

Preliminary Scoping Study to Estimate Greenhouse Gas Emissions in Banswara City, Southern Rajasthan

Mr Sagar Gupta

Assistant Professor, University College of Engineering
Govind Guru Tribal University, Banswara, Rajasthan

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INTRODUCTION

Carbon Emission are Emissions of *greenhouse gases (GHGs)*, *precursors* of GHGs and *aerosols* caused by human activities. These activities include the burning of *fossil fuels*, *deforestation*, *land use* and *land-use changes* (LULUC), livestock production, fertilisation, waste management and industrial processes.

* [Source -](#) SPECIAL REPORT: GLOBAL WARMING OF 1.5 °C, **CH00 Glossary**

The **carbon budget** (the maximum CO₂ we can emit while still keeping warming below 1.5°C) is almost **exhausted**, with only 170 billion tonnes of CO₂ remaining (about four years of emissions at 2025 levels).

Prompting a climate conscious actions India devised its Long term Low emission – (LT-LEDS) Strategies path in addressing – “CLIMATE”

INTRODUCTION

There are seven key strategic transitions-

C – Clean Electricity

L – Low-Carbon Transport

I – Inclusive Urban Adaptation

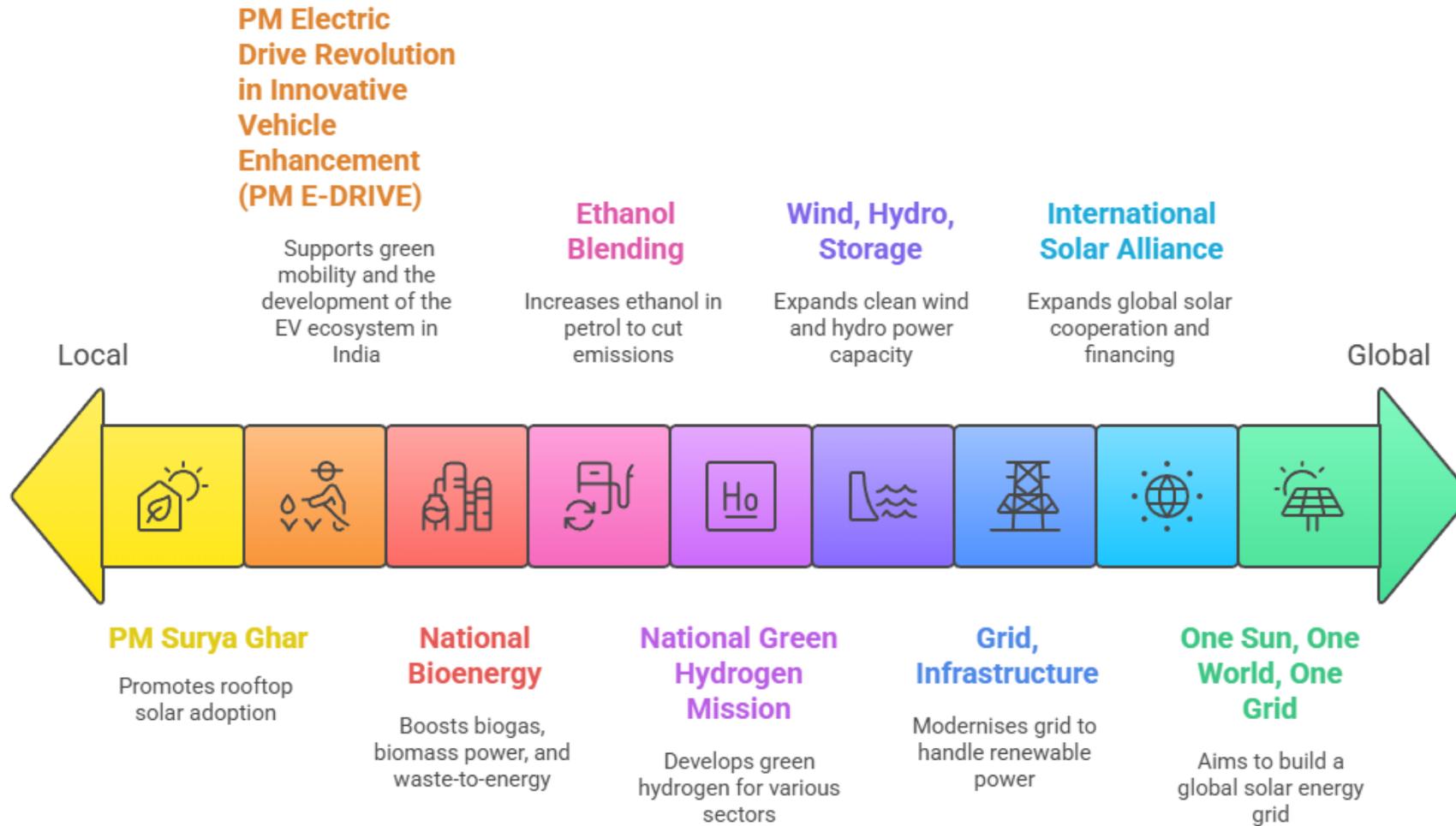
M – Manufacturing & Industry Decarbonisation

A – Atmospheric CO₂ Removal

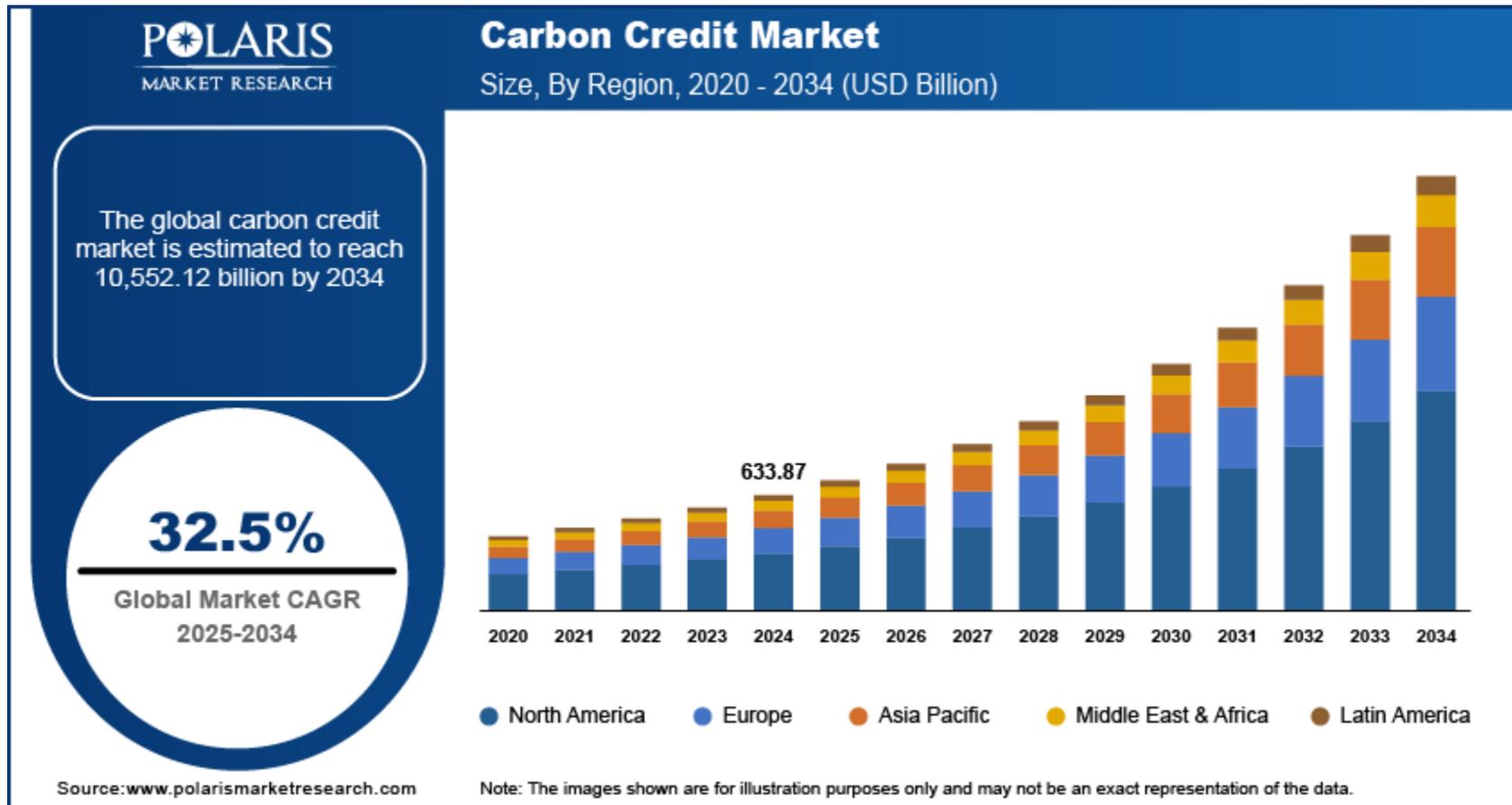
T – Tree & Vegetation Enhancement

E – Economic Path to Net-Zero

India's Carbon Emission Reduction Initiatives



INTRODUCTION



The carbon credit market size was valued at **USD 633.87 billion in 2024**.

*Source - <https://www.polarismarketresearch.com/industry-analysis/carbon-credit-market#:~:text=Market%20Overview,blockchain%2C%20carbon%20capture%20innovations>).

How to bring this global thought to local level?

- This study attempts to consolidate existing literature, guidelines, working papers, research publications, and relevant articles to develop a beginner-friendly methodology for conducting a city-level emissions assessment.
- For this study, secondary data has been sourced from government open-data portals.

ABOUT SCOPE OF STUDY

The scoping study aims to:

- Compile **available secondary data** across major emission sectors
- Estimate emissions using **IPCC default emission factors**
- Apply **GPC BASIC (Scope 1) methodology**
- Identify **data gaps, assumptions & institutional mapping**
- Provide direction for a full **city-level GHG inventory**

ABOUT SCOPE OF STUDY



SUSTAINABLE DEVELOPMENT GOALS

1 NO POVERTY

2 ZERO HUNGER

3 GOOD HEALTH AND WELL-BEING

4 QUALITY EDUCATION

5 GENDER EQUALITY

6 CLEAN WATER AND SANITATION

7 AFFORDABLE AND CLEAN ENERGY

8 DECENT WORK AND ECONOMIC GROWTH

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

10 REDUCED INEQUALITIES

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION

14 LIFE BELOW WATER

15 LIFE ON LAND

16 PEACE, JUSTICE AND STRONG INSTITUTIONS

17 PARTNERSHIPS FOR THE GOALS



About Banswara aka “100 island”



* Source - https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcR-NNpEqRjgM3gXDGcJkCt-azYvtrg34s1TKk6sX3NJMzSy7F8cHA4KrztVtvo5_FDL8cDc4qLKwXwqgACbg3Hxj6KGMYuKPfo&s&ec=121528441



Jua Fall, Banswara



Chacha Kota, Banswara



Mahi Sagar Bajaj Dam, Banswara

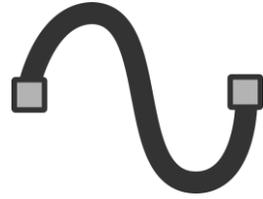


Jhola Fall, Bagidora, Banswara

About Banswara



Banswara is located southernmost part of Rajasthan, India



Banswara is well-connected by road via NH-56 and NH-927A, with RSRTC and private buses operating regularly. It has no direct railway station, with the nearest being Ratlam (85 km) and Udaipur (160 km)



Banswara has population of approx. 1,17,563. 82% of population belong to tribal



Temperature in summer upto 45° and in winter is 10°C



Of this, approximately 224,000 hectares are designated as net cultivated area, accounting for about 44.5% of the district's total land area. The remaining land comprises forests, pastures, and non-agricultural uses.



Banswara district in Rajasthan experiences an average annual rainfall ranging between **825.90 mm and 935.5 mm.**

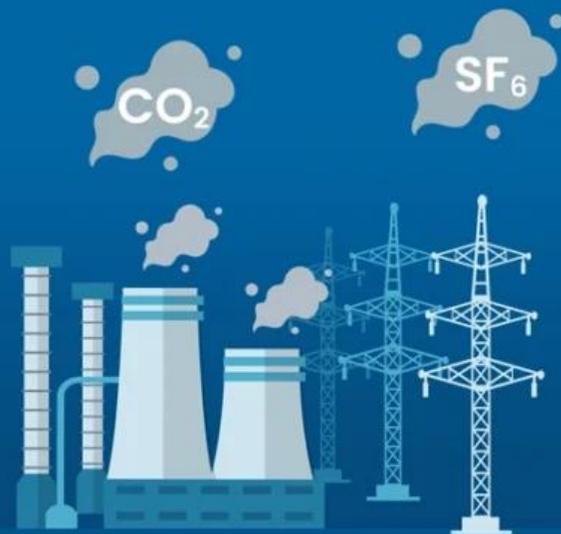


Banswara's water bodies are spread across different directions, with the Mahi River flowing from the northeast towards the center. In the north, Kagdi Pick Up Weir serves as a reservoir, while the Mahi Bajaj Sagar Dam in the south supports irrigation and hydroelectricity. The Anas River flows in the southeast, while the Eran River and seasonal streams contribute to the east. In the west, Anand Sagar Lake aids in water conservation, and Jua Falls and Kadeliya Fall enhance the monsoon landscape.



100 % of population rely the piped water. However, Ground Water withdrawal against availability **66.27%**

SCOPE OF CARBON EMISSIONS



SCOPE 2

INDIRECT

Upstream activities



SCOPE 1

DIRECT

Direct emissions
from the company



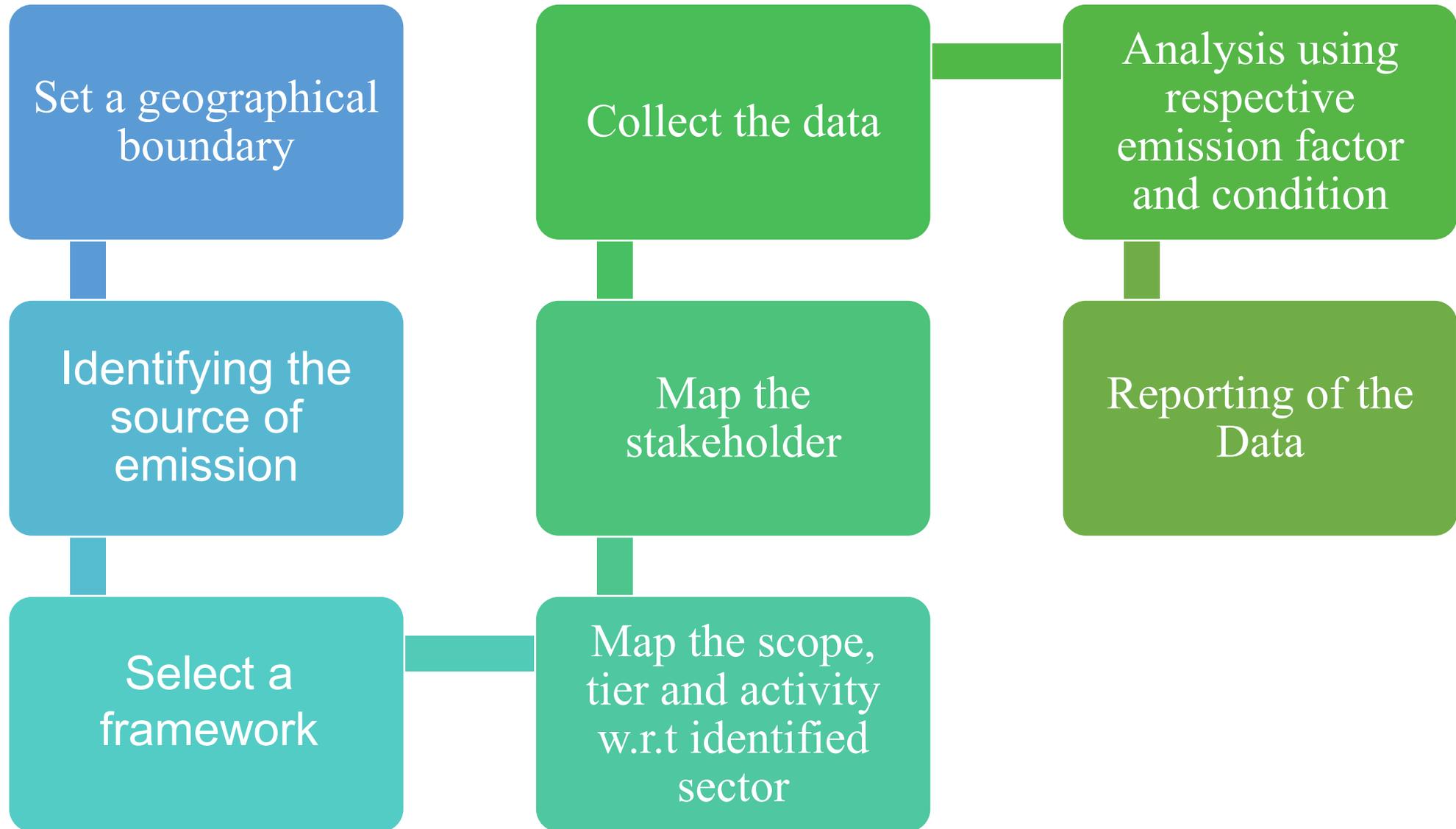
SCOPE 3

INDIRECT

Downstream activities

*Source - <https://www.ubqmaterials.com/scope-1-2-3-emissions/>

Approach Used for City level emission study



Computation of city-wide carbon emission using **Global Protocol for Community-Scale Greenhouse Gas Inventories Developed by World Resource Institute**

The GHG emissions shall be classified in six categories

I. Stationary Energy

II. Transportation

III. Waste

IV. Industrial Processes and Product uses (IPPU)

V. Agriculture, Forestry and other land use (AFOLU)

VI. Any other emissions occurring outside the geographic boundary as a result of city activities

(collectively referred to as Other Scope 3).

Scopes definitions for city inventories

Scope	Definition
Scope 1	GHG emissions from sources located within the city boundary.
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

From Geography to Mathematics

$$\text{GHG Emissions} = \text{Activity Data} \times \text{Emission Factor}$$

Activity Data: A quantitative measure of activity (e.g., liters of petrol, kWh of electricity, tonnes of waste).

Emission Factor: The mass of GHG released per unit of activity (e.g., kgCO₂e per kWh).

GHG Emissions Summary

Sector		Total by scope (tCO ₂ e)				Total by city-induced reporting level (tCO ₂ e)	
		Scope 1 (Territorial)	Scope 2	Scope 3 included in BASIC/ BASIC+	Other Scope 3	BASIC	BASIC+
Stationary Energy	Energy use (all I emissions except I.4.4)						
	<i>Energy generation supplied to the grid (I.4.4) (included in Scope 1)</i>						
Transportation (all II emissions)							
Waste	Generated in the city (all III.X.1 and III.X.2).						
	<i>Generated outside city (all III.X.3)</i>						
IPPU (all IV emissions)							
AFOLU (all V emissions and removals)							
Total		(All Scope 1 (territorial) emissions)				(All BASIC emissions)	(All BASIC & BASIC+ emissions)

● Sources required for BASIC reporting

● + ● Sources required for BASIC+ reporting

● Sources included in Other Scope 3

● Sources required for Scope 1 (territorial) total but not for BASIC/BASIC+ reporting (*italics*)

● Non-applicable emissions

Name	Formula	GWP values in IPCC Second Assessment Report ¹⁹ (CO ₂ e)	GWP values in IPCC Third Assessment Report ²⁰ (CO ₂ e)	GWP values in IPCC Fourth Assessment Report ²¹ (CO ₂ e)	GWP values in IPCC Fifth Assessment Report ²² (CO ₂ e)
Carbon dioxide	CO ₂	1	1	1	1
Methane	CH ₄	21	23	25	28
Nitrous oxide	N ₂ O	310	296	298	265
Sulfur hexafluoride	SF ₆	23,900	22,200	22,800	23,500
Carbon tetrafluoride	CF ₄	6,500	5,700	7,390	6,630
Hexafluoroethane	C ₂ F ₆	9,200	11,900	12,200	11,100
HFC-23	CHF ₃	11,700	12,000	14,800	12,400
HFC-32	CH ₂ F ₂	650	550	675	677
HFC-41	CH ₃ F	150	97	92	116
HFC-125	C ₂ HF ₅	2,800	3,400	3,500	3,170
HFC-134	C ₂ H ₂ F ₄	1,000	1,100	1,100	1,120
HFC-134a	CH ₂ FCF ₃	1,300	1,300	14,300	1,300
HFC-143	C ₂ H ₃ F ₃	300	330	353	328
HFC-143a	C ₂ H ₃ F ₃	3,800	4,300	4,470	4,800
HFC-152a	C ₂ H ₄ F ₂	140	120	124	138
HFC-227ea	C ₃ HF ₇	2,900	3,500	3,220	3,350
HFC-236fa	C ₃ H ₂ F ₆	6,300	9,400	9,810	8,060
HFC-245ca	C ₃ H ₃ F ₅	560	640	-	716
Nitrogen trifluoride	NF ₃	-	-	17,200	16,100

Stationary Energy

I		STATIONARY ENERGY	
I.1		Residential buildings	
I.1.1	1	Emissions from fuel combustion within the city boundary	
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	
I.2		Commercial and institutional buildings and facilities	
I.2.1	1	Emissions from fuel combustion within the city boundary	
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	
I.3		Manufacturing industries and construction	
I.3.1	1	Emissions from fuel combustion within the city boundary	
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	
I.4		Energy industries	
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	
I.4.4	1	<i>Emissions from energy generation supplied to the grid</i>	
I.5		Agriculture, forestry and fishing activities	
I.5.1	1	Emissions from fuel combustion within the city boundary	
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	
I.6		Non-specified sources	
I.6.1	1	Emissions from fuel combustion within the city boundary	
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary	
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal	
I.7.1	1	Emissions from fugitive emissions within the city boundary	
I.8		Fugitive emissions from oil and natural gas systems	
I.8.1	1	Emissions from fugitive emissions within the city boundary	

Aggregate Calculation

$$\begin{aligned} &26,141 \text{ Households} \\ &\quad \times 24 \text{ Cylinders} \\ &\quad \quad \times 14.2 \text{ kg} \\ &= \underline{8,908,612 \text{ kg (Total Annual Mass)}} \end{aligned}$$



≈ 8,909 Tonnes / Year

B. Stationary Energy Emission Computation (Scope 1 Only)

Fuel / Source	Quantity	Unit	EF (IPCC Tier-1)	Emissions (kg CO ₂ /year)	Emissions (tCO ₂ e/year)
LPG (Residential)	8,908,612	kg/year	3.00 kg CO ₂ /kg	26,725,836	26,726
Firewood	0	—	—	0	0
Coal	0	—	—	0	0
Kerosene	0	—	—	0	0
Industrial fuel	Not applicable	—	—	0	0
Commercial fuel	Not applicable	—	—	0	0

TRANSPORTATION

II		TRANSPORTATION	
II.1		On-road transportation	
II.1.1	1	Emissions from fuel combustion on-road transportation occurring within the city boundary	
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	
II.2		Railways	
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	
II.3		Waterborne navigation	
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	
II.4		Aviation	
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	
II.5		Off-road transportation	
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	

Parameters Considered for Estimating Greenhouse Gas Emissions from Transport Registered Motor Vehicles

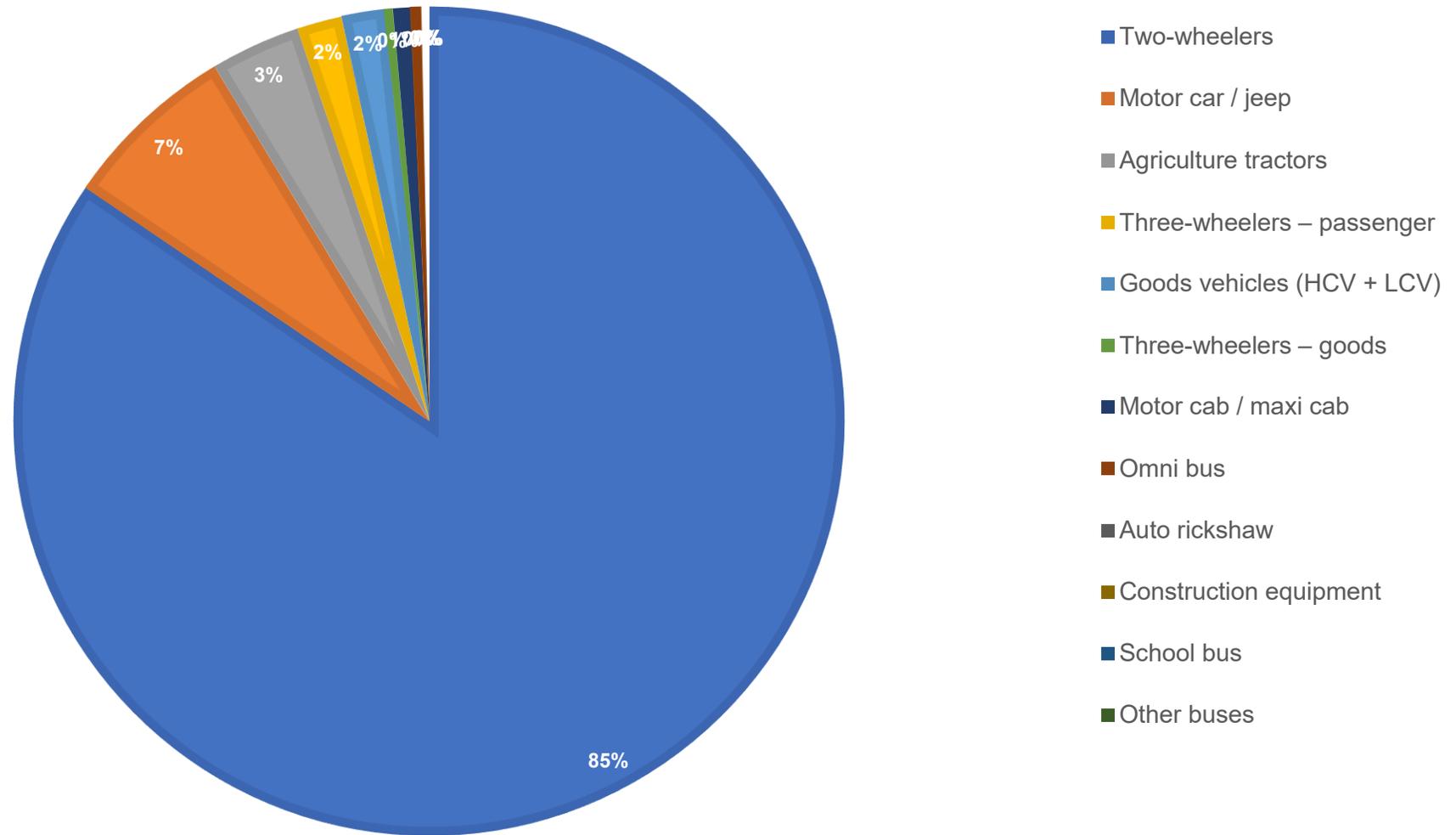
- Registered vehicle population (as of 2022)
- Distribution of vehicle types (MoRTH averages)
- Annual vehicle kilometres travelled
- Category-wise fuel consumption
- Petrol, diesel, CNG emission factors
- CO₂, CH₄, N₂O factors and GWP values
- IPCC Tier-1 calculation methodology
- District-only boundary and 2022 base year
- Assumptions on vehicle usage and efficiency
- Data limitations & uncertainty range

Data Used (Banswara District – 2022)

Parameter	Number
Total Registered Vehicles	387,810
Population (2022 est.)	2.168 million
Vehicles per 1,000 population	179

*Source – Annual Report 2022-23, Transport Department of Rajasthan, Pg. No. 24, Table no. 3, col no. 42

Data Used (Banswara District – 2022)



*Source – Annual Report 2022-23, Transport Department of Rajasthan, Pg. No. 24, Table no. 3, col no. 42

Assumption used in study

EMISSION FACTORS (IPCC Tier-1)			
Fuel	EF CO ₂	EF CH ₄	EF N ₂ O
Petrol	2.31 kg/L	0.1 g/km	0.08 g/km
Diesel	2.68 kg/L	0.1 g/km	0.08 g/km
CNG	2.75 kg/kg	0.02 g/km	0.01 g/km

Vehicle Category	Count	Fuel Type	Default km/day	km/year	Fuel Efficiency (km/L)	Annual Fuel Use	Fuel Used Unit
Two-wheelers	327,267	Petrol	22	2,629,047,810	45	58,423,285	Litres
Cars (Petrol 60%)	15,886	Petrol	32	185,606,720	17	10,918,042	Litres
Cars (Diesel 40%)	10,591	Diesel	32	123,737,280	20	6,186,864	Litres
Auto rickshaw	683	70% Petrol / 30% CNG	90	22,432,350	25 (Petrol) / 30 (CNG)	Petrol: 612,350 CNG: 53,683	L / kg
Passenger 3-wheelers	6,752	90% Diesel	80	197,097,600	35	5,631,360	Litres
Goods 3-wheelers	1,353	90% Diesel	65	32,055,975	30	1,068,532	Litres
Goods vehicles (LCV + HCV)	6,416	Diesel	85	199,207,400	4	49,801,850	Litres
School buses	78	Diesel	120	3,412,800	3.5	974,800	Litres
Other buses	130	Diesel	120	5,694,000	3.5	1,626,857	Litres
Omni buses	1,612	Diesel	120	70,488,000	3.5	20,139,429	Litres
Maxi Cab / Taxi	2,535	Diesel	80	74,022,000	12	6,168,500	Litres
Agriculture tractors	13,540	Diesel	40	197,336,000	3.5	56,381,714	Litres
Construction equipment	280	Diesel	400	40,880,000	2.8	14,600,000	Litres

FINAL CITY TRANSPORT EMISSIONS (II.1.1 – Scope 1)

Component	Emissions (tCO ₂ e/year)
CO ₂ from Diesel	425,520
CO ₂ from Petrol	161,469
CO ₂ from CNG	148
CH ₄ + N ₂ O (all vehicles)	5,870
TOTAL (Transport Sector)	592,900

III.WASTE

The **Global Protocol for Community-Scale GHG Inventories (GPC)** was selected. At BASIC level, only **Scope 1 emissions** from the Waste sector are mandatory:

- III.1.1 – Solid waste disposal within city
- III.2.1 – Biological treatment within city
- III.3.1 – Incineration/open burning within city
- III.4.1 – Wastewater treatment within city

III		WASTE	
III.1		Solid waste disposal	
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	
III.1.3	1	<i>Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary</i>	
III.2		Biological treatment of waste	
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	
III.2.3	1	<i>Emissions from waste generated outside the city boundary but treated biologically within the city boundary</i>	
III.3		Incineration and open burning	
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	
III.3.3	1	<i>Emissions from waste generated outside the city boundary but treated within the city boundary</i>	
III.4		Wastewater treatment and discharge	
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	
III.4.3	1	<i>Emissions from wastewater generated outside the city boundary but treated within the city boundary</i>	

Activity Classification by GPC Category

Collected activities were mapped as per GPC Waste Categories:

III.1.1 – Waste to landfill/open dump within city boundary

III.2.1 – Waste treated biologically (vermicomposting) within city

III.3.1 – Waste incinerated/burned within city

III.4.1 – Domestic wastewater treated at city-level SBR STP

Only **Scope 1** categories are included for BASIC reporting.

Stakeholder Mapping

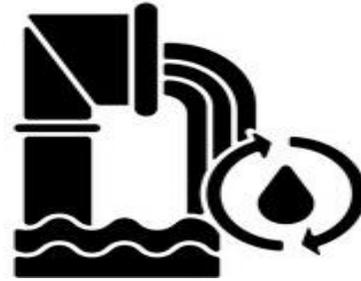
Key stakeholders identified:

- Municipal corporation (solid waste & wastewater)
- STP operator (SBR)
- Composting/vermicomposting facilities
- Sanitation workers & waste collection agencies
- Local landfill/dump operators

Banswara's Sanitation Scenario



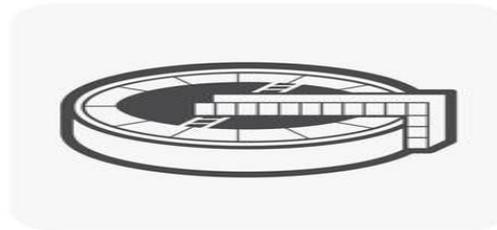
As per 2021 population of Banswara was 1,17,563.



Banswara City generates around 12.63 MLD of wastewater.



61.15% of households is sewer connection and 38.85% on non-sewered sanitation (as per analysis).

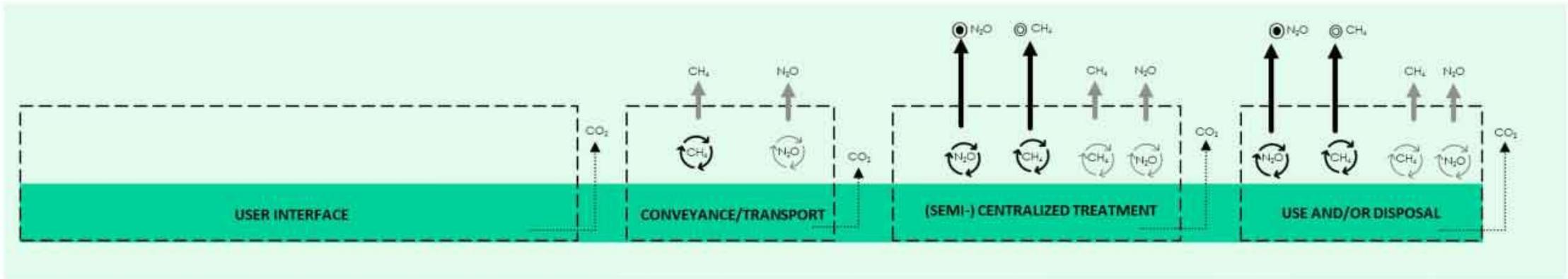


Banswara has WWTP capacity is 59.02% of which is above National Average of 55.14%.

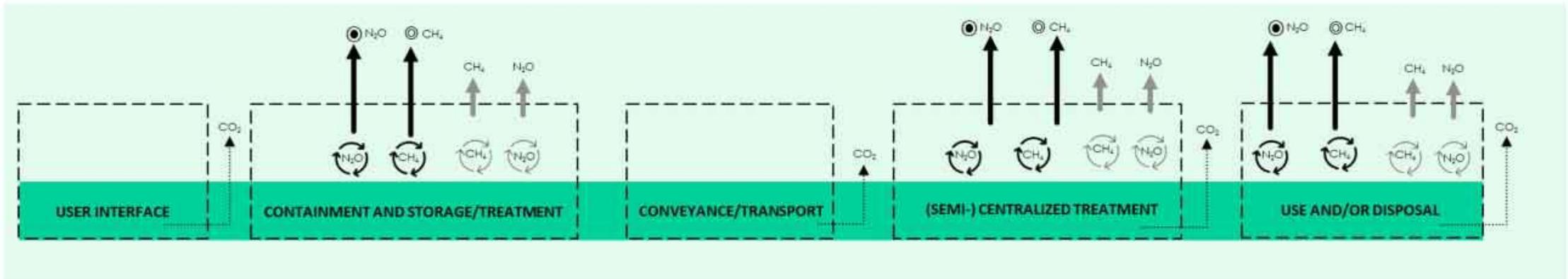
*Source- <https://knoema.com/atlas/India/Rajasthan/Population>
<http://jaipurmc.org/presentation/aboutmcjaipur/cityprofile.aspx>

Parameter Consider for estimating GHG emission from Wastewater Treatment Plant

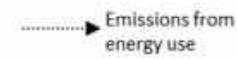
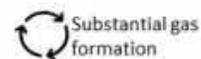
SEWER-BASED
SANITATION SYSTEMS
WITH CENTRALIZED
TREATMENT



NON-SEWERED
SANITATION SYSTEMS
INCLUDING FAECAL
SLUDGE MANAGEMENT



● AEROBIC CONDITIONS ● ANAEROBIC CONDITIONS



Activity Classification by GPC Category

Data Collected (Summary)

Solid Waste:

- Total municipal waste: **10 TPD**
- Organic fraction: **60%**
- Treatment inside city:
 - **5 TPD** to vermicomposting
 - **10 TPD** to open dump
- Burning inside city: **30 tonnes/year** (20% plastic)

Wastewater:

- STP Capacity: **9.42MLD**
- STP flow: **6.49 MLD** (SBR technology)





Collection & Screening



Primary Treatment



Secondary Treatment



Sludge Accumulation



Sector-Wise Emission Summary

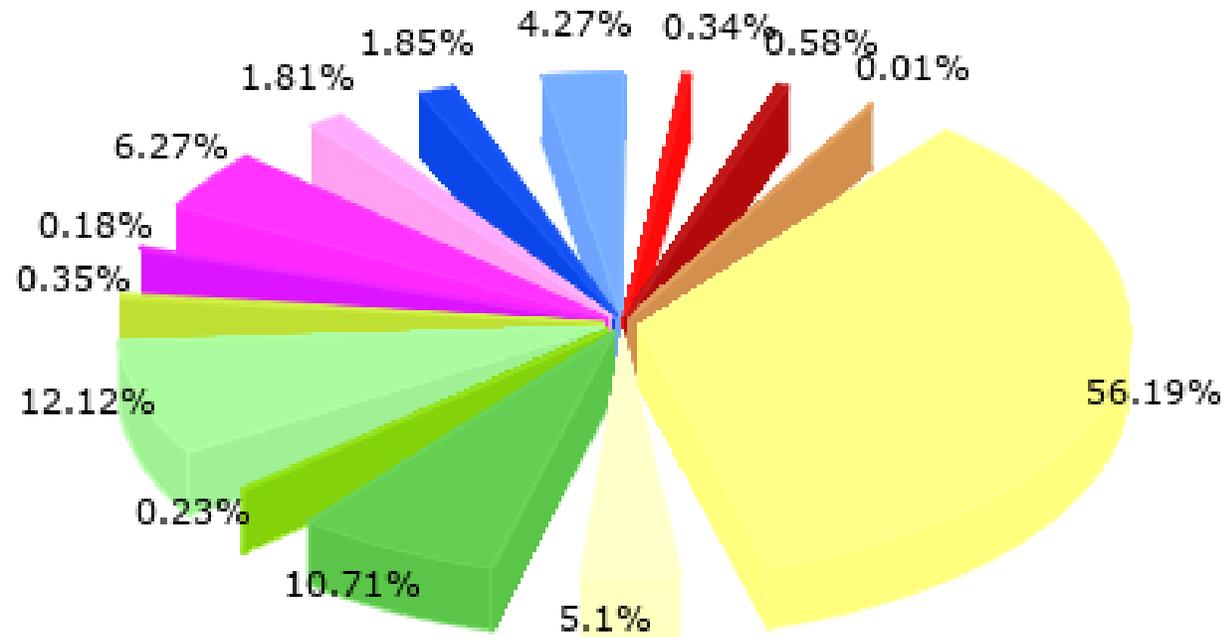
Sector	Emissions (tCO ₂ e/year)
Solid Waste – Disposal (III.1.1)	2038.4
Biological Treatment (III.2.1)	349.5
Incineration/Burning (III.3.1)	16.5
Wastewater (III.4.1)	82.7

**TOTAL CITY WASTE SECTOR EMISSIONS =
2,487.1 tCO₂e/year**

Total Emission from Banswara

Sector	Sub-Sector	GPC Code	Emissions (tCO ₂ e/year)
I. Stationary Energy	Residential LPG combustion	I.1.1 (Scope 1)	26,726
	Other fuels (kerosene/coal/firewood)	—	0
	Municipal electricity (hydro; Scope 2 optional)	—	0
II. Transportation	In-boundary fuel combustion (petrol/diesel/CNG)	II.1.1 (Scope 1)	592,900
III. Waste – Solid Waste	Landfill/open dump inside city	III.1.1	2,038.40
	Vermicomposting (50%)	III.2.1	349.5
	Open burning (inside city)	III.3.1	16.5
III. Wastewater	Sewage treated in SBR WWTP (6.49 MLD)	III.4.1	82.7
		TOTAL	622,113

LAND USE LAND COVER (LULC) of BANSWARA

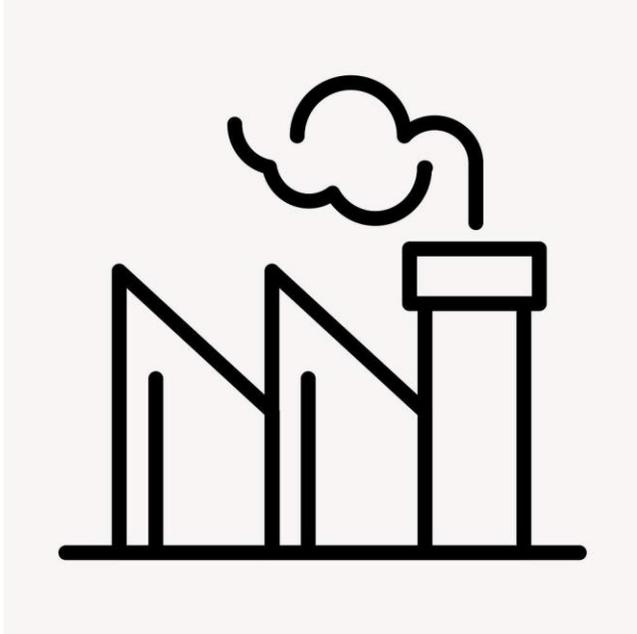


LULC Class	Area (Sq.Km)	LULC Class	Area (Sq.Km)
Builtup, Urban	17.16	Builtup, Rural	29.02
Builtup, Mining	0.37	Agriculture, Crop land	2830.19
Agriculture, Fallow	256.94	Forest, Deciduous	539.49
Forest, Forest Plantation	11.69	Forest, Scrub Forest	610.45
Grass/Grazing	17.43	Barren/unculturable/ Wastelands, Gullied/Ravinous Land	9.15
Barren/unculturable/ Wastelands, Scrub land	315.83	Barren/unculturable/ Wastelands, Barren rocky	91.08
Wetlands/Water Bodies, River/Stream/canals	92.97	Wetlands/Water Bodies, Reservoir/Lakes/Ponds	215.23

Carbon Sink Calculation

Sink Type	Area Used	IPCC Default Factor	Removal (tCO ₂ /yr)
Deciduous Forest	53,949 ha	4.5	242,771
Scrub Forest	61,045 ha	2.25	137,351
Forest Plantation	1,169 ha	12.5	14,613
Cropland SOC	283,019 ha	0.65	183,962
Fallow SOC	25,694 ha	0.30	7,708
Grasslands	1,743 ha	1.5	2,615
		TOTAL	588,000 tCO₂/year

Net Emissions



$$\begin{aligned}\text{Net Emissions} &= \text{Gross} \\ \text{Emissions} - \text{Carbon Sink} \\ &= 622,113 - 588,000 \\ &= 34,113 \text{ tCO}_2\text{e/year}\end{aligned}$$

Interpretation & Future Scope of Study

- Land use dominates climate behavior, not energy
- Transport is the only major emitter
- Forest & cropland management decide future carbon balance
- Waste sector emissions are small because the city has low TPD waste and half is vermicomposted.
- Wastewater emissions are also small because SBR is aerobic.

Interpretation & Future Scope of Study

- **Upgrade to GPC BASIC+ (Include Scope 2 & 3 Emissions)**
- Incorporate **electricity-related emissions (Scope 2)** based on actual grid emission factors.
- Add **waste transported or treated outside city (Scope 3)**.
- Capture **imported goods and services**, which have indirect but high emissions.

Further study will be covered in



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Thank You

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