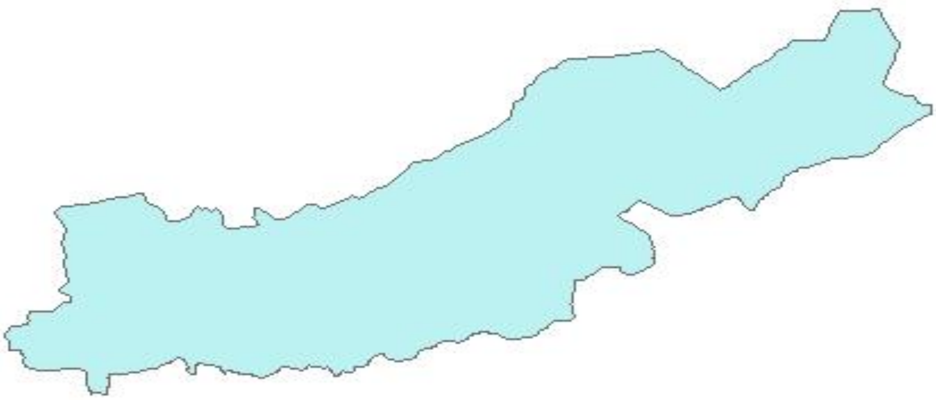
Dire Dawa City Administration
2018 Greenhouse Gas Emissions Inventory Report



April 2022
Dire Dawa, Ethiopia

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List of Acronyms

AD	Activity Data
AFOLU	Agriculture, forestry, and other land use
AR4	4th Assessment Report of the IPCC
CIRIS	City Inventory Reporting and Information System (CIRIS)
CRGE	Climate Resilience Green Economy Strategy
CSA	Ethiopia Central Statistics Agency
DDCA	Dire Dawa City Administration
EF	Emission Factor
GDP	Gross Domestic Product
GGEI	Greenhouse Gas Emission Inventories
GHG	Greenhouse gas emissions
GPC	Global Protocol on Community-Scale
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial processes and product use
M&P	Measurement and Planning
QA	Quality Assurance
QC	Quality Control
tCO_2e	ton of Carbon dioxide equivalent
TJ	Terajoules

Executive Summary

Dire Dawa City Administration 2018 GHG emissions:

5.2 $MtCO_2e$

Dire Dawa City Administration (DDCA) GHG emissions in 2018 is 5.2 $MtCO_2e$. Of which, 5.17 $MtCO_2e$ (99.2%) is from sources within the city boundary (*scope 1*) while the remaining 43,273 tCO_2e (0.8%) is from emissions occurring outside the city boundary (*scope 3*). The following table provides an overview of GHG emissions for the city.

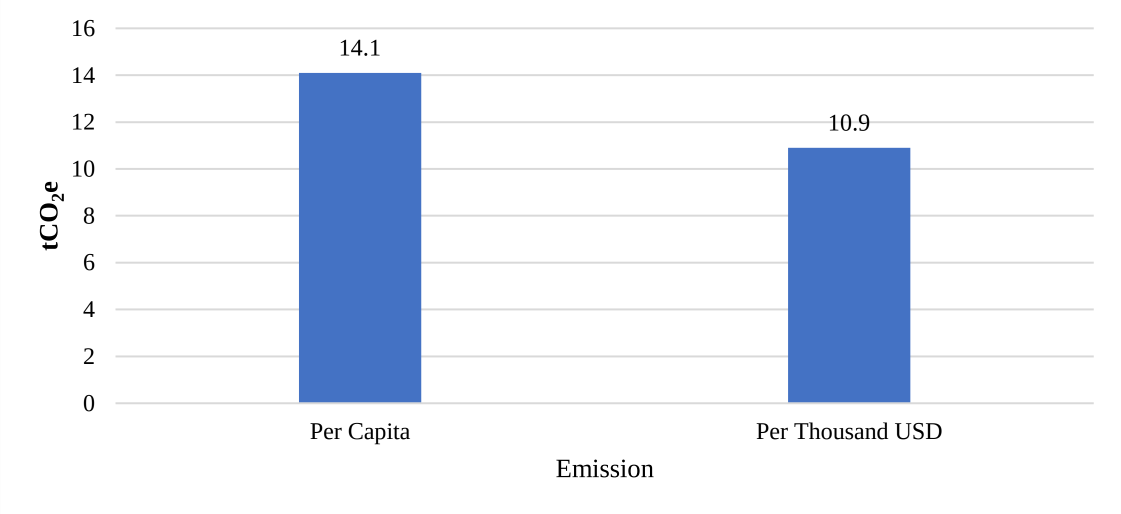
NAME:	**Dire Dawa City Administration**
LEVEL:	**Basic**
INVENTORY YEAR:	**2018**
POPULATION:	**479,000**
LAND AREA (km^2):	**1,288**
GDP (US$ million):	**370**

GHG Emissions Source (By Sector)		Total GHGs (metric tonnes CO_2e)				
		Scope 1	Scope 2	Scope 3	BASIC	BASIC+
STATIONARY ENERGY	Energy use (all emissions except I.4.4)	2,224,059	16		2,224,075	2,224,075
	Energy generation supplied to the grid (I.4.4)					
TRANSPORTATION	(all II emissions)	135,093		38,446	173,539	173,539
WASTE	Waste generated in the city (III.X.1 and III.X.2)	388,223			388,223	388,223
	Waste generated outside city (III.X.3)					
IPPU	(all IV emissions)	719,136				719,136
AFOLU	(all V emissions)	1,716,064				1,716,064
OTHER SCOPE 3	(all VI emissions)					
TOTAL		**5,182,575**	16	38,446	**2,747,391**	**5,221,037**

Key Emission Indicators

Dire Dawa City Administration's GHG emissions are equal to 10.9 tCO_2e per capita, or 14.1 tCO_2e per thousand US$ GDP. Dire Dawa City Administration's emissions per capita are significantly higher than the national average.

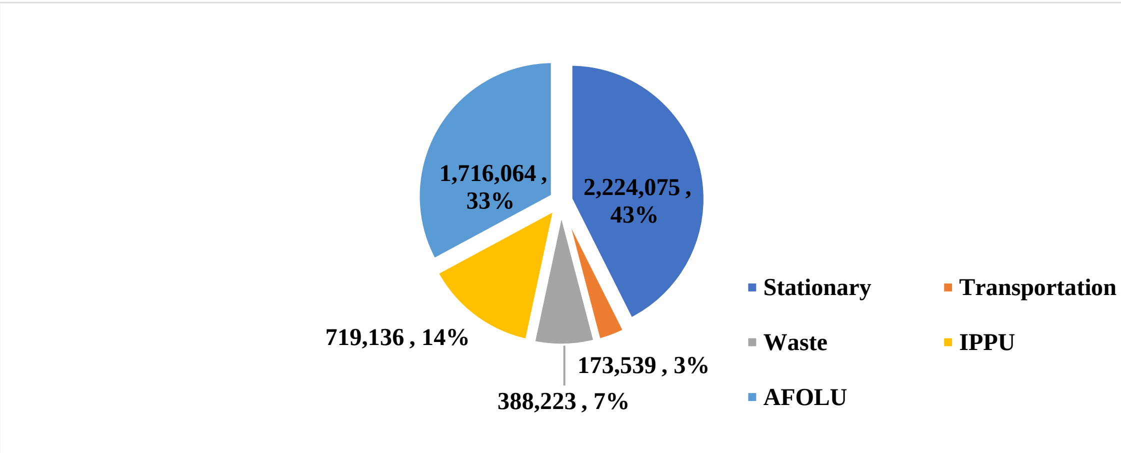
DDCA GHG emissions in 2018 are equal to 10.9 tCO_2e per capita, or 14.1 tCO_2e per thousand US$ GDP. According to the CRGE, Ethiopia's 2011 GHG emissions were approximately 1.88 tCO_2e per capita and it is projected to be 3.0 per capita by 2030. National GHG inventories are comparable to these city emissions, so it can be concluded that per capita emission is significantly higher than the national average emission per capita. The Addis Ababa City GHG inventory result which was conducted for the year 2016 which showed that the per capita emission is 4.3 tCO_2e. This shows that the DDCA per capita emission is higher than the Addis Ababa City Per Capita Emission. One of the reasons can be the Addis Ababa City GHG emission did not cover the land use change emission.



Result Analysis

Stationary energy, AFOLU, and IPPU Sector have the highest GHG emission.

The DDCA has emitted 5.22 million-tones CO_2e in 2018. Among the emission sources, the Stationary was found to be the highest emitter which account about 43 % of the total emissions, followed by the AFOLU, IPUU and Waste sector which shared 33%, 14% and 7% respectively. Transport was the lowest emitter sector. The high emissions in the stationary sector can be attributed to the energy type used in industry such as coal and biomass energy consumption at the residential and commercial institutions.

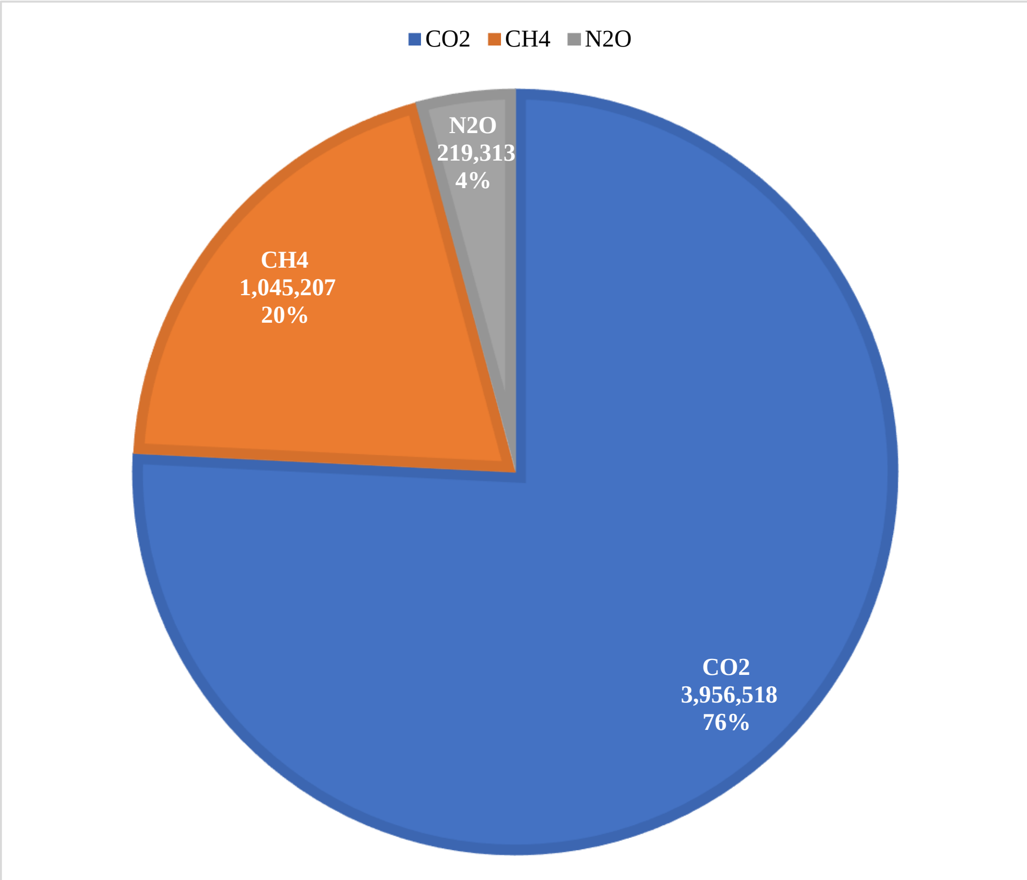


Dire Dawa City Administration's GHG emission Sector (tCO_2, %)

To evaluate the GHG mitigation potential, it is necessary to understand what proportion of these emissions are from sources within the (*scope 1*) where the city has more opportunities to implement low-carbon policies and programs. All of the above-mentioned emissions from the highest emitter sector Stationary energy and AFOLU 3.94 $MtCO_2e$ are *scope 1*, while almost 72% of transportation emission 135 thousand tCO_2e occurred within the city boundary.

Carbon dioxide (CO_2) gas shared the highest emission proportion

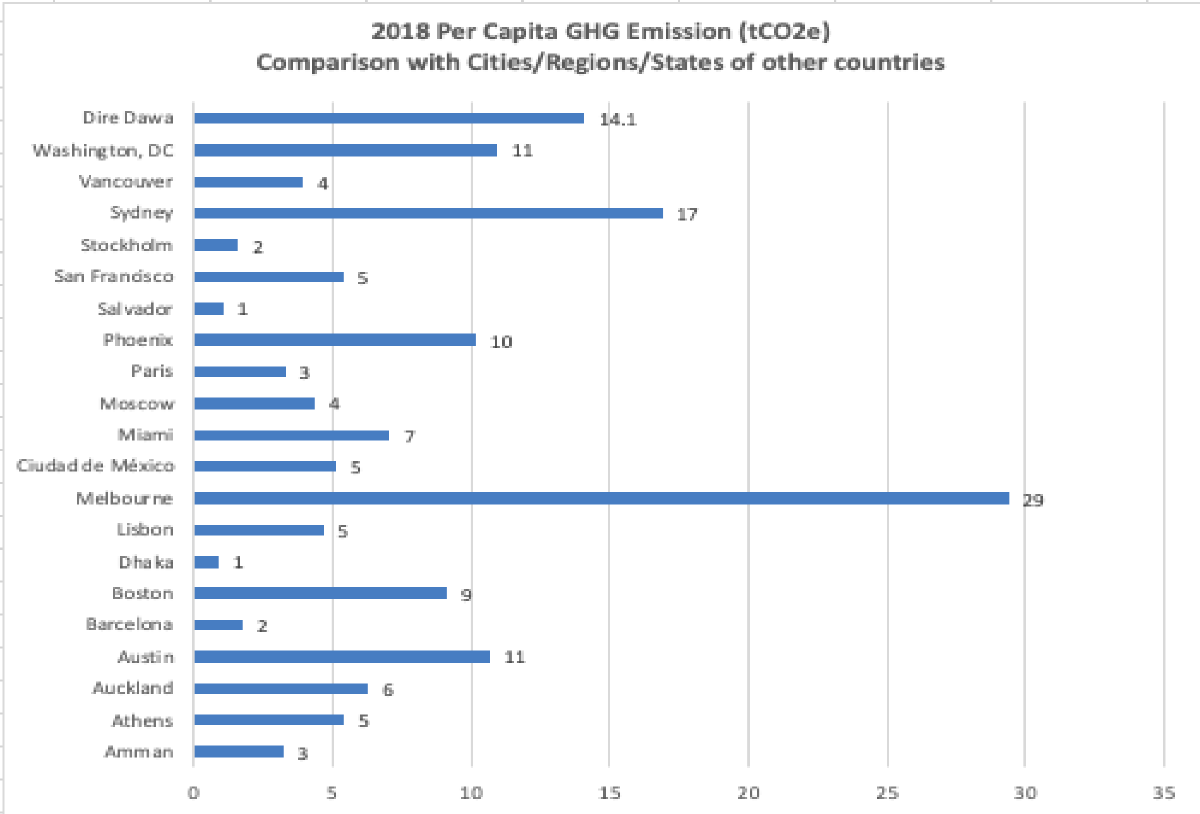
The finding has showed that 76% of the CO_2e emission was coming from carbon dioxide. It is followed by methane 20% and nitrox oxide 4%. The carbon dioxide emission is mainly related to the stationary energy emission where the methane is from livestock and waste management. The nitroxide is mainly related to the agriculture.



GHG emission by gases tCO_2, %)

Comparison with cities/region of the world

DDCA's GHG emissions (BASIC) were compared with estimated emissions for 2018 from a range of mega cities from around the world as shown in Figure below. DDCA was found to have the significantly higher GHG emissions compared with the developing countries. It is critical to note that DDCA' per capita emissions are amongst the lowest, while the emissions per 1,000 USD amongst the significant in the Ethiopia.



This is the second GHG emission estimation exercise for the Dire Dawa City. This first GHG emission was undertaken by Haromaya University for the year 2015. The general principle followed for GHG emission estimation for both inventories were the IPPC but this inventory has followed the GPC protocol customized from IPCC which is enable to undertake sub-national boundaries emission. It has a lot of advantages of using GPC for emission calculation such as comparable across time, and with other cities which are using this protocol to undertake the GHG emission estimation (see the detail in the Methodology Section of this report).

The table shows the DDCA GHG emission estimation for the two period of times.

S/N		2015 Emission	2018 Emission	Explanation for Changes
1	Stationary Energy	402,424	2,224,075	Methodological approaches difference and data sources are the main causes in making the inventory consistent. For instance, for 2015 transport sector GHG calculation had used fuel sale approach whereas this inventory (2018) used Vehicle kilometer travel.
2	Transport	727,560	173,539	
3	Waste	454,155	388,223	
4	IPPU	3,787,278	719,136	
5	AFOLU	274,653	1,716,064	
Total		**5,646,070**	**5,221,037**	

1. Introduction

Gases that trap heat in the atmosphere are called greenhouse gases. The Greenhouse effect is a leading factor in keeping the Earth warm because it keeps some of the planet's heat that would otherwise escape from the atmosphere out to space. The main greenhouse gases include, CO_2, methane, nitrous oxide (N_2O) and other gases.

The clear effect of the greenhouse gases is the stable heating of Earth's atmosphere and surface, thus, global warming. The ability of certain gases, greenhouse gases, to be transparent to inbound visible light from the sun, yet opaque to the energy radiated from the earth is one of the best still events in the atmospheric sciences. The existence of greenhouse effect is what makes the earth a comfortable place for life.

Almost all the countries in the world signed the Paris Agreement which is an international treaty made at COP21 in Paris in 2015. The aim of the agreement is to keep the rise in the global average temperature to 'well below' 2 degrees above pre-industrial levels, ideally 1.5 degrees; strengthen the ability to adapt to climate change and build resilience; and align all finance flows with 'a pathway towards low greenhouse gas emissions and climate-resilient development'. The agreement has a 'bottom-up' approach where countries themselves decide by how much they will reduce their emissions by a certain year. They communicate these targets to the UNFCCC in the form of 'nationally determined contributions', or 'NDCs'.

Ethiopia's NDCs embodied a vision for an ambitious and prosperous future. It drew heavily from the country's Climate Resilient and Green Economy (CRGE) Strategy, which lays out climate-compatible development efforts across all sectors of Ethiopia's economy. Ethiopia submitted its latest updated NDC in July 2021, building on an interim NDC update submitted in December 2020. The updated NDC integrates the country's national climate and development objectives by aligning the GHG emissions pathways with national development priorities and sectoral targets from Ethiopia's new 10-year development plan.

According to this updated NDC, Ethiopia commits to a 68.8% reduction below a revised business-as-usual (BAU) scenario conditional on international support (incl. LULUCF). This target includes an unconditional component, a 14% reduction below BAU, which Ethiopia will undertake with its own resources. Ethiopia intends to achieve both of these targets primarily (around 85% of total reductions) through reductions in its land sector emissions. The unconditional target results in an emissions level of 269 $MtCO_2e$ in 2030 (excl. LULUCF), while the conditional target would limit emissions to 237 $MtCO_2e$.

Sub-national actors including regions, cities, sub-cities, zones and woredas have the role to contribute the emission reduction towards national and international goal set by the NDC. This inventory is an example of how the sub-national level actors can take bold actions in meeting the objectives of the Paris Agreement, by accounting the GHG emission and by taking corresponding mitigation action for the prioritized sector which will have high mitigation potential.

As this is the second GHG emission inventory for Dire Dawa City which enable to measure its overall emissions and compare with the pervious and get a sense of how to make future mitigation reduction actions, as well as understand the contribution of different activities within the city. This GHG report summarizes the results of the inventory for 2018, including emissions from the stationary energy sector, used by different buildings types (such as residential, commercial, industrial etc.), energy used in the transport sector, waste sector related emissions, Industrial process and product use and agriculture forestry and other land use change.
The report is divided into five main Sections:

i. **Section 1**: provides introduction
ii. **Section 2**: provides an overview of the methodology, emission sources, and the calculation and reporting processes undertaken.
iii. **Section 3:** summarizes the inventory compilation process including institutional arrangements, timeline of activities, inventory compilation and quality assurance process.
iv. **Section 4:** presents a summary of the latest year emissions and emission trends
v. **Section 5:** presents the results for each sector in detail. The final section includes recommendations and improvements identified.

2. Methodology

This inventory was compiled following the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (also referred to as GPC) Standard, which is a GHG Protocol Standard developed by C40, World Resources Institute (WRI) and ICLEI – Local Governments for Sustainability. The GPC provides a robust framework for accounting and reporting GHG emission for any sub-national level entity such as, regions, sub-cities etc. It seeks to:

- Develop a comprehensive and robust GHG inventory.
- Establish a base year emissions inventory, set reduction targets and track their performance.
- Ensure consistent and transparent measurement and reporting of GHG emissions between cities[1]/sub-national level, following internationally recognized GHG accounting and reporting principles.
- Enable cities' inventories to be aggregated at subnational and national levels. Demonstrate the important roles that cities play in tackling climate change, and facilitate insight through benchmarking and aggregation of comparable data.

2.1 GPC methodology

The GPC methodology helps to understand the GHG emission within the city/ sub-national state and outside the boundary that is generated as result of activities in the city. These will help the city to understand the responsibility and the power to act on the GHG emission brought by the activities. Therefore, the activities such as social or economic activities taking place within a city can generate GHG emissions that occur inside as well as outside the city boundary. To distinguish among them, the GPC has grouped emissions into three categories based on where they occur: Scope 1, Scope 2 and Scope 3 emissions. Definitions are provided in Table 1, based on an adapted application of the Scopes Framework used in the GHG Protocol Corporate Standard.

Table 1: Scopes definition for city inventories

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

[1] Note, the term "city" is used in GPC protocol to refer to any geographically discernible subnational entity, such as a town, city, province, and state covers all levels of subnational jurisdiction as well as local government as legal entities of public administration.

The scopes framework helps to differentiate emissions occurring physically within the sub-national state (Scope 1), from those occurring outside the sub-national state (Scope 3) and those arising from the use of electricity, steam, and/or heating/cooling supplied by grids which may or may not cross boundaries (Scope 2). Scope 1 emissions may also be termed “territorial” emissions because they occur discretely within the territory defined by the geographic boundary. Figure 1: illustrates which emission sources occur solely within the geographic boundary established for the inventory, which occur outside the geographic boundary, and which may occur across the geographic boundary.

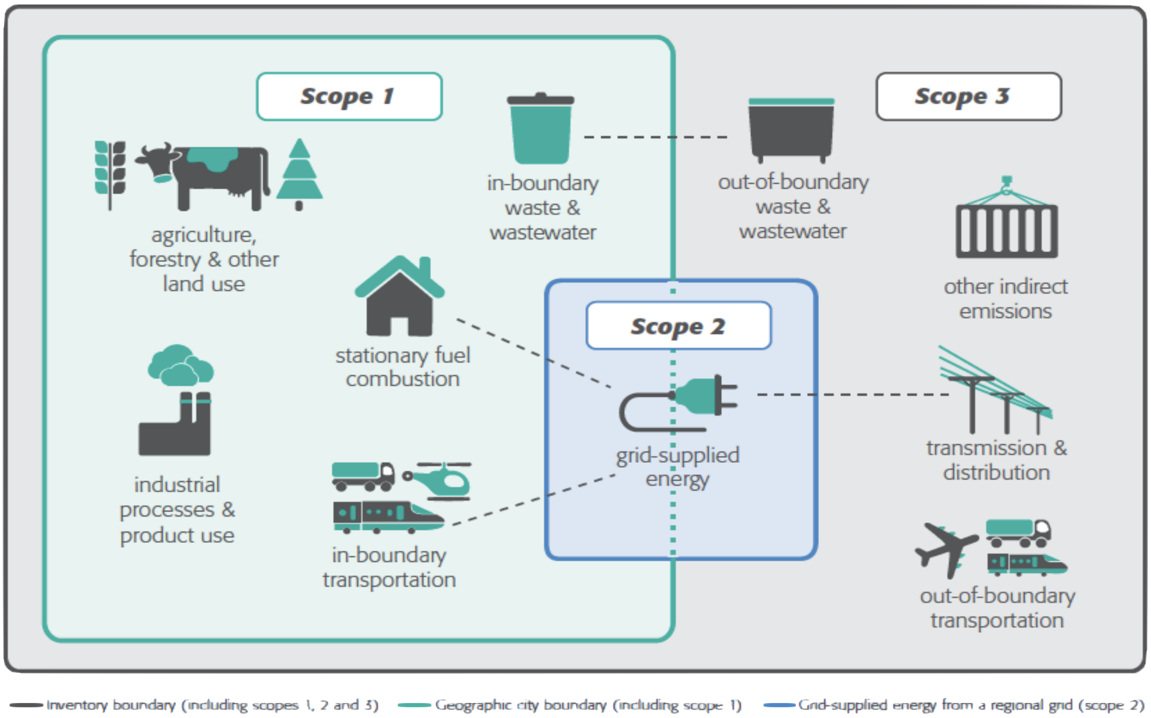


Figure 1: Sources and boundaries of GHG emissions in GPC inventories

2.2 Emission Calculation and Reporting

GHG emissions are calculated by multiplying activity data (AD) by an emission factor (EF) associated with the activity. Activity data represents a quantity of an activity that results in GHG emissions during a given period of time (for example: kilowatt-hours (kWh) of electricity consumed within a year). Emission factors are used to calculate the quantity of GHG emissions generated for each unit of a specific activity (for example: tones of CO_2 emissions from the use of electricity, expressed as t CO_2/kWh).

The City Inventory Reporting and Information System (CIRIS) Tool has been used calculate, monitor and report GHG emissions within the DDCA, based on activity data, emission factors and other defaults data inputs.

In this inventory, emissions are classified into five main sectors as follows:

i. Stationary energy
ii. Transport
iii. Waste
iv. Industrial processes and product use (IPPU)
v. Agriculture, forestry, and other land use (AFOLU)

The detail GPC definition for the five sectors and sub-sectors are given in the Annex 10. To accommodate limitations in data availability and differences in emission sources, the GPC requires the use of notation keys, as recommended in IPCC Guidelines. The notation keys must be applied with an accompanying explanation to justify exclusion or partial accounting of GHG emission source categories, for example, if the activity does not occur or when sufficient activity data is unavailable. The notation keys are described Table 2.

Table 2: Use of notation keys

Notation key	Definition	Explanation
IE	Included Elsewhere	GHG emissions for this activity are estimated and presented in another category of the inventory. That category shall be noted in the explanation.
NE	Not Estimated	Emissions occur but have not been estimated or reported; justification for exclusion shall be noted in the explanation.
NO	Not Occurring	An activity or process does not occur or exist within the.
C	Confidential	GHG emissions which could lead to the disclosure of confidential information and therefore cannot be reported.

The GPC also offers cities two levels of reporting demonstrating different levels of completeness. The BASIC level covers emission sources that occur in almost within most sub-national activities such as stationary energy, in-boundary transportation, and emissions from in-boundary generated waste, including waste disposed outside the boundary. The BASIC+ level has a more comprehensive coverage of emissions sources such as IPPU, AFOLU, trans-boundary transportation, and energy transmission and distribution losses and reflects more challenging data collection and calculation procedures. This GHG inventory reports data consistent with BASIC and pretty good data included for IPPU and AFOLU sectors.

2.3 Inventory boundary, GHG accounted and time span

a) Inventory Boundary

The Dire Dawa City Administration (DDCA) is one the two chartered City Administration system in the Federal Democratic Republic of Ethiopia. It is relatively located in most eastern part of the country. The city lies between 9^0 27' 50"N to 9^0 49' 20" North of latitude and from 41^0 38' 28" to 42^0 18' 54" East of longitude. It is bordered by Oromia regional state to the south, Somali region to north and north east. The total area of the administrative city estimated about 1288.02 km^2. This chartered city is divided administratively into two Woredas, the town proper and the non-urban woreda of Gurgura (WFP, 2009). The city of Dire Dawa is located at a distance of 515 km from the Federal city of Addis Ababa.

Table 3: Facts about Dire Dawa (Source: Compiled from different sources)

Climate	Between 950 – 1250 MASL, and which is characterized by warm and dry climate with a relatively low level of precipitation
Rainfall	The city has two rain seasons; that is, a small rain season from March to April, and a big rain season that extends from August to September. The aggregate average annual rainfall that the city gets from these two seasons is about 604 mm
Temperature	The mean annual temperature 25.4^0C. The average maximum temperature 31.4^0C, while its average minimum temperature is about 18.2^0C
Population	479, 000
Economic Activities	The economic mainstay is trade and its function as a logistics hub. Located on the eastern edge of the Rift Valley, Dire Dawa lies at the intersection of roads from the city, Harar and Djibouti. The Dire Dawa airport offers flights to and from Addis Ababa and Djibouti
GDP	369,560,475 USD (app using national GDP per capita = 771.525 USD)
Area	1288.02 km^2
Administration	Subdivided into 9 urban and 32 rural kebeles (CSA, 2012).

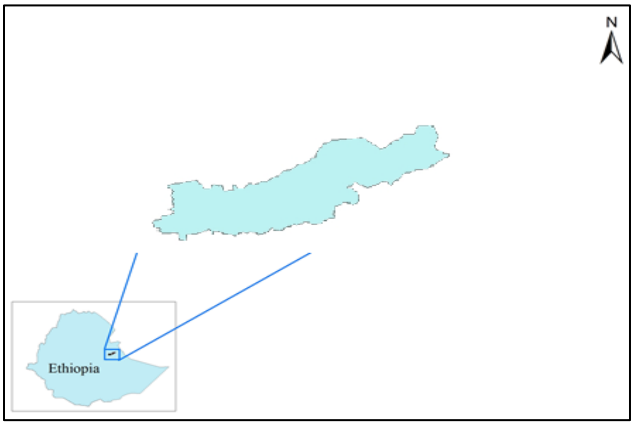


Figure 2: Map of the Dire Dawa city's boundary

(Source: Colorado General Business Consulting)

b) Greenhouse gas

The GHG emission gases are carbon dioxide (CO_2), methane (CH_4), Nitrous Oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). This GHG inventory covers emissions of CO_2, CH_4 and N_2O. The other four GHGs required by the GPC are considered negligible in DDCA during the period of this inventory.

c) Time span

This GHG inventory was developed to reflect emissions during 2018. While Ethiopia follows the Julian calendar, this GHG inventory was developed based on the twelve-month cycle of Gregorian calendar to ensure international compatibility.

2.4 Summary of sources and activities covered by inventory

The sources and activities covered by this inventory are summarized in the table below, listed under scopes from 1 to 3. The tick mark (√) showed in the table represents the covered sources and activities and notation keys (e.g., NO = Not Occurring and IE = Included Elsewhere) provide further detail.

Table 4: Sources and activities covered by the inventory

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
Stationary energy			
Residential buildings	✓	NO	NO
Commercial buildings	✓	NO	NO
Institutional buildings	✓	NO	NO
Manufacturing industries and construction	✓	NO	NO
Energy industries	NO	NO	NO
Energy generation supplied to the grid	NO		
Agriculture, forestry, and fishing activities	✓	NO	NO
Non-specified sources	NO	NO	NO
Fugitive emissions from coal	NO		NO
Fugitive emissions from oil and natural gas systems	NO		NO
Transportation			
On-road	✓	NO	✓
Railways	NO	NO	NO
Waterborne navigation	NO	NO	NO
Aviation	NO	NO	NO
Off-road	✓	NO	NO
Waste			
Solid waste generated in the	✓		NO
Solid waste generated outside the	NO		
Biological waste generated in the	✓		NO
Biological waste generated outside the	NO		
Incinerated and burned waste generated in the	NO		NO

Sectors and sub-sectors	Scope 1	Scope 2	Scope 3
Incinerated and burned waste generated outside	NO		
Wastewater generated in the	✓		NO
Wastewater generated outside the	NO		
Industrial processes and product use (IPPU)			
Industrial processes	✓		NO
Product use	✓		NO
Agriculture, forestry, and fishing activities (AFOLU)			
Livestock	✓		NO
Land	✓		NO
Other agriculture	✓		NO
Other scope 3			

White	= sources required for reporting
Green	= sources required for BASIC reporting
Green + Blue	= sources required for BASIC+ reporting
Purple	= additional scope 1 sources required for territorial reporting
Orange	= other scope 3 sources
Grey	= non-applicable emission sources

3. Inventory Compilation Process

The compilation process basically has five major steps. These are i) organizing team and sector leads, ii) prepare the data collection template as per GPC protocol, iii) Data collection, iv) data analysis and gaps identification and improvement and preparation of the final GHG inventory report. The compilation of DDCA's GHG inventory followed the process in Figure 3 below.

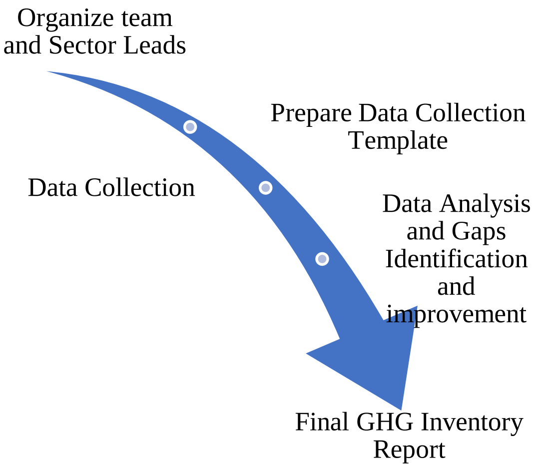


Figure 3. Overview of the GHG compilation steps

a) Inventory compilation team

Arranging the thematic working group at DDCA Environment Protection Authority (DDEPA).
a) Focal Persons Meeting (FPM). The focal persons meeting FPM have been organized and facilitated by National EPA MRV office in order to create enabling environment for proper planning, implementation and follow up of the activities. The FPM was conducted at DDEPA. Those FPM and succeeding different collaboration resulted in the following activities

- Setting Goals and deadlines with tasks & responsibilities.
- Identifying stakeholders & partners in city
- Preparation of data collection tool

The data collection template was prepared following the GPC guideline and then the data collectors were given a brief explanation on what activities data required in each sector. Since the data collection needs a certain process to collect quality and reliable data, all necessary qualitative and quantitative data from different sources were collected for triangulation.

The following activities have been accomplished with regards to data collection.

- ✓ Getting familiar the thematic working groups with the GPC.
- ✓ Setting inventory boundaries.

- ✓ Setting reporting level.
- ✓ Identifying data required by scope.
- ✓ Identifying data required by sector & sub sector.
- ✓ Identifying calculation methodologies to use considering available data.
- ✓ Identifying local and national data sources.
- ✓ Understanding and adjusting data to local situation.

b) Data Analysis and Report

Both the sectoral data from the sectors and sub-sectors data collectors for better quality and reliable data. The secondary data collection and analysis were also undertaken to fill the data gaps. The CIRIS tool used to analyze the data and calculate GHG emission.

These are some of the data sources were reviewed and used for activity data and emission factor:

- ✓ Government departments and statistics agencies: Census data, a country's national greenhouse gas inventory report.
- ✓ International organizations: IPCC default assumptions and FAO statistics.
- ✓ Universities, research institutes and NGOs: Local surveys, project reports and Scientific and technical articles in environmental books, journals and reports.
- ✓ Local utilities and service providers: Waste contractor collection data and metered consumption data.
- ✓ Sector experts/stakeholder groups/ government colleagues.

Table 5: Data Quality Checklist

Data quality	Activity data	Emission factor
High (H)	Detailed activity data	Specific emission factors
Medium (M)	Modelled activity data using robust assumptions	More general emission factors
Low (L)	Highly modelled or uncertain activity data	Default emission factors

c) Inventory review and quality assurance processes

The review and quality control were done by the compilers among themselves. Additionally, sectors coming from national ministries and Federal EPA experts gave feedback and provided valuable input towards this process.

4. Total Emissions and Trends

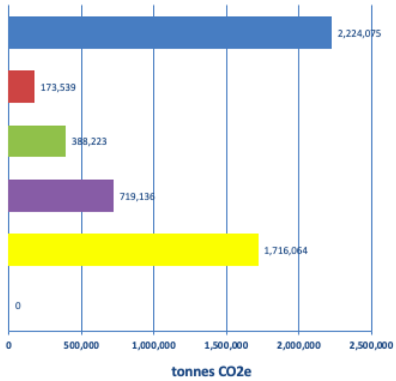
The total GHG emissions estimated for DDCA in 2018 was 5,221,037 tCO_2e. The largest contribution was found to be from the Stationary energy sector emission was 2,224,075 tCO_2e (43 % of the total GHGs), followed by AFOLU sector, 1,716,064 tCO_2e (33 % of the total GHGs), waste sector which was 388,223 tCO_2e (7% of the total GHGs,) and transport emission was 173,539 tCO_2e (3 % of the total GHGs). The figure below presents the outputs from the CIRIS Tool, including total, sectoral, per capita and per GDP emissions.

SUMMARY

NAME OF CITY: Dire Dawa City Administration, Ethiopia
BOUNDARY: BASIC
INVENTORY YEAR: 2018

POPULATION: 479,000
LAND AREA (km2): 1,288
GDP (US$ million): 370

tCO2e	BASIC+	Scope 1	Scope 2	Scope 3
	Stationary	2,224,059	16	
	Transportation	135,093		38,446
	Waste	388,223		
	IPPU	719,136		
	AFOLU	1,716,064		
	Other Scope 3			
	TOTAL	5,221,037		



Intensity indicators	Per capita	Per unit land area (km2)	Per unit GDP (US$m)
Emissions	10.9	4,054	14,128

Figure 3: Summary analysis of DDCA GHG emissions, 2018

The DDCA GHG emission is almost all are Scope 1 which is account 99.2 % (5,177,764 tCO_2e). The remaining emission which is 0.8% (43,273 tCO_2e) from scope 3 and from Scope 2 negligible which is about (16 tCO_2) which is mainly from the on-road transport sector and grid electricity energy consumption respectively. As the national grid electricity mainly from hydro-electricity, the Scope 2 emissions are very small and are related to grid electricity consumption in buildings.

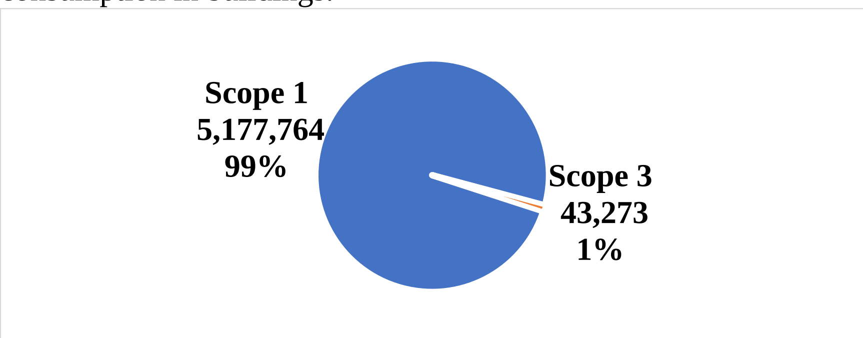


Figure 4: GHG emissions by Scope

4.1 Emissions by sub-sector

The sub-sector analysis showed that Emissions from manufacturing and industries energy consumption occurring in the city boundary was the highest which is 1,760,401 tCO_2e (34% of the total GHG emission) followed by emissions from land which was account 1,329,266 tCO_2e (25%) of the total -wide GHG emissions. Industrial process was the next highest contributing sub-sector. Figure 5 below illustrates the total community emissions produced in the DDCA by sub- sectors. A more in-depth breakdown of the sub- sectors per emission source can be found in chapter 5.

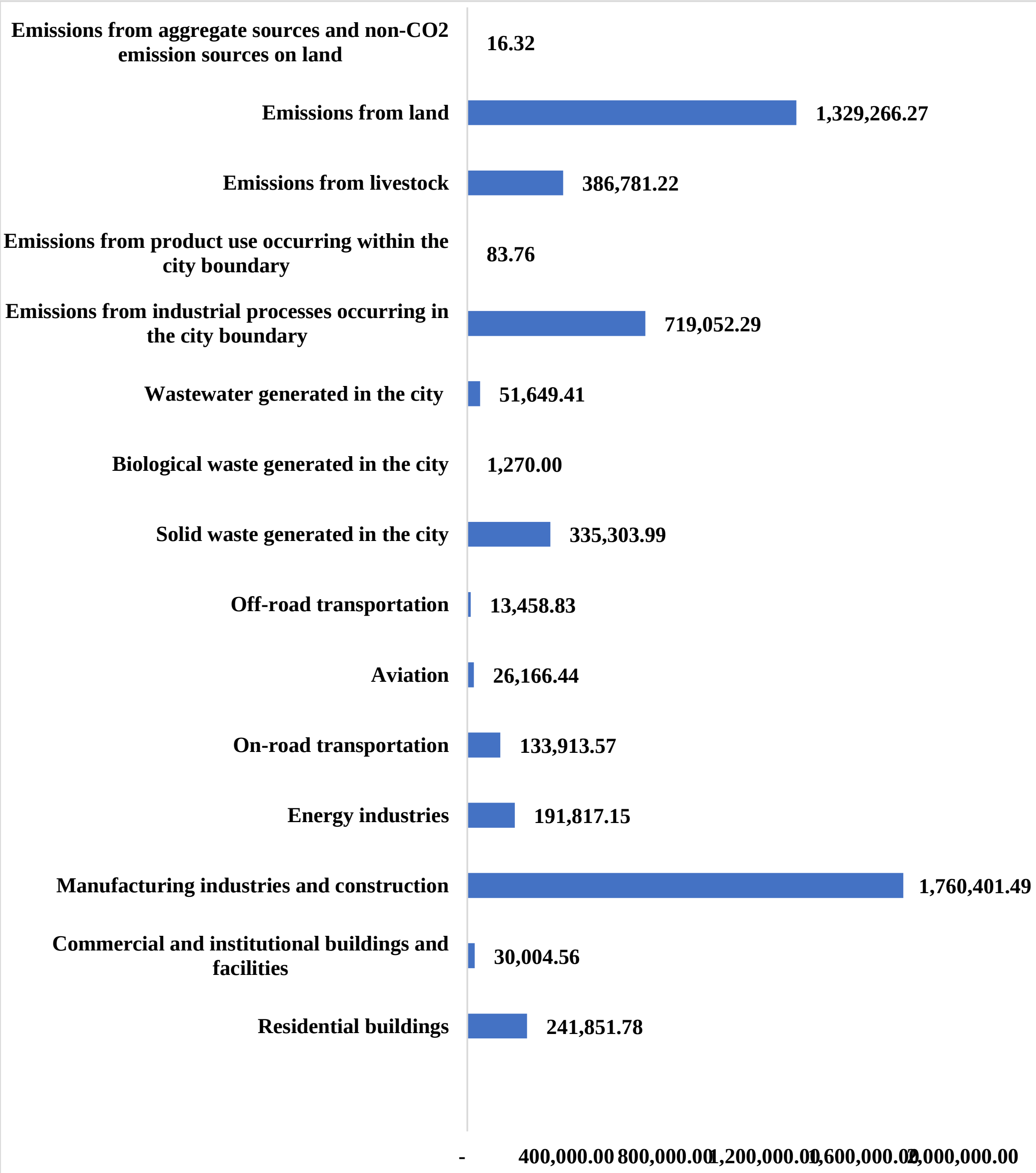


Figure 5: Overview of GHG emissions by sub-sector for 2018 year (tCO_2e)

Table 6: GHG emissions sources by sector and sub sector

GPC ref No.	GHG Emissions Source (By Sector and Sub-sector)	Total GHGs (metric tonnes CO_2e)			
		Scope 1	Scope 2	Scope 3	Total
I	**STATIONARY ENERGY**				
I.1	Residential buildings	241,847	4	NE	241,852
I.2	Commercial and institutional buildings and facilities	30,001	3	NE	30,005
I.3	Manufacturing industries and construction	1,760,393	9	NE	1,760,401
I.4.1/2/3	Energy industries	191,817	NO	NO	191,817
I.4.4	Energy generation supplied to the grid	NO			
I.5	Agriculture, forestry and fishing activities	0	NO	NO	0
I.6	Non-specified sources	NO	NO	NO	0
I.7	Fugitive emissions from mining, processing, storage, and transportation of coal	NO			0
I.8	Fugitive emissions from oil and natural gas systems	NO			0
SUB-TOTAL	**(City induced framework only)**	2,224,059	16	0	2,224,075
II	TRANSPORTATION				
II.1	On-road transportation	121,634	NO	12,280	133,914
II.2	Railways	NO	0	NE	0
II.3	Waterborne navigation	NO	NO	NE	0
II.4	Aviation	NO	NO	26,166	26,166
II.5	Off-road transportation	13,459	NO	NO	13,459
SUB-TOTAL	**(City induced framework only)**	135,093	0	38,446	173,539
III	WASTE				
III.1.1/2	Solid waste generated in the city	335,304		NO	335,304
III.2.1/2	Biological waste generated in the city	1,270		NO	1,270
III.3.1/2	Incinerated and burned waste generated in the city	0		NO	0
III.4.1/2	Wastewater generated in the city	51,649		NO	51,649
III.1.3	Solid waste generated outside the city	NO			
III.2.3	Biological waste generated outside the city	NO			
III.3.3	Incinerated and burned waste generated outside city	NO			
III.4.3	Wastewater generated outside the city	NO			
SUB-TOTAL	**(City induced framework only)**	388,223		0	388,223
IV	INDUSTRIAL PROCESSES and PRODUCT USES				
IV.1	Emissions from industrial processes occurring in the city boundary	719,052			719,052
IV.2	Emissions from product use occurring within the city boundary	84			84
SUB-TOTAL	**(City induced framework only)**	719,136			719,136
V	AGRICULTURE, FORESTRY and OTHER LAND USE				
V.1	Emissions from livestock	386,781			386,781
V.2	Emissions from land	1,329,266			1,329,266
V.3	Emissions from aggregate sources and non-CO_2 emission sources on land	16			16
SUB-TOTAL	**(City induced framework only)**	1,716,064			1,716,064
VI	OTHER SCOPE 3				
VI.1	Other Scope 3			NE	0
TOTAL	**(City induced framework only)**	5,182,575	16	38,446	5,221,037

4.2 Projected Emission Trend

Emission projections analysis show that total baseline emissions are projected to increase from 120,446.1 tCO_2e in 2018 to 9,774,920.39 tCO_2e in 2030. The emissions in the Energy Sector are projected to increase from 2224075tCO_2 eq. in 2018 to 4163953.647tCO_2 eq. representing a growth of 87.22 percent followed by AFOLU, IPPU, Waste and Transportation consecutively as shown in Figure 6. The GDP and population growth factors are the main variables used to estimate GHG emission projection. Economic growth is often expressed in the GDP. It has a direct positive relationship with the emission growth if the growth is brought by the traditional economic development activities (which does not account for the emission) or business as usual (BAU). The population is another factor that can lead to increased emission in the BAU scenario. Every individual has an emission footprint while using energy, transport, waste generation etc. under BAU scenario. According to the CSA, the Dire Dawa population growth was estimated to be 2.77% on the year 2018-2022. The real GDP growth of the national level was 8.44 % for the period of 2001 to 2019 (Ethiopian Economy 2020/2021 by Economic Association). The GHG emission projection was undertaken by considering both parameters as a weighted percentage of GHG emission growth as equal impact.

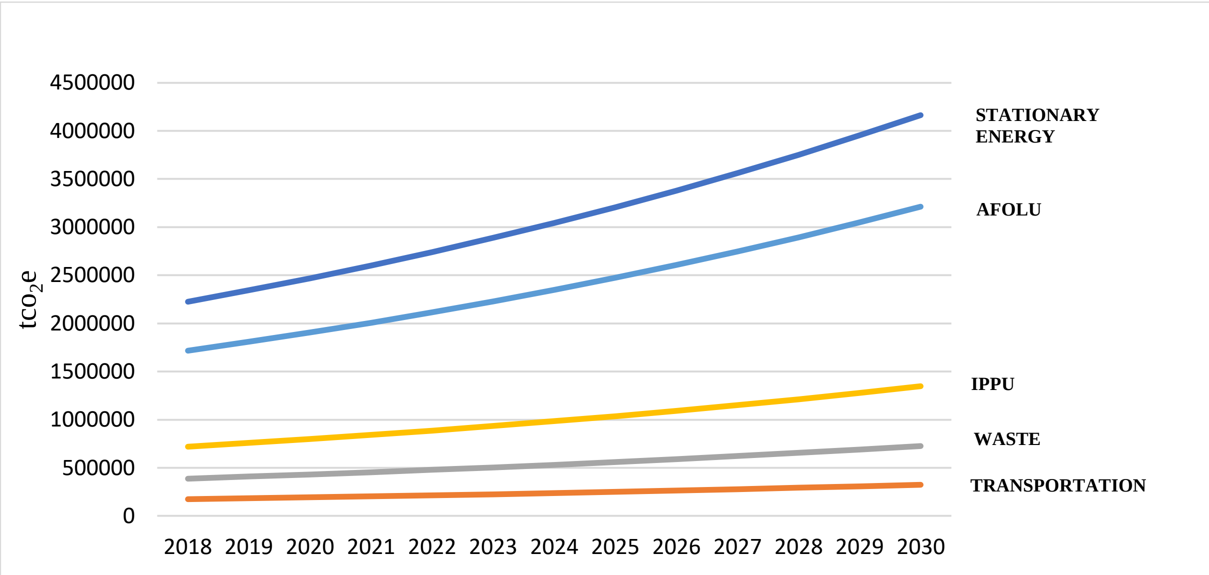


Figure 6: GHG Emission Projection (2019 to 2030)

5. GHG Emissions by Sector

5.1 Stationary Energy

Stationary energy is an energy type that people use at different types of buildings. Among the common types of buildings are residential, commercial, institutions and industries, and manufacturing. The stationary energy category is also including the energy used in agriculture such as fishing, motor pumps for irrigation, machinery for sowing or harvesting, etc. The energy type commonly used in the buildings are biomass fuels, fossil fuels and electricity. The common biomass fuels used in the city include charcoal, wood, branch-leaves, twigs (BLT), dung and to some extent crop residue. With regards to fossil fuels, residential and commercial premises typically use kerosene and LPG. Manufacturing industries commonly use furnace oil. The city grid-electricity is produced from hydro power and it is commonly used in all building types which has negligible emission. Emissions arising from the use of these energy sources are divided into the following sub-sectors:

I. Residential buildings
II. Commercial and institutional buildings and facilities
III. Manufacturing industries and construction
IV. Energy industries
V. Agriculture, forestry and fishing activities

From the total GHG emission in this inventory, 43 % of emissions (2,224,075 tCO_2e) arose from stationary energy combustion, which is the 1st highest emission source in the city. Within this source category, energy used at the manufacturing industries and construction contributed the highest emissions at 79 % (1,760,401 tCO_2e), followed by residential building which shared about 11% (241,851 tCO_2e), energy industries used to produce such as charcoal making process shared 9% (191,81 tCO_2e), and commercial and institutional buildings and facilities have shared nearly 1% (30,004 tCO_2e), and. The following graph shows the contributions from stationery energy sub sectors.

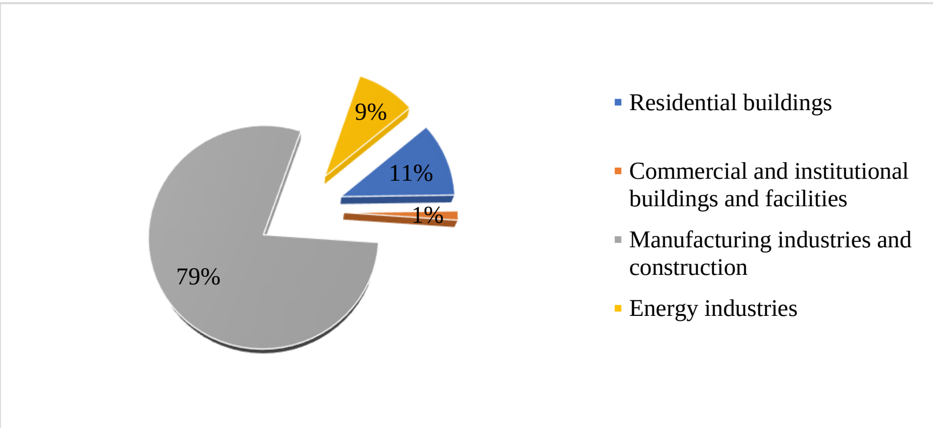


Figure 7: Stationary energy emissions by sub-sector

Coal as energy is responsible for the majority of emissions from the stationary energy sector, followed by wood waste, charcoal and diesel. A detailed description of the activity data, emissions and data sources for stationary energy can be found in Annex 2.

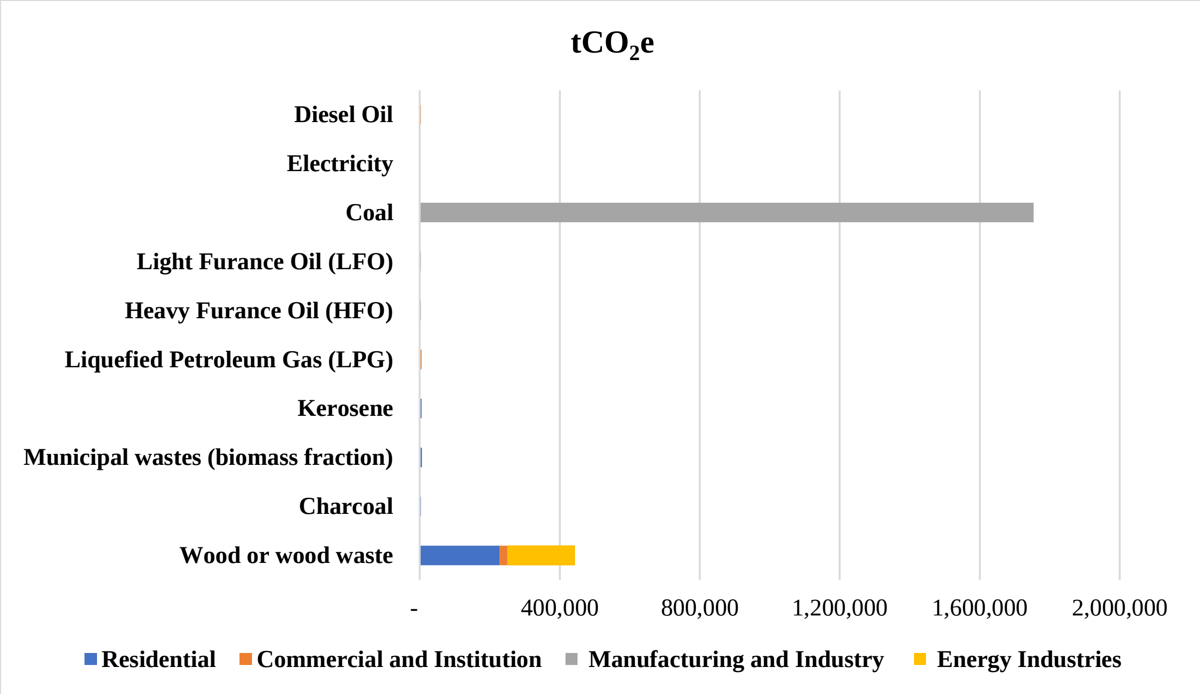


Figure 8: Stationary energy emissions by sub-sector and fuel type

The following provides a brief description of each sub-sector:

Residential Buildings

The residential buildings were use the biomass (wood, branches, charcoal), kerosene and LPG as the major sources of energy for cooking, heating, boiling etc. activities in the household. The residential sector emitted a total of 241,851.78 tCO_2e.Within the residential buildings subsector, most of the emissions are from the combustion of wood and wood waste which include wood, BLT (branches, leaves, and twigs), saw dust and municipal solid waste etc. It was about 228,298 tCO_2e GHG emission, followed by kerosene (5,100 tCO_2e) and charcoal (2,923 tCO_2e). LPG energy consumption has the lowest among all energy type in the residential building’s category.

Commercial and Institutional Buildings

The commercial and institutions building shared a total of 30,004 tCO_2e. The biomass energy consumption specifically wood waste shared the largest emission in this building followed by LPG consumption. The biomass (wood or wood waste) and LPG energy emissions was 21,902 tCO_2e and 4,731 tCO_2e emission respectively.

Manufacturing Industries and Construction

The manufacture industries and construction used various types of energy to produce industrial products and in the processing of construction. This inventory addresses the heavy and light furnace oil consumed by these industries. The emission from these industries were coming from coal which was the highest emitter in this sub-sector. The emission from coal was estimated 1,753,6631 tCO_2e. In addition, emission from heavy and light furnace oil usage had 3,419 tCO_2e and 3,342 tCO_2e respectively.

Energy industry

The energy industries here was consider that the energy used to produce charcoal, the emission from the energy industries was estimated 191,818 tCO_2e.

5.2 Transport

The DDCA transport system is mainly incorporate the on-road transport system. The on-road transport system used for both freight and passenger. There is also off-road transport system which are mainly function for agriculture and construction activities. The emissions from the transport sector come from directly combusting fuel or indirectly consuming grid-delivered electricity. For transport occurring within the city, emissions from combustion of fuels are reported in Scope 1 and emissions from grid-supplied electricity are included in Scope 2. DDCA had no any scope 2 emission from the transport. Scope 3 reports the emissions from a portion of transboundary journeys occurring outside the city. The emissions are calculated for on-road vehicles and off-road vehicles. These are the types of on-road and off-road vehicles in the city categorized as follows:

Table 7: On-road and off-road vehicle stock

S/N	Categories	Vehicle Stock
A	**On-Road Vehicles**	
1	Cars (Ambulance, Automobile, Field Vehicle)	1430
2	Buses (Bus (< 12 Seats), Bus (> 11 Seats))	1213
3	Trucks (Dry Cargo (<=10 Quintals), Dry Cargo (>10 Quintals))	1186
4	Trucks &Trail (Gotach, Liquid Cargo, Liquid Trailer, Trailer)	8
5	Bajaj	11,084
6	Motor Bicycle	1,115
B	**Off-Road Vehicles**	
8	Combiner	1
9	Dozer	0
10	Forklift	8
11	Grader	2
12	Tractor	21

13	Dual Purpose Vehicle	1370

The transport system for on-road and off-road transport had consumed about 9.4 million liters of gasoline and 38.2 million liters of diesel during 2018. The aviation sector in the Dire Dawa airport has used 891,508 liters of jet-fuel for trip originated from Dire Dawa to Garaad Wiil-Waal Airport (Jijiga Air Port) and Addis Ababa Bole International Airport. The following figure show the emission from the combustion of these fuel in the transport system and the shared of the on-road, aviation and off-road vehicles system in the city.

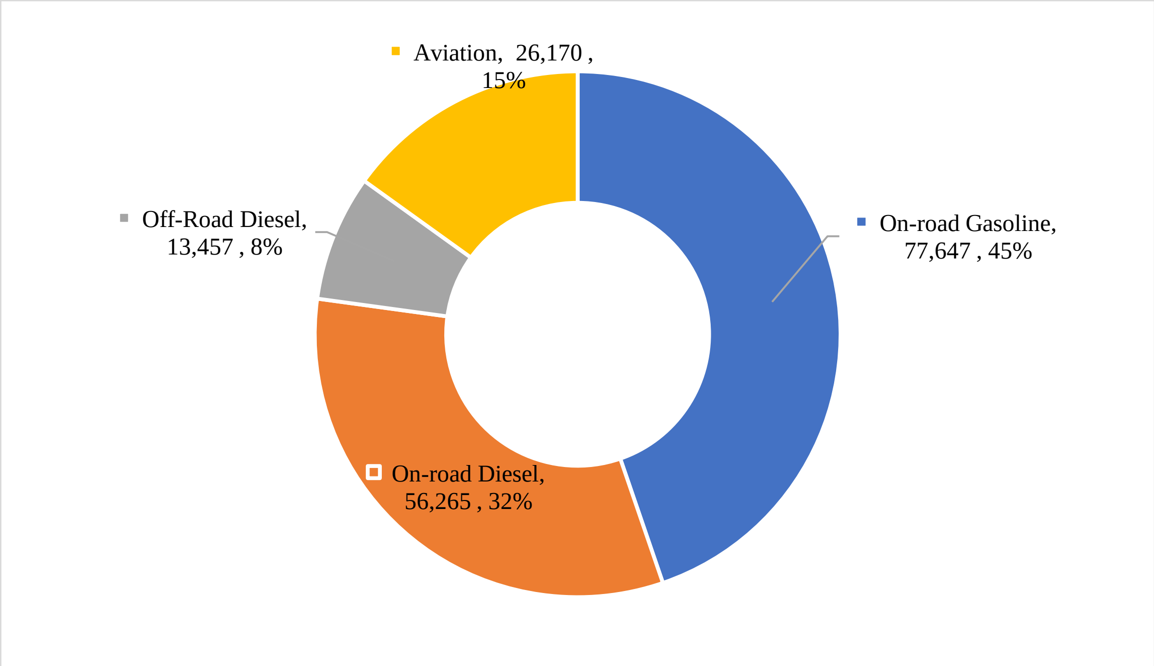


Figure 9: Transportation emissions by sub-sector

The transport sector accounts for 3% of DDCA city's GHG emissions in the 2018 inventory. From the total emission in the transport sector, On-road diesel vehicles share the highest emission contributors which was about 45% of the total transport emission which followed by the on-road gasoline vehicles which had 32% emission from within the transport sector.

The methodology and scope definition for the transport sector is as follows:

- **Scope 1** fuels include diesel and petrol. The Emissions were calculated using a bottom-up approach using VKT and fuel economy to calculate the total fuel consumption.
- **Scope 2** (grid-supplied energy) electric powered transport system not exist or negligible
- **Scope 3** include aviation and trans-boundary movement of on-road transport

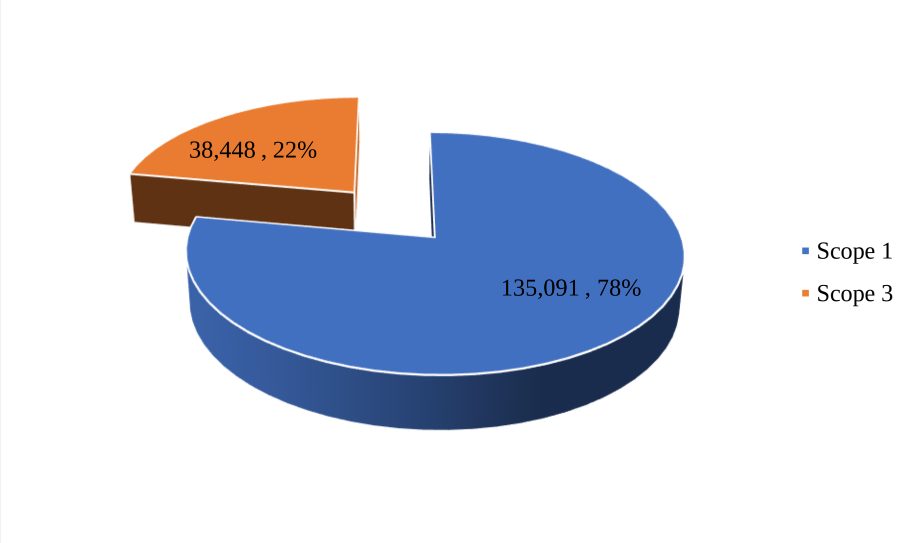


Figure 10: 2018 transport emission by scope definition

The relative emissions split between the different scopes are as follows: Scope 1:135,091 tCO_2e; No Scope 2; and Scope 3 – 38,448 tCO_2e. A detailed description of activity data, emission results and data sources can be found in Annex 3. The following provides a brief description of each sub-sector:

On-road Transport

Based on the types of the vehicle and fuel type analysis, the Bajaj-gasoline vehicles shared the highest emission which was 50,111 tCO_2e which followed by truck diesel 29,407 tCO_2e. The following figure showed the vehicle type and fuel emission.

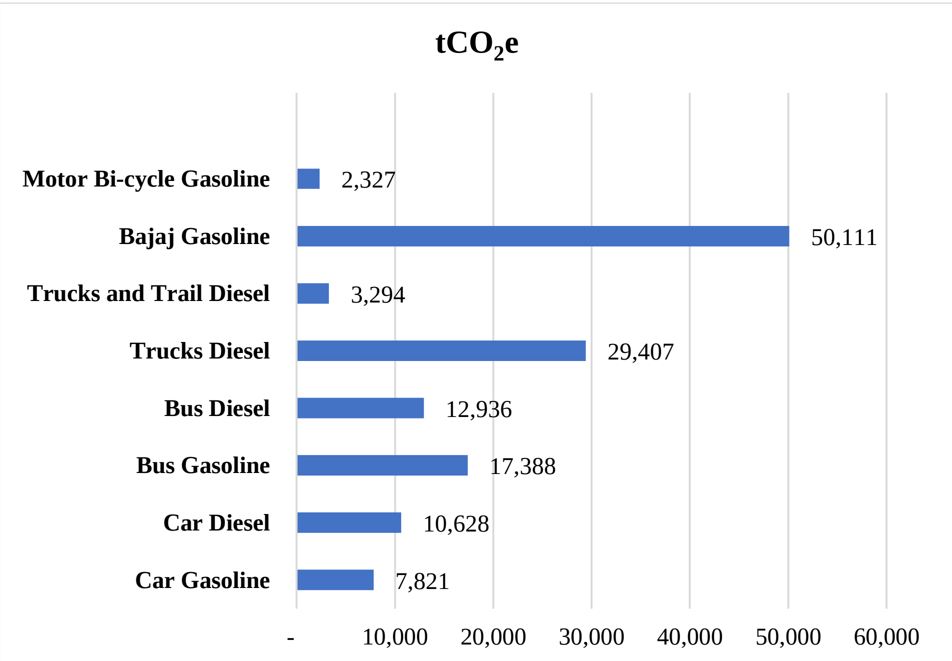


Figure 11: Emission by Vehicle Types

Aviation

The Dire Dawa Air Port had about a total of 908 itinerary in the year that originate in the airport and its destination was in Addis Ababa and Jigjiga Air Ports. The following table shows the total fuel burn and emission.

Table 8: Jet-fuel Consumption by Origin-Destination

ORIGIN	DESTINATION	DEPARTURE FUEL (kg)	FTFUEL BURN (kg)	ARRIVAL FUEL (kg)	2017	Projected 2018	Emission (tCO_2e)
Dire Dawa	Garaad Wiil-Waal Airport (Jijiga Air Port), Addis Ababa Bole International Airport	2858114	867313	1990481	867,313	891,508	26,166

Off-road transport

The off-road category included vehicles and mobile machinery used within the agriculture, forestry, and industry (including construction) sectors. The vehicles / machinery types considered under the 2018 inventory included combiners, graders, forklifts, and tractors. Operational hours per year by vehicle type were multiplied by their respective fuel economy (litter per hour) to determine fuel consumption. The fuel consumptions by vehicles / machinery type were then multiplied by relevant emission factors to estimate the quantity of GHG emissions.

Table 9: Vehicles/machinery emission

Vehicle Type	tCO_2e
Combiner	4
Forklift	46
Grader	50
Tractor	91
Dual Purpose Vehicle	13266

5.3 Waste

Waste contributed 7% of Dire Dawa city's GHG emissions in 2018. The total emission from waste was 388,223 tCO_2e emitted. The wastewater emission was found the highest emitter for the city which shared 51,649 tCO_2e from the total of emission in the waste sector. A detailed description of the activity data, emissions results and data sources can be found in Annex. The following provided a brief description of each sub-sector.

Solid Waste and Biological Treatment

The city waste generation was found to be 279,793 tones. The composting amount was 14,726 tones.

Wastewater Treatment

The wastewater was estimated using default parameter from the IPCC using city population number.

Table 10: Waste emissions by sub-sector

	tCO_2e
Municipal solid waste	335,304
Composting	1,270
Domestic Wastewater	51,148
Industrial Wastewater	502

5.4 Industrial Processes and Product Use (IPPU)

The IPPU has two emissions from the process and product use. The emission from the process was accounted for emission released during the production of such as clinker, glass, soda ash, iron and steel production and Ferroalloy. The clinker is a production that used to produce the cement. The GHG emission estimation was based on these products produced in the inventory year. The Product use estimated the GHG emission from the use of lubricant and paraffin in the city.

Table 11: IPPU emissions by sub-sector

IPPU	**tCO_2e**
Industrial Processes	
Cement production	**716,550**
Glass	**142**
Soda Ash	**80**
Iron and Steel Production	**2,246**
Ferroalloy production	**34**
Product use	
Lubricant	**83**
Paraffin	**1**

Based on the GHG emission from IPPU, the industrial process emission from the cement production was highest which was estimated 716,550 tCO_2e which by far followed by Iron and steel production which was estimated 2,246 tCO_2e (see Table 11 above).

5.5 Agriculture, Forestry and Other Land Use (AFOLU)

The emission from the AFOLU sector is divided into three categories: livestock, land, and aggregate and non-CO_2 emissions sources on land. GHGs from AFOLU consist of CH_4, N_2O and CO_2. The livestock production emissions are linked to enteric fermentation and manure management. Emissions from enteric fermentation consist of CH_4, produced in digestive systems of ruminants, and to a lesser extent of non-ruminants. GHG emissions from manure management consist of CH_4 and N_2O from aerobic and anaerobic decomposition processes.

The land emission was accounted the change in the land use from one category into from the six land categories in the IPCC i.e., crop, grass, forest, wetland, settlement, wet and other land categories. The other category in the AFOLU is aggregate and non-CO_2 emissions sources on land, which accounted the application of fertilizers, manure left on pasture, manure applied to soils, cultivation of organic soils, crop residues decay, prescribed burning of savannahs and field burning of crop residues.

The emission from the AFOLU sector was found the 2nd highest when we compare the other sector. It accounted 33% of the total emission in the city for the year. The total GHG estimation was 1,716,064 tCO_2e. The highest contributor within this sector is the land use change which was from forest land conversion to crop and grassland which had contributed 638,034tCO_2e and 639,759tCO_2e respectively. The following figure showed that the AFOLU sector emission by sub-sectors.

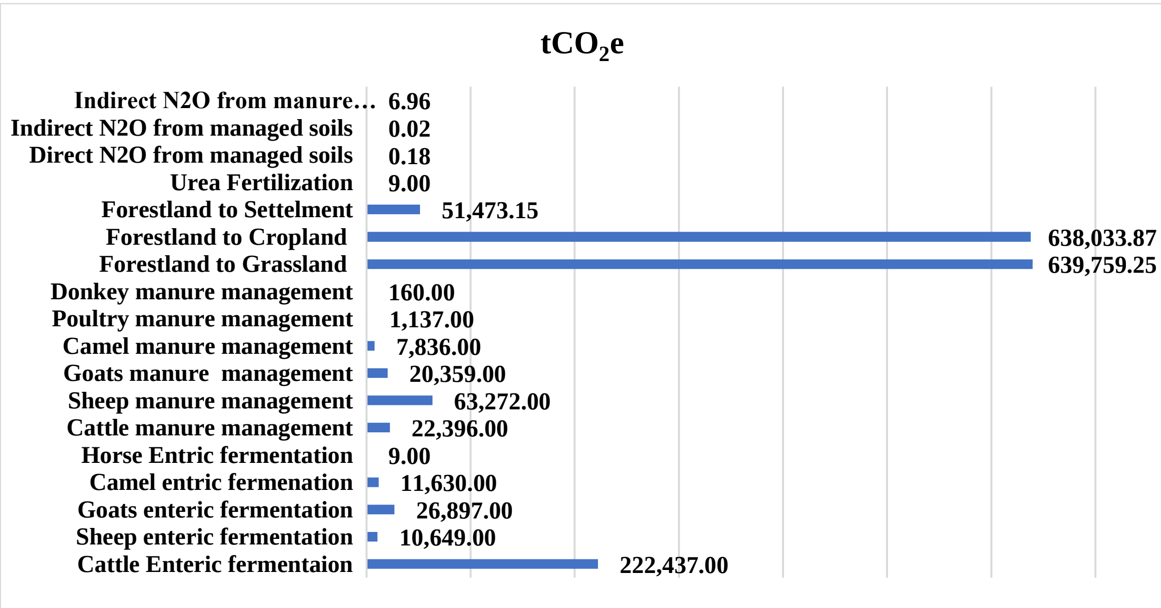


Figure 12: GHG emissions from AFOLU sectors in Dire Dawa city

Livestock

The livestock production emission has mainly methane (CH_4). It is produced by the digestive processes of livestock (enteric fermentation) and through management of their manure. N_2O is emitted from the manure management system. The number of livestock (dairy cattle, non-dairy cattle, sheep, goat and poultry) in the city was sourced from the Dire Dawa EPA and CSA data.

The GHG emissions from enteric fermentation were 271,622 tCO_2e whereas Emissions of manure management was 115,160 tCO_2e.

Land

The land use change category emission estimated was the highest emitter in the AFOLU sector. The emission estimation was projected from the land use change data from Dire Dawa EPA using an average carbon pool emission factor. Based on the finding the emission from the all-land use change estimated 1,329,266 tCO_2e.

Table 12:Land use Change Emission

Initial/ Final (2000-2018)	2018 Land use (ha)	Biomass (AG +BG)		Deadwood		SOC		tCO_2e		
		Carbon Stock (t CO_2/ha)		Carbon Stock (tCO_2/ha)		Carbon Release (tCO_2/ha/Yr)		Carbon Stored	Carbon Released	Net Released
		Initial	Final	Initial	Final	Initial	Final			
FL to GL	34,563.59	347.45	22	3.55	2.5	2	9	(11,285,012 .14)	230,654.36	639,759. 25
FL to CL	37,449	347.45	75.5	3.55	3	2	37	(10,204,852 .50)	1,279,757. 16	638,033. 87
FL to SL	2,816	347.45	20	3.55	0	2	0	(932,148.96)	(5,632.32)	51,473.1 5

Aggregate sources and non-CO_2 emission sources on land

The emission from aggregate sources and non-CO_2 emission sources on land were calculated based on the data on the use of urea fertilizer consumption in the city agricultural land. The emissions from fertilizers were 9 tCO_2e. The direct and indirect N_2O emission also calculated as shown in the Figure 12.

6. Uncertainty and Key Categories analysis

a) Uncertainty

The IPCC uses "tiers" to rank methodology, and increasing accuracy in methodology often requires more detailed or higher quality data.

In the GPC, where relevant, references are provided within each emission source category to the corresponding IPCC methodology tiers and methods. In addition to identifying the method used to calculate emissions, our GHGIR has evaluated the quality of both the activity data and the emission factors used. Each of these is assessed as high, medium or low, based on the degree to which data reflect the geographical location of the activity, the time or age of the activity and any technologies used, the assessment boundary and emission source, and whether data have been obtained from reliable and verifiable sources. See for each sector and sub-sectors in the Annexes.

b) Key categories

According to IPCC guideline, a key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals. The analysis should be performed at the level of IPCC categories or subcategories at which the IPCC methods and decision trees are generally provided in the sectoral volumes.

Where, both national- and city-level GHG inventories represent geographically explicit entities, and can share similar boundary setting principles and emission calculation methodologies. The main difference between city-level accounting and national-level accounting is that due to relatively smaller geographic coverage, "in-boundary" activities for a country can become transboundary activities for a city. In addition, 2006 IPCC Guidelines divide emissions sources into four sectors: Energy, IPPU, Waste and AFOLU. GPC reviewed standards generally followed this division method, except for some minor adaptations, which include using two major categories—Stationary and Mobile—instead of Energy, and adding an additional major category of Upstream Emissions.

In general, the IPCC Guidelines, has developed for national GHG inventories, provide detailed guidance on uncertainty management and key categories analysis but in GPC, there is no guidance and methodologies for both purposes of analysis. Despite challenges such as this, an indication of data quality is provided for each data point and exclusions are identified transparently in the inventory with appropriate notation keys. A rigorous assessment of the overall uncertainty has not been made with the hope that improvements can be prepare in future GHG inventories. But, Emissions by subsector has been analyzed for the year 2018 in our reports, which has almost comparable to identifications of IPCC key categories- level assessment.

7. Conclusion and Recommendations

7.1 Conclusion

GHG emission inventory is not a one-time action. The DDCA needs to account its emission continuously by establishing institutional arrangement that can make available those data which are necessary to undertake GHG emission inventory. It is important also to take measure on highest prioritized sector which has highest mitigation potential which will help to contribute to the national climate resilience green economy strategy (CRGE) goal/ NDC goal and the Paris Climate Change Agreement.

This inventory represents the first in an envisioned series of emissions inventories through using GPC GHG emission estimation protocol. Through the inventory process, it is observed that there are data gaps in data availability and quality. There is room for data improvement, but the inventory presents a good indicative picture of the emissions and potential mitigation action that the city should focus for total effort towards carbon-neutral economy. The emission inventory shows the amount of emission released to the atmosphere as result of different human activities in the DDCA was 5.2$MTCO_2e$ in 2018. The sources of GHG emissions are transportation, energy use, waste, IPPU and AFOLU. The emission from the Stationary was the highest which is followed by AFOLU and IPPU respectively. The inventory will be used to prepare the emission reduction target and monitor the emission over time. The highest emitter sectors will be prioritized in the city climate action plan that reduce the existing emission.

7.2 Recommendation

Two recommendations were suggested to increase the accuracy and reliability of future GHG emission estimation and to reduce emission in the city. These are:

- Strengthen the data system:

Ø Activity Data: Most of the data used in the calculation of the ONRS emission come from the national level data. These reduced the accuracy of GHG estimation. The ONRS should consider the types of data required to make an inventory. This can be done through establishing MRV system to collect activity data and GHG calculation. The Annex 8 has GHG improvement activities that the region should address in the subsequent emission inventories like include the reporting of activities data as part of institutional regular reporting system.

Ø Emission Factors and defaults: It is crucial to improve the emission factors and other defaults through developing national, regions, and cities wise. E.g., Develop an emission factor for tire 2 and tire 3 level. It will increase the quality of the GHG emission estimation.

- Methodologies: Emission calculation numerical figures result varies when we use different methodologies, activity data sources, global warming potential and emission factors. The national EPA should develop a customized protocol where the it will make similar across the sub-national level inventories. This will increase the comparability and helps to do national aggregate.
- Capacity building training: The national level, regions and cities should start to build their technical capacities to undertake similar assignment in the future. It is important to train experts to have verified certificate which will help them to lead similar GHG emission inventories exercise with their regions, Therefore, experts should train with IPCC and GPC guideline and protocol
- Update the inventory: it is important to update the inventory in two years interval time. Which can be feed to the national level activities such as NDC update, national communication, biannual reports etc. It is important also to consider recalculation of some of the sector whenever better emission factors and activities data are obtained. This should be done based on the IPCC and GPC guidelines.
- Climate Action Planning: Develop a climate action plan that can reduce emission from the highest priorities sector.

Annex 1: Abbreviations

a) Abbreviations for Greenhouse Gases and Chemical Compounds

CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
NF_3	Nitrogen trifluoride
SF_6	Sulphur hexafluoride
CO	Carbon monoxide
NMVOC	Non-methane volatile organic compound
NOx	Nitrogen oxides (reported as nitrogen dioxide)
SO_2	Sulphur oxides (reported as Sulphur dioxide)

b) Abbreviations for Technical Terms

GPC	Global Protocol for Community-Scale GHG Emission Inventories
IPCC	Intergovernmental Panel on Climate Change
C40	C40 Cities Climate Leadership Group
CIRIS	Inventory Reporting and Information System
IPPU	Industrial Processes and Product Use
AFOLU	Agriculture, Forestry and Other Land Use
GHG	Greenhouse Gas
GWP	Global Warming Potential
AR2 / AR4 / AR5	2^{nd} / 4^{th}/ 5^{th} Assessment Report of the IPCC

Annex 2: Stationary Energy Activity Data, Data Sources and Emission Result

Energy Type	Activity Data		Emission Factor			GHG Emission				AD Quality	EF Quality	Data Source
	Amount	Unit	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total tCO_2e			
Residential												
Wood or wood waste	576,524,400	kg		7.50	1.19	-	87,904	13,971	101,873	L	L	CSA
Charcoal	18,692,496	kg		5.00	0.30	-	2,757	164	2,921	L	L	CSA
Wood or wood waste	87,422,290	kg		7.50	1.19	-	13,329	2,118	15,448	L	L	CSA
Wood or wood waste	628,043,724	kg		7.50	1.19	-	95,758	15,219	110,977	L	L	CSA
Municipal wastes (biomass fraction)	57,097,758	kg		7.50		-	5,528	-	5,528	L	L	CSA
Kerosene	1,873,848	l (litre)	71.90	0.25	0.18	5,069	18	13	5,100	L	L	CSA
Liquefied Petroleum Gas (LPG)	157	l (litre)	61.30	0.13	0.03	0	0	0	0.25	L	L	CSA
Electricity	93	TJ				2	-	2	4	L	L	Dire Dawa Energy Bureau
Commercial and Institutional		Please select	-	-	-							
Wood or wood waste	123,949,174	kg		7.50	1.19	-	18,899	3,004	21,902	L	L	CSA
Liquefied Petroleum Gas (LPG)	3,002,035	l (litre)	61.30	0.13	0.03	4,719	10	2	4,731	L	L	CSA

Diesel Oil	45	TJ	74.10	0.25	0.18	3,349	11	8	3,369	L	L	Dire Dawa Energy Bureau
Electricity	69	TJ				2	-	1	3	L	L	Dire Dawa Energy Bureau
Manufacturing and Industry		Please select	-	-	-							
Residual fuel oil	1,090	tonne	77.40	0.08	0.18	3,408	3	8	3,419	M	L	EPSE
Residual fuel oil	1,065	tonne	77.40	0.08	0.18	3,331	3	8	3,342	M	L	EPSE
Coal	634,910	tonne	94.60	0.03	0.45	1,744,925	461	8,245	1,753,631			
Electricity	186	TJ				5		4	9	L	L	Dire Dawa Energy Bureau
Energy Industries												
Wood or wood waste	1,085,537,578	kg		8	1	-	165,512	26,305	191,818	L	L	CSA

Annex 3: Transport Activity Data, Traffic Count and Data Sources and Emission Result

Transport Activities	Scope 1	Activity Data		Emission Factor			GHG Emission				AD Quality	EF Quality
		Amount	Unit	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total tCO_2e		
On-road												
Car Gasoline	1	2,687,300	litres	73.00	0.2500	3.278	6,835	23	307	7,165	L	L
Car Diesel	1	3,032,700	litres	74.80	0.2375	3.576	8,732	28	417	9,177	L	L
Bus Gasoline	1	6,058,611	litres	73.00	0.2500	3.278	15,409	53	692	16,154	L	L
Bus Diesel	1	3,590,253	litres	74.80	0.2375	3.576	10,337	33	494	10,864	L	L
Trucks Diesel	1	8,471,429	litres	74.80	0.2375	3.576	24,391	77	1,166	25,634	L	L
Trucks and Trail	1	66,667	litres	74.80	0.2375	3.576	192	1	9	202	L	L
Bajaj	1	18,794,769	litres	73.00	0.2500	3.278	47,801	164	2,146	50,111	L	L
Motor Bi-cycle	1	872,616	litres	73.00	0.2500	3.278	2,219	8	100	2,327	L	L
Car Gasoline	3	246,033	litres	73.00	0.2500	3.278	626	2	28	656	L	L
Car Diesel	3	479,765	litres	74.80	0.2375	3.576	1,381	4	66	1,451	L	L
Bus Gasoline	3	462,895	litres	73.00	0.2500	3.278	1,177	4	53	1,234	L	L
Bus Diesel	3	684,874	litres	74.80	0.2375	3.576	1,972	6	94	2,072	L	L
Trucks Diesel	3	1,246,913	litres	74.80	0.2375	3.576	3,590	11	172	3,773	L	L
Trucks and Trail Diesel	3	1,021,894	litres	74.80	0.2375	3.576	2,942	9	141	3,092	L	L

Off-road												
Combiner	1	1,440	litres	74.8	0.2375	3.576	4	-	-	4	L	L
Forklift	1	15,360	litres	74.8	0.2375	3.576	44	-	2	46	L	L
Grader	1	16640	litres	74.8	0.2375	3.576	48	0	2	50	L	L
Tractor	1	30240	litres	74.8	0.2375	3.576	87	0	4	91	L	L
Dual Purpose Vehicle	1	4384000	litres	74.8	0.2375	3.576	12623	40	603	13,266	L	L
Aviation												
Jet-fuel Consumption	3	1,108,841	litres	0.002611	0.000425	0.020562	2,895	475	22,800	26,170	M	M
Total Emission							143,305	938	29,296	173,539		
Data Sources: Vehicle stock from Dire Dawa Transport Bureau, Traffic count from Ethiopian Road Authority, Fuel Economy from Dire Dawa Transport Bureau and Global fuel Economy Study												

Traffic Count Data

										VEHICLE KILOMETER OF TRAVEL				
ROAD NO	ROUTE NO	ROUTE NAME		LENGT	CARS	BUSES	TRUCK	TRUCK TRAILE	TOTAL	CARS	BUSES	TRUCKS	TRUCK & TRAILER	TOTAL
A10a	10	DENGEGO	DIREDEW	20	436	856	1,362	1,043	3,697	8,720	17,120	27,240	20,860	73,940
C101	8	ERER	DIREDEWA	56	264	264	654	116	1,298	14,784	14,784	36,624	6,496	72,688
E100	82	DIRE DAWA	SHINILE	10	77	42	340	496	955	770	420	3,400	4,960	9,550
				86	777	1162	2356	1655	5950	24274	32324	67264	32316	156178

Annex 4: Waste Activity Data, Data Sources and Emission Result

Waste Activities	Scope	Activity Data		GHG Emission					AD Quality	EF Quality	Source
		Amount	Unit	CO_2	CH_4	N_2O	Total tCO_2e	CO_2(b)			
Solid Waste											
Municipal solid waste	1	279,793	tonne		335,304		335,304	18,544	L	L	Dire Dawa Waste Management Bureau
Composting	1	14,726	tonne		740	530	1,270		L	L	
Waste Water											
Domestic Wastewater	1	479,000	Population		45,654	5,494	51,148		L	L	IPCC default and Ministry of Industry
Industrial Wastewater	1	3,558	tonne product		502		502		L	L	

Annex 5: IPPU Activity Data, Data Sources and Emission Result

IPPU Activities	Activity Data		Emission Factor			AD Quality	EF Quality	Data Sources
	Amount	Unit	Units	CO_2	Total tCO_2e			
Industrial Processes								
Clinker	1,405,000	tonne	tCO_2e/TJ	0.51	716,550	L	L	Dire Dawa Industry Bureau and Ministry of Industry
Glass	1,415	tonne	tCO_2e/TJ	0.10	142	L	L	
Soda Ash	158	tonne	tCO_2e/TJ	0.44	80	L	L	
Iron and Steel Production	624	tonne	tCO_2e/TJ	3.60	2,246	L	L	
Ferroalloy production	68	tonne	tCO_2e/TJ	3.60	34	L	L	
Product use			tCO_2e/TJ					
Lubricant	162	TJ	tCO_2e/TJ	14.67	83	L	L	
Paraffin	2	TJ	tCO_2e/TJ	14.67	1	L	L	

Annex 6: AFOLU Activity Data, Data Sources and Emission Result

AFOLU Activities	Activity Data (No Head)	Emission Factor (tCO2e/head)				GHG Emission				AD Quality	EF Quality	Data Source
	Amount	Units	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total tCO_2e			
Livestock Emission												
Cattle Enteric fermentation	171741	tCO_2e/head		1.2951875		-	222,437	-	222,437	L	L	
Sheep enteric fermentation	59576	tCO_2e/head		0.17875		-	10,649		10,649	L	L	
Goats' enteric fermentation	181123	tCO_2e/head		0.1485		-	26,897		26,897	L	L	
Camel enteric fermentation	10113	tCO_2e/head		1.15		-	11,630		11,630	L	L	
Horse Enteric fermentation	19	tCO_2e/head		0.45		-	9		9	L	L	
Mule and asses Enteric fermentation	0	tCO_2e/head		0.25		-	-		-	L	L	
Cattle manure management	171741	tCO_2e/head			0.1304048	-		22,396	22,396	L	L	Dire Dawa EPA and CSA Data
Sheep manure management	59576	tCO_2e/head		0.004125	1.0579	-	246	63,026	63,272	L	L	
Goats manure management	181123	tCO_2e/head			0.1124056	-		20,359	20,359	L	L	
Camel manure management	10113	tCO_2e/head			0.7748	-		7,836	7,836	L	L	
Horse manure management	19	tCO_2e/head	0	0	0				-	L	L	
Mule and asses manure management	0	tCO_2e/head	0	0	0				-	L	L	
Poultry manure management	40460	tCO_2e/head			0.0281014	-		1,137	1,137	L	L	
Donkey manure management	31789	tCO_2e/head			0.0050362	-		160	160	L	L	
Land use/Land use change												
Forestland to Grassland		Emission				639,759			639,759			
Forestland to Cropland		Emission				638,034			638,034			

Forestland to Settlement		**Emission**				**51,473**			**51,473**			
AGGREGATE SOURCES												
Urea Fertilization	**0.500**	**tonne**		**18.3330**			**9**		**9.00**	**L**	**L**	**CSA**
Direct N_2O from managed soils	**Emission**							**0.18**	**0.18**			
Indirect N_2O from managed soils	**Emission**							**0.02**	**0.02**			
Indirect N_2O from manure management	**Emission**	**7**						**6.96**	**6.96**			

Annex 7: Summary of methods and assumptions

Source	Method	Assumption
Stationary Energy		
Biomass energy	Activity data x emission factor	Average national data for energy consumption from CSA
Kerosene	Activity data x emission factor	
Electric	Activity data x emission factor	
LPG	Activity data x emission factor	
Diesel Oil	Activity data x emission factor	
Gasoline Oil	Activity data x emission factor	
Residual fuel	Activity data x emission factor	
Transport		
On-Road		
Diesel	Induced activity method. Activity data x emission factor	Vehicles travel data, fuel economy and traffic count
Gasoline	Induced activity method. Activity data x emission factor	
Aviation	Fuel consumption approach	
Waste		
Municipal Solid Waste	Methane commitment approach, using CIRIS calculator	CIRIS solid waste calculator used for methane commitment method. Waste composition data available. Tonnage is for 2018. No landfill gas capture or energy, unmanaged site, >5m deep. Assumed all organic waste is food waste and the waste composition of board is assumed to be wood.
Composting-all organic waste	Using CIRIS calculator	CIRIS biological treatment calculator used. Assumed 5% of organic waste fraction of total solid waste is composted - household composting and some associations. Used IPCC default factors from CIRIS calculator. Assumed wet waste.
Domestic wastewater	Using CIRIS calculator	Using the population data and IPCC default factor
Industrial wastewater	Using CIRIS calculator	Calculated using CIRIS wastewater calculator for industrial wastewater, based on tone-product data of key industries scaled to Dire Dawa City based on national population
IPPU		
Lubricant and Paraffin	Activity data x emission factor	Data from Dire Dawa EPA
Clinker, Glass, Soda Ash, Iron and Steel Production and Ferroalloy production	Activity data x emission factor	
AFOLU		
Enteric fermentation	Activity data x emission factor	The activity data is the numbers of livestock (head) data has been multiplied by IPCC 2006 default values for livestock types and Inventory of greenhouse gas emissions from cattle, sheep and goats in Ethiopia (1994-2018) calculated using the IPCC Tier 2 approach
Manure management	Activity data x emission factor	Manure management N_2O are estimated following IPCC 2006 Guidelines, calculating an implied emission factor for each livestock category and manure management regime. Dung used as fuel has been excluded. All IPCC defaults are used except for proportions of manure management systems utilized taken from the Ethiopia 2nd National Communication and Inventory of greenhouse gas emissions from cattle, sheep and goats in Ethiopia (1994-2018) calculated using the IPCC Tier 2 approach
Urea fertilizer application	Activity data x emission factor	Activity data is urea fertilizer applied to agricultural land and default emission factor from IPCC 2006 guideline

Annex 8: GHG Inventory Improvements

Source	Improvement
Stationary Energy	
Biomass energy	• The data in the energy balance of the city is very outdated (It was done in 2002), if the city can undertake the energy balance of the city which enable to understand the energy consumption of biomass, fossil fuel etc. and emission trend in the city • Strengthen the data quality for energy consumption by buildings and energy types • Include the reporting of activities data as part of institutional regular reporting system • The city administration should also work to improve the emission factors through developing citywide emission factors such as tire 2 and tire 3 level.
Kerosene	
Electricity	
LPG	
Diesel Oil	
Gasoline Oil-	
Residual fuel	
Transport	
On-Road	
Diesel	• Develop mechanisms to collect activity data through annual vehicle inspection program e.g. of data type such fuel economy, annual kilometer travel, vehicle age etc. • Develop a mechanism to collect the amount of fuel sale to vehicles from fuel suppliers • The city administration should also work to improve the emission factors through developing city wise emission factors such as tire 2 and tire 3 level. • Include the reporting of activities data as part of institutional regular reporting system
Gasoline	
Waste	
Municipal Solid Waste	There is a data gaps in the waste and wastewater sector. The activity data gaps should be filled in the subsequent inventories. These include • Waste converted in to biological treatment, • Amount of waste managed by open burning and incineration. • Respective department should work to fill the data gaps • The city administration should also work to improve the emission factors through developing city wise emission factors such as tire 2 and tire 3 level. • Include the reporting of activities data as part of institutional regular reporting system
Composting-all organic waste	
Open burning of waste/incineration	
Domestic wastewater	
Industrial wastewater	
IPPU	
Industrial Product	
Lubricant	• Fill the data gaps in relation to industrial product consumption and industrial process activity data at city level • The city administration should also work to improve the emission factors through developing city wise emission factors such as tire 2 and tire 3 level. • Include the reporting of activities data as part of institutional regular reporting system
Paraffin	
Industrial Process	
Clinker	• The industrial process activities data were derived from the national figures. There is a need to fill the data gaps in the subsequent inventories by strengthening data collection system from industries at the city level • The city should also work to improve the emission factors through developing city wise emission factors such as tire 2 and tire 3 level. • Include the reporting of activities data as part of institutional regular reporting system
Glass	
Soda Ash	
Iron and Steel Production	
Ferroalloy production	
AFOLU	
Livestock	The livestock sector had relatively a quality data compared to other sectors.

	• The city administration with relevant department such as agriculture bureau and CSA are collecting data relevant for undertaking emission such as livestock head by city and some of the livestock management practices, these is good and needs to be strengthen • It is good to strengthen the quality data that enables to have an accurate number of livestock, feeding and manure management practices. • The city should also work to improve the emission factors through developing city wise emission factors such as tire 2 and tire 3 level. • Include the reporting of activities data as part of institutional regular reporting system
Land	• There is a huge data gaps in accessing the land use and land use changes, needs to establish a system to track the land use changes. • It is good practice if the city can collect the data i.e., yearly or one time in two years etc. • The city should also work to improve the emission factors through developing city wise emission factors such as tire 2 and tire 3 level. • Include the reporting of activities data as part of institutional regular reporting system
Aggregate Sources	• There are huge activity data gaps for aggregate sources emission such as direct and indirect N_2O emission from soil and management, it is important to fill the data gaps in subsequent inventories. • The city should also work to improve the emission factors through developing city wise emission factors such as tire 2 and tire 3 level. • Include the reporting of activities data as part of institutional regular reporting system

Annex 9: Global Warming Potentials

GWPs used in the calculation of emissions

Table A 9.1 Global warming potentials (GWP) used in calculations, adapted from IPCC 2006 Guidelines.

Industrial designation or common name	Chemical formula	Lifetime (years)	Radiative efficiency ($W\ m^{-2}\ ppb^{-1}$)	Global warming potential for given time horizon (100 years)
Carbon dioxide	CO_2		$1.4x10^{-5}$	1
Methane	CH_4	12	$3.7x10^{-4}$	25
Nitrous oxide	N_2O	114	$3.03x10^{-3}$	298

Annex 10: GPC Definitions

Sectors and sub-sectors	Definition
Stationary energy	GHG emissions come from fuel combustion, as well as fugitive emissions released in the process of generating, delivering, and consuming useful forms of energy (such as electric or heat).
Residential buildings	All emissions from energy use in households
Commercial buildings	All emissions from energy use in commercial buildings and facilities
Institutional buildings	All emissions from energy use in public buildings such as schools, hospitals, government offices, highway street lighting, and other public facilities
Manufacturing industries and construction	All emissions from energy use in industrial facilities and construction activities, except those included in energy industries sub-sector. This also includes combustion for the generation of electric and heat for own use in these industries
Energy industries	All emissions from energy production and use in energy industries
Energy generation supplied to the grid	All emissions from the generation of energy for grid-distributed electric, steam, heat and cooling
Agriculture, forestry, and fishing activities	All emissions from energy use in agriculture, forestry, and fishing activities
Non-specified sources	All remaining emissions from facilities producing or consuming energy not specified elsewhere
Fugitive emissions from mining, processing, storage, and transportation of coal	Includes all intentional and unintentional emissions from the extraction, processing, storage and transport of fuel in the
Fugitive emissions from oil and natural gas systems	Fugitive emissions from all oil and natural gas activities occurring in the. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases.
Transportation	transportation systems are designed to move people and goods within and beyond borders. Transport vehicles and mobile equipment or machinery produce GHG emissions directly by combusting fuel or indirectly by consuming grid-delivered electric.
On-road	On-road vehicles are designed for transporting people, property or material on common or public roads, thoroughfares, or highways. This category includes vehicles such as buses, cars, taxis, trucks, motorcycles, on-road waste collection and transportation vehicles (e.g., compactor trucks), etc.
Railways	Railways typically use energy through combustion of diesel fuels or electric. Railways can be divided into four sub-categories: urban railway subway systems inc. trams, regional commuter rail national rail and international rail. Each can be further classified as passenger or freight.
Waterborne navigation	Water transportation includes ships, ferries, and other boats operating within the boundary, as well as marine-vessels whose journeys originate or end at ports within the 's boundary but travel to destinations outside of the.

Sectors and sub-sectors	Definition
Aviation	Civil aviation, or air travel, includes emissions from airborne trips occurring within the geographic boundary (e.g., helicopters operating within the) and emissions from flights departing airports that serve the
Off-road	Off-road vehicles are those designed or adapted for travel on unpaved terrain. This category typically includes airport ground support equipment, all-terrain vehicles, landscaping and construction equipment, bulldozers, forklifts, snowmobiles etc.
Waste	Waste disposal and treatment produces GHG emissions through aerobic or anaerobic decomposition, or incineration.
Solid waste generated in the	Solid waste may be disposed of at managed sites (e.g., sanitary landfill and managed dumps), and at unmanaged disposal sites (e.g., open dumps, including above-ground piles, holes in the ground, and dumping into natural features, such as ravines)
Biological waste generated in the	The biological treatment of waste refers to composting and anaerobic digestion of organic waste, such as food waste, garden and park waste, sludge, and other organic waste sources.
Incinerated and burned waste generated in the	Incineration is a controlled, industrial process, often with energy recovery where inputs and emissions can be measured and data is often available. By contrast, open burning is an uncontrolled, often illicit process with different emissions and can typically only be estimated based on collection rates.
Wastewater generated in the	Wastewater can be treated aerobically (in presence of oxygen) or anaerobically (in absence of oxygen). Wastewater can generally be categorized as domestic wastewater or industrial wastewater, and cities must report emissions from both.
Industrial processes and product use	GHG emissions resulting from non-energy related industrial activities and product uses. All GHG emissions occurring from industrial processes, product use, and non-energy uses of fossil fuel, shall be reported under IPPU.
Industrial processes	GHG emissions are produced from a wide variety of industrial activities. The main emission sources are releases from industrial processes that chemically or physically transform materials. Note, if fuels are combusted for energy use, the emission shall be reported under Stationary Energy.
Product use	Products such as refrigerants, foams or aerosol cans can release potent GHG emissions
Agriculture, forestry, and fishing activities	GHG emissions are produced through a variety of pathways, including land-use change that alter the composition of the soil, methane produced in the digestive processes of livestock, and nutrient management for agricultural purposes.
Livestock	Livestock production emits CH_4 through enteric fermentation, and both CH_4 and N_2O through management of their manure.
Land	Emissions and removals of CO_2 are based on changes in ecosystem C stocks and are estimated for each land-use category. C stocks consist of above-ground and below-ground biomass, dead organic matter, and soil organic matter.
Other agriculture	Other sources of GHG emissions from land include rice cultivation, fertilizer use, liming, and urea application.
Other scope 3	Cities may optionally report other scope 3 emissions, such as GHG emissions embodied in fuels, water, food and construction materials.