Ethiopia: Transport Sector GHG Emissions

FDRE: Ministry of Transport

Federal Democratic Republic Of Ethiopia
Ministry of Transport
Transport Sector GHG Inventory Report
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Addis Ababa, Ethiopia

Echnoserve Consulting (www.echnoserve.com) has prepared this report on behalf of the Ministry of Transport (MoT).

ACRONYMS

AD: Activity Data
BAU: Business as Usual
CRGE: Climate Resilience Green Economy
GDP: Gross Domestic Product
GTP II: Growth and Transformation Plan II
GHG: Greenhouses Gas
EF: Emission Factor
IPCC: Inter-governmental Panel on Climate Change
LTR: Light Rail Transit
MEFCC: Ministry of Environment Forest and Climate Change
MoFEC: Ministry of Finance and Economic Cooperation
MoT: Ministry of Transport
Mt CO2e: Millions of Metric ton Carbon dioxide
ppmv: parts per million by volume
tCO_2e ton of Carbon dioxide Equivalent
USD: United Stated Dollar
UNFCCC: United Nations Framework Convention on Climate Change
VKT: Vehicles Kilometer Traveled
VKM: Vehicles kilometer

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

EXECUTIVE SUMMARY

The Government of the Federal Democratic Republic of Ethiopia launched Climate Resilient Green Economy (CRGE) Strategy in 2012 to insure sustainable and environmentally friendly economic growth. Ethiopia aspires to reach a middle-income country by 2025 and sets a goal of double-digit economic growth needs a green economy strategy that helps in multidimensional aspects to the country, which is highly vulnerable to climate change. As part of their mandate, sectorial ministries are required to prepare annual Greenhouse Gas (GHG) inventory. The preparation and reporting of national GHG inventories can provide a number of benefits to a country in addition to meeting national UNFCCC reporting obligations.

This report is one of the first sectorial GHG reporting conducted to account the country's transport sector GHG emissions. It is done based the principles and methodology set in the 2006 IPCC guideline. Accordingly, emissions from mobile combustion are estimated by major transport activity, i.e., road, off-road, air, and water-borne navigation and railway is included in the inventory. The report was done for 2014, 2015, 2016 as well as projection for 2017-2030. Since as per the 1996 Revised Guidelines, international aviation and maritime transport are not considered as national emissions and are reported separately under international bunkers.

Ethiopia's transport sector GHG emission was 6,647,656 tCO_2e in 2014 and that number grew by about 27% in 2015 to 8,456,864 tCO2e and another 48 % to about 12,544,346 tCO_2e in 2016. During the inventory years (2014-2016), road transport accounted for the major emission which was an average 96% of the transport emission and Addis Ababa City took the major sources of GHG emissions as compared to other regions.

Under the business usual Scenario i.e. assuming if no new mitigation measures are implemented between 2017-2030, the emission from the transport sector will grow from 12,544,346 tCO_2e in 2016 to 53,227,425 tCO2e by 2030. The projection is made taking average growth rate of 10.8% per year which was used in the CRGE strategy. Emission from road transport will grow from 11,635,203 tCO_2e in 2016 to 49,367,920 tCO_2e by 2030, accounting for the majority (93%) of emission from transport sector by 2030.

The 2016 and 2015 inventory for rail transport focused on emission removal from Addis Ababa Light Rail Transit. In 2016 the Addis Ababa LRT transported total of 161,755 passengers per day, which would have been transported by public road transport (Minibus, midi bus and Maxi bus) that run on fossil fuel. Assuming that the operation of the Addis Ababa Electric LRT replaced traffic that would otherwise be made by public transit, the emission removed by LRT is estimated to be 6,272 tCO_2e in 2016. The passenger transported by LRT (120,000 passenger per day) represents 5% of Addis Ababa's daily passenger using public transport, which is about 3,172,401 passenger/day. 2015 GHG reduction from Addis Ababa Light Rail Transit was about 4,652 tCO_2e.

I. INTRODUCTION

I. INTRODUCTION

I.1 Background Information

The world's governments adopted the United Nations Framework Convention on Climate Change (UNFCCC) on 9 May 1992. The UNFCCC entered into force on 21 March 1994 and as of 24 May 2004, 189 countries were Parties to the Convention.

Ethiopia was one of the countries to these parties of convention and ratifies the UNFCC convention in 1994. The objective of the UNFCCC is to stabilize greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous human-induced interference with the climate system. It receives countries GHG reduction plans and reports in various ways of platforms to enforce and manage their GHG emissions.

The Government of the Federal Democratic Republic of Ethiopia launched the Ethiopia s CRGE Strategy in 2012 to insure sustainable and environmentally friendly economic growth. Ethiopia aspires to reach a middle-income country by 2025 and sets a goal of double-digit economic growth needs a green economy strategy that helps in multidimensional aspects to the country, which is highly vulnerable to climate change. It has triple goals of economic growth, net-zero emission and building resilience. With these goals, the CRGE facility is established and has ministerial steering, technical and management committee that comprised of the Ministry of Finance and Economic Cooperation (MoFEC) and Ministry of Environment Forest and Climate Change (MEFCC). Sectorial ministries such as the Ministry of Transport are considered implementing entities. The Ministry of Transport is mandated for the transport sector for the overall developmental endeavour on the part of the transport CRGE strategy, which also is integrated with GTP II.

As part of their mandate, sectorial ministries are required to prepare annual Greenhouse Gas (GHG) inventory. The preparation and reporting of national GHG inventories can provide a number of benefits to a country in addition to meeting national UNFCCC reporting obligations.

These benefits include:

- Providing information useful to economic development assessment and planning, such as information on the supply and utilization of natural resources, industrial demand and production;
- Providing information useful for addressing other environmental issues (e.g., air quality, land use, waste management, etc.);
- Clarifying national data gaps that, if filled, may be beneficial for other reasons, e.g., vehicle fleet data;
- Evaluating GHG mitigation options; and
- Providing the foundation for emissions trading schemes.

This report is one of the first sectorial GHG reporting conducted to account the country's transport sector GHG emissions. It is done based the principles and methodology set in the 2006 IPCC guideline. Accordingly, emissions from mobile combustion are most estimated by major transport activity, i.e., road, off-road, air, railways, and water-borne navigation.

The report has four sections. Section I covers introduction to CRGE and global GHG emissions of the transport sector. Section II covers methodology used to conduct the GHG inventory report; section III has GHG inventory results and section IV has conclusion and recommendations.

I.2 Ethiopia's Green Economy Strategy

The CRGE was launched in 2012. Its initiative aims to "climate-proof" its National Development Plan goals so as to stabilize its net greenhouse gas emission while building resilience to against current climate risks and future climate change and to laid the foundation for green development and help the country achieve middle income status by 2025. It led to establishment of new institutions, new efforts in capacity building and financial resource mobilization, and triggered comprehensive climate risk and vulnerability analyses.

The CRGE strategy estimated that if a business as usual path were followed, emissions would increase from 150 Mt to 400 Mt CO2e (2010 to 2030). The current Ethiopia's total emissions of around 150 $MtCO_2e$ represent less than 0.3% of global emissions. Of the 150 $MtCO_2e$ in 2010, more than 85% of GHG emissions came from the agricultural and forestry sectors. These are followed by power, transport, industry and buildings which contributed 3% each.

The CRGE strategy has indicated that the baseline emission from the transport sector was around 4.5 Mt CO2e in 2010. Around 75% of the emissions come from road transport, particularly freight and construction vehicles, and to a lesser extent private passenger vehicles. Air transport also contributes a significant share (23% of transport related emissions). Emissions from inland water transport are minimal. Emissions from transport in Ethiopia are projected to grow from around 5 MtCO2e in 2010 to 40 MtCO2e in 2030. The increased emissions are driven first by higher emissions from freight transport (+13% p.a.) and also by higher emissions from passenger transport (+9% p.a.) (CRGE, 2010).

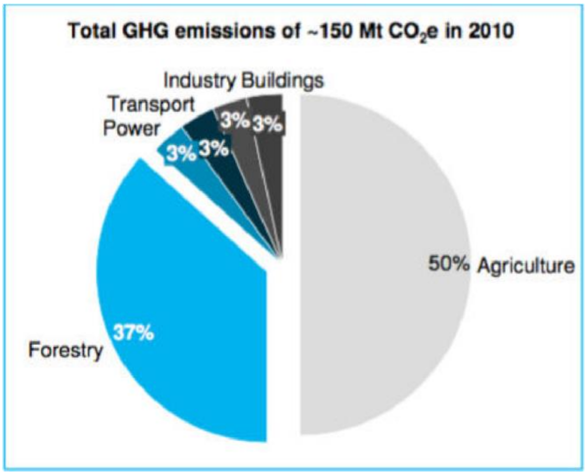

Figure 1: Ethiopia's GHG Emissions by Sectors-2010 (Source CRGE)

Transport offers various opportunities to decrease emissions. All of these opportunities achieve their abatement potential through increased efficiency or a shift to lower-emitting fuel. The largest initiatives with the greatest abatement potential are the construction of an electric rail network (9 Mt CO2e) followed by the introduction of fuel efficiency standards for all vehicles (3 Mt CO2e). This assumes the construction of more than 5000 km of rail tracks and new fuel efficiency standards for 30% of passenger vehicles and 10% of freight vehicles by 2030. Although the abatement potential is not as large, the introduction of bio-fuels will also form a priority. The combined abatement potential of increasing the use of ethanol and biodiesel in the fuel mix is 1 Mt CO2e. (CRGE, 2010)

The CRGE strategy has indicated that incorporating 5% biodiesel into the national diesel fuel mixture has an abatement potential of 0.7 Mt CO2e by 2030. Furthermore, the strategy has indicated that it would be possible to increase the ethanol content of the gasoline from 10% in the Addis Ababa fuel mix to 15% nationally – the maximum feasible ethanol mix that does not require mechanical alteration to vehicles – has an abatement potential of 0.2 Mt CO2e in 2030. However, such scenario might require additional modification on cars.

CRGE strategy document identified that the development of a green economy will be based on four pillars. One of these are related to transport sector, this is leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings. Based on one of these pillar, the transport sector identified eight abatement levers fall into four categories which lead to greening the transport economy, these are: i) improving the public transport system in Addis Ababa, ii) improving vehicle efficiency, iii) changing the fuel mix, and iv) constructing an electric rail network for efficient freight transport. A total abatement potential has been identified of up to 13.3 Mt CO2e in 2030. In addition to the above levers, the government is also considering other levers such as changing roads from gravel to asphalt, establishing dry ports, encouraging the use of telecommunication, promoting scooters and bicycles. These additional possible levers were not quantified as of yet due to limited expected abatement potential or current constraints in implement ability. Nonetheless, they should be considered for future implementation as the initiatives may have significant societal benefits.

These initiatives will cost USD 22.9 billion until 2030. This cost is comprised almost entirely of capital expenditure. The expenditure for the period until and including 2015 is USD 2.8 billion, mostly representing the capital expenditure for the electric rail network starting in 2013.The cost savings in the period 2011-2030 are significant as well, while the savings are less significant in the period from 2011-2015. The societal costs savings in the period until and including 2015 is USD 420 million, which leaves the country with a net cost of USD 2.4 billion. For the 20-year period of 2011-2030, these savings are even larger at USD 22.9 billion, resulting in a net societal saving of USD 10 million.

I.3 Climate Change and GHG Emissions in Transport Sector

Anthropogenic climate change is due to the fact that energy consumption and changes in land use produce large quantities of greenhouse gases as by products. The principal greenhouse gas is carbon dioxide, but methane and nitrous oxide, and certain industrial gases are also powerful. The volumes of them in the atmosphere have risen swiftly, and they remain there for decades. The annual emissions of anthropogenic carbon dioxide are around 25 billion tones (giga tonnes), of which the active component, carbon, amounts to about 6.5 giga tonnes, or roughly 1 tonne per person on Earth, though of course the emissions are predominantly from developed countries. The key issue is what proportion of the atmosphere is composed of greenhouse gases. The level of atmospheric concentrations measured in parts per million by volume (ppmv). In 2015 carbon dioxide (CO_2) reached 400 ppmv, compared to its natural level between Ice Ages, of around 280 ppmv.

The primary greenhouse gases produced by the transportation sector are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydro fluorocarbons (HFC). Carbon dioxide, a product of fossil fuel combustion, accounts for 95 % of transportation GHG emissions.

The transport sector is a significant and growing contributor of greenhouse gas emissions that lead to climate change. Transportation contributed 15% of 2015 global greenhouse gas emissions. The GHG emissions from this sector primarily involve fossil fuels burned for road, rail, air, and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel. CO_2 emissions from historical and projected energy consumption by the transportation sector show a five-fold increase in emissions between 1970 and 2050 (figure 2). Emissions growth from sea transport is relatively small, whereas air and road transport increases are huge with the highest growth rates projected for air transport.

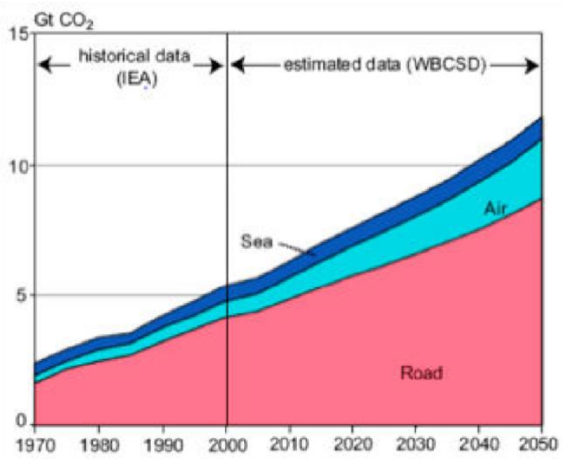

Figure 2 Global transport sector GHG emissions by mode

Apart from the causes for climate change, transport sector is also vulnerable to the impacts of climate, including heavy rains and sea level rise. Increasing in temperature and flooding making high infrastructural designs costs and damaging roads, bridges, rail roads and airport landings. An efficient, effective and climate-resilient transport sector is crucial to lower the overall cost and to increase competitiveness in the sector.

While most investments in infrastructure for transport are aimed at reducing transportation costs, facilitating trade, and improving the reliability and efficiency of networks. The incorporation of climate change adaptation and mitigation is not given wider attention. These days, studies are showing the co-benefits of climate adaptation and mitigation action in a sustainable transport approach. These include improvements in air quality, traffic safety, and increased mobility and access to goods and services for all income groups, but particularly for lower-income groups, who are more dependent upon public transport, walking, and biking. Additionally, building transport infrastructure that is more resilient to climate change may lead to increased economic returns on investments. Given that the benefits of integrating climate change mitigation strategies into projects have local costs but global benefits, such co-benefits can help make projects economically viable for countries facing key trade-offs in the allocation of scarce financial resources.

II. METHODOLOGY

II. GENERAL DESCRIPTION OF THE DATA AND METHODOLOGY

II.1 Methodological Approach

II. 1.1.Methodology Process

The GHG inventory was undertaken using secondary data collection using IPCC methodology. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories provides methodologies for estimating national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases. Based on the this methodology, there are six steps that are being used to prepare the GHG emission inventory (see Fig. 3)

Figure 3: GHG Emission Inventory Steps

Step	Activity	Task
1	Planning and Organization:	Reviewed relevant documents to determine emission sources, to identify data required and availability of data and the potential data sources.
2	Assessment:	Analyzed the available data into categories and numbers according to the data requirements for various kinds of methods.
3	Identification of Estimation Methods:	Reviewed the available estimation methods and selected methods that suit the available data for each modes of transport.
4	Estimation:	The GHG estimation involved calculation of emission by source and GHGs.
5	Data Analysis:	Analyzed the GHG estimation to shows the GHG result by gases, by modes of transports, by regions and aggregate at national level.
6	Reporting:	Prepared reported based on the data collected and analyzed, showing methodological steps, process and results for the national transport sector GHG emission

II.1.2 Planning Steps

The transport sector GHG emissions inventory includes the five modes of transport. To conduct GHG inventory, two types of data were required. These are activity data and emission factors. The activity data are includes data such as passenger's kilometre, tons of freight kilometres and the energy consumptions for both. Emission factors were also needed which are the mass of GHG emitted per unit of activities (e.g., Gg CH4 per litre of gasoline). The activities data were collected from federal, regional and cities and the emission factors are from default value of 2006 IPPC guideline under tire 1 (see fig 4).

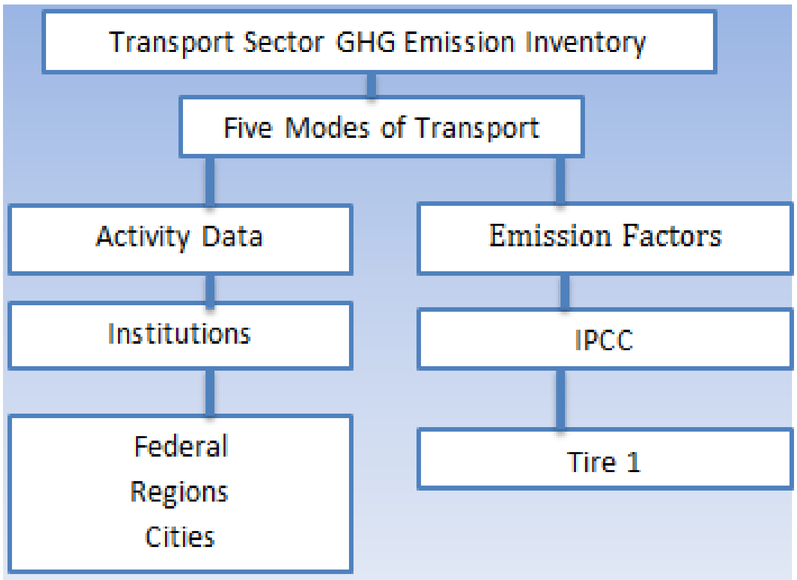

Figure 4 :Planning steps used to Conduct GHG Emission Inventory

II.1.3. Activity Data Collection

The following approaches were followed in designing the activity data collection tools and data collection. These are broadly classified into two, document review and stakeholder consultation. Here is the detail under these:

- **Document Review**: The research team has conducted document review at the initial stage of the project implementation. Some of the documents reviewed were:
  - National CRGE Strategy of Ethiopia,
  - Transport Sector CR Strategy (Draft Document),
  - 2nd National Communication of the Government of Ethiopia,
  - Addis Ababa CRGE Strategy,
  - Transport Sector Annual Statistics Bulletin ,
  - Global Fuel Economy Initiative Study in Ethiopia,
  - IPCC 2006 guideline.
- **Stakeholder Consultation**: Key actors at federal, regionals and cities level were also consulted. The purpose of transport data collection at each category was different. The data collection at federal level included data collections for all types

of modes of transport, whereas at regional level it focused on roads, off-roads and water-borne transport, this was because the aviation and railway transport data were only accessed centrally at federal institutions. Though, most of the regionals data were also available at federal level, regionals data collections were undertaken for quality assurance. The cities level the data collection was done to draw a sample for regional cross-boundaries trip for scope determination. This was done for estimated based on major regional cities roads traffic counts at cities outlets.

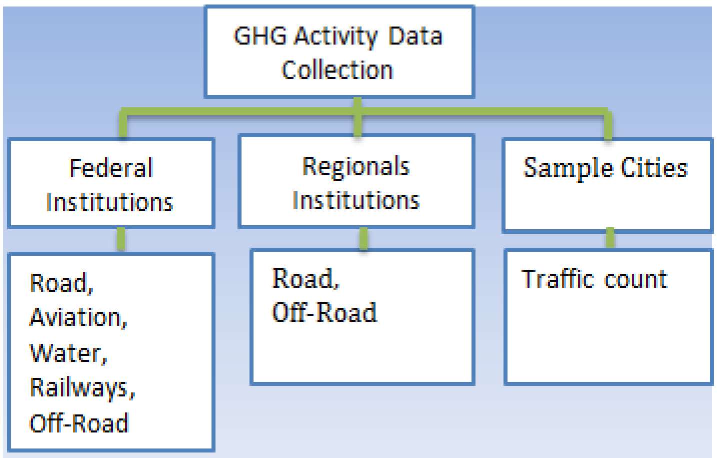

Figure 5: Types of Data Collected from Federal, Regions and Sample cities

These are the list of institutional actors and sample cities that are participated in providing data. The institutional actors are classified into federal and regional institutions, and the sample cities are drawn from each region.

A. Federal Institutions

There are 16 federal institutions that were involved in providing the activity data. These are the list and the type of data they provide for GHG emission inventory:

- **Ministry of Transport (MoT):** Provided data transport sector annual statistical bulletin, draft transport CRGE, CRGE MoU document between MoT and MEFCC.
- **Federal Transport Authority**: Provided activity data generated which included annual vehicle stock; type of fuel consumed; vehicles (by regions and national); annual vehicle travel for passenger and freight.
- **Ethiopian Road Authority:** Provided activity data that included annual traffic count for cities and yearly road length.
- **Ethiopian Airlines**: Provided activity data such as jet fuel consumption (domestic and international flight); annual passenger and freight; number of landing and take-off on each airport.
- **Ethiopia Airport Enterprise**: Provided activity data that included aircraft movement (disaggregated by airports); passenger number (disembarks and embarks); and freight (unloaded and loaded)

- **Civil Aviation Authority:** Provided activity data such as regulatory activities; and summary data from airline and airport.
- **Maritime Affair Authority:** Provided information on regulatory information on maritime activities, number of motorized boats and fuel consumption of inland water transport.
- **Ethiopian Shipping and Logistics Services Enterprise**: Provided activity data such as domestic and international ships; fuel consumption of ships; fuel type used; fuel economy; operation day per year; and passengers & freight volume.
- **Ethiopian Railway Cooperation:** Provided activity data on LRT hauled passenger per year; number of km/day; and operation day per year.
- **Ethio-Djibouti Railway Cooperation**: Railways fuel consumption per year.
- **Ministry of Agriculture and Natural Resources**: Consulted activity data on off-road transportation mainly the number of agriculture machinery & tractors.
- **Ethiopia Petroleum Supply Enterprise**: Provided activity data on imported petroleum products.
- **Ministry of Mine, Petroleum and Natural Gases**: Consulted on petroleum quality and energy mix such as ethanol and biodiesel.
- **Ministry of Trade**: Consulted number of car imported per year; petroleum and any transport related transactions.
- **Central Statistics Agency**: Provided data on current and projection population for estimation of emission and/or emission footprint.
- **National Planning Commission**: Provided data generated on national GDP and planning.

B. Regional Sector Institutions

Regional sector institutions are established under the regional state governments and city administrations of the country. These institutions report to their regional government cabinets and they only have working partnership with MoT. They submit annual plan and report to their regional cabinets and send a copy to MoT. As already been written above, the data collection from regions include road, off-road and water-borne. The names of regional entities of the transport sector that are key in the process GHG measurement and reporting are listed below.

1. Addis Ababa City Administration Road and Transport Bureau
2. Tigray Regional State Construction, Road and Transport Bureau
3. Amhara Regional State Road and Transport
4. Somali Regional State Trade and Transport Bureau
5. SNNP Regional State Transport and Road Development Bureau
6. Harari Regional State Road and Transport Office
7. Afar Regional State Trade, Industry and Transport Investment Bureau
8. Gambella Regional State Transport and Road Development Bureau
9. Benishangul Gumz Regional State Trade, Industry and Transport Bureau
10. Dire Dawa City Administration Road and Transport Branch Office

11. Oromia Regional State Transport Authority

C. Sample Cities- Emission Allocation by Scope

Activities taking place within a region can generate GHG emissions that occur inside the region boundary as well as outside the region boundary. For emission occurring within a region boundary, regional governments have high level of influence over them and they have less ability to influence emission that occur outside the region boundary as either the origins or destinations are located outside a region's jurisdictions. Comprehensively accounting and reporting these emissions, regardless of where they occur, ensure that regions have a complete and accurate account of their GHG impact and mitigation opportunities.

To help delineate the emission occurring within a region and outside a region requires regional specific data on vehicle stock by type and purpose (Intercity and intra city), average daily traffic by vehicle type , population of other region served by the target region and average length of outlet roads from a region's centre. To collect these data, 14 cities were selected based on their population size. However, these data were not available. This making it difficult to distinguish between emission occurring within a region and outside a region's boundary.Therfore, the inventory has not included the scope 1 and 3 GHG emission for regions.

Table 1: Name of Sample Regions and Cities

S/N	Region	City
1	Oromiya	Adama & Jimma
2	Amhara	Bahir Dar & Gonder
3	Tigray	Mekele
4	SNNPR	Hawassa & Sodo
5	Dire Dawa	Dire Dawa
6	Somali	Jigjiga
7	Harari	Harari
8	Gambella	Gambella
9	Benishangul	Assosa
10	Afar	Asayita
11	Addis Ababa	Addis Ababa

II.1.4. Tiers and Emission Factors

A tier represents a level of methodological complexity. There are three tiers; 1, 2 and 3.

Tier 1 Method: The Tier 1 method is fuel-based, since emissions from all sources of combustion can be estimated on the basis of the quantities of fuel combusted (usually from national energy statistics) and average emission factors. Tier 1 emission factors are available for all relevant direct greenhouse gases.

Tier 2 Method: In the Tier 2 method for energy, emissions from combustion are estimated from similar fuel statistics, as used in the Tier 1 method, but country-specific emission factors are used in place of the Tier 1 defaults. Since available country-specific emission factors might differ for different specific fuels, combustion technologies or even individual plants, activity data could be further disaggregated to properly reflect such disaggregated sources.

Tier 3 Method: In the Tier 3 methods for energy, either detailed emission models or measurements and data at individual plant level are used where appropriate. Properly applied, these models and measurements should provide better estimates primarily for non-CO2greenhouse gases, though at the cost of more detailed information and effort.

Ethiopia did not produce a national emission factor (Tier 2) for transport sector. Therefore, for this particular study Tier 1 method was considered.

The UNFCCC has a clear reporting recommendation and requirement for countries. Different reporting requirements have been given for developed and developing countries (UNFCCC Annex I and non-Annex I Parties, respectively). Ethiopia is a non-Annex I country and reporting of National Communications and other GHG reports using Tier 1 countries is acceptable. Considering the national capacity, data requirements and level of GHG emissions within these countries, the UNFCCC and other multilateral organizations largely accept GHG reports produced using Tier 1 approach by Non-Annex 1 countries.1

Use of tier 1 for emissions calculation at the current stage is acceptable for Ethiopia for the following reasons.

1) Results of emissions using tier 1 are accepted by international organizations and bilateral program for Ethiopia as Non-Annex 1 country,
2) User of unapproved emission factor or Tier 2 will nullify the result,
3) Developing country specific emission factor or Tier 2 will take time and money.

Preparing country level emission factor for Ethiopia is not necessary as it is not obliged to report using tier 2 approach as it is non-annex I country in the UNFCCC. As non-annex I country, the donor community and the international system allow Ethiopia to report using default values or tier I approach.

Furthermore, developing acceptable Tier 2 or country level emission factor will take up to two years to be accepted by IPCC.

II.1.5. Choices of Methodologies

There are two main IPCC methodological options for estimating current direct CO2 emissions from the transport sector:

- Top-down methodologies, and
- Bottom-up methodologies.

The bottom-up approach Calculates GHG emissions based on transport activities. The top-down approach Calculates GHG emissions based on statistical data on the final energy consumption of one or several means of transportation (e.g. total fuel consumption or fuel sales).

The choice of approaches and methodologies to be utilized will depend on the study s scope as well as on data availability. Further, the method choices will be based on the data gather fulfilment of GHG accounting principles of relevance, completeness, consistency, transparency, accuracy and measurability. For instance, if the data availability for fuel sale is fulfilling the accounting principle like completeness more than the travel distance, the fuel sale approach will be used. Similarly the other principles will be reviewed against each accounting principles.

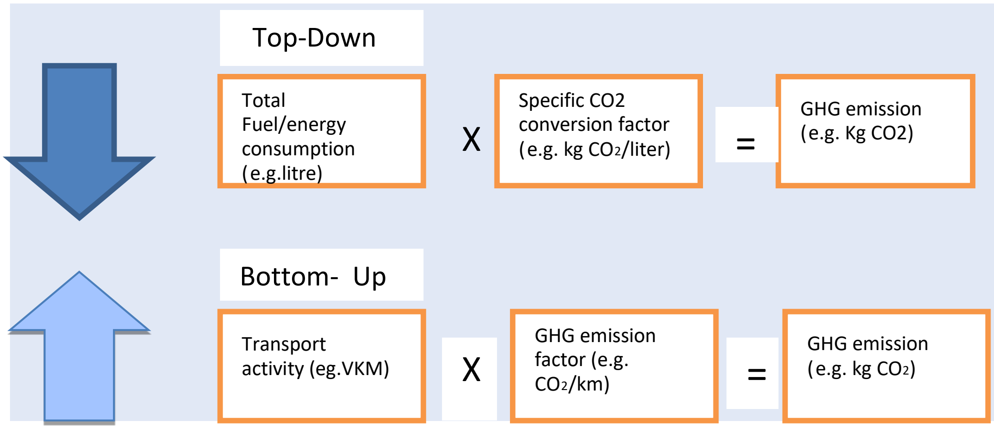

Figure 6 Methodological Options

The GHG inventory was calculated using mix of approaches for each mode of transports. In addition, an emission projection was carried out under each emission source for the year 2030. The projection will be done first by understanding the consumption patter, growth of demand and related other factors.

These are approaches used for each modes of transport;

Table 2: Methodologies Used for Modes of Transport

Modes of Transport	Methodology	Scope
On-Road Transport	Bottom-up	National & Regional
Off-Road Transport	Bottom-up	National & Regional
Aviation	Top-down	National
Water	Top-Down	National & Regional
Railways	Top-Down	National & Regional

These were the methodological steps that were applied for activities data collections and GHG calculation:

I. On-Road Transportation

Activity data Collection Requirements:

- The types of vehicles operated on roads and highways within the national(regional) and their respective fuel economies,
- Total vehicle kilometers (or miles, abbreviated as VKT or VMT) traveled by vehicles within the national(regional),
- The types of fuels consumed by vehicles on national (regional) roads (e.g. gasoline, diesel, etc.)
- The quantity (volume) and types of fuel consumed by vehicles operating within the national (regional).

To calculate emissions from on-road transportation vehicle use, follow these steps were undertaken:

Step 1: Determine the amount of fuel consumed by fuel type for on-road transportation, by vehicle class, these can include cars, SUVs, light trucks, heavy-duty trucks, etc. and vehicle classifications may vary between regions or countries.

Step 2: Determine emissions factors for CO_2, CH_4, and N_2O for each fuel type used.

Step 3: Insert fuel consumption figures and emissions factors and quantify annual GHG emissions, by gases.

II. Rail way Transportation

Activity data Collection Requirements:

- Railways which exist within the national(regional), service to and from the national(regional), and how they are powered,
- Quantity (volume or energy units) of each type of fuel or energy consumed.

To calculate emissions from railways, follow these steps were used:

Step 1: Identify the various railways servicing at the national (regional), and their energy sources (in electric trains, identify if the electricity is grid-supplied), application, including freight, subway, regional transit, amongst others.

Step 2: Determine the quantity of energy consumed by railways within the national (regional) geopolitical boundary: Fuel volumes by fuel type used in combustion locomotives and electricity to power trains, trams, and other electrified rail options.

Step 3: Determine appropriate emissions factors by energy type.

Step 4: Insert emissions factors and activity data and calculate GHG by energy type and railway application, where possible (e.g. freight, subway, inter-city transit).

III. Water

Activity data Collection Requirements:

- The types of fuels consumed in water-borne navigation for trips that originate at ports located within the national geopolitical boundary.
- Quantity (volume or energy) of each type of fuel loaded onto these water-borne vessels as they begin their trips.
- Whether the water-borne navigation trips are in-city, nationally domestic, or international (regional) trips.

Calculating emissions from water-borne navigation involved the following steps:

Step 1: Determine the fuel volumes by fuel type used in water-borne navigation, separated by geographic scale of the activity (whether the navigation is in-city, regional, national, or international).

Step 2: Determine emissions factors for CO_2, CH_4, and N_2O for each fuel type used.

Step 3: Insert emissions factors and activity data and calculate GHG emissions, by gas.

IV. Aviation

Activity data Collection Requirements:

- Types of fuels consumed in aviation trips that originate from airports within the national(regional) geopolitical boundaries,
- Quantity (volume or energy) of each type of fuel consumed by the aircraft which are associated with these flights,
- Whether the aviation trips are in-city, regional, national, or international trips.

Calculating emissions from aviation involved the following steps:

Step 1: Determine the fuel volumes by fuel type used in aviation, separated by geographic scale of the activity (whether the trips are in-city- helicopter only, regional, national, or international),

Step 2: Determine emissions factors for CO_2, CH_4, and N_2O for each fuel type used,

Step 3: Insert emissions factors and activity data and calculate GHG emissions, by gas.

V. Off-Road

Activity data Collection Requirements

- Types of fuels consumed by off-road mobile combustion,
- Quantity (volume or energy) of each type of fuel consumed for off-road mobile combustion.

Calculating emissions from off-road transportation involved the following steps:

Step 1: Determine the fuel volumes by fuel type used in off-road engines.

Step 2: Determine emissions factors for CO_2, CH_4, and N_2O for each fuel type used.

Step 3: Insert emissions factors and activity data and calculate GHG emissions, by gas.

II.2 Input Data and Calculation Procedure per Transport Mode

II.2.1 Road Transport

Road transport covered all internal combustion vehicles used for passengers and goods mobility in Ethiopia. Types of vehicles investigated in this inventory were classified into the following categories: passenger cars, buses, trucks and motorcycles.

Table 3 : Description of Vehicles Categories

Vehicle Category	Description
Passenger cars	Vehicles Primarily for transport of persons and having a capacity of fewer than 12 person
Buses	Vehicles primarily for transportation of passengers and having a capacity of 12 person and more
Trucks	All Vehicles primly for the transportation dry and liquid cargo.
Motorcycle	Motor vehicles designed to travel with not more than three wheels

GHG emissions from road transport was estimated using the tier 1 methodology, presented in equation 1 and 2, and based on the number of vehicles per categories and their activity in terms of distance travelled.

Equation 1 Tire 1 Estimation of GHG from road transport

$$Emission = \sum_a (Fuel_a \times EF_a)$$

Where:

Emission = Emissions of CO_2 (kg)

Fuel a = fuel Consumed

EF a = emission factor (kg/l).

a = type of fuel

Equation 2: Tire 1 Estimation of fuel consumption for road transport

$$\textbf{Vehicles Fuel Estimated} = \sum_{ij} (\textbf{Vehicles} \times \textbf{distance} \times \textbf{consumption}_{ij})$$

Where:

Estimated Fuel =total estimated fuel use estimated from distance travelled (VKT) data

$Vehicles_{i,j,}$ = number of vehicles of type i and using fuel j

$Distance_{i,j,}$ = annual kilometers travelled per vehicle of type i and using fuel j

$Consumption_{i,j,}$ = average fuel consumption (l/km) by vehicles of type i and using fuel j

i = vehicle type

j = fuel type

In this Approach, Vehicles Travel Distances (VKT) by vehicle type is multiplied by their respective fuel economy to determine fuel consumption and the fuel consumptions by vehicles type are multiplied by relevant emission factors. Availability of activity data was the major driver for choosing these approaches among the various accounting approaches.

The activity data and emission factors defined as follows:

- **Activity Data** : For the tier 1 approach, the needed activity data includes The Vehicle stock by types registered in each regions, The fuel economy by vehicles types, Annual distance (VKT) travelled by vehicles types and the types of fuels consumed by the vehicles (see table 4). For detail on-road disaggregated activity data (see Annex I)

Table 4: On-Road Transport Activities Data

Vehicle category	Vehicle Type	Fuel Type	Vehicle Stock(No)	Fuel economy (Km/l)	Annual (VKM)
Passengers	Ambulance, Automobile ,Field Vehicle and Dual purpose Vehicle	Gasoline and diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Bus	Bus (<12 seats), Bus (>11 seats)	Gasoline and diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Motorcycles	Bajaj, Motor-bicycle ,Three wheel public load and, Tri Cycle	Gasoline	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Trucks	Dry cargo (<=10Q), Dry cargo (>10Q), Three wheel dry load, Liquid cargo, liquid trailer ,Gotach and Trailer	Gasoline and diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016

- **Emission Factors**: Since no fuel-specific emission factors are established for Ethiopia, the default values of the IPCC guideline for gasoline and diesel fuels for the tier 1 approach were used. The tire 1 has three emission factors options (lower, default, lower and upper value). Upper value emission factors were considered since the fuel used in the country has high sulphur content and older aged vehicles.

Table 5: 2006 IPCC Defaults Emission Factors Used for On-Road Vehicles

Fuel type	CO2(kg /TJ)	CH4(kg /TJ)	N2O(kg /TJ)
Motor Gasoline	73000	110	11
Gas/ Diesel Oil	74800	9.5	12

II.2.2. Off- Road Transport

The off-road category included vehicles and mobile machinery used within the agriculture, forestry and industry (including construction). The vehicles/machineries types considered under the inventory included combiner, doze, grader, forklift, dump trucks and tractors. The GHG emissions for off road was estimated using the tier 1 methodology, presented in equation 3, and based on the number of vehicles/machinery per category.

Equation 3: Tire 1 Estimation of GHG from Off road transport

Emission=$\sum_a$(Fuel $_a$ x EF $_a$)
Where: Emission = Emissions of CO2 (kg)
Fuel $_a$ = fuel Consumed
EF $_a$ = emission factor (kg/l).
a = type of fuel

In this approach, operation hour per year by vehicle type was multiplied by their respective fuel economy (hour per litter) to determine fuel consumption and the fuel consumptions by vehicles/ machinery type are multiplied by relevant emission factors. The activity data and emission factors defined as follows:

- **Activity Data**: For the tier 1 approach, the needed activity data includes the vehicle/machine stock by types registered in each region, the fuel economy by vehicles/machine types, operation hour per year by vehicles types and the types of fuels consumed by the vehicles (see table 6). For detail off-road disaggregated activity data (see Annex II)

Table 6: Off-Road Transport Activities Data

Vehicle Type	Fuel Type	Vehicle Stock	Operation hour per year	Fuel economy (Hour/litter)
Combiner	Diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Dozer	Diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Grader	Diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Forklift	Diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Tractor	Diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016
Vehicle with Machinery	Diesel	For year 2014,2015 and 2016	For year 2014,2015 and 2016	For year 2014,2015 and 2016

- **Emission Factors**: Since no fuel-specific emission factors are established for Ethiopia, the default values of the IPCC guideline for gasoline and diesel fuels for the tier 1 approach were used. The tire 1 has three emission factors options (lower, default, lower and upper value). Upper value emission factors were considered since the fuel used in the country has high sulphur content and older aged vehicles.

Table 7: 2006 IPCC Defaults Emission Factors Used for Off-Road Vehicles

Fuel type	CO2(kg /TJ)	CH4(kg /TJ)	N2O(kg /TJ)
Gas/ Diesel Oil	74800	9.5	12

II.2.3 Air Transport

Emissions from Aviation comprise domestic and international flights. The domestic flights includes passenger and freight traffic that departs and arrives with in Ethiopia and the international flights Emissions considers flights that made outside Ethiopia.

The aviation transport GHG emissions was estimated using the tier 1 methodology, presented in equation (4), and based on the volume of fuel consumption for domestic and international aviation. In this Approach, fuel consumption of jet kerosene has been used with their associated emission factor to calculate the GHGs emission. The activity data and emission factors defined as follows:

Equation 4: Tire 1 Estimation of GHG from Aviation

Emission=∑ (Fuel x EF)
Where:
Emission = Emissions of CO2 (kg)
Fuel = fuel Consumed
EF = emission factor (kg/l).

- **Activity Data**: The activity data for international civil aviation included the jet-kerosene consumption for international and domestic aviation. It was collected from Ethiopian Airlines, Civil Aviation Authority and Ministry of Mines, Petroleum and Natural Gas

Table 8 Aviation fuel consumption

Category	Fuel Consumption (Metric tons)		
	2014	2015	2016
International	708,427	929,669	1056586
Domestic	23,311	18,193	46,344
Total	731,738	947,861	1,102,931

- **Emission Factors**: since there is no fuel-specific emission factors are established for Ethiopia. The emission factors used were the tier 1 approach that are the default values of the IPCC guideline for the jet-kerosene,

Table 9: 2006 IPCC Default Emission Factor Used for Aviation

Fuel type	Emission Factor (kg CO2/TJ)		
	CO2	CH4	N2O
Jet-A1	74,400	0.5	2

II.2.4. Water-Borne Transportation

The inventory for water-borne transportation in Ethiopia includes international and domestic water born transport. The GHG emissions for water-borne was estimated using the tier 1 methodology, presented in equation 5 and based on fuel consumption data.

Equation 5: Tire 1Estimation of GHG from water borne transport

Emission=$\sum_a$ (Fuel $_a$ x EF $_a$)
Where:
Emission = Emissions of CO2 (kg)
Fuel $_a$ = fuel Consumed
EF $_a$ = emission factor (kg/l).
a = type of fuel

In this Approach, fuel consumption data has been used with their associated emission factor to calculate the GHGs emission. The activity data and emission factors defined as follows:

- **Activity Data**: The activity data for water born transport included fuel consumption for international maritime, and daily average fuel consumption data, operation days per year and vessel stock s for inland water transport collected from Ethiopian Shipping and Logistics Services Enterprise and federal maritime authority.

Table 10: International and National Water-Borne Activity Data

Water Ways	2014	2015	2016
International (metric ton)	53,197.3	45,698.0 1	34,275.1
National (Av.Fuel/day/vessel)	20	20	20
• Lake Tana (vessels stock)	113	126	140
• Lake Tana (operation days/year)	250	275	302
• Lake Hawassa (vessels stock)	34	38	42
• Lake Hawassa (operation days/year)	250	275	302
• Baro River (vessels stock)	4	4	5
• Baro River (operation days/year)	120	120	120

- **Emission Factors**: since no fuel-specific emission factors are established for Ethiopia, The emission factors used are tier 1 approach of the IPCC residual fuel oil. The tire 1 has three emission factors options (lower, default, lower and upper value). Upper value emission factors were considered since the fuel used in the country has high sulphur content and older aged vehicles.

Table 11 : 2006 IPCC Default Emission Factor Used for Water-Borne Transport

Fuel type	Emission Factor (kg CO2/TJ)		
	CO2	CH4	N2O
Residual fuel oil –International maritime	78,800	9.5	12
Gas/ Diesel Oil -inland water transport	74800	9.5	12

II.2.5. Railway Transport

The Emission from railway transport is focused on Ethio-Djibouti railway. The inventory covers the emission resulting from activities along Dire Dawa-Djibouti route covering 221km.

The railway transport GHG emissions was estimated using the tier 1 methodology, presented in equation (6), and based on the volume of fuel consumed. In this Approach, Diesel fuel consumption has been used with their associated emission factor to calculate the GHGs emission. The activity data and emission factors defined as follows:

Equation 6: Tier 1 Estimation of GHG from railway

Emission=∑ (Fuel x EF)
Where:
Emission = Emissions of CO2 (kg)
Fuel = fuel Consumed
EF = emission factor (kg/l).

- **Activity Data**: The activity data for Ethio-Djibouti railway transport included the Diesel fuel consumption, collected from Ethio-Djibouti railway cooperation.

Table 12 :Railway fuel consumption

Fuel type	Fuel Consumption (litters)		
	2014	**2015**	**2016**
Diesel	82,653	103,800	187,000

- **Emission Factors**: since no fuel-specific emission factors are established for Ethiopia. The used emission factors for the tier 1 approach are the default values of the IPCC guideline for diesel. The tire 1 has three emission factors options (lower, default, lower and upper value). Upper value emission factors were considered since the fuel used in the country has high sulphur content and older aged vehicles.

Table 13 : 2006 IPCC Default Emission Factors Used for Railway

Fuel type	**Emission Factor (kg CO2/TJ)**		
	CO2	CH4	N2O
Railway- Diesel Oil	74800	10.4	85.8

II.2.6. LRT Emission Removal

The estimation of emissions reduction was based on the modal shift from road public transport to Addis Ababa Light Railway Transit (LRT). The estimation is made by considering the business as usual scenario and project scenario. The business-as-usual scenario reflects the mode of transport that would have been used within the city of Addis Ababa in the absence of LRT system i.e. mini bus, midi bus and maxi bus. The project scenario assumed that the implemented electric LRT is powered through renewable energy and therefore contributes zero emissions.

Therefore, the emission reductions estimated as the greenhouse gas emissions that would have occurred if the business-as-usual passengers continued to use road public transport powered by fossil fuel. This was done by distributing the LRT daily passenger to road public transport based on their modal share and determined the number of road public vehicles needed in the absence of LRT system. The activity data and emission factors defined as follows:

- **Activity Data**: The activity data for Addis Ababa LRT included the daily passenger volume by rail way, modal share of road public transport (minibus taxi, midi bus and maxi bus) and their corresponding daily passenger and daily KM coverage as well as their fuel economy (Km/l). LRT daily passenger was 161,175 for 2016 and 120,000 passenger for 2015.

Table 14: Activity Data on Public Road Transport

Modes of Transport	Mode Share (%)	Daily KM Covered
Maxi bus	21	77
Minibus taxi	56	138
Minibus taxi	23	100

- **Emission Factors**: since no fuel-specific emission factors are established for Ethiopia. The used emission factors for the Tier 1 approach are the default values of the IPCC guideline for road transport gasoline and diesel fuels. The tire 1 has three emission factors options (lower, default, lower and upper value). Upper value emission factors were considered since the fuel used in the country has high sulphur content and older aged vehicles.

II.2.8. Uncertainty Management

The uncertainties for the estimation of GHG emissions from the transport sector primarily arise from lack of activity data required for estimating GHG emission. The major challenges associated with activity data are:

- Underdeveloped institutional arrangement for transport data monitoring and reporting,
- Lack of standardize/centralize transport data reporting,
- Inaccessibility of existing data and lack of institutional arrangement for data exchange,
- Inconsistency in vehicle stock classification between regions, as well as at federal level,
- Unavailability of specific activity data
    - ✓ Road Transport (incomplete vehicle stock, Annual vehicle Km, fuel economy, vehicle classification by fuel type etc.)
    - ✓ Water borne transportation (vessels stock and fuel consumption rate for all water borne user regions)
    - ✓ Off Road (Incomplete vehicle/machinery stock, fuel consumption, Operation day per year etc.)

Overall, the uncertainty assessment has looked at activity data and emission factor quality using GPC, 2014 inventory data quality assessment framework backed by expert judgment. This approach was adopted because most of the activity data were mainly from secondary sources that hardly reported uncertainty ranges in their metadata, making it difficult to determine uncertainties with activity data.

Even though the way the uncertainty assessment is conducted in the current inventory is not the recommended quantitative approach for estimating uncertainties, the adopted approach is helpful to report transparently by assigning the data quality based on the sources of data and emission factors used (see table 15).

Table 15: Data quality Assessment Criteria

Data Quality	Activity data	Emission Factor
High (H)	Detailed Activity data	Specific Emission factor
Medium (M)	Modeled Activity data using robust assumption	More general Emission factor
Low (L)	Highly-modeled or uncertain activity data	Default Emission factor

The quality assessment for the validation of activity data as well as the emission factors used and the QA/QC actions in is presented in table below.

Table 16: Uncertainty assessment and QA/QC

Mode	Parameter assessed		Data quality	QA/QC actions
On-Road	Activity data used for the tier 1 methodology	Fuel economy data by Vehicle type is estimated by means of assuming the average L/km based on data used in CRGE, 2011.	L	The obtained Activity data were verified by consulting with relevant stakeholders
		Vehicle KM data by vehicle type generated by Projecting 2011 data to inventory year using ERA's an annual growth rate of 9.2% .	M	The obtained annual travelled distances were verified by checking the consistency with annual travelled distances data reported by Federal Transport Authority (FTA).
		Vehicle stock data by vehicle type collected from MoT's annual Statistical bulletin	M	The obtained vehicles stock was verified by comparing the data obtained from various sources (MoT, FTA and Regional transport bureaus).
	Emission factors used for the tier 1 methodology	IPCC Default (upper value) emission factor	L	Upper value emission factor used considering the high sulfur content and the age of the vehicle stock
Off-Road	Activity data used for the tier 1 methodology	Machinery Stock data by type collected from MoT's annual Statistical bulletin	M	The obtained vehicles stock was verified by comparing the data obtained from various sources (MoT and FTA).
		Fuel economy & operation day per year data estimated by means of assuming the average Fuel economy & operation based on international industry average	L	The obtained Activity data were verified by consulting with relevant stakeholders
	Emission factors used for the tier 1 methodology	IPCC Default (upper value) emission factor	L	Upper value emission factor used considering the high sulfur content and the age of the vehicle stock
	Activity data used for the tier 1 methodology.	Fuel consumption data for kerosene are collected from Ethiopian Airline	H	Comparison of the obtained emissions results to the results generated by Ethiopian Civil Aviation Authority (Draft State Action Plan for Reduction of CO2 in International Aviation, 2017)

Aviation		Emission factors used for the tier 1 methodology	IPCC Default (upper value) emission factor	L	Upper value emission factor used considering the high sulfur content of fuel
Water-born	International	Activity data used for the tier 1 methodology	Fuel Consumption data collected from Ethiopian Shipping and Logistics Services Enterprise	H	Comparison of the obtained fuel consumption data to the results generated by using daily average fuel consumption and operation day per year.
		Emission factors used for the tier 1 methodology	IPCC Default emission factor for Residual fuel oil	L	Upper value emission factor used considering the high sulfur content of fuel
	Inland	Activity data used for the tier 1 methodology	Ship and boat stock, fuel consumption rate per day and operation days per year collected from respective regional bureaus for Lake Tana and Hawassa. The activity data for Baro river was generated through assumptions.	M	Verification of the calculation through multiple checks of the calculation files
		Emission factors used for the tier 1 methodology	IPCC Default emission factor for diesel	L	Upper value emission factor used considering the high sulfur content of fuel and fuel efficiency of ships and boats in Ethiopia
Railways	Ethio-Djibouti	Activity data used for the tier 1 methodology	Fuel Consumption data collected from Ethiop-Djibouti railway cooperation	H	Comparison of the obtained fuel consumption data to the results generated by using daily average fuel consumption and operation day per year.
		Emission factors used for the tier 1 methodology	IPCC Default emission factor for diesel	L	Upper value emission factor used considering the high sulfur content and fuel efficiency of old aged railway locomotives
	LRT	Activity data used for emission removal	Activity data on Daily passenger volume a collected from Ethiopian Railways Cooperation and data on Addis Ababa's public road transport collected from Public transport system study by Mulu Eshete, Addis Ababa University.	M	The obtained data was verified by comparing the data obtained from various sources (MoT, and ERC).

III. RESULT

III. RESULTS

III.1 Ethiopia's Transport Sector GHG Emissions 2016

III.1.1 Summary

The results of the national GHG emissions from the transport sector include the road transport, domestic air transport, off road transport, inland water transport and railway transport. Since as per the 1996 Revised Guidelines, international aviation and maritime transport are not considered as national emissions and are reported separately under international bunkers.

GHG emissions from Ethiopia s transport sector totalled 12,544,346 tons (t) CO2e for 2016. Carbon dioxide, methane, and nitrous oxide constitute 11,890,272 t, 3,419 t, and 1,878 t respectively (see table 17).

Table 17: Transport Sector GHG Emissions by Modes of Transport, 2016

Mode of Transport	GHG emissions (t CO2e)
Road	11,635,203
Off road	783,165
Domestic Aviation	122,051
Ethio-Djibouti railway	682
Inland Water born	3,245
Total	12,544,346

The percentage value by gases showed that the emission from the transport sector constitutes 94% for CO_2, 5% for N_2O and 1% for CH_4 (see table 18).

Table 18: Transport sector GHG Emissions, 2016

Direct GHG	GHG emissions (t)	Contribution (%)
CO2e	12,544,346	-
CO2	11,890,272	94
CH4	3,419	1
N2O	1,878	5

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

Looking at the contribution of the different modes to total emissions, road transport is by far the largest contributor, emitting 11,635,203 t CO2e in 2016 and accounting for 92.7 % of the total emission. Domestic Air transport and off Road transport emitted 122,051 t CO2e and 783,165t CO2e respectively and the contribution to the total emission is 0.97 % for air transport and 6.2 % for off road transport (see fig 7).

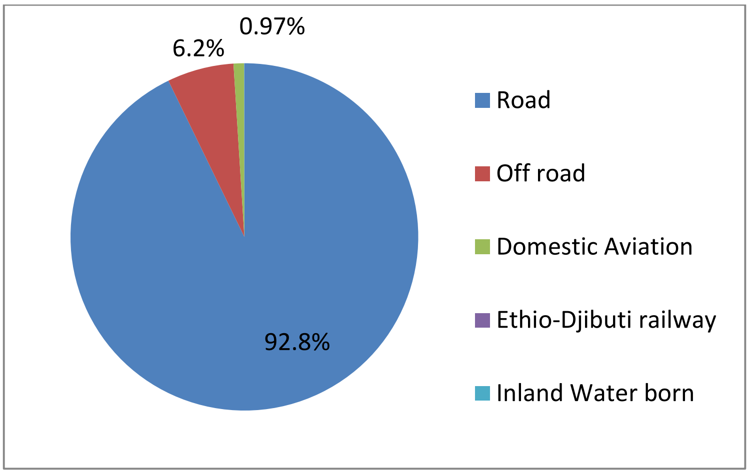

Figure 7: Transport Sector Emission by Modes of Transport, 2016

Inland water transport and Ethio-Djibouti railway have insignificant Contribution to total transport sector emission. Emission from Inland water transport was estimated to be 3,245 t CO2e and Ethio-Djibouti railway's emission for the year was 682 t CO2e.

III.1.2 Road Transport

Road Transportation included all types of vehicles such as passenger cars, buses, trucks and motorcycles as described in the table above. These vehicles operate on two types of liquid fuels, gasoline and diesel. The combustion of these fuels produces CO2, CH4, and N2O, often referred as direct GHG emissions.

Road transport constitutes the biggest contributor to emissions originating from the transport sector, emitting 11,635,203 tCO2e in 2016 and accounting for 98.7% transport emission. The fuel consumed in this year was 555,214 ton of gasoline and 3,469,174 ton of diesel, accounting for 17% and 83% of road transport emission respectively.

When the emissions are distributed over the three direct GHGs, carbon dioxide accounted for the major GHG emitted gas, contributing to 95% of the direct emission and methane, and nitrous oxide constituted 0.5% and 4.5% respectively (see table 19).

Table 19: Road Transport GHG Emissions, 2016

Direct GHG Emission	GHG Emissions (t)	Contribution (%)
CO2e	11,635,203	-
CO2	11,021,490	95
CH4	3,324	0.5
N2O	1,754	4.5

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

As for the contribution of the different vehicle categories, freight trucks had the highest share of the 2016 emissions with 67% of the total road transport GHG emissions, while buses, passenger cars and motorcycles accounted for 21%, 11%, and 1% respectively 9 (see figure 8).

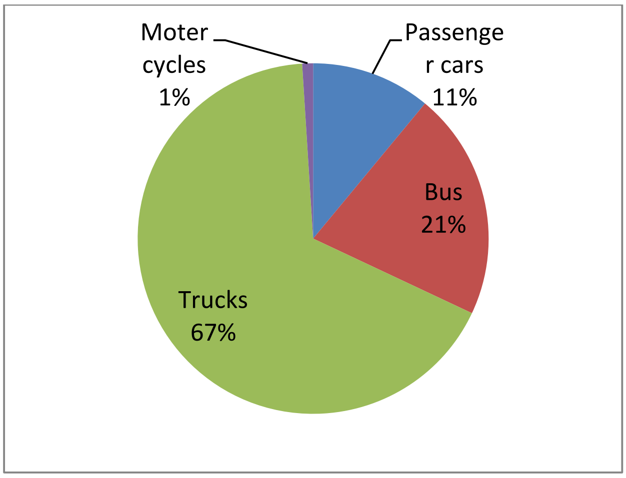

Figure 8: Contribution to Road Transport Emission by Vehicle Category, 2016

As for regional distribution, Addis Ababa was by far the largest contributor, emitting 8,493,130 t CO2e in 2016 and accounted for 73 % of the total road transport emission. Following Addis Ababa, Oromiya, Amhara and Tigray region made significant contribution accounting for 6.3%, 6.1% and 5% respectively. The rest of the regions contributed, together, 10 % of Road transport sector emission (see figure 9).

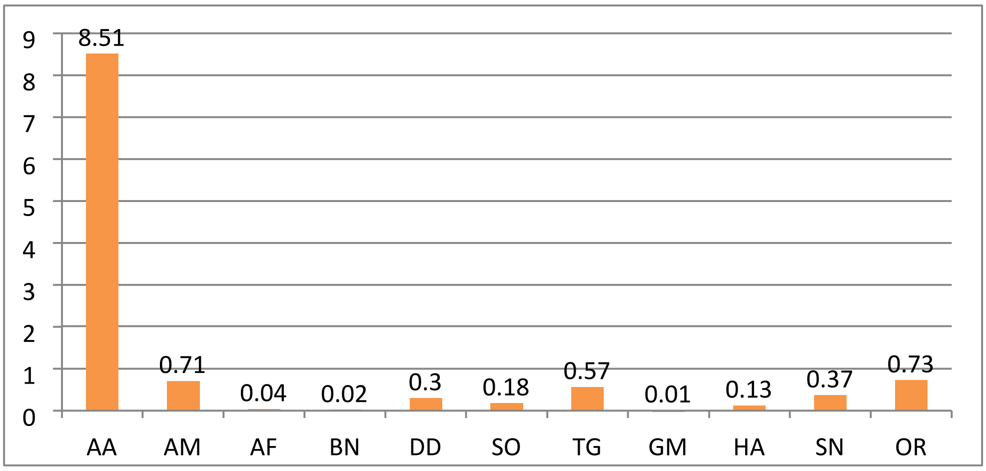

Figure 9 : Road Transport GHG Emissions by Regions (Mt CO2e), 2016

III.1.3 Off-Road Transport

The off-road category included vehicles and mobile machinery used within the agriculture, forestry and industry (including construction). The vehicles/ machineries types considered under the 2016 inventory included Combiner, Doze, Grader, Forklift and tractors.

In 2016, 268,162tons of diesel fuel was consumed by off road transport and the resulting Emission from combustion of diesel was estimated to be 783, 165 tCO2e, accounting for 6.2 % of emission from the transport sector.

When these emissions was distributed over the type of off road vehicles/machineries, grader accounts for the major GHG emitted, contributing to 55 % of the GHG emitted from the off road transport and forklift accounted for 36% of off road emission. Combiner, dozer, tractor and vehicles with machineries together accounted for the remaining 9% of off road transport emission (see figure 10).

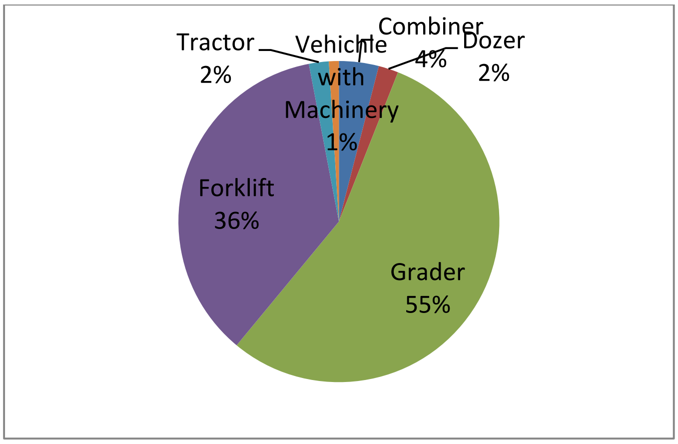

Figure 10: Contribution to Off Road Transport by Region (%), 2016

As for regional distribution, Oromiya region is by far the largest contributor by emitting 577, 065 t CO2e and accounting for 74% of total off road emission. SNPPR emitted 175, 524t CO2e, accounting for 22 % off road emission in 2016. The remaining regions together accounted to 4 % of total emission from off road (see fig 11).

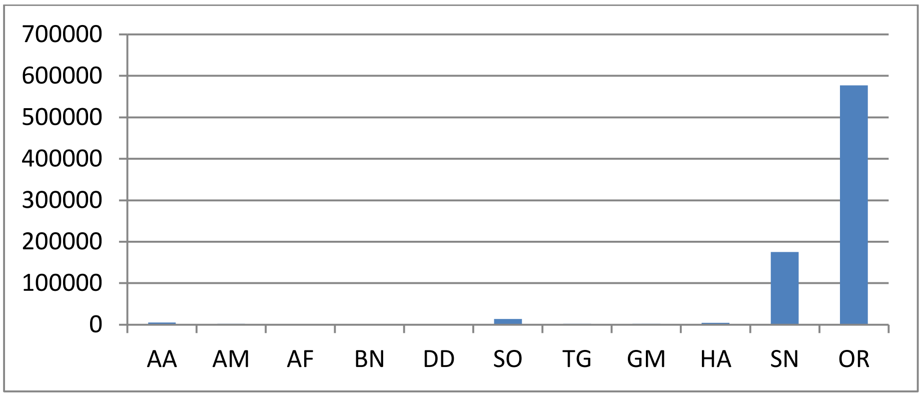

Figure 11: Contribution to off road transport by region (tCO2e), 2016

III.1.4 Domestic Air Transport

In 2016, the total emission from domestic air transport was estimated to be 122,051 t CO2e and this accounted for 0.97 % of the transport sector total emission. When these emissions were distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emission, contributing 99% of the direct GHG emitted and methane, and nitrous oxide constituted 0.1 % and 0.8 % respectively (see table 20).

Table 20: Domestic Air Transport GHG Emissions, 2016

Direct GHG Emission	GHG emissions (t)	Contribution (%)
CO2e	122,051	-
CO2	121,025	99.1
CH4	0.813	0.1
N2O	3.25	0.8

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

III.1.5 Inland Water Transport

Inland Water Transport includes Emissions from fuels used by vessels that depart and arrive in Ethiopia. In 2016, Emission from inland water transport was estimated to be 3,245 t CO2e, having insignificant contribution to transport sector emission (see table 21).

Table 21: Inland Water Transport GHG emission (tCO2e), 2016

WATER WAYS	GHG EMISSION (tCO2e)
Lake Tana	2,469
Lake Hawassa	741
Baro River	35
Total	3,245

When these emissions was distributed over the water ways, Lake Tana accounts for the major GHG emitted, contributing to 76 % of the GHG emitted from the inland water transport. Lake Hawassa and Baro River Constituted 23 % and 1% respectively (see figure 12).

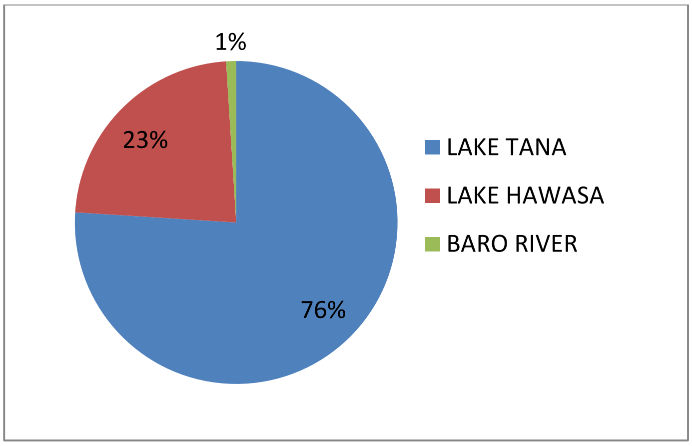

Figure 12: Contribution to inland water transport by waterways (%), 2016

III.1.6 Ethio-Djibouti Railway

The Emission from railway transport is focused on Ethio-Djibouti railway. The inventory covers the emission resulting from activities along Dire Dawa-Djibouti route covering 221km.

In 2016, the total emission from Ethio-Djibouti Railway was estimated to be 682 t CO2e, having insignificant contribution to transport sector total emission. When these emissions were distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emission, contributing to 73 % of the direct GHG emitted and methane, and nitrous oxide constituted 0.2 % and -26 % respectively (see table 22).

Table 22: Ethio-Djibouti railway GHG Emissions, 2016

Direct GHG Emission	**GHG emissions (t)**	**Contribution (%)**
CO2e	682	-
CO2	502	73.6
CH4	0.07	0.2
N2O	0.6	26.2

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

III.1.7. International bunkers GHG inventory for 2016

International bunkers constitute international aviation and maritime transport. For international bunkers, the total direct GHG emissions from aviation and marine amounted to 2,889,899 t CO2e in 2016. When these emissions are distributed over the three direct GHGs, carbon dioxide accounted for the major GHG emitted, contributing to 99% of the direct emission and methane, and nitrous oxide constituted 0.8.% and 0.2% respectively (see table 23).

Table 23: International bunker GHG emission, 2016

Direct GHG Emission	**GHG emissions(t)**	**Contribution (%)**
CO2e	2,889,899	-
CO2	2,865,464	99
CH4	28	0.2
N2O	77	0.8

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

Of the total emission from international bunker, around 96% of the GHG emissions originated from aviation, accounting for 2,782,594 tCO2e and the remaining 4% is contributed by international maritime, emitting 107,304 t CO2e (see table 24).

Table 24: International bunker GHG Emissions by category, 2016

Category	**GHG emissions (t CO2e)**	**Contribution (%)**
International Aviation	2,782,594	96
international maritime	107,304	4
Total	2,889,899	100

III.1.8 Emission Removal from LRT

The 2016 inventory for rail transport focused on emission removal from Addis Ababa Light Rail Transit (LRT). In 2016 the Addis Ababa LRT transported total of 161,755 passengers per day, which would have been transported by public road transport (Minibus, midi bus and Maxi bus) that run on fossil fuel. Assuming that the operation of the Addis Ababa Electric LRT replaced traffic that would otherwise be made by public road transit, the emission removed by LRT is estimated to be 6,272t CO2e in 2016.

The passenger transported by LRT represents 5 % of Addis Ababa s daily passenger using public transport i.e. 3,172,401 passenger/day. When the modal shift is distributed over the modes of road transport, 56% is estimated to be from minibus, 23% from midi bus and the remaining 21% from Maxi bus.

III.2 Ethiopia's Transport Sector GHG Emissions for 2015

III.2.1 Summary

GHG emissions from Ethiopia s transport sector totalled 8,456,864 tons (t) CO2e for 2015. carbon dioxide, methane, and nitrous oxide constitute 7,991,056 t, 3,618t, and 1,257 t respectively (see table 25).

Table 25: Transport Sector GHG Emissions by Modes of Transport, 2015

Mode of Transport	GHG emissions (t CO2e)
Road	8,380,478
Off road	25,433
Domestic Aviation	47,912
Ethio- Djibouti railway	378
Inland Water born	2,662
Total	**8,456,864**

The percentage value by gases showed that the emission from the transport sector constitutes 94% for CO2, 5% for N2O and 1% for CH4 (see table 26).

Table 26: Transport sector GHG Emissions, 2015

Direct GHG	GHG emissions (t)	Contribution (%)
CO2e	8,456,864	-
CO2	7,991,056	94
CH4	3,618	1
N2O	1,257	5

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

Looking at the contribution of the different modes to total emissions, road transport is by far the largest contributor, emitting 8,380,478t CO2e in 2015 and accounting for 99.1% of the total emission. Domestic Air transport and off Road transport emitted 47,912 tCO2e and 25,433 t CO2e respectively and the contribution to the total emission is 0.6% for air transport and 0.3% for off road transport (see figure 13).

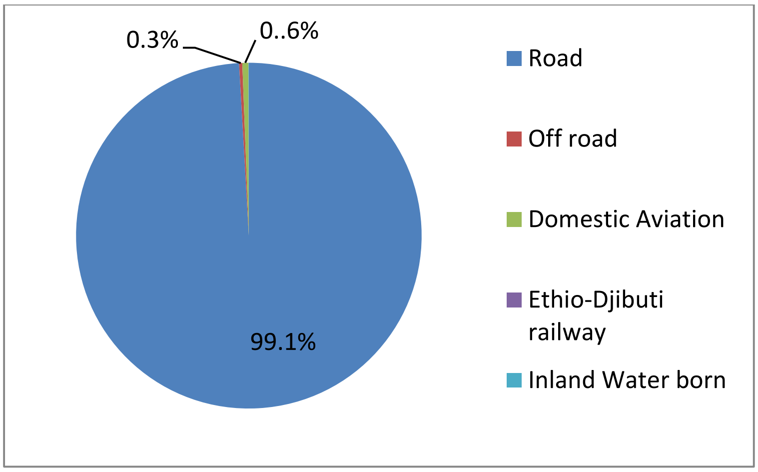

Figure 13: GHG Emission by Modes of Transport, 2015

Inland water transport and Ethio-Djibouti railway have insignificant Contribution to total transport sector emission. Emission from Inland water transport was estimated to be 2,662 t CO2e and Ethio-Djibouti railway's emission for the year was 378t CO2e.

III.2.2 Road Transport

Road transport constituted the biggest contributor to emissions originating from the transport sector, emitting 8,380,478 t CO2e in 2015 and accounting for 99% transport emission. The fuel consumed in this year was 752,987ton of gasoline and 2,171,350 ton of diesel, accounting for 24% and 76% of road transport emission respectively.

When these emissions are distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emitted, contributing to 95% of the direct GHG emitted and methane, and nitrous oxide constitute 1% and 4% respectively (see table 27).

Table 27: Road Transport GHG Emissions, 2015

Direct GHG Emission	GHG emissions (t)	Contribution (%)
CO2e	8,380,478	-
CO2	7,916,571	95
CH4	3,615	1
N2O	1,252	4

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

As for the contribution of the different vehicle categories, freight trucks have the highest share of the 2015 emissions with 55 % of the total road transport GHG emissions (CO2eq.), while buses, passenger cars and motorcycles account for 31%, 11%, and 3% respectively(see figure 14).

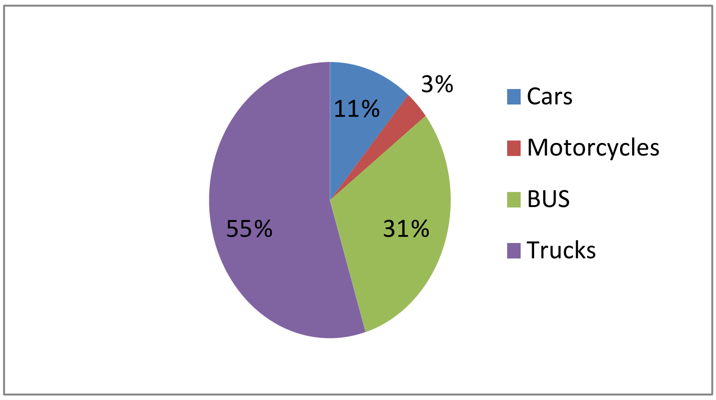

Figure 14: Contribution to Road Transport GHG emissions by Vehicle category, 2015

With respect to regional contribution to road transport sector emission, Addis Ababa was by far the largest contributor, emitting 5,383,144 t CO2e in 2015 and accounted for 64% of the total road transport emission (see figure 15). Following Addis Ababa, Oromia, SNNPR, Tigray and Amhara regions made significant contribution accounting for 16%, 7%, 7% and 3% respectively. The rest of the regions together contributed 3% of combined.

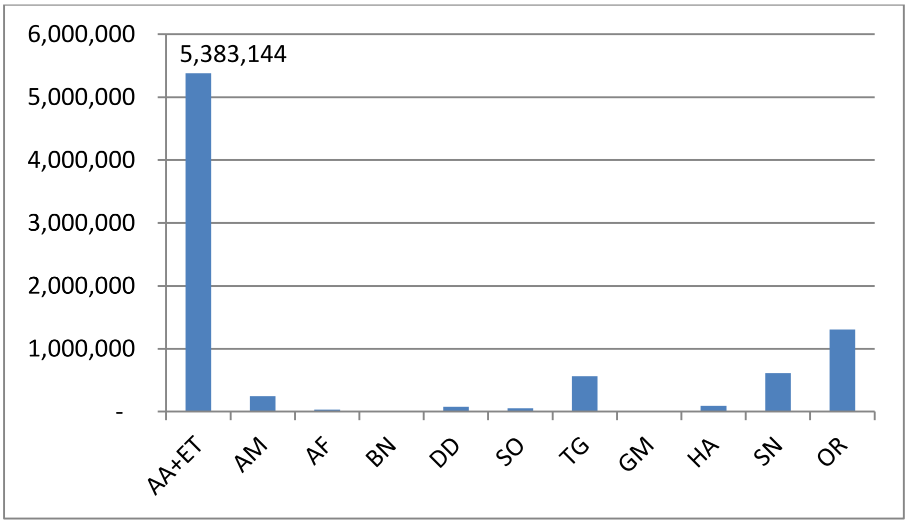

Figure 15: Contribution to road transport emission by region (tCO2e), 2015

II.2.3 Off -Road Transport

In 2015, 8, 709 tons of diesel fuel was consumed by off road transport and the Emission was estimated to be 25,433 tCO2e, accounting for 0.3 % of emission from the transport sector. When the emissions results are distributed over the type of vehicles/machineries, dump trucks accounts for the major GHG emissions, contributing to 93% of the total GHG emitted from the off road transport (see figure 28).

Table 28: Off Road Transport GHG Emissions by Vehicle (Machinery) Type (t CO2e), 2015

Off Road Vehicle	GHG Emission (t CO2e)	Contribution (%)
Tractor	1,678	7
Dump Truck	23, 755	93
Total	25,433	100

As for regional contribution, Addis Ababa was by far the largest contributor, emitting 22,388 t CO2e in 2015 and accounted for 88% of the total off road transport emission and Oromia, Amhara, Dire Dawa and Somali accounted for about 6%, 2%, 1% and 1% respectively. The rest of the other region together accounted only for 2 % of the total off road emission (see figure 16).

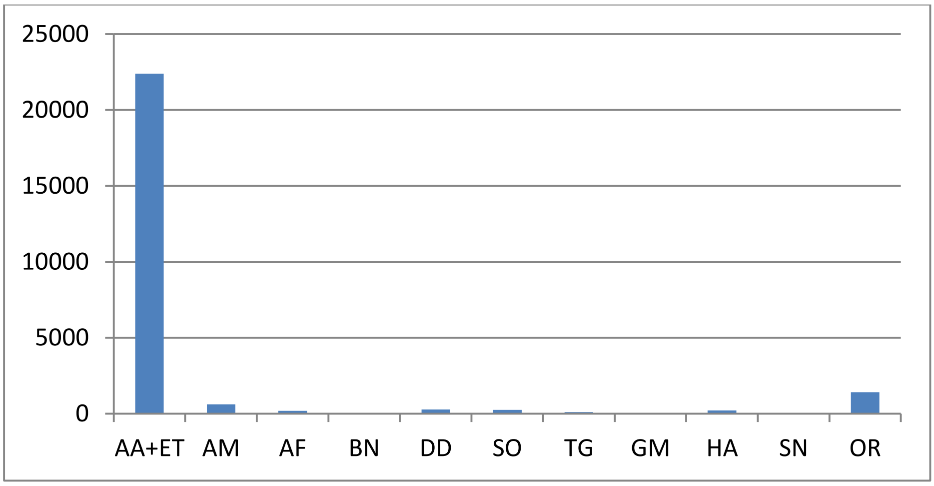

Figure 16: Contribution to off road transport emission by region (tCO2e), 2015

III.2.4 Domestic Air Transport

In 2015, the total emission from domestic air transport was estimated to be 47,912 t CO_2e and this accounted for 0.6% of the transport sector total emission. When these emissions were distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emission, contributing 99% of the direct GHG emitted and methane, and nitrous oxide constituted 0.1 % and 0.8 % respectively (see table 29).

Table 29: Domestic Air Transport GHG Emissions, 2015

Direct GHG Emission	GHG emissions (t)	Contribution (%)
CO_2e	47,912	-
CO_2	47,510	99.1
CH_4	0.3	0.1
N_2O	1.3	0.8

GWP of 1 was used for CO_2, 21 for CH_4 and 310 for N_2O

III.2.5. Inland Water Transport

Inland Water Transport includes Emissions from fuels used by vessels that depart and arrive in Ethiopia. In 2015, Emission from inland water transport was estimated to be 2,662 t CO_2e, having insignificant contribution to transport sector emission (see table 30).

Table 30: Inland water transport GHG emission (tCO_2e), 2015

WATER WAYS	GHG EMISSION (TCO_2E)
Lake Tana	2,023
Lake Hawassa	610
Baro River	28
Total	2,662

When these emissions was distributed over the water ways, Lake Tana accounts for the major GHG emitted, contributing to 76 % of the GHG emitted from the inland water transport. Lake Hawassa and Baro River Constituted 23 % and 1% respectively (see figure 17).

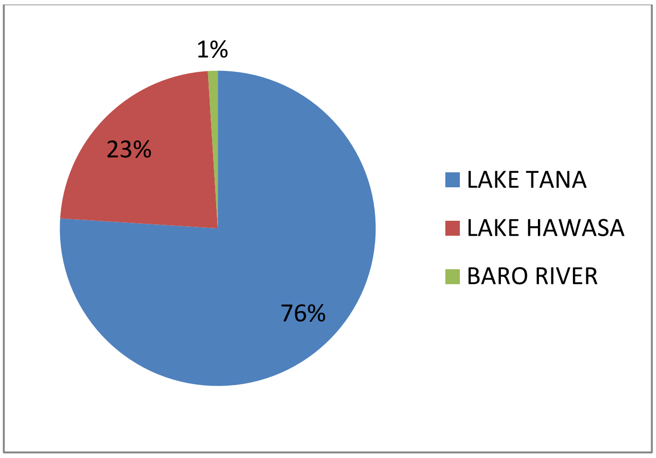

Figure 17: Contribution to inland water transport by waterways (%), 2015

III.2.6. Ethio-Djibouti Railway

The Emission from railway transport is focused on Ethio-Djibouti railway. The inventory covers the emission resulting from activities along Dire Dawa-Djibouti route covering 221km.

In 2015, the total emission from Ethio-Djibouti Railway was estimated to be 378 t CO2e, having insignificant contribution to transport sector total emission. When these emissions were distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emission, contributing 73 % of the direct GHG emitted and methane, and nitrous oxide constituted 0.2 % and -26 % respectively (see table 31).

Table 31: Ethio-Djibouti railway GHG Emissions, 2015

Direct GHG Emission	GHG emissions (t)	Contribution (%)
CO2e	378	-
CO2	278	73.6
CH4	0.04	0.2
N2O	0.32	26.2

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

III.2.7. International bunkers GHG inventory for 2015

International bunkers constitute international aviation and maritime transport. For international bunkers, the total direct GHG emissions from aviation and marine amounted to 2,591,414 t CO2e in 2015. When these emissions are distributed over the three direct GHGs, carbon dioxide accounted for the major GHG emitted gas, contributing to 99% of the direct emission and methane, and nitrous oxide constituted 0.8.% and 0.2% respectively (see table 32).

Table 32: International bunker GHG emission, 2015

Direct GHG Emission	GHG emissions(t)	Contribution (%)
CO_2e	2,591,414	-
CO_2	2,569,438	99
CH_4	29	0.2
N_2O	69	0.8

GWP of 1 was used for CO_2, 21 for CH_4 and 310 for N_2O

Of the total emission from international bunker, around 96% of the GHG emissions originated from aviation, accounting for 2,448,348 tCO_2e and the remaining 4% is contributed by international maritime, which emitted 143,066 tCO_2e (see table 33) .

Table 33: International bunker GHG Emissions by category, 2015

Category	**GHG emissions (t CO_2e)**	**Contribution (%)**
International Aviation	2,448,348	96
international maritime	143,066	4
Total	2,591,414	100

III.2.8. Emission Removal from LRT

The 2015 inventory for rail transport focused on emission removal from Addis Ababa Light Rail Transit. In 2015 the Addis Ababa LRT transported total of 120,000 passengers per day, which would have been transported by public road transport (minibus, midi bus and maxi bus) that run on fossil fuel. Assuming that the operation of the Addis Ababa Electric LRT replaced traffic that would otherwise be made by public transit, the emission removed by LRT was estimated to be 4, 653 t CO_2e in 2015.

The passenger transported by LRT represents 3.7% of Addis Ababa s daily passenger using public transport i.e. 3,172,401 passenger/day. When the modal shift was distributed over the modes of road transport, 56% was estimated to be from minibus, 23% from midi bus and the remaining 21% from maxi bus.

III.3 Ethiopia's Transport Sector GHG Emissions for 2014

III.3.1 Summary

GHG emissions from Ethiopia s transport sector totalled 6,647,656 tons (t) CO_2e for 2014. carbon dioxide, methane, and nitrous oxide constitute 6,280,386t, 2,958 t and 984 t respectively (see figure 34).

Table 34: Transport Sector GHG Emissions by Modes of Transport, 2014

Mode of Transport	GHG emissions (t CO_2e)
Road	6,559,204
Off road	24,584
Domestic Aviation	61,393
Ethio-Djibouti railway	301
Inland Water born	2,175
Total	6,647,656

The percentage value by gases showed that the emission from the transport sector constitutes 94.5% for CO_2, 5% for N_2O and 1% for CH_4 (see table 35).

Table 35: Transport sector GHG Emissions, 2014

Direct GHG	GHG emissions (t)	Contribution (%)
CO_2e	6,647,656	-
CO_2	6,280,386	94
CH_4	2,958	0.04
N_2O	984	0.02

GWP of 1 was used for CO_2, 21 for CH_4 and 310 for N_2O

Looking at the contribution of the different modes to total emissions, road transport is by far the largest contributor, emitting 6,559,204t CO_2e in 2014 and accounting for 98.7% of the total emission. Domestic Air transport and off Road transport emitted 61,393t CO_2e and 24,584t CO_2e respectively and the contribution to the total emission is 0.9% for air transport and 0.36 % for off road transport (see figure 18).

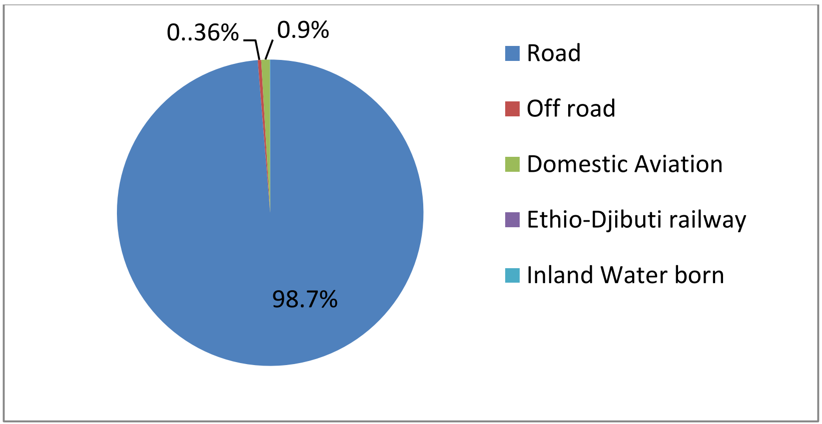

Figure 18: Contribution to Transport sector emission by modes of transport, 2014

Inland water transport and Ethio-Djibouti railway have insignificant Contribution to total transport sector emission. Emission from Inland water transport was estimated to be 2,175 t CO2e and Ethio-Djibouti railway's emission for the year was 301 t CO2e.

III.3.2 Road Transport

Road transport constituted the biggest contributor to emissions originating from the transport sector, emitting 6,484,893t CO2e in 2014 and accounting for 99% transport emission. The fuel consumed in this year was 625,726 ton of gasoline and 1,665,732 ton of diesel, accounting for 24% and 76% of road transport emission respectively.

When these emissions are distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emitted, contributing to 95% of the direct GHG emitted and methane, and nitrous oxide constitute 1% and 4% respectively (see table 36).

Table 36: Road Transport GHG Emissions, 2014

Direct GHG Emission	GHG emissions (t)	Contribution (%)
CO2e	6,484,893	-
CO2	6,123,251	95
CH4	2,946	1
N2O	967	4

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

As for the contribution of the different vehicle categories, freight trucks have the highest share of the 2014 emissions with 55 % of the total road transport GHG emissions (CO2eq.), while buses, passenger cars and motorcycles account for 29%, 13%, and 3% respectively (see figure 19).

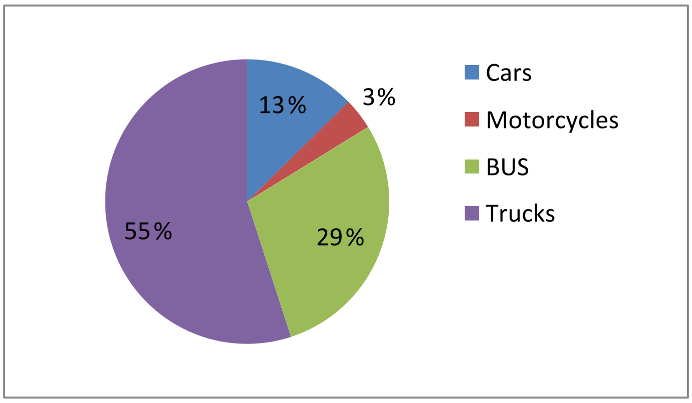

Figure 19: Road Transport GHG emissions by Vehicle category, 2014

With respect to regional contribution of road transport sector emission, Addis Ababa is by far the largest contributor, emitting 4,296,776 t CO2e in 2014 and accounting for 66% of the total road transport emission (figure 20). Following Addis Ababa, Oromia, SNNPR, Tigray and Amara region made significant contribution accounting for 12%, 9% 8% and 2% respectively. Rest of the regions contributed 3% together of road transport total emission.

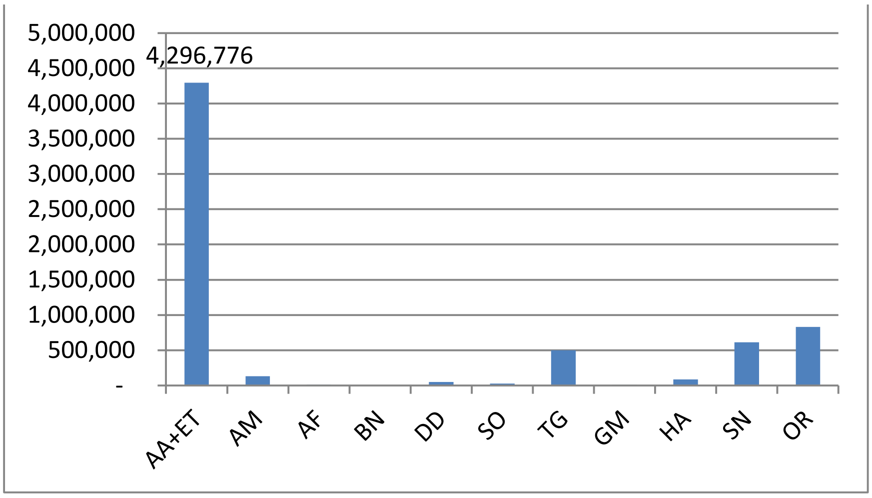

Figure 20: Contribution to road transport emission by region, 2014

III.3.3 Off -Road Transport

In 2014, 8,418 tons of diesel fuel was consumed by off road transport and the Emission was estimated to be 24,584 t CO_2e, accounting for 0.36 % of emission from the transport sector.

When the emissions results are distributed over the type of vehicles/machineries, dump trucks accounts for the major GHG emissions , contributing to 97% of the total GHG emitted from the off road transport (see table 37).

Table 37: Off Road Transport GHG Emissions by Vehicle (Machinery) Type (t CO2e), 2014

Off Road Vehicle	GHG Emission (t CO2e)	Contribution (%)
Tractor	828	3
Dump Truck	23,755	97
Total	**24, 583**	100

Addis Ababa was by far the largest contributor, emitting 22, 202 tCO_2e in 2014 and accounted for 90% of the total off road transport emission. Oromiya, Amhara, Dire Dawa and Somali accounted for 4%, 2%, 1% and 1% of the total off road emission respectively (see figure 21).

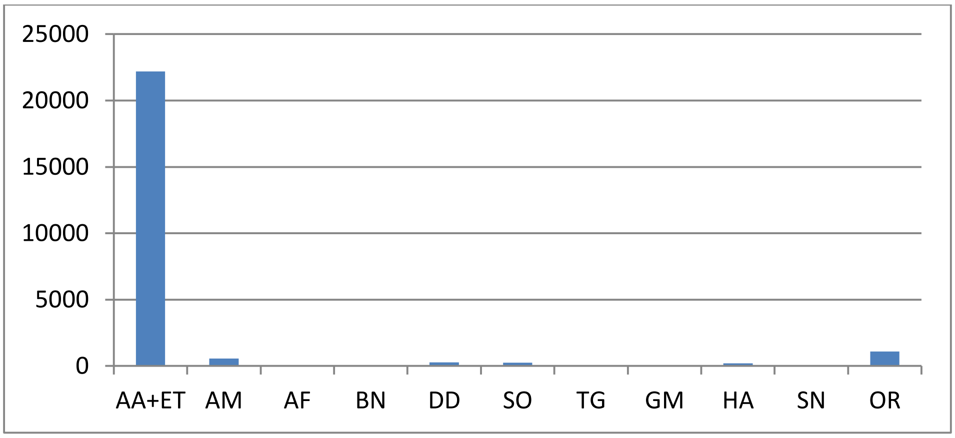

Figure 21: Contribution to off road transport emission by regions (tCO2e), 2014

III.3.4 Domestic Air Transport

In 2014, the total emission from domestic air transport was estimated to be 61,392 t CO_2e and this accounted for 0.9% of the transport sector total emission. When these emissions were distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emission, contributing 99% of the direct GHG emitted and methane, and nitrous oxide constituted 0.1 % and 0.8 % respectively (see table 38).

Table 38: Domestic Air Transport GHG Emissions, 2014

Direct GHG Emission	**GHG emissions (t)**	**Contribution (%)**
CO_2e	61,392	-
CO_2	60,877	99.1
CH_4	0.4	0.1
N_2O	1.6	0.8

GWP of 1 was used for CO_2, 21 for CH_4 and 310 for N_2O

III.3.5. Inland Water Transport

Inland Water Transport includes Emissions from fuels used by vessels that depart and arrive in Ethiopia. In 2014, Emission from inland water transport was estimated to be 2,175t CO_2e, having insignificant contribution to transport sector emission (table 39).

Table 39: Inland Water Transport GHG Emission (tCO_2e), 2014

Water Ways	**GHG emission (tCO_2e)**
Lake Tana	1,650
Lake Hawassa	496
Baro River	28
Total	2,175

When these emissions was distributed over the water ways, Lake Tana accounts for the major GHG emitted, contributing to 76 % of the GHG emitted from the inland water transport. Lake Hawassa and Baro River Constituted 23 % and 1% respectively (see Figure 22).

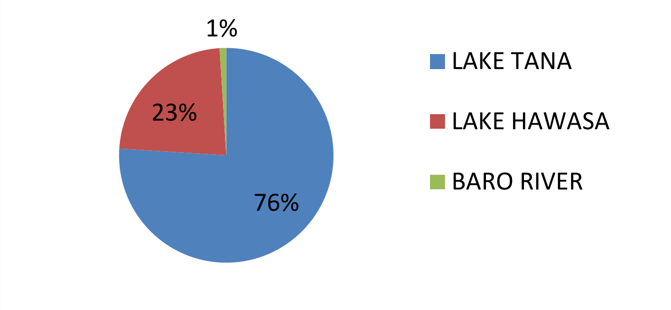

Figure 22: Contribution to inland water transport by waterways (%), 2014

III.3.6. Ethio-Djibouti Railway

The Emission from railway transport is focused on Ethio-Djibouti railway. The inventory covers the emission resulting from activities along Dire Dawa-Djibouti route covering 221km.

In 2015, the total emission from Ethio-Djibouti Railway was estimated to be 301 t CO2e, having insignificant contribution to transport sector total emission. When these emissions were distributed over the three direct GHGs, carbon dioxide accounts for the major GHG emission, contributing 73 % of the direct GHG emitted and methane, and nitrous oxide constituted 0.2 % and 26 % respectively (see table 40).

Table 40: Ethio-Djibouti railway GHG Emissions, 2014

Direct GHG Emission	GHG emissions (t)	Contribution (%)
CO2e	301	-
CO2	222	73.6
CH4	0.031	0.2
N2O	0.25	26.2

GWP of 1 was used for CO2, 21 for CH4 and 310 for N2O

III.3.7. International bunkers GHG inventory for 2014

International bunkers constitute international aviation and maritime transport. For international bunkers, the total direct GHG emissions from aviation and marine amounted to 2,032,236 t CO2e in 2014. When these emissions are distributed over the three direct GHGs, carbon dioxide accounted for the major GHG gas emitted, contributing to 99% of the direct emission and methane, and nitrous oxide constituted 0.8% and 0.2% respectively (see table 41).

Table 41: International bunker GHG emission, 2014

Direct GHG Emission	GHG Emissions(t)	Contribution (%)
CO_2e	2,032,236	-
CO_2	2,014,926	99
CH_4	27	0.2
N_2O	54	0.8

GWP of 1 was used for CO_2, 21 for CH_4 and 310 for N_2O

Of the total emission from international bunker, around 96% of the GHG emissions originated from aviation, accounting for 1,865,691 tCO_2e and the remaining 4% is contributed by international maritime, which amounted to 166,544 tCO_2e (see table 42)
.

Table 42: International bunker GHG Emissions by category, 2014

Category	**GHG emissions (t CO_2e)**	**Contribution (%)**
International Aviation	1,865,691	9 6
international maritime	166,544	4
Total	2,032,236	100

III.4 Ethiopia's Transport Sector GHG Emissions 2030 Projection

Under the business usual Scenario i.e. assuming if no new mitigation measures are implemented between 2017-2030, the emission from the transport sector will grow from 12,540,419 t CO_2e in 2016 to 53,227,425 t Co2e by 2030. The projection is made taking growth rate of 10.8% per year by taking the average projection rate used in the Ethiopian CRGE strategy, 2011 (see table 43).

Table 43: Transport Sector GHG Emission Forecast 2017-2030

Year	GHG Emission (t CO_2e)
2020	18,959,585
2025	31,767,162
2030	53,227,425

When these emissions are distributed over the modes of transport:

- Emission from road transport will grow from 11,635,203 t CO_2e in 2016 to 49,367,919 t CO_2e by 2030 accounting for 92.7 % of transport emission by 2030.
- Emission from off-road transport will grow from 783,165 t CO_2e in 2016 to 3,322,953 t CO_2e by 2030 accounting for 6 % of transport emission by 2030.
- Emission from Domestic air transport will grow from 122,051t CO_2e in 2016 to 517,859 t CO_2e by 2030 accounting for 0.9 % of transport emission by 2030. (see figure 23)

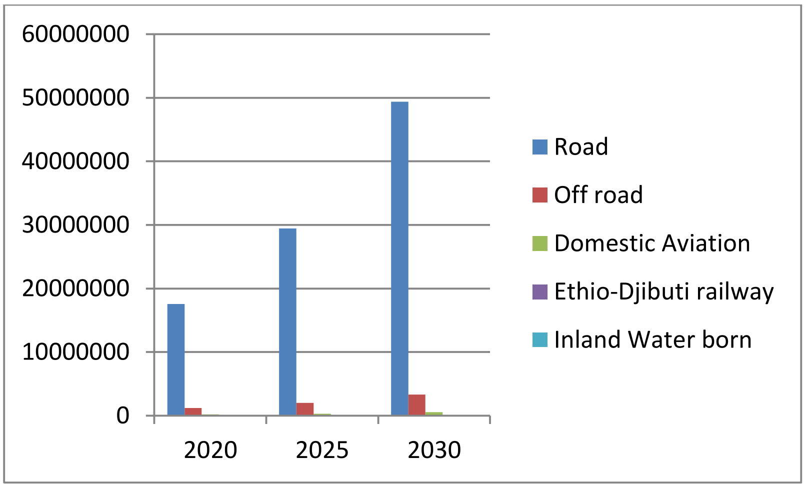

Figure 23: Transport sector emission projection by modes of transport

Inland water transport and Ethio-Djibouti railway will have insignificant Contribution to total transport sector emission by 2030. Emission from Inland water transport is estimated to reach 13,770 tCO_2e and Emission from Ethio-Djibouti railway will grow to 2,892 tCO_2e by 2030 (see table 44). For detail transport sector GHG emission projection year by year from 2017 up to 2030 (see Annex V).

Table 44: Transport Sector GHG Emission Forecast by Modes of Transport, 2017-2030

Modes	GHG Emission (t CO2e)			Contribution (%) by 2030
	2020	2025	2030	
Road	17,583,629	29,462,980	49,367,920	92.7
Off road	1,183,553	1,983,152.2	3,322,953	6
Domestic Aviation	184,448	309,061	517,860	0.97
Ethio-Djibouti railway	1,030	1,726	2,892	0.005
Inland Water born	4,905	8,218	13,770	0.03
Road	18,959,585	31,767,162	53,227,425	100

III.5 International bunker GHG Emissions 2030 Projection

Under the business usual Scenario i.e. assuming if no new mitigation measures are implemented between 2017-2030, the emission from the international bunker will grow from 2,889,899 t CO2e in 2016 to 12,261,779 t Co2e by 2030. The projection is made taking growth rate of 10.8% per year by taking the average projection rate used in the Ethiopian CRGE strategy, 2011 (see table 45). For detail international bunker emission projection year by year from 2017 up to 2030 (see Annex V).

Table 45: International bunker GHG Emission Forecast 2017-2030

Year	GHG Emission (t CO2e)
2020	4,367,342
2025	7,317,881
2030	12,261,779

When the emissions are distributed over the two modes of transport:

- Emission from international aviation will grow from 2,782,594t CO2e in 2016 to 11,806,489t CO2e by 2030 accounting for 96 % of international bunkers emission by 2030.
- Emission from international maritime will grow from 107,304t CO2e in 2016 to 455,290t CO2e by 2030 accounting for 4% of international bunkers emission by 2030.

IV. CONCLUSION

IV.CONCLUSION: GHG REDUCTION ACTIONS AND STRATEGIES

Transport is one the sector that is given due consideration in the GTP II and CRGE Strategy. Transport is assumed to play a major role in the country s economic development and also in the emission reduction goals through the sector s green economy initiatives. When GTP II was launched last year in 2016, the National Planning Commission (NPC) has announced that the national plans are integrated with the CRGE Strategy at policy level. Cascading that policy level integration down to sector and program levels is the key responsibility of sector institutions including MoT.

GTP II, the current economic plan for 2015 to 2010, is integrated with CRGE strategy. The integration is happening at a policy level so far and it is expected that will be cascaded into sector and program levels. In the GTP II, The Government of Ethiopia has allocated large investment to expand transport infrastructure and transport service delivery. Transport infrastructure contributes to accelerating growth and transformation by enhancing the efficient use of transport infrastructure, by reducing transportation cost and thereby improving competitiveness. To this end, the major strategic directions pursued in the GTP included enhancing the capacity of management and human resource in the transport sub-sector and rendering the transport system efficient. Accordingly, during GTP I period, total distance covered by buses increased from 70,000 Km in 2009/10 to 101,983 Km by 2014/15. The number of passengers transported increased from148.1 million to 394 million. The number of deaths (due to car accident) per 10,000 vehicles decreased from 70 deaths per 10,000 to 60 during the same period. Although the volume of transport services has increased significantly, more needs to be done to improve quality of services and safety by strengthening modern transport and traffic management information system and conducting studies related to traffic accident during the period of GTP II (GTP II, 2016).

Transport sector in CRGE Strategy

Ethiopia hopes to capitalize on its current economic growth by becoming more resilient to the impacts of climate change while developing its economy in a carbon neutral way. Ethiopia s Climate Resilient Green Economy Strategy (CRGE) sets out this vision (CRGE 2011). It’s viewed as an opportunity to transform the country s development model by leapfrogging to modern energy-efficient development trajectories.

The transport sector contributes to the national GHG emission is one of the lowest (3%) compared to the other CRGE sectors. According to the CRGE Strategy, 75% of the transport sector emissions come from road transport, particularly freight and construction vehicles, and to a lesser extent private passenger vehicles. Air transport also contributes a significant share (23% of transport related emissions).

Emissions from inland water transport are minimal (CRGE, 2011). The CRGE Strategy also detailed, emissions from the sector are projected to grow from around 5 Mt CO_2e in 2010 to 40 Mt CO_2e in 2030. The increased emissions are driven first by higher emissions from freight transport (+13% p.a.) and also by higher emissions from passenger transport (+9% p.a.) (CRGE, 2011).

GTP II Strategic Directions for Transport Sector

In the past two decades, focus has been given for the development of transport infrastructure. Investments have been allocated for the development of roads, aviation and air transport, sea transport and maritime services, and recently rail way transport infrastructure. As a result, the transportation service sector has been expanding fast. During the GTP II period, the transport and logistics sector is set to bring about fundamental changes. In view of the required high capacity in the transport infrastructure, it needs to be guided by a clear vision and integrated transport strategy or master plan. This calls for formulating an Integrated National Transport and Logistics Strategy/Master Plan based on the assessment of the sector in the past and the future development vision and international experiences.

In GTP II, the Government of Ethiopia has indicated a plan to reduce transportation cost through creating an integrated system and increasing efficiency of transport services. It is also planned to enhance the capacity of the private sector to enable it play its role in providing transport services. Ensuring linkages between the ever growing major agricultural products to the major market centers, to enable agriculture and rural economy to expand its base and supply industrial input and thereby strengthen linkages to urban areas, expanding the accessibility of rural transport so as to link rural kebeles and woredas to market centers are the other focus areas of the sub sector. It is also planned to ensure that dry ports built in the country have the required quality, efficiency and generate economic benefits. To improve the standard of the transport corridors currently used for import and export products, expanding and enhancing their capacity are the other focus areas in the development of the sector. The other strategic focus of the sector is to fundamentally change the road traffic safety landscape of the country. To this end, road designs will consider the road traffic safety requirements. The transport management system will be improved to provide efficient and quality transport services at national, regional and city levels. The road, railways, maritime and air transport system will be expanded in an integrated manner. Expansion of transport infrastructure and services is planned to be undertaken through mainstreaming cross cutting issues (GTP II, 2016).

Focus will also be given to maritime transport and logistics services given its key role in expanding manufacturing industry and export development. To realize its mission of creating modern information system, comprehensive, consistent, timely and accessible information will be provided to service providers and customers about the end-to-end shipping, logistics and support services (GTP II, 2016).

Transport sector: the Green Growth Plan/Ambition

Building a green economy (which is the main focus of CRGE strategy) offers an opportunity to achieve its economic development targets sustainably. It represents the ambition to achieve economic development targets in a resource-efficient way that overcomes the possible conflict between economic growth and fighting climate change. This would be achieved by emphasizing good stewardship of resources and seizing opportunities for innovation based on the latest production platforms.

The transport sector is a prime example of this. The total cost for export shipments, for example, could be significantly reduced by revamping the railway connecting Addis Ababa with the seaport of neighbouring Djibouti. However, maintaining the road connecting both cities in good condition requires much less capital investment than revamping the railway. Shifting transport from road to rail would not only decrease transport costs and improve the trade balance through reduced import of fossil fuels (economic benefits), but would also lower emissions, congestion, air pollution, and traffic accidents (social and environmental benefits).

Transport Sector Mitigation Actions

Transport offers various opportunities to reduce emissions. All of these opportunities achieve their abatement potential through increased efficiency or a shift to lower-emitting fuel sources. The largest initiatives with the greatest abatement potential are the construction of an electric rail network (9 Mt CO2e) followed by the introduction of fuel efficiency standards for all vehicles (3 Mt CO2e). This assumes the construction of more than 5000 km of rail tracks and new fuel efficiency standards for 30% of passenger vehicles and 10% of freight vehicles by 2030. Although the abatement potential is not as large, the introduction of bio-fuels will also form a priority. The combined abatement potential of increasing the use of ethanol and biodiesel in the fuel mix is 1 Mt CO2e (CRGE, 2011).

According to CRGE and INDC, there are lists of mitigation actions that are intended to be undertaken until 2030. As a result the transport sector has a total to reduce a 13.18 MtCO2e/year until the year 2030 through the recommended abatement actions. A total of USD 22.9 billion is required to implement the intended projects. Here is a summary of the mitigation actions with a breakdown of the abatement potential against each action.

On-road

- Bus rapid transit (0.04 MtCO2e/year)
- Hybrids vehicles (0.1 MtCO2e/year)
- Plug-in electric vehicles (0.04 MtCO2e/year)
- E15 fuel blend (0.2 MtCO2e/year)
- B5 fuel blend (0.7 MtCO2e/year)

Railway

- Electric rail (8.9 MtCO2e/year)

- Light rail transit (0.1 MtCO2e/year)

Aviation

According to the Ethiopian Civil Aviation Authority draft report titled Ethiopian Draft State Action Plan for Reduction of CO2 in International Aviation states the following mitigation actions have been identified for the aviation sector (EAA, 2017).

- Purchase of new aircraft for replacement
- Continuous Climb Operations (CCO)
- Continuous Descent Operations (CDO)
- Minimizing weight
- Minimizing flaps (Take-off)
- Minimizing flaps (Landing)
- Single engine taxi
- E-taxi
- Engine wash
- Selecting aircraft best suited to the mission

In addition to the above levers, more ideas for carbon abatement in the transport sector are under discussion and could possibly be implemented in the future. Ideas include changing roads from gravel to asphalt, establishing dry ports, encouraging the use of telecommunication as well as promoting scooters and bicycles. These additional possible levers were not quantified as of yet due to limited expected abatement potential or current constraints in implementation. Nonetheless, they should be considered for future implementation as the initiatives may have significant societal benefits.

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ANNEX I: 2014 to 2016 On-Road Transport Activity Data

On-Road Transport Activity Data for 2016															
				Vehicle Stock(No)											
Vehichle Type	Fuel Type	National Average Fuel Economy (Km/l)	National Average (VKM/yr)	Addis Ababa	Amhara	Oromiya	SNNP	Gambella	Tigray	Diredawa	Somali	Afar	Bensanguel	Harare	National
Ambulance	GASOLINE	12	22043	17171	0	160	6	8	71	8	0	26	27	4	17482
Automobile	GASOLINE	12	22043	138278	1380	6373	11906	21	951	2020	566	47	27	1294	162863
Bajaj	GASOLINE	20	25435	110	1140	5147	4754	185	0	0	0	1799	1148	544	14828
Moter Bicycle	GASOLINE	33	10174	18439	17649	401	1	2	5853	6362	1102	875	2355	0	53040
Three wheel public load	GASOLINE	26	25435	15	0	7	0	0	5177	88	2	0	2	0	5292
Tri Cycle	GASOLINE	33	25435	0	3709	16526	0	0	0	0	0	0	0	0	20235
Field Vehicle	DIESEL	11	15261	47000	1474	7163	78	45	1061	415	850	281	128	452	58947
Dual purpose Vehicle	DIESEL	11	22043	40686	2885	131	75	1	1708	1038	397	318	231	37	47508
Bus (<12 seats)-Gasoline	GASOLINE-51%	12	109361	11988	3125	7287	0	0	1465	579	382	215	110	0	25152
	DIESEL-49%	11	109361	11518	3003	7286	0	0	1407	557	367	207	106	0	24450
Bus (>11 seats)	DIESEL	6	83426	14248	6977	2067	1456	143	1561	448	514	280	171	362	28225
Dry cargo (<=10Q)	DIESEL	11	50869	29201	1201	1063	41	48	752	752	902	228	90	179	34456
Dry cargo (>10Q)	DIESEL	5	84782	92053	3688	509	0	2	4486	3926	2305	213	87	2	107271
Three wheel dry load	GASOLINE	20	25435	0	0	263	0	0	67	0	0	0	0	1	331
Liquid cargo	DIESEL	5	70539	5350	207	358	1523	13	637	222	116	33	2	7	8469
liquid trailer	DIESEL	5	70539	630	10	2188	29	24	0	0	0	0	0	341	3222
Gotach	DIESEL	5	84782	750	0	1305	3628	0	316	57	0	0	0	1724	7780
Trailer	DIESEL	5	84782	19318	255	13	0	0	2550	353	1	8	1	0	22499

On-Road Transport Activity Data for 2015

Vehicle Type	Fuel Type	Fuel Economy (Km/l)	National Average (VKM/yr)	Vehicle Stock(No)												
				Addis Ababa	Amhara	Oromiya	SNNP	Gambella	Tigray	Diredawa	Somali	Afar	Benishangul	Harare	ET	National
Ambulance	GASOLINE	12	20186	163	131	32	3	8	74	40	69	10	9	6	882	1428
Automobile	GASOLINE	12	20186	92230	21669	10053	10728	21	7163	601	83	47	102	1827	6242	150766
Bajaj	GASOLINE	20	23292	32024	15891	8122	3140	185	2325	11997	8022	1182	199	768	0	83857
moto cycle	GASOLINE	33	9317	13818	3641	9692	16357	214	4238	156	591	682	527	454	8061	58431
Field vehichle	GASOLINE	11	13975	22440	154	1640	629	48	71	71	60	236	59	252	21841	47502
Double cabin	GASOLINE	11	13975	12811	165	2516	234	143	1353	52	79	207	65	512	13876	32011
pick up	DIESEL	11	13975	12252	131	3205	817	24	0	77	39	149	46	481	2067	19288
mini bus	GASOLINE-51%	12	20186	3829	35	8320	1521	12	184	149	31	201	29	2	1286	15600
	Diesel-49%	11	20186	3679	34	7994	1461	11	177	143	30	193	28	2	1236	14989
medium bus	DIESEL	6	100147	7748	51	9360	2995	45	0	28	31	38	25	638	937	21895
higher bus	DIESEL	6	100147	4891	1390	641	295	2	217	82	88	207	6	3	2012	9834
passenger	DIESEL	6	76397	0	0	462	612	13	324	0	0	0	1	10	0	1422
Dry cargo	DIESEL	5	46584	17128	335	8299	2098	59	690	689	264	411	28	512	20311	50823
trailer dry	DIESEL	5	77640	71	64	223	0	0	151	43	31	0	0	0	14606	15188
power	DIESEL	5	64596	3734	311	499	1	2	4853	150	77	0	4	0	10996	20628
quintal	DIESEL	5	64596	1662	0	0	18	0	470	0	0	0	0	103	0	2253
semi trailer dry	DIESEL	5	77640	72	54	412	0	0	1033	29	31	1	0	1	12470	14105
semi trailer liquid	DIESEL	5	77640	95	67	8	0	0	3962	49	39	3	0	0	1543	5765
liquid	DIESEL	5	77640	1599	121	165	3766	1	917	84	76	28	1	52	5181	11990
trailer liquid	DIESEL	5	77640	93	64	2	0	0	1	40	39	0	0	0	4396	4634

On-Road Transport Activity Data for 2014																
Vehichle Type	Fuel Type	Fuel Economy (Km/l)	National Average (VKM/yr)	Vehicle Stock(No)												
				Addis Ababa	Amhar a	Oromi ya	SNNP	Gamb ella	Tigra y	Diredawa	Somali	Afar	Benish angul	Harare	ET	National
Ambulance	GASOLINE	12	18486	164	58	25	3	8	44	36	36	6	9	6	686	1080
Automobile	GASOLINE	12	18486	100042	17952	8165	11306	21	7179	429	41	25	102	1827	4856	151947
Bajaj	GASOLINE	20	21330	35676	13006	6597	3206	185	1452	11593	5515	347	199	768	0	78545
moto cycle	GASOLINE	33	8532	12928	239	6671	14398	214	3419	152	406	68	527	454	6272	45749
Field vehichle	GASOLINE	11	12798	21779	68	1332	375	48	0	49	39	47	59	252	16992	41040
Double cabin	GASOLINE	11	12798	14282	136	1697	139	143	1370	50	54	205	65	512	10796	29448
pick up	DIESEL	11	12798	10126	109	2159	467	24	0	74	27	147	46	481	1608	15269
mini bus	GASOLINE-51%	12	18486	7151	58	11128	1910	23	0	42	38	351	57	2	1962	22721
	Diesel-49%	11	18486	0	0	0	0	0	0	0	0	0	0	2	0	2
medium bus	DIESEL	6	91710	8637	43	6746	1747	45	0	27	21	37	25	638	729	18695
higher bus	DIESEL	6	91710	4347	53	521	169	2	0	34	27	4	6	3	1565	6731
passenger	DIESEL	6	69961	0	0	375	450	13	328	0	0	0	1	10	0	1177
Dry cargo	DIESEL	5	42659	13502	72	5419	1145	59	399	79	124	160	28	512	15802	37300
trailer dry	DIESEL	5	71099	79	53	181	0	0	152	42	21	0	0	0	11364	11892
power	DIESEL	5	59154	4162	258	405	0	2	4913	146	53	0	4	0	8555	18498
quintal	DIESEL	5	59154	1853	0	0	19	0	476	0	0	0	0	103	0	2451
semi trailer dry	DIESEL	5	71099	81	45	335	0	0	1046	29	21	1	0	1	9702	11260
semi trailer liquid	DIESEL	5	71099	106	55	7	0	0	4010	47	27	3	0	0	1201	5455
liquid	DIESEL	5	71099	1509	100	128	7285	1	875	29	27	25	1	52	4031	14061
trailer liquid	DIESEL	5	71099	103	53	1	0	0	1	39	27		0	0	3420	3644

ANNEX II: 2014 to 2016 Off-Road Transport Activity Data

Off-Road Transport Activity Data , 2016

Vehicle Type	Fuel Type	Hr/year	National	Addis Ababa	Amhara	Afar	Benishangul	Dire Dawa	Somali	Tigray	Gambella	Harare	SNNPR	Oromiya	
Combiner	Diesel	240	6882	16	19	0	0	1	2	8	59	357	98	6322	
Dozer	Diesel	640	296	14	0	3	0	0	1	5	0	20	1	252	
Grader	Diesel	640	17769	4	2	0	0	1	1	0	23	3	218	17517	
Forklift	Diesel	640	50710	16	0	2	0	3	0	2	214	317	30276	19880	
Tractor	Diesel	240	4666	715	213	44	114	16	3141	184	0	0	1	238	
Vehicles with Machinery	Diesel	320	617	149	99	12	1	103	27	62	0	0	0	164	

Off-Transport Activity Data , 2015

Vehicle Type	Fuel Type	Hr/year (VKM)	National	Addis Ababa	Amhara	Afar	Benishangul	Diredawa	Somali	Tigray	Gambella	Harare	SNNPR	Oromiya	ET
Combiner	Diesel	240	0	0	0	0	0	0	0	0	0	0	0	0	0
Dozer	Diesel	640	0	0	0	0	0	0	0	0	0	0	0	0	0
Grader	Diesel	640	0	0	0	0	0	0	0	0	0	0	0	0	0
Forklift	Diesel	640	0	0	0	0	0	0	0	0	0	0	0	0	0
Tractor	Diesel	240	399	105	13	43	0	0	0	25	0	0	0	213	0
Dum truck	Diesel	28000	2324	510	55	0	0	26	25	0	0	20	0	51	1637

Off-road Transport Activity Data , 2014

Vehicle Type	Fuel Type	Hr/year	National	Addis Ababa	Amhara	Afar	Benishangul	Diredawa	Somali	Tigray	Gambella	Harari	SNNPR	Oromiya	ET
Combiner	Diesel	240	0	0	0	0	0	0	0	0	0	0	0	0	0
Dozer	Diesel	640	0	0	0	0	0	0	0	0	0	0	0	0	0
Grader	Diesel	640	0	0	0	0	0	0	0	0	0	0	0	0	0
Forklift	Diesel	640	0	0	0	0	0	0	0	0	0	0	0	0	0
Tractor	Diesel	240	197	61	0	0	0	0	0	0	0	0	0	136	0
Dum truck	Diesel	28000	2324	510	55	0	0	26	25	0	0	20	0	51	1637

ANNEX III: 2014 to 2016 On-Road Transport GHG Emission (CO_2e)

National Road Transport GHG Emission for 2016													
Vehicles Type	**National**	**Addis Ababa**	**Amhara**	**Oromiya**	**SNNP**	**Gambella**	**Tigray**	**Diredawa**	**Somali**	**Afar**	**Benishangul**	**Harare**	
Ambulance	78265	76875	0	716	26	36	317	37	0	118	121	18	
Automobile	729131	619065	6177	28532	53303	94	4258	9045	2534	209	121	5792	
Bajaj	45957	342	3533	15953	14734	573	0	0	0	5577	3558	1686	
Motor Bicycle	39853	13854	13261	301	1	2	4398	4780	828	658	1769	0	
Three wheel public load	12616	35	0	17	0	0	12343	211	6	0	5	0	
Tri Cycle	38011	0	6967	31043	0	0	0	0	0	0	0	0	
Field Vehicles	238838	190433	5974	29023	314	182	4298	1683	3445	1137	519	1830	
Dual purpose Vehicles	278039	238116	16884	767	441	6	9998	6076	2322	1862	1354	214	
Bus (<12 seats)-Gasoline	558646	266264	69416	161851	0	0	32530	12870	8490	4786	2439	0	
	709919	333576	87185	211551	0	0	40857	16164	10664	6011	3064	0	
Bus (>11 seats)	1146156	577091	283312	83936	59112	5807	63370	18173	20868	11356	6955	14711	
Dry cargo (<=10Q)	465357	393383	16216	14357	547	648	10157	10154	12186	3079	1217	2412	
Dry cargo (>10Q)	5312205	4547044	182610	25206	0	99	222136	194435	114168	10537	4315	101	
Three wheel dry load	1025	0	0	815	0	0	207	0	0	0	0	3	
Liquid cargo	348918	219877	8521	14750	62744	536	26251	9146	4781	1378	83	293	
liquid trailer	132772	25903	424	90149	1193	989	0	0	0	0	0	14048	
Gotach	385297	37038	0	64625	179674	0	15649	2837	0	0	0	85380	
Trailer	1114199	954233	12636	644	0	0	126260	17493	59	401	50	0	

National Road Transport GHG Emission for 2015													
Vehicles Type	**National**	**Addis Ababa**	**Amhara**	**Oromiya**	**SNNP**	**Gambella**	**Tigray**	**Diredawa**	**Somali**	**Afar**	**Benishangul**	**Harare**	**ET**
Ambulance	5853	670	538	131	13	33	304	163	285	42	35	23	3616
Automobile	618108	378123	88837	41215	43982	86	29367	2464	342	191	420	7490	25591
Bajaj	238014	90895	45104	23054	8914	525	6600	34052	22769	3354	566	2180	0
moto cycle	40205	9508	2506	6669	11255	147	2916	107	407	469	363	313	5547
Field vehichle	147082	69482	478	5079	1948	149	220	219	186	731	184	781	67626
Double cabin	99116	39668	510	7789	724	443	4189	160	244	640	200	1584	42965
pick up	71568	45461	487	11892	3031	89	0	284	143	553	172	1786	7669
mini bus	890687	315185	2094	380770	121822	1831	0	1138	1255	1526	1009	25940	38117
	80330	19718	182	42842	7831	60	948	766	162	1035	150	11	6622
medium bus	1067321	377690	2509	456282	145981	2194	0	1364	1504	1828	1209	31085	45676
higher bus	479358	238398	67742	31263	14363	97	10584	4020	4287	10079	315	140	98069
passenger	52890	0	0	17171	22771	483	12051	0	0	0	40	373	0
Dry cargo	1382881	466047	9103	225808	57090	1605	18763	18755	7178	11197	763	13920	552653
trailer dry	688773	3200	2918	10107	0	0	6828	1937	1399	0	0	0	662384
power	778302	140879	11749	18814	40	75	183116	5668	2910	0	163	0	414887
quintal	85008	62699	0	0	673	0	17743	0	0	0	0	3893	0
semi trailer dry	639652	3284	2451	18686	0	0	46858	1336	1399	46	0	65	565526
semi trailer liquid	261436	4294	3034	364	0	0	179665	2204	1749	138	0	0	69988
liquid	543754	72496	5485	7489	170805	45	41564	3807	3428	1287	49	2339	234959
trailer liquid	210142	4210	2918	73	0	0	49	1803	1749	0	0	0	199340

National Road Transport GHG Emission for 2014													
Vehicles Type	**National**	**Addis Ababa**	**Amhara**	**Oromiya**	**SNNP**	**Gambella**	**Tigray**	**Diredawa**	**Somali**	**Afar**	**Benishangul**	**Harare**	**ET**
Ambulance	4048	614	216	93	14	30	166	134	135	23	32	22	2576
Automobile	568640	375595	67400	30655	46352	79	26953	1612	155	94	385	6859	18233
Bajaj	203621	92728	33805	17147	9099	481	3775	30131	14336	902	518	1996	0
motor cycle	28750	8146	150	4204	9907	135	2155	96	256	43	332	286	3952
Field vehicle	116179	61754	193	3777	1160	136	0	138	111	134	168	715	48181
Double cabin	83112	40496	387	4811	431	405	3883	142	153	580	183	1451	30611
pick up	51446	34405	369	7336	1734	82	0	253	90	501	158	1636	5464
mini bus	690096	321764	1589	251287	71071	1676	0	1013	790	1382	924	23755	27157
	74311	0	0	0	0	0	0	0	0	0	0	10	0
medium bus	826951	385574	1904	301120	85166	2009	0	1214	947	1656	1107	28466	32542
higher bus	300452	194034	2379	23253	8242	89	0	1533	1184	179	289	128	69870
passenger	39988	0	0	12771	16725	443	11171	0	0	0	37	342	0
Dry cargo	926019	336421	1806	135016	31151	1470	9935	1961	3092	3998	698	12747	393742
trailer dry	493851	3266	2214	7517	0	0	6330	1724	881	0	0	0	471920
power	639156	143820	8914	13993	0	69	169745	5044	1832	0	149	0	295589
quintal	83720	64007	0	0	709	0	16448	0	0	0	0	3565	0
semi trailer dry	467615	3352	1859	13899	0	0	43437	1189	881	42	0	60	402913
semi trailer liquid	226553	4384	2302	270	0	0	166546	1961	1101	125	0	0	49863
liquid	583358	62663	4162	5300	330351	42	36327	1189	1101	1041	45	2142	167398
trailer liquid	151339	4298	2214	54	0	0	46	1605	1101	0	0	0	142021

ANNEX IV: 2014 to 2016 Off-Road Transport GHG Emission (CO_2e)

National Off-Road Transport GHG Emission , 2016													
Vehicle Type	**National**	**Addis Ababa**	**Amhara**	**Afar**	**Benishangul**	**Dire Dawa**	**Somali**	**Tigray**	**Gambella**	**Harare**	**SNNPR**	**Oromiya**	
Combiner	28942	67	80	0	0	4	8	34	248	1501	412	26587	
Dozer	12725	602	0	129	0	0	43	215	0	860	43	10833	
Grader	431760	97	49	0	0	24	24	0	559	73	5297	425637	
Forklift	284349	90	0	11	0	17	0	11	1200	1778	169768	111474	
Tractor	19623	3007	896	185	479	67	13210	774	0	0	4	1001	
Vehicles with Machinery	5766	1392	925	112	9	963	252	579	0	0	0	1533	
National Off-Road Transport GHG Emission , 2015													
Vehicle Type	**National**	**Addis Ababa**	**Amhara**	**Afar**	**Benishangul**	**Dire Dawa**	**Somali**	**Tigray**	**Gambella**	**Harare**	**SNNPR**	**Oromiya**	**ET**
Combiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Dozer	0	0	0	0	0	0	0	0	0	0	0	0	0
Grader	0	0	0	0	0	0	0	0	0	0	0	0	0
Forklift	0	0	0	0	0	0	0	0	0	0	0	0	0
Tractor	1678	442	55	181	0	0	0	105	0	0	0	896	0
Dum truck	23755	5213	562	0	0	266	256	0	0	204	0	521	16733
National Off-Road Transport GHG Emission , 2014													
Vehicle Type	**National**	**Addis Ababa**	**Amhara**	**Afar**	**Benishangul**	**Dire Dawa**	**Somali**	**Tigray**	**Gambella**	**Harari**	**SNNPR**	**Oromiya**	**ET**
Combiner	0	0	0	0	0	0	0	0	0	0	0	0	0
Dozer	0	0	0	0	0	0	0	0	0	0	0	0	0
Grader	0	0	0	0	0	0	0	0	0	0	0	0	0
Forklift	0	0	0	0	0	0	0	0	0	0	0	0	0
Tractor	828	257	0	0	0	0	0	0	0	0	0	572	0
Dum truck	23755	5213	562	0	0	266	256	0	0	204	0	521	16733

ANNEX V: Emission Projection (CO_2e) from 2017 to 2030

Transport Growth Rate															
Growth	**Min (%)**	**Max (%)**	**Average (%)**												
Freight	12.4	13.7	13.05												
Passenger	8.3	9.1	8.7												
Average for Transport Sector	**10.35**	**11.4**	**10.875**												
Transport sector Emission project from 2017 to 2030 (tCO2e)															
Modes	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Road	11635203	12900531	14303464	15858966	17583629	19495848	21616022	23966764	26573150	29462980	32667079	36219623	40158507	44525745	49367920
Off road	783165	868334	962766	1067466	1183553	1312265	1454974	1613202	1788638	1983152	2198820	2437942	2703068	2997026	3322953
Domestic Aviation	122051	135324	150040	166357	184449	204508	226748	251407	278747	309061	342671	379937	421255	467066	517860
Ethio-Djibouti railway	682	756	838	929	1030	1142	1266	1404	1557	1726	1914	2122	2353	2608	2892
Inland Water born	3245	3598	3990	4424	4905	5438	6030	6685	7412	8218	9112	10103	11202	12420	13771
Total	**12540419**	**13904190**	**15416270**	**17092790**	**18951631**	**21012621**	**23297743**	**25831373**	**28640534**	**31755192**	**35208570**	**39037502**	**43282830**	**47989838**	**53208732**
International bunker Emission project from 2017 to 2030 (tCO2e)															
Modes	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
International Aviation	2782594	3085202	3420717	3792720	4205178	4662492	5169538	5731725	6355050	7046162	7812432	8662034	9604030	10648468	11806489
International maritime	107304	118974	131912	146258	162163	179798	199351	221031	245068	271719	301269	334031	370357	410634	455290
Total	**2889899**	**3204175**	**3552629**	**3938978**	**4367342**	**4842290**	**5368889**	**5952756**	**6600118**	**7317881**	**8113700**	**8996065**	**9974387**	**11059102**	**12261779**

ANNEX VI: Data Sources and Types

S/N	Name of Institution	Data Type
1	Ministry of Transport	National and regional vehicle stock, annual passenger and freight travel, vehicle fuel type
2	Ethiopia Airport Enterprise	aircraft movement, passenger number disembark and embark, freight unloaded and loaded disaggregated by airports
3	Ethiopian Airline	Fuel sale or uplift fuel per airplanes and their destination
4	Ethiopian Railway Cooperation	Addis Ababa light railways passengers travels per years
5	Civil Aviation Authority	Draft ICAO report, institutional arrangement for the organization collected
6	Maritime Affair Authority	Inland motor boats stock, fuel consumption per year
7	Ethiopian Road Authority	Traffic count and road length for some years
8	Federal Transport Authority	National and regional vehicles stock
9	Ministry of Mine, Petroleum and Natural Gases	Actual import data for benzene, diesel, Jet fuel, light and heavy actual, the growth rate for fuel demand
10	Ministry of Agriculture and Natural resources	Interviews and indicative stocks for agriculture and machineries equipments,and fuel consumption
11	Central Statistics Agency	Current and projected up to 2037 for national, regional and town
12	Ministry of Trade	Fuel import data
13	National Planning Commission	GDP growth data per year
14	Ethiopia Petroleum Supply Enterprise	Fuel import data per year
15	Ethiopian Shipping and Logistic Services Enterprise	Number of ships and fuel consumptions
16	Ethio-Djibouti Railway Cooperation	Fuel consumption of the railways per year
17	Regional Transport bureaus/Authorities	On-road, off-road and water-borne transport activity data
18	Sample cities	Traffic-count

ANNEX VII: Transport Sector GHG Inventor Data Collection Tool

1. ON-ROAD TRANSPORT

Mode: On Road Transport
Scope: National
Inventory year: 2014,2015,2016 and Projection
Name of the Institution (Data Source): ---------------

Group		Vehicle type	Vehicle Stock	Fuel type	Annual VKT (in Km)	Fuel economy	Annual Freight-	Annual PKM/TKM
Passenger		Private Autos (<5 seats)						
		Field Vehicles (6-11 seats)						
		Taxi - 3-Wheelers						
		Taxi – small						
		Taxi - mini bus (12 seats)						
		Taxi – midi Bus (13-44 seats)						
		Taxi- Maxi Bus (> 45 seats)						
		Motor Cycles						
		Bus - mini						
		Bus - midi						
		Bus - Maxi						
Freight	Dry	Light duty trucks (<34 quintals)						
		Medium duty trucks (34-70 quintals)						
		Heavy duty trucks (>70 quintals)						
	Liquid	Light duty trucks (<10,000L)						
		Medium duty trucks(10,000-14,000L)						
		Heavy duty trucks (>14,00L)						

Mode: <u>On Road Transport</u>
Scope: <u>Regional</u>
Inventory year: <u>2014,2015,2016 and Projection</u>
Name of the Institution (Data Source): ---------------

Group		Vehicle type	Vehicle Stock	Fuel type	Annual VKT (in Km)	Fuel economy (km/l)	Annual Freight- (in ton)/ Passenger (in	Annual PKM/TKM
Passenger		Private Autos (<5 seats)						
		Field Vehicles (6-11 seats)						
		Taxi - 3-Wheelers						
		Taxi – small						
		Taxi - mini bus (12 seats)						
		Taxi – midi Bus (13-44 seats)						
		Taxi- Maxi Bus (> 45 seats)						
		Motor Cycles						
		Bus - mini						
		Bus - midi						
		Bus - Maxi						
Freight	Dry	Light duty trucks (<34 quintals)						
		Medium duty trucks (34-70 quintals)						
		Heavy duty trucks (>70 quintals)						
	Liquid	Light duty trucks (<10,000L)						
		Medium duty trucks(10,000-14,000L)						
		Heavy duty trucks (>14,00L)						

Mode: On Road Transport
Scope: City
Inventory year: 2014,2015,2016 and Projection
Name of the Institution (Data Source): ---------------

Group		Vehicle type	Vehicle Stock	Fuel type	Annual VKT (in Km)	Fuel economy (km/l)	Annual Freight-(in ton)/ Passenger (in	Annual PKM/TKM
Passenger		Private Autos (<5 seats)						
		Field Vehicles (6-11 seats)						
		Taxi - 3-Wheelers						
		Taxi – small						
		Taxi - mini bus (12 seats)						
		Taxi – midi Bus (13-44 seats)						
		Taxi- Maxi Bus (> 45 seats)						
		Motor Cycles						
		Bus - mini						
		Bus - midi						
		Bus - Maxi						
Freight	Dry	Light duty trucks (<34 quintals)						
		Medium duty trucks (34-70						
		Heavy duty trucks (>70 quintals)						
	Liquid	Light duty trucks (<10,000L)						
		Medium duty trucks(10,000-						
		Heavy duty trucks (>14,00L)						

Supporting data

Traffic count Data on major city outlet City:-------- Road name: ----------- Road length form city center:--------- Name of the Institution (Data Source): ----------------			
Vehicle type	Vehicle/day		
	2014	2015	2016
Private autos			
Taxi - 3-Wheelers			
Taxi - small			
Taxi - mini bus			
Taxi - midi			
Taxi- Maxi Bus			
Field vehicle			
Motor Cycles			
Bus - mini			
Bus - midi			
Bus - Maxi			
Light duty trucks (<34 quintals)			
Medium duty trucks (34-70 quintals)			
Heavy duty trucks (>70 quintals)			
Light duty trucks (<10,000L)			
Medium duty trucks(10,000-14,000L)			
Heavy duty trucks (>14,00L)			

Demographic Data Name of the Institution (Data Source): ----------------			
Item	Year		
	2014	2015	2016
Population of the target city			
Population of surrounding towns of other			
Population size of major cities of other region served by regional transit originating/terminating in the target city			

Fuel import Data Name of the Institution (Data Source): ----------------										
Item	Year									
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gasoline										
Diesel										
Jet fuel										
Maritime										

GDP Data Name of the Institution (Data Source): ----------------									
Year									
2012	2013	2014	2015	2016	2017	2018	2019	2020	2021

2. OFF-ROAD

Mode: Off-Road Transport Scope: National Inventory year: 2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------					
No.	Vehicle type	Vehicle Stock	Fuel type	Annual VKT (in Km)	Fuel economy (km/l) orl/Hr
	Dump Truck				

Mode: Off-Road Transport Scope: Regional Inventory year: 2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------					
No.	Vehicle type	Vehicle Stock	Fuel type	Annual VKT (in Km)	Fuel economy (km/l) or l/Hr
	Dump Truck				

Mode: Off-Road Transport Scope: City Inventory year: 2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------					
No.	Vehicle type	Vehicle Stock	Fuel type	Annual VKT (in Km)	Fuel economy (km/l) orl/Hr
	Dump Truck				

Mode: **Off-Road Transport**
Scope: **National**
Inventory year: **2014,2015,2016 and Projection**
Name of the Institution (Data Source): ----------------

No.	Vehicle type	Vehicle Stock	Fuel type	Fuel economy (l/hour)	Operation hour per day	Operation day per year
1	Construction wheel loaders					
2	Bulldozers					
3	Non road trucks					
4	Excavators					
5	Forklift trucks					
6	Mobile cranes					
7	Road maintenance equipment (road					
8	Industrial drilling riges					
9	Agricultural tractors					
10	Harvester machine					

Mode: Off-Road Transport Scope: Regional Inventory year: 2014,2015,2016 and Projection Name of the Institution (Data Source): ---------------						
No.	Vehicle type	Vehicle Stock	Fuel type	Fuel economy (l/hour)	Operation hour per day	Operation day per year
1	Construction wheel loaders					
2	Bulldozers					
3	Non road trucks					
4	Excavators					
5	Forklift trucks					
6	Mobile cranes					
7	Road maintenance equipment (road compaction					
8	Industrial drilling riges					
9	Agricultural tractors					
10	Harvester machine					

3. Aviation

Mode: AVIATION Scope: National Inventory year: 2012,2013,2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------										
Fuel Sale data										
Imported Jet-A1 fuel per year in Lts						Jet-A1 fuel demand per year in Lts				
Suppliers	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
National Oil Ethiopia PlC (NOC)										
Libya Oil Ethiopia Limited										
Total Ethiopia										
Total imported fuel										

Mode: AVIATION
Scope: Regional/Domestic Flights
Inventory year: 2014,2015,2016 and Projection
Name of the Institution (Data Source): ---------------

Domestic Flights						
Airport	**Annual**	**Annual Freight**	**Annual Passenger km**	**Annual Ton km (TKM)**	**Landing and take offs**	**Annual Fuel**
Addis Ababa						
Mekele						
Diredawa						
Bahir Dar						
JImma						
Gondar						
Lalibela						
Axum						
Arba Minch						
Assosa						
Gambella						
Jigiga						
Robe Goba						
Gode						
Humera						
Semera						
Kombolcha						
Shire						
Kebri Dahar						
Awassa						
Jinka						
Neqemte						

Mode: AVIATION
Scope: International
Inventory year: 2014,2015,2016 and Projection
Name of the Institution (Data Source): ----------------

International Flights

Airport	Passenger	Freight	Passenger km (PKM)	Ton km (TKM)	Landing and	Annual Fuel Sale in
Addis Ababa						
Mekele						
Diredawa						
Bahir Dar						

4. Water-born navigation

Mode: WATER BORNE Scope: National Inventory year: 2012,2013,2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------										
Fuel Sale data										
Imported fuel per year in Lts						Fuel demand per year in Lts				
Fuel Type	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total imported										

Mode: WATER BORNE Scope: International Inventory year: 2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------						
International						
No.	Vessel type	Vessel Stock	Fuel type	Fuel economy (tons/day)	Operation day per year	

Mode: WATER BORNE Scope: National Inventory year: 2014,2015,2016 and Projection Name of the Institution (Data Source): ---------------						
Domestic						
No.	Vessel type	Vessel Stock	Fuel type	Fuel economy (ton/day)	Operation day per year	

Mode: WATER BORNE Scope: International Inventory year: 2012,2013,2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------										
Freight Volume										
Hauled freight per year in tone						**Freight Transport demand per year in tons**				
Freight type	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Import										
Export										
Total Hauled freight										

Mode: WATER BORNE
Scope: National
Inventory year: 2012,2013,2014,2015,2016 and Projection
Name of the Institution (Data Source): ----------------

Passenger Volume										
Hauled passenger per year						Passenger Transport demand per year				
Lake/River	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Tana										
Baro										
Total Hauled passenger										

5. Railway

Mode: Railway Scope: City/National Inventory year: 2014,2015,2016 and Projection Name of the Institution (Data Source): ----------------								
Passenger Volume								
Hauled passenger per year				Expected Passenger Transport demand per year				
Route	2014	2015	2016	2017	2018	2019	2020	2021
East-West								
North-South								
Total Hauled passenger								

Mode: Railway
Scope: City/National
Inventory year: 2014,2015,2016 and Projection
Name of the Institution (Data Source): ---------------

KM/day				No. Trips/day (one direction)			Operational day/year
Route	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**	
East-West							
North-South							

Mode: **Railway**
Scope: **Addis Ababa**
Inventory year: **2014,2015,2016 and Projection**
Name of the Institution (Data Source): ----------------

Modal Share of alternative Public Transport (%)				Km/day			No. Trips/day (one direction	Operational	Passenger
Mode	**2014**	**2015**	**2016**	**2014**	**2015**	**2016**			
Mini-bus									
Midi-bus									
Maxi-bus									