, exists in the city **Energy Consumption & GHG Emissions:** Total GHG emission from SWM in Rajkot is	1. Illegal waste dumping on streets and natural drains chock up sewage lines leading to stagnation, health and hygiene issues 3. Open dumping leads to growth of disease vectors and environmental	Over all Solid Waste Management - Solid Waste Management Department, RMC Solid Waste Treatment - Wealth out of Waste Cell (WoW Cell)	Unsegregated Municipal Solid Waste is collected and disposed in an open dumpsite, causing deleterious environmental and health impacts and also renders the	1. Increasing temperatures accelerate decomposition rates and also create potentially hazardous conditions in open dumpsites by increasing the probability of landfill fires

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	193,450 tCO_2e, contributes to 7% of total GHG emission from city.	pollution 4. Increase in temperature may result in spontaneous burning of waste at dumpsite 5. Choke up of sewer lines during intense rainfall, due to litter and debris deposited in the drains		decentralized waste management plants (compost and bio-methanation) ineffective	2. Disposal of untreated municipal solid waste results in direct methane emissions, contributing to global warming and impacting health of residents
	Redundancy: • Waste segregation is identified as the biggest issue in Rajkot 300 TPD compost & RDF facility was shut down after 2012-13 so the mixed waste is collected and disposed at the open dumping site which is located at Nakrawadi due to lack of waste treatment facilities. • Solid waste is being dumped on streets and natural drains degrading environmental conditions 3 decentralised waste management facilities exist in the City, with a total capacity of 10.5 MT per day, but do not receive sufficient quantum of segregated waste. This is critical since these plants process only biodegradable waste				
	Safe failure: • Various SWM initiatives are already proposed by RMC at centralized and decentralized level i.e. 600 TPD waste to energy plant, 5 TPD capacity waste to				Solid waste littered in streets is washed into drains and

Urban system	Why is it critical or fragile?	What are the existing and anticipated problems caused by the fragility of this system?	Part of city function (Completely / Shared / No)	Fragility statement	Climate Fragility Statement
	composting plants in 18 wards (3 are already constructed, 5 are is in tendering phase), 5 TPD biomethanation plant, construction of two leachate collection tanks at Nakravadi, capping of first and second cell of Nakrawadi dumping site. • RMC also proposes to issue a notification to citizens in residential and commercial areas, urging them to segregate dry waste, wet waste and hazardous waste in three different dustbins				open sewer manholes, during periods of high intensity rainfall, blocking outflow and resulting in stagnation, leading to public health impacts

Tool 3.2D (Exercise 2) - Actor Analysis				
Actors	**Capacity to respond (a)**	**Resources available (b)**	**Capacity to access information (c)**	**Adaptive capacity score (a*b*c)**
Rajkot Municipal Corporation	5	3	5	75
Traffic and city police department	5	3	4	60
Regional Transport Office	3	2	3	18
Road side vendors	2	1	1	2
Private vehicle owners	2	1	1	2
Vulnerable people (Cyclist, pedestrian, women, children, elderly people)	2	1	1	2
Migrant labours	1	1	1	1
Hospitals (Government and private hospitals, UHC, medical colleges)	4	3	3	36
Slum areas	2	1	1	2
Community residing on bank of natural drains and Aji River	2	1	1	2
Residential Housing Societies	3	2	1	6
Rajkot Smart Societies	3	3	1	9
Local NGOs i.e. Bolbala charitable trust , Ram krushna mission trust, Nav Bharat Mission	4	3	2	24
Health workers, Asha workers and Anganwadi workers	3	3	3	27
Public Relation Office, RMC	3	3	3	27
Safai Kamdar of RMC	3	3	1	9
Gujarat Water Supply and Sewerage Board (GWSSB)	3	3	5	45
Narmada water supply - Gujarat Water Infrastructure Limited (GWIL)	3	5	3	45
Ground Water Management in city Limit - Gujarat Water Resources Development Corporation (GWRDC)	3	3	3	27
Agencies registered for water supply through tankers	3	3	2	18
Agencies registered for maintaining drainage line	3	3	2	18
Gujarat Pollution Control Boards	3	3	5	45
Private contractors registered for septage management	3	3	2	18
Private contractor operating and maintaining STP plants	3	3	2	18
People residing near STP plant	1	1	1	1
Farmers using sludge as manure	1	1	1	1
Rag pickers and local pastiwalas	2	2	1	4

Tool 4.2: Prioritisation of Resilience Interventions (Table1)							
Sector	**Interventions**	**Redundancy - whether the intervention will help provide alternates to the existing system - yes/no**	**Flexiblity - whether the intervention will allow the system to operate under different climatic conditions such as higher/lower temp or excess/less rain - yes/no**	**Responsiveness - whether the intervention is responsive to climate change impacts on the system - yes/no**	**Acess to infromation - whether the intervention provides information that may help in future planning - yes/no**	**Energy saving and GHG emission mitigation potential - whether the intervention helps to save energy and emissions - yes/no**	**Overall Resilience Score 5/5: very high 4/5: High 3/5: Medium 2/5: Average 1/5: Low**
Water	Implementation of Rain water harvesting system	Yes - Intervention will support a higher degree of self-sufficiency at the household level.	Yes - Rain water is not utilised in absence of required infrastructure, intervention will allow for water to be utilised on site or channelized towards recharging groundwater as well	Yes - In case of shutdown of the city's water supply system, households have stored rainwater for use	No - As responsibility lies with individual households, requires strong monitoring mechanism for information for any future planning	Yes - Reduce energy consumption and GHG emission from water pumping	High
	Strengthen the implementation of dual plumbing system and strict monitoring	Yes - Rajkot is in water scares region, reuse and recycling of waste water for non-portable use has good potential to reduce consumption of fresh water for the purpose	Yes - As grey and black water collected seperately has great potential of effective treatment on site or nearby, which will reduce load and dependency on existing sewerage network	Yes - as dual plumbing system has potential to treat waste in decentralised manner, which will reduce use of electricity for pumping - Fresh water usage can be reduce for non-portable purposes		Yes - Energy consumption from waste water pumping from site till sewage treatment plant will reduce and hence GHG emission	High
	Compulsion of water meters for all new construction with socially acceptable water metering pricing policy	Yes - Intervention has potential to change usage habits among public, which will reduce waste of fresh water.	Yes - Intervention will reduce wastage of freshwater will lead to availability of freshwater for various purposes		Yes - It will be possible for city to get information on actual water requirement and if there is any water leackages. Improve efficiency of water collection charges		Medium

	Assessment of potential for augmenting local water resources (groundwater recharge, rainwater harvesting, and waste water reuse) under CapaCITIES project	Yes - Local aquifer recharge and an improvement in the ground water situation are desired outcomes along with reuse of treated wastewater, which will help to address water scarcity and pressure on the declining ground water resource	Yes - Intervention will reduce city's dependency on Narmada water	Yes - In case of break down in Narmada water supply, city will have water stored in local water resources for use		Yes - Water is pumped over a distance of around 700 Km, requiring a total of 143 million kWh electricity consumption for pumping leads to 117,540 tCO2e of GHG emission per year. Intervention will help to reduce energy consumption and GHG emission from pumping water from Narmada source	High
	Replacement of existing old pipelines with new DI pipeline	Yes - supports city to reduce Non-revenue water due to leackages and illegal water connections	Yes - Freshwater will be available for longer period due to reduction in NRW	Yes - It will be possibleto reduce fresh water contamination and hence releted health issues	Yes - RMC can identify illegal connections and leakage	Yes - Reduced NRW will lead to save electiricity and related GHG emission	Very High
	Legalise all illegal existing water connections and stop direct pumping	Yes - Illegal water connections and direct pumping leads to water pressure drop during subsequent supply next day due to empty water supply network.	Yes - Beneficiery will be able to receive sufficient water as per designed pressure levels with in 20minutes			Yes - Reduced energy consumption with subsequent social benefit	Medium
Sewerage	Implementation of 100% Sewerage network in city, including peri-urban areas	Yes - Around 25% of total households are using septic tanks, providing inefficient treatment, which may lead to additional soil and groundwater pollution and related health issues.	Yes - All proposed STP has enough capacity to treat sewerage efficiently, linkage of all this areas with STP through this intervention ha spotential to reduce pollution and related health impacts	Yes - Proper treatment of wastewater will improve condition of natural drains and reduce water pollution in Aji river		GHG emission reduction due to direct waste water dumping and reduced BOD load after treatment	High
	Improve treatment quality and adequacy of existing old STP plants	Yes - Existing STPs do not comply with the recently revised national standards (10mg/L BOD level in treated waste water) with 50% Adequecy of treatment. Excess water is bypassed in natural drain causing pollution	Yes - System will provide efficient treatment and hence reduce direct waste water dumping in natural drainage	Yes - Treated water water will flow in natural drain will lead to reduce pollution and related health issues.		GHG emission reduction due to direct waste water dumping and reduced BOD load after treatment and energy consumption of waste water pumping.	High
	Assessment of gas digester chamber at Raiya STP to stop direct methane emission	Yes - Direct methane emissions from the structurally compromised gas digesters at the 50MLD STP plant at Raiya pollute the environment	Yes - Energy can be produce by utilising methane gas generated from STP	Yes - Direct methane emission is more harm full for climate, intervention will help to stop this emission	Yes - Intervention will provide information on energy generation potential which may be utilise with in plant	Yes - GHG emission reduction by stopping direct methane emission from STP plant	Very High

	Stop direct usage of dry sludge without quality check and provide additional treatment if required	Yes - Using dry sludge with out quality check may be harmfull due to E-Coli and hard metals	Yes - By providing additional required treatment, manure can be utilise by farmers, less harmfull for agriculture	Yes - Direct usage of dry sludge may be harmfull for agricultural issues, lead to critical health issues	Yes - Land pollution by using without quality check		High
	Rejuvenation of existing natural drains	Yes - Natural drains are being used for waste water and solid waste dumping, degraded environmental condition leads to severe health issues	Yes - Rejuvenated natural drains may be utilise for effective storm water management in city	Yes - Inervention has potential to reduce health hazards due to degraded environmental quality			Medium
	Implementation of storm water drainage	Yes - absence of storm water drainage, sanitary sewer network doubles up as a conveyance network during periods of intense rainfall. Channels leading to natural drains are built over causing water logging and flooding in the streets during intense, long duration rainfall	Yes - Storm water may be utilise for various purpose if not mixed with sewerage line	Yes - Stop direct dumpign of excess wastewater in natural drains			Medium
Traffic	Study on the existing BRTS corridor for the last mile connectivity and pre-feasibility for potential electrification of the corridor	Yes - Shorter trips and inadequate frequency of available public transportation leads to increase in number of private vehicles. Intervention will provide lastmile connectivity which will reduce usage of private vehicles	Yes - Reduced used of auto rickshaws will leads to safe and comfrtable public transportation	Yes - use of cleaner fuel		Yes - Reduce GHG emission by using electric mobility and reduced private vehicles on road	High
	Effective Traffic management and awareness	Yes - reduce traffic congestion and accidents in city	Yes - Smooth mobilisation of traffic in case of any critical situation in city	Yes - Reduce intensity of airpollution due to traffi congestion			Medium
	Providing NMT and pedestrian infrastructure	Yes - providing safe and secure infra for vulnerable people (i.e. cyclist and pedestrians) in city		Yes - reduce rate of accidents on roads		GHG emission reduction by using more NMT	Medium
	Remove illegal encroachment by providing hawkers zone and effective pay and park facilities			Yes - Provide more Right of Way to vehicular traffic will reduce congestion			Low

	Maximise use of clean fuel (electric mobility)	Yes - maximise use of electric vehicles will reduce dependency on stationary fuel				Yes - Reduce GHG emission from stationary fuels by providing electric mobility	Average
SWM	Scientific capping of first and second cell of Nakrawadi landfill dumpsite	Yes - reduce waste related issues during rainfall and temperature increase i.e. degradation and waste burning	Yes - Reduce vector borne diseases and healh related issues, Methane can be utilised	Yes - Effective management of waste will reduce direct methan emission and waste related issues		GHG emission reduction by utilising methan emission	High
	Construction of leachate collection ponds at Nakrawadi landfill site	Yes - Provide effective treatment to leachate	Yes - Stop GW contamination	Yes - Reduce water contamination and related health impacts			Medium
	Zone wise solid waste material recovery facilities	Yes - Effective treatment possible due to segregation	Yes - employment generation for rag pickers	Yes - Quantity of waste being dump in dumpsite can reduce due to waste recovery on site		GHG emission reduction due to reduced quantity of waste send to dumpsite	High
	Training on roof gardening and organic farming, link with waste composting in city	Yes - 18 waste to composting plant is proposed in city, composting may be utilise	Yes - Reduce direct heat from roof and hence cooling requirement			GHG emission reduction due to reduced cooling demand	Medium
	Notification by RMC to segregate dry waste, wet waste and hazardous waste in three different dustbins at source by residential and commercial area	Yes - Segregated waste collection will lead to effective waste treatment	Yes - treatment effciency will be enhanced due to waste quality			GHG emission reduction by providing effective waste treatment and waste not dumped in dumping site	Medium
Health	Prepare detailed health inventory for city - including health risk maps for critical diseases, prepare disease surveillance plan and link with various service utilities for cross sectorial actions	Yes - Preventive measures can be taken based on inventory	Yes - Cross sectorial actions can be taken based on disease surveillance	Yes - Reduce risk during critical events	Yes - Health indicator can be utilised for healthy and happy community		High
	Prepare emergency response plans for health facilities in case of extreme weather event management : which also includes development and implement effective risk communication strategy for the health issues in case of emergency	Yes - Prior communication regarding predictions on extreme weather event and related health issues my reduce health risk during critical events	Yes - preventive measures can be planned during critical events	Yes - Health risk can be reduced by using prior communication strategy	Yes - Prior weather information and forecasting can be utilised for future planning		High
	Establish/strengthen and support research networks, within and across city	Yes - Integrate climate and health modules in existing curricula/ courses such as community medicine and public health may provide additional support during extreme events	Yes - Additional support to existing health infrastructure, preparation of communication stretegy and capacity building	Yes - Immediate actions can be taken and hence reduction in health risk	Yes - Facilitate access to meteorological and health data and develop capacity for conducting research on health impacts and effectiveness of adaptation measures.		High

	Reduce vulnerability of health care facilities by proper designing and location of health centres for accessibility during climatic hazards	Yes - Intervention will make health- care facilities resilient to climate change (by retrofitting to make them safe from various climatic hazards such as flooding, storms), which will Provide access to vulnerable people during epidemic break out	Yes - Availability of affordable pubic health care facilities and public hospitals with advanced facilities for treatment will reduce health risk	Yes - Increase in accessibility during epidemic break out by siting urban health centers in safe areas which will be accessible for all and reduce health risk	Yes - provides information for future planning of urban health centers requirement and accessiblity		High
	Develop coordinating platforms for climate change and health focal point to other climate-sensitive programmes and health-determining sectors (such as water, environment, drainage, energy)	Yes - capacity building to focal point will improove departmental strength	Yes - Capacity building of staff through various climate sensitive programmes will provide additional strength during epidemic events	Yes - Help in identifying cross sectorial interventions to reduce health risk			Medium

Tool 4.2: Prioritisation of Resilience Interventions (Table2)					
Sector	Interventions	Feasibility of the intervention			Impact (Short/Medium/Long Term) - when will the impact be seen in the city
		Technical	Political	Financial	
Water	Implementation of Rain water harvesting system	High - Various effective technologies are easily available	High - It is already mendatory as per General Development Control Regulation to implement, RMC has also implemented rain water harvesting in 16 affordable housing schemes	High - cost of intervention is not high with substantial results	Short
	Strengthen the implementation of dual plumbing system (including residential buildings) and strict monitoring	Medium - City has no technical expertisefor implementation and monitoring but can be access the required skills	High - It is already mendatory as per General Development Control Regulation to implement such interventions for some kind of buildings. i.e. hospitals and hospitalities (>5000 sq.m construction); hostels, education institutions, community centers, commercial and industries (> 10000 sq.m construction)	Low - cost of intervention is high	Medium
	Compulsion of water meters for all new construction with socially acceptable water metering pricing policy	Medium - City has no technical expertise for implementation and set socially acceptable price	Medium - This intervention require to develop socially acceptable water prices, which may lead to social issues - strong political will needed RMC has proposed to install water meters for 15000 households in city on pilot bases, city is planning to replicate project based on this pilot implementation	High - RMC has proposed pilot under AMRUT scheme	Medium
	Assessment of potential for augmenting local water resources (groundwater recharge, rainwater harvesting, and waste water reuse) under CapaCITIES project	High - Technical support for this project is being provided under CapaCITIES project	Medium - Implementation of such intervention will need public participation and strong administrative and political support	Medium	Medium
	Replacement of existing old pipelines with new DI pipeline	High - City has technical capacity	High - 15% of total water distribution network is replaced with DI pipeline, and proposed the same in phase wise manner in wards 1,8,9,10,11, and 12 by RMC	High - ADB funding is available for city for this intervention	Short
	Legalise all illegal existing water connections and stop direct pumping	High - City has regularized 21697 illegal water connections, issued notice to 1259 direct pumping cases, cut 5874 illegal water connections and issued notice to 549 HHs wasting water	High	High	Short
Sewerage	Implementation of 100% Sewerage network in city, including peri-urban areas	High	High - Approved in Municipal Budget and standing committee meeting	High - Rajkot Muncipal Budget	Short
	Improve treatment quality and adequacy of existing old STP plants	High - City has already proposed to develop all plants on SBR technology	High	High - AMRUT Scheme	Medium
	Assessment of gas digester chamber at Raiya STP to stop direct methane emission	High - Technical support for this project is being provided under CapaCITIES project	High	High - AMRUT Scheme	Medium
	Stop direct usage of dry sludge without quality check and provide additional treatment if required	Medium - Less technical expertise	Low - City doen't aware of criticality of situation	Low	Medium
	Rejuvenation of existing natural drains	Low - Less technical expertise	High - Some of the projects are already sanctioned by standing committee	High - AMRUT Scheme	Medium
	Implementation of storm water drainage	Medium - Less technical expertise	Low - City doen't aware of criticality of situation	High - AMRUT Scheme	Medium
Traffic	Study on the existing BRTS corridor for the last mile connectivity and pre-feasibility for potential electrification of the corridor	Medium - Less technical expertise	High	High - Swiss Agency for Development and Cooperation	Medium
	Effective Traffic management and awareness	Low - lack of traffic management related awareness and infrastructure	Medium - This is not priority for city and different departments are involved	Low - enforcement is needed	Long
	Providing NMT and pedestrian infrastructure	Medium - Less technical expertise	High - Some of the projects are already sanctioned by standing committee	High - Rajkot Muncipal Budget	Medium
	Remove illegal encroachment by providing hawkers zone and effective pay and park facilities	High	High - RMC has implemented total 24 pay and park facilities and 100 hawker's zones in city to reduce on-road parking and encroachment of road by hawkers and smooth management of traffic	High - Rajkot Muncipal Budget	Medium

	Maximise use of clean fuel (electric mobility)	Low - Lack of technical expertise and related infrastructure	Medium - RMC has already proposed electric vehicles (ebikes) for RMC field officers - public involvment is needed State government has already introduced policy to provide subsidy on ebikes	Medium	Short
SWM	Scientific capping of first and second cell of Nakrawadi landfill dumpsite	Medium - Less technical expertise	High - Approved in Municipal Budget and standing committee meeting	High - Swachh Bharat Mission	Medium
	Construction of leachate collection ponds at Nakrawadi landfill site	Medium - Less technical expertise	High - Approved in Municipal Budget and standing committee meeting	High - Swachh Bharat Mission	Medium
	Zone wise solid waste material recovery facilities	Medium - Less technical expertise	High - Approved in Municipal Budget and standing committee meeting	High - Swachh Bharat Mission	Medium
	Training on roof gardening and organic farming, link with waste composting in city	Low - very less technical expertise	Low - Not priority for Corporation but capacity building needed	Low	Long
	Notification by RMC to segregate dry waste, wet waste and hazardous waste in three different dustbins at source by residential and commercial area	High	High - Notification by RMC	High - No cost required	Long
Health	Prepare detailed health inventory for city - including health risk maps for critical diseases, prepare disease surveillance plan and link with various service utilities for cross sectorial actions	Medium - Lack availability of information	Medium - Cross sectorial planning needed through policy interventions	Medium	Long
	Prepare emergency response plans for health facilities in case of extreme weather event management : which also includes development and implement effective risk communication strategy for the health issues in case of emergency	Medium - Lack of information and expertise	Medium - Strong political and administrative support needed for reventive measures and communication stretagies Heat Action Plan is already prepared by RMC RMC has already in place emergency response procedures for disease outbreaks	Medium - under various National Government Schemes and Missions	Long
	Establish/strengthen and support research networks, within and across city	High - Local educational institutions can support	High - Volunteers program can be started by RMC	High - No additional costs required	Long
	Reduce vulnerability of health care facilities by proper designing and location of health centres for accessibility during climatic hazards	Medium - Lack of information on safe areas and technical knnowledge	Medium	Low	Long
	Develop coordinating platforms for climate change and health focal point to other climate-sensitive programmes and health-determining sectors (such as water, environment, drainage, energy)	Medium	Medium	Low	Long