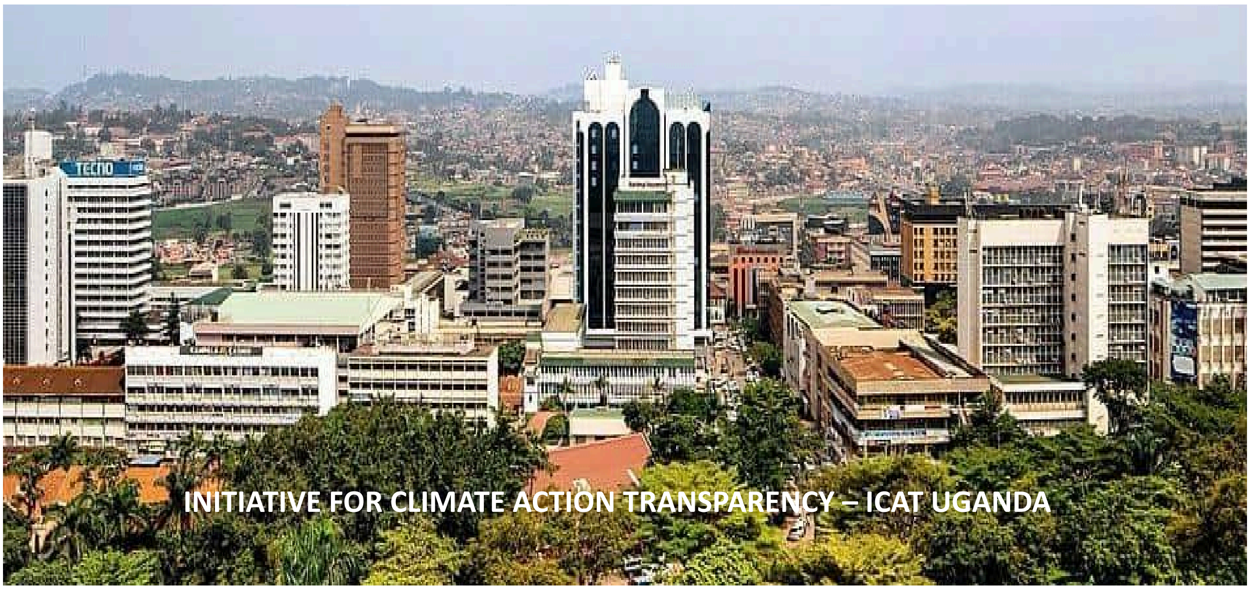
ICAT Initiative for Climate Action Transparency



Improvement of the process for and development of GHG Inventory Estimate, Baseline Emission Estimates and Emission Projection for the Transport and Waste Sectors

Ref. No. MoWE/CONS22-23/000025

Baseline and Mitigation Scenarios and Assumptions for the Transport and Waste Sectors

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Abbreviations

BAU	Business As Usual
BUR	Biennial Updated Report
CCD	Climate Change Department
CDM	Clean Development Mechanism
ERA	Electricity Regulatory Authority
FAO	Food and Agricultural Organisation
GACMO	Greenhouse gas Abatement Cost Model
GHG	Greenhouse gas
ICA	International Consultation and Analysis
ICAT	Initiative for Climate Action Transparency
INC	Initial National Communication
KCCA	Kampala Capital City Authority
GHGMI	Greenhouse Gas Management Institute
LEAP	Low Emissions Analysis Platform
MAAF	Ministry of Agriculture, Animal Husbandry and fisheries
MEMD	Ministry of Energy and Mineral Development
MoU	Memorandum of understanding
MRV	Monitoring / Measurement Reporting and Verification
MWE	Ministry of Water and Mineral Development
MWT	Ministry of Works and Transport
NARO	National Agricultural Research Organisation
NFA	National Forestry Authority
NDC	Nationally Determined Contributions
NWSC	National Water and Sewerage Corporation
QA/QC	Quality Assurance /Quality Control
REDD+	Reduced Emissions from Deforestation and Forest Degradation+
SCCO	Senior Climate Change Officer
SD	Sustainable Development
TraCAD	Transport Climate Action Data tool
TRACE	Transport sector climate Action Co-benefit Evaluation tool
SWG	Sector Working Groups
UBOS	Uganda Bureau of Statistics
UNDP	United Nation Development Program
UNEP- CCC	United Nation Environment Programme, Copenhagen Climate Centre
UNFCCC	United Nations Framework Convention on Climate Change

URA	Uganda Revenue Authority

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Executive summary

The Initiative for Climate Action Transparency (ICAT) project focuses on sustainably enhancing the greenhouse gas (GHG) emission inventory, projections and mitigation analysis modelling capability for the Transport and Waste sectors to enhance Uganda's ability to track the NDC actions in these two sectors. This project has the specific objectives to:

1. Contribute towards ongoing efforts to build a national transparency framework that meets international standards and is tailored to domestic needs;
2. Strengthen the national capacity to apply methodologies and tools to assess GHG and sustainable development impacts, and the effectiveness of policies, measures, actions and plans included in the NDC;
3. Contribute towards ongoing efforts to improve the availability and quality of data required to measure GHG and sustainable development impacts;
4. Support the formulation of NDC indicators in a manner that allow consistent monitoring and evaluation of progress; and
5. Contribute towards ongoing efforts to develop frameworks that facilitate tracking of progress on NDC implementation and strengthen capacities to construct and apply indicators towards that end.

To implement the project, data collection templates and database for waste and transport sectors were prepared. Introductory tools webinar and mitigation modelling training were also done. The final keys stage of this project included selection of modelling tools for preparing mitigation analysis scenarios. For the waste sector GACMO (Greenhouse gas Abatement Cost Model) and IPCC were used and the transport sector used LEAP (Low Emissions Analysis Platform). The training workshop was on the selected projection tools. Recommendations were made to enhance data inventory and GHG emission reporting for transport and waste sectors. The project concluded with a validation workshop.

1. Introduction

Uganda has experienced relatively high economic growth rates over the last decade and the GDP was 7.7% and 4.8 % per annum for 2010 and 2016 respectively[1]. Over the last 12 years the average annual growth rate has been 4.6%. The government has put in place appropriate policies and developed infrastructure which promote investment in all sectors of economy.

The energy sector and the transport sub-sector are directly linked to other sectors of the economy. The waste sector covers all value chains in the economy as there are waste and other by-products from all sectors. The waste sector is, therefore, one of the climate change sectors considered for greenhouse gases (GHG) emissions assessment in Uganda. The transport sector plays a key role in movement of goods and services while the waste sector is to manage waste from all economic activities. This has meant that demand for energy has also been growing and waste generated per capita is increasing. It is imperative to note that energy is a crucial ingredient for economic development. The transport sector is the largest source of GHG emissions in the energy sector. Uganda imports all the fuel used in the transport sector. The number of vehicles is on increase, which cause traffic jam during rushing hours.

Uganda has relatively a high population growth rates at about 3% per annum. The number of cities and municipalities are on the increase. There are many new industries developing along the highways and new industrial parks. It is imperative that the amount of waste generated will increase from these mainstreams. If not well handled, the waste will increase on GHG emissions on the environmental loading in the national water and lakes.

Uganda being a party to the UNFCCC, is required to periodically update and publish its inventory of the country's GHG emissions. The GHG emissions reports are important to national plans and strategies for addressing the impacts of climate change. Like many developing countries, Uganda's national inventory system is not yet well developed. Therefore, a number of approaches have been initiated to expand the national GHG Inventory Management System and operationalize a National Determined Contribution (NDC) tracking framework. Capacity Building is therefore an important element to developing an effective and efficient national inventory system. One such projects to enhance capacity for national GHG Inventory Management System and reporting is the Initiative for Climate Action Transparency (ICAT) project described in the next section.

[1] *Source: Uganda Bureau of Statistics (UBOS) 2015. Statistical Abstract.*

1.1. The Initiative for Climate Action Transparency (ICAT) project

The Initiative for Climate Action Transparency (ICAT) project in Uganda focuses on sustainably enhancing the GHG emission inventory, projections and mitigation analysis modelling capability for the Transport and Waste sectors to enhance Uganda's ability to track the NDC actions in these two sectors.

The ICAT project is titled: "Expansion of the National GHG Inventory Management System and Operationalization of NDC Tracking Framework". This project has the specific objectives to:

1) Contribute towards ongoing efforts to build a national transparency framework that meets international standards and is tailored to domestic needs;
2) Strengthen the national capacity to apply methodologies and tools to assess GHG and sustainable development impacts, and the effectiveness of policies, measures, actions and plans included in the NDC;
3) Contribute towards ongoing efforts to improve the availability and quality of data required to measure GHG and sustainable development impacts;
4) Support the formulation of NDC indicators in a manner that allow consistent monitoring and evaluation of progress; and
5) Contribute towards ongoing efforts to develop frameworks that facilitate tracking of progress on NDC implementation and strengthen capacities to construct and apply indicators towards that end.

The project has already carried out specific activity to: Strengthen the sector working group's capacity to manage sector GHG inventories, conduct baseline and mitigation scenario projections. A workshop was done to study and assess the following potential modelling tools for preparing mitigation analysis scenarios for Uganda in support of its NDC and related policy making processes: GACMO (Greenhouse gas Abatement Cost Model); Long-range Energy Alternatives Planning (LEAP) System; PROSPECTS+; TRACE (Transport sector climate action co-benefit evaluation tool).

Following the workshop, to follow the project objectives, the following were done:

1. Data collection templates for transport and waste sector inventories were prepared.
2. Database of inventory activity data for transport and waste sector inventories were prepared.

The next step activity in this project is: Support data collection and processing to prepare GHG baseline and mitigation projections. Therefore, baseline and policy impact projections for the transport and waste sectors were developed and this report presents the baseline scenarios, assumptions and policy impact trajectory for the Transport and Waste sectors.

1.2. Background

1.2.1. Transport Sector

Transport plays a major role in economic activities; it aids and facilitates growth and development in all other sectors of the economy. Over the last decade the nation transport system, road, railway, air and inland water transport have been developing, with road transport taking the lead. Effective transport provides support to increased agricultural, industrial production, trade and tourism, social and administrative services and ultimately, promotes growth and overall economic integration. The availability of an adequate transport infrastructure is a prerequisite for poverty alleviation, attraction of private investors and facilitation of regional economic integration and international trade.

Although the overall emissions for Uganda are low relative to international levels, Uganda is committed to follow a low carbon development path. The energy sector contributes about 10% to 13% of the GHG national emission. It envisaged that the growth of emission in the energy will increase in the near future.

1.2.2. The Waste Sector

The waste sector plays a significant role in greenhouse gas (GHG) emissions production in a country. When waste is not properly managed, it releases two potent greenhouse methane and carbon dioxide that are released into the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC), the waste sector accounts for approximately 3-5% of global GHG emissions[2]. However, this percentage can vary widely between countries depending on their waste management practices. In many developing countries, including Uganda, waste management infrastructure is inadequate, and large amounts of waste are dumped in open landfills or openly burned. Such practices contribute significantly to GHG emissions. So, waste management systems, in addition to seek to prevent environmental pollution, focus on greenhouse gas (GHG) emission reductions, in conformity with international obligations such as the Kyoto Protocol (1997) that came in to force in 2005 and the UNFCCC requirements.

Appropriate mitigations such as recycling, composting, and waste-to-energy technologies, can be exploited to reduce GHG emissions associated with the waste sector. These include implementing policies and regulations to encourage waste

[2] Chapter 2: Emissions trends and drivers- IPCC. www.ipcc.ch

reduction, recycling, and composting, as well as investing in more advanced waste management technologies. By doing so, Uganda can not only mitigate its GHG emissions, but also reduce pollution and improve public health and well-being.

2. Transport sector

Transport plays a crucial role in national development. It is for this reason that the modes of transport, the infrastructure and the general demand for transport and the fuel used for transport are increasing. The government must keep pace with the demand, both with policy and infrastructure development. Furthermore, while Uganda emits GHG, the development must be done following a sustainable low carbon pathway, bearing in mind the national commitment to reduce emissions under the Paris Agreement.

2.1. Methodology

The study started with literature review of the transport sector and related policies. The modes of transport considered in the study are road, railway, aviation, off road and marine/waterways, while Uganda's pipeline to the Indian Ocean is one of the upcoming modes of transport for oil and gas in the near foreseeable future.

The first step in developing projections is the development of emission estimates for the base year. The first part of the ICAT project was obtaining updated activity data for estimating emissions for the transport sector for year up to the most recent year available. Based on the different transport modes, templates were developed and presented to guide inventory compliers how to capture relevant data in their respective sectors. The final templates were delivered to the inventory compliers to document the data. The data was obtained from Ministry of Works and Transport (MoWT), Uganda Railway Corporation (URC), Uganda National Road Authority (UNRA), Uganda Bureau of Statistics (UBOS), Ministry of Agriculture Animal Industry and Fisheries (MAAIF), Civil Aviation Authority (CAA), Ministry of Energy and Mineral Development (MEMD). This information was used in the development of base year emissions for the projections. The data were analysed and incorporated into the LEAP model to complete the projections.

LEAP is structured based on the analysis of the available data on the base year transport modes. The road transport is divided into two subsectors namely, passenger and freight. The off-road vehicles include tractors, engineering equipment and uncategorised vehicles. Railways transport is also sub-divided into freight and passenger. The aviation transport combines cargo and passengers, due the availability of data, it could be segregated. It can also be subdivided into passengers and cargo and thereafter passenger kilometres and tonne-kilometres. Water transport includes boats, marine vessels and ferries. The boats are generally used for fishing and transport at less extent. There are other uses such as leisure, hire etc. It was a challenge to get for the base year for the boats, which was due to the long-time lag for regarding the number of boats. The base year data was based on the interpolation of Initial National Communication and the recent survey made between 2018 to and 2020 by the Ministry of Agriculture, Animal Industry and Fisheries.

The transport sector mitigation assessment was done by building different scenarios: Business as usual – BAU, with existing measures (WEM) and with current development plans. These emission scenarios were modelled from the 2015 base year, and were defined as follows[3]:

- Baseline / Business-as-usual: a scenario that considers existing measures, and forecasts future GHG emissions based on expected trends.
- ‘With Existing Measures’ (WEM): includes mitigation measures that were in place up to 2015 (the base year).
- **Current Development Policy (CDP): includes mitigation measures that have been in place** since 2015, but also include planned measures and/or targets and commitments that have not yet been implemented.
- With Additional Measures (WAM): includes additional mitigation measures or measures in earlier scenarios implemented to a higher degree of ambition.

2.2. Base year emissions

The base year in this study is 2015 to align with the NDC. The emissions from the four modes of transport (road, rail, aviation and water-borne) were calculated based on the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5), the *2019* Refinement to the *2006* IPCC Guidelines for National Greenhouse Gas Inventories guidelines and the data gathered in the previous deliverable. Uganda national energy balance, prepared by the Ministry of Energy and Mineral Development in 2015, (MEMD, 2016) is one of the main documents used in this study. In cases where the data from the energy subsectors are lower than the data given in the national energy balance, the data from the sector is taken under consideration. That is because there is energy loss expected during transport and transformation. It should be noted at times there was fuel miss match between the activity data and type of fuel consumptions. As an

[3] *Uganda Climate Promise Project (2021). Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda’s Nationally Determined Contribution (NDC). Government of Uganda & UNDP. Version 1.0.*

example, in the previous energy balances, diesel is the main fuel used in agriculture, most probably by tractors in agriculture sector. But in this energy balance for 2015, petrol is the main fuel used in agriculture. Then based on expert knowledge that tractors use diesel this correction was made to the energy balance data.

Generally, there are two types of approaches used for analysis of energy consumption in the transport sector, the top down and bottom up. Bottom up is more accurate than top down. At times both can be applied in a given subsector.

depending on the availability of the data and the required level of uncertainty. Bottom up has a lower level of uncertainty than top down. All efforts were made to reach lowest levels thus energy intensity, passenger – kilometres and tonne-kilometres, thus the use of bottom-up approach. In cases where it is not possible to go to lower level of energy intensity, due to the limited availability of data, final energy consumption, thus top-down approach is used as the base for computation of energy consumption and greenhouse gas emissions.

The Computation of emissions in the transport sector.

The energy consumption data is fed into LEAP software. It computes GHG emissions, which is combination of comprised of direct greenhouse gases (Carbon dioxide (CO_2), Methane (CH_4) and Nitrous oxide (N_2O). LEAP in terms of CO2 equivalent based on the 5^{th} assessment report of the Revised 2006 IPCC Guidelines and 2019 refinement to the 2006 guidelines.

2.2.1. Road transport

The main energy consumers in this sector are passenger and freight transport. Bottom -approach was used in this subsector. It is important to have a knowledge of the vehicle fleet.
The following equations were used in this assessment to compute energy consumption and GHG emissions in the transport sector

Passenger-kilometre is a product of vehicle use (vehicle – kilometres) and load factor (passenger-kilometres/ vehicle-kilometre).
Energy intensity in passenger transport:
E_p = 1/ (X*Y) (litre/ passenger-kilometre)
Where,
X = vehicle fuel economy (vehicle- kilometre / litre),
Y = load factor (passenger-kilometre)/ (vehicle - kilometre).

Energy intensity E_f in freight transport:

$E_f = 1/(W*X)$ (litre)
Where,
W =the average capacity of the vehicle (tonnes),
X = vehicle fuel economy (vehicle- kilometre / litre)

Energy consumption on the road for passenger and freight.
$E_{passenger}$= Passenger -kilometre * Energy intensity in passenger

Energy Consumption in freight
E freight= Tonne- kilometre* energy intensity in freight

GHG Emissions in the passenger transport
$E_{emission}$ = Activity data * Emission factor
The activity data is this case is the amount of energy consumption in the passenger travel
The emission factor is the amount of greenhouse gases emitted by the fuel used. The Unit is CO2
equivalent. It takes into account the CO2, CH4 and NO2 emitted during the combustion of fuel

GHG emissions computation in freight
$E_{freight}$ = Activity data * Emission factor for the fuel
In this case the activity data is the energy consumption in the freight

Off Road Vehicles

Off road is one of the road transports. The covers tractors, engineering equipment and other non-specified equipment. In the case top down is used in computation of the emissions. The energy consumption in the agriculture as presented in the national energy balance was used as basis for computation of emissions. Expert judgment was used to estimate energy consumption in the engineering equipment and other non-specified equipment.

GHG Emissions in the passenger transport
$E_{emission}$ = Activity data * Emission Factor

The activity data is the energy consumption by the equipment, while the emission factor is the amount of GHG emitted during the combustion of fuel

Railway Transport

There are both passenger and freight transport. Bottom approach was used in computation of the energy consumption. The energy consumption in based on the number of the passengers, the distance travelled and amount of fuel consumed. The fuel can be diesel, electric or blended bio diesel.

The Energy consumption is based on person-kilometres and fuel intensity

E_{rail} = person-kilometres * fuel intensity

The GHG emissions in passenger transport

E emissions = Fuel * EF_{fuel}

Fuel used in transport and the EF based on the IPCC guidelines

Freight transport

Energy consumption is based on the fuel consumption in the freight in tonnes.

E_{fright} =The tonne-kilometres * energy intensity

Emissions in freight is based on the energy consumption and the tonnes carried by the freight.

$E_{emission\ freight}$= amount of fuel consumed * emission factor.

Water Navigation

The marine vessels

The energy consumption is computed based on the fuel economy nautical miles.

Emission from marine vessel = fuel economy * nautical miles

Ferries

The energy consumption in the ferries is based on the fuel consumption distance travelled by ferries. In most cases the ferries carry both cargo and passengers. If there are dedicated ferries for transport and then it can be separated. In this case bottom-up approach was used.

The emission from ferries is computed:

$E_{emission}$ =Fuel consumption * EF (the emission factor)

The emission from marine Vessels

E_{mv} = the fuel economy * distance travelled* Emission Factor

Emission from the boats

Boats are largely used for commercial fishing; However, they are also used for transport and others such as leisure. The fishing boats were categorised as freight transport.

The energy consumption depends of the weight of the catch / harvest (kg), the distance travelled and fuel consumption depending on the capacity of the boat engine.

Boat transport

The number of boats has to be estimated for the baseline to compute the energy consumption. The number of boats. The consumption of boats depends size of the engine.

Fuel Consumption

$Fuel_{Boats}$ = number No boats* fuel consumption* no of boat* fuel economy

Aviation Transport

Based on the data received from the Civil Aviation Authority, top-down approach was used in the computation of emissions from the aviation transport. The fuel use is aggregated for both domestic and international flight. The cargo is also aggregated with passenger air craft.

The emission computation

E_{air}= Fuel consumption * EF (Emission factor)

The fur used in the aviation transport is jet kerosene.

2.2.1.1. Growth rates in number of vehicles

Road transport is the dominant means of transport in Uganda. The MoWT is responsible for the registration of the vehicles. New registration of vehicles is carried out according to ownership, private and government vehicles.

Table 2.1 presents statistics on newly registered motor vehicles from 2005 to 2015. The results show that the there is a general increase in the number of newly registered private vehicles over decade. The average growth rates of the road vehicles are as seen in Table 2.2. The registration process does not take into account the number of vehicles which no longer on the road.

Table 2.1: Registration of new Vehicles (2005-2015)

Category of vehicles	2005	2006	2007	2008	2009	2010	2011	2012	2013
Car	9870	9,764	11,375	11,975	14,578	16,822	20,228	23,633	27,255
Minibus	6583	6,367	8,431	10,943	14,578	16,822	11,046	5,270	5,962
Pickups	4206	3,658	4,407	3,486	2,597	4,334	3,748	3,162	3,577
Motorcycles	27916	36,599	49230	70727	69998	70104	79,327	88,550	90,264
Trucks up 10 tonnes	1218	1,648	1942.2	3386.4	3296.4	3551	3562	3754	3946
Trucks above 10 tonnes	812	1098.8	1294.8	2257.6	2197.6	2367.2	1,404	441	1,336
Medium Bus	16	15	31	52	48	29	228	426	430
Buses	62	61	124	210	192	118	910	1702	1721
Off Road									
Tractors	272	197	207	378	534	769	671	573	704
Uncategorised	106	125	158	223	293	262	191	120	115
Engineering plants	46	84	105	149	196	174	408	642	911
Total	51,107	59,617	77,305	103,787	108,508	115,352	121,721	128,272	136,221
Cumulative	51,107	110,724	188,029	291,816	400,324	515,676	637,397	765,669	901,890

Table 2.2: The average percentage annual increase in vehicle registration.

Category of vehicles	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Average
Car	-1.1	16.5	5.3	21.7	15.4	20.2	16.8	15.3	4.6	15.2	13.0
Minibus	-3.3	32.4	29.8	33.2	15.4	-34.3	-52.3	13.1	-2.8	15.1	4.6
Pickups	-13.0	20.5	-20.9	-25.5	66.9	-13.5	-15.6	13.1	-2.8	15.1	2.4
Motorcycles	31.1	34.5	43.7	-1.0	0.2	13.2	11.6	1.9	8.1	-12.0	13.1
Trucks up 10 tonnes	35.3	17.8	74.4	-2.7	7.7	0.3	5.4	5.1	-14.4	-38.4	9.1
Trucks above 10 tonnes	35.3	17.8	74.4	-2.7	7.7	-40.7	-68.6	202.9	-13.4	-61.5	15.1
Buses	-2.6	103.9	69.0	-8.4	-38.8	**673.8**	**87.1**	1.1	17.6	60.6	**96.3**
Off Road Vehicles											
Tractors	-27.6	5.1	**82.6**	41.3	44.0	-12.7	-14.6	22.9	29.5	-30.8	14.0
Uncategorised	17.9	25.8	41.4	31.5	-10.8	-27.1	-37.1	-4.2	-12.2	25.7	5.1
Engineering plants	**83.3**	25.8	41.4	31.5	-10.8	**134.1**	**57.3**	41.9	6.9	-2.7	40.9

Source: Computed based on the data from UBOS and MoWT

Growth of cars and motorcycles is 13% and 13.1% respectively, while for minibus is about 5% over the same period. There are other vehicles which show extraordinarily high increasing rates in registration especially bases and engineering plants.

The growth in number of freight vehicles is about 9% and 15% for vehicles below 10 tonnes and above 10 respectively, while for the pick-up is 2.4 %. It estimated that the growth in freight transport is 8% However, the cases where the growth rates are much higher than normal e.g. the buses and engineering plants. It should be noted that within this period, large numbers of buses for city services were imported. But after about 5 years of services, they were scrapped off the road.

There is, however, no data on the number of vehicles written off due to accidents and poor mechanical conditions. The Uganda Police Force recorded a total of about 18,495 road traffic crashes in 2015. It implies that many vehicles are written off. A total of 18,426 casualties from road traffic crashes was registered in 2015 and passengers formed the highest percentage with (39 percent). The leading cause of road accidents in 2015 was careless driving (40 percent). About 28 percent of road accident crashes occurred between 4:00-8:00pm (UBOS, 2016). That could be due to drivers' fatigue and high rate of mobility in rush hours. There is no national statistics on the national fleet. The MoWT estimated the fleet is to be within the range of 10% and 15% of the registered vehicles

2.2.1.2. Vehicle fleet and fuel consumption

By 2015, there was no detailed study on the number of road vehicles in Uganda. Therefore, it is not possible to link numerically the number of the fleet and fuel consumption. If fuel consumption is estimated from these vehicle registration numbers, then the fuel consumption will be higher than that estimated in the 2015 national energy balance. Therefore, in this study the number of vehicles was scaled down, so that it can match with the energy balance (Table 2.3). The scaling down the number of vehicles was based on the expected life of the vehicles, the usage, as an example, motorcycles have a shorter life span compared to cars (Table 2.4).

Table 2.3: Scaled down vehicle registration numbers to align with energy balance

Category of vehicles	New registrations 2005-2015	Downscaled fleet
Car	206,852	175,824
Minibus	98,459	59,076
Pickups	40,650	30,487
Motorcycles	766,190	498,024
Trucks up 10 tonnes	31,764	26,999
Trucks above 10 tonnes	14,812	13,331
Medium Bus	2,593	2,074
Buses	10,372	8,298
Off Road		
Tractors	4,971	4,971
Uncategorised	1,457	1,457
Engineering plants	3,709	3,709
Total	1183998	824,250

Table 2.4: Percentage downscale for the different vehicle types

Category of vehicles	Scaled down by percentage
Cars	15%
Minibus (excessive use)	40%
Pickups	25%
Three wheelers	N/A (their numbers negligible)
Electric Motorcycles	N/A (their numbers negligible)
Motorcycles	35%
Trucks up 10 tonnes	25%
Trucks above 10 tonnes	25%
Buses	30%
Off Road Vehicles	
Tractors	15%
Uncategorised	15%
Engineering plants	15%

2.2.1.3. Fleet composition

The estimated composition of the vehicles on road in the base year, is dominated by motorcycles (61%) followed by cars (21), minibus 7% pick-up 4 % and others (4. %) including buses, trucks etc, as shown in Figure 2.1.

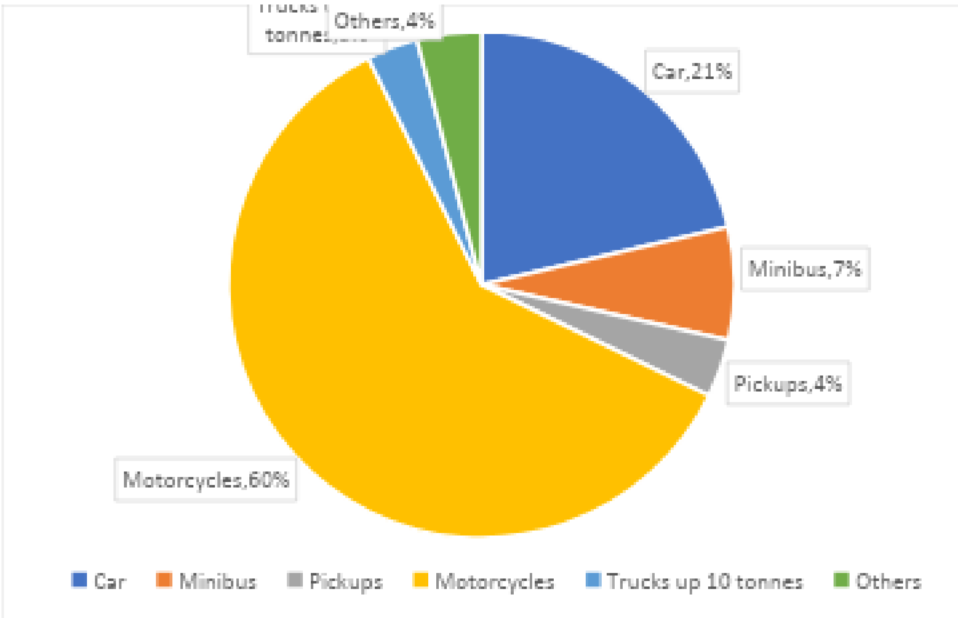

Figure 2.1: The composition of vehicles in 2015.

2.2.1.4. Estimated annual Distance travelled by category of vehicles

An indicative assumption of the distances travelled by different category of vehicles is used to compute the total vehicle- kilometres of the distances travelled by each type of vehicles were made (Table 2.5). Thereafter multiply by the adjusted number of vehicles (see Table 2.3) on the road.

Table 2.5: Estimated Distance (km) travelled in year in 2015[4]

Category of vehicles	Estimated Distance (km) travelled in year	Vehicle kilometre (million)
Car	17,500	3076.9
Minibus	40,000	2363.0
Pickups	25,000	762.2
Motorcycles	10,000	5976.3
Trucks up 10 tonnes	45,000	1350.0
Trucks above 10 tonnes	60,000	799.9
Medium buses	35,000	72.6
Buses	60,000	497.9
Off Road Vehicles		
Tractors	150	1.2
Uncategorised	50	0.1

[4] *Sources from different publications.*

Engineering plants	50	0.2
Total		14,900

The total number of vehicles travelled on the road in 2015 is estimated at 14,897 million vehicle- kilometres. The motorcycles have the highest vehicle kilometres with 34% followed my cars and minibus with 22% and 20% respectively. Other categories of vehicles vary between 8% and 4% as seen in the Figure 2.2.

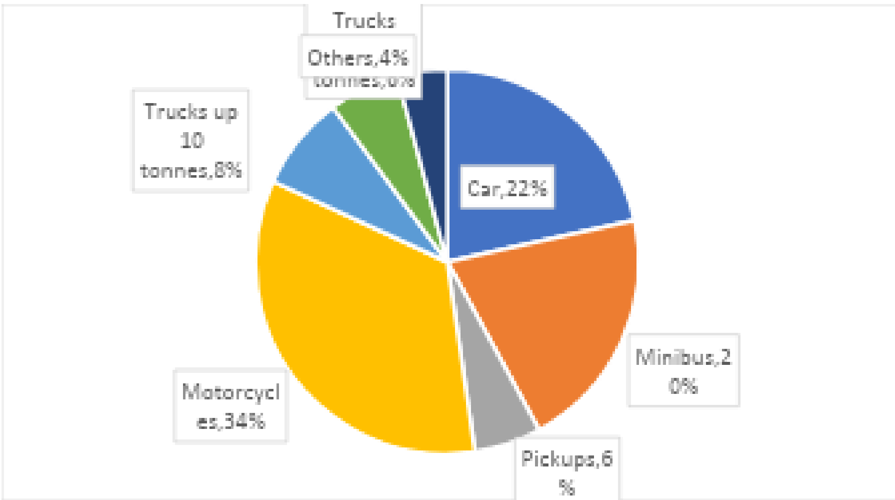

Figure 2.2: The number in percentages of vehicles travelled on road in 2015

2.2.1.5. Passenger vehicle fuel economy and energy intensity

Minibuses are the main sources of passenger traveling followed by large buses (Figure 2.3).

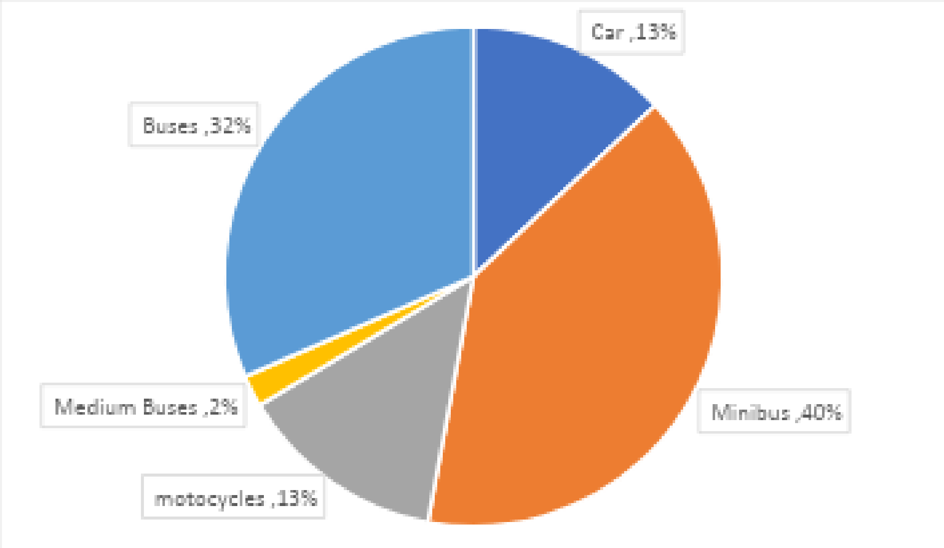

Figure 2.3: The most common means of transport in Uganda

Energy consumption in transport sector is a product of vehicle category and the fuel economy. Vehicle fuel economy is expressed in terms of litres of gasoline per 100 kilometres of travel (L/100-km). LEAP software uses kilometres per litre for fuel economy. The fuel economy for petrol and diesel is as shown in Table 2.6 and Table 2.7. Overall, vehicles of small engine capacity consume smaller amounts of fuel per 100 kilometres travelled and, therefore, tend to be more fuel efficient. The average fuel efficiency rate across engine capacity is estimated to be 8.6L/100 KM for petrol vehicles which remains higher than the GFEI target of 7.2L/100 KM (GFEI 2014). Thus, strong policies are required to bring down the fuel inefficiencies experienced currently.

Table 2.6:: Average FE of Petrol Vehicles (L/100/Km) (Source: Mutenyo et al., 2015).

Engine_CC	2005	2008	2011	2014
500_1200CC	7.4	6.4	6.2	6.1
1201_1500CC	8.0	7.9	7.6	7.6
1501_2000CC	8.6	8.5	8.4	8.3
2001_2500CC	10.0	10.1	9.7	9.4
2501_3000CC	11.6	11.1	10.9	10.6

3001_3500CC	14.5	13.9	13.7	13.8
3501_4000CC	20.3	18.0	18.3	15.6
4001_5000CC	27.2	25.1	26.9	25.9
>5000CC			16.9	19.7
Grand Total	**8.6**	**8.7**	**8.8**	**8.6**

Table 2.7:: Average FE of Diesel vehicles (L/100Km) (Source: Mutenyo et al., 2015)

Engine_CC	**2005**	**2008**	**2011**	**2014**
500_1200CC	-	-	9.0	5.6
1201_1500CC	7.4	6.7	7.1	7.3
1501_2000CC	8.0	8.1	8.1	8.0
2001_2500CC	10.0	9.2	8.4	8.5
2501_3000CC	9.8	9.6	9.7	9.5
3001_3500CC	11.3	9.9	10.4	11.2
3501_4000CC	12.6	12.6	12.6	12.8
4001_5000CC	13.1	12.8	14.5	13.5
>5000CC	33.0	34.6	31.6	30.2
Grand Total	**15.5**	**15.8**	**15.8**	**14.4**

The average capacity of car is estimated (1501- 2000 CC), while for the minibus (3000-3500 CC) the while medium buses and lorries under 10 tonnes are (3500- 4000 CC). The lorries above 10 tonnes and buses are over 5000 CC. The fuel economy is based on the type of the vehicle, fuel and its capacity. In this study of the fuel - economy is expressed in kilometre per litre (Table 2.8). The load factor of the vehicles is the average number of passengers it can carry. The vehicles will not always carry full load. Example minibus carry 15 persons, in this study 12 is assumed to be the average load. The energy intensity for the passenger transport is calculated based on the LEAP training manual (Table 2.9).

Table 2.8 : Estimated kilometre per litre for passenger transport[5]

Category	Fuel Economy Petrol km/l	Fuel economy Diesel km/litre	Load Factor Passenger
Car	12	12.5	3
Minibus	7.2	8.2	12
Motorcycles	52		1.6
Medium bus	6.4	7.8	20
Large bus		3.3	45

Table 2.9: The energy intensity for the passenger transport sector.

Category	Energy Intensity litres/passenger: Petrol	Energy Intensity litres/passenger: Diesel
Cars	0.028	0.027
Minibus	0.0115	0.010
Motorcycles	0.012	
Medium buses	0.008	0.006
Buses		0.0067

2.2.1.6. Freight vehicle fuel economy and energy intensity

Fuel consumption for the freight depends on the capacity it can carry and the load factor. When the vehicle is fully loaded it consumes more fuel than when it is empty, therefore an average value is used. There are three categories of vehicles used in freight transport, the pickups and lorries. Their pickup and lorries with capacity less that than 10 tonnes use both gasoline and diesel. While buses and lorries with capacities above 10 tonnes use diesel. The average value is given in the Table 2.10.

Table 2.10: The fuel economy and average tonne vehicle km[6]

[5] *Sources: The fuel economy L/km derived from Mutenyo et al., 2015; the estimates for the load factor.*
[6] *Sources: The fuel economy L/km derived from Mutenyo et al., 2015; WWF, 2015.*

Category	Fuel Economy Petrol km/l	Fuel economy Diesel km/litre	Average (Tonne/vehicle-km)
Pickups	9.4	10.5	0.97
Trucks up 10 tonnes	6.4	7.8	5.7
Trucks above 10 tonnes		3.3	5.7

Table 2.11 shows the energy intensity for freight vehicles. The pickups and lorries use gasoline and diesel, lorries above 10 tonnes use diesel only. The intensity is computed as 1/(km)/litre) *(maximum tonne).

Table 2.11: The energy intensity in freight transport

Category	Freight Energy Intensity litres/tonne-km: Diesel	Freight Energy Intensity litres/tonne-km: Petrol
Pickups	0.063	0.071
Lorries less than	0.013	0.016
Lorries above 10 tonnes	0.015	

2.2.2. Energy consumption

In 2015, the energy sources consumed in Uganda's transport sector were diesel and petrol for road, railway, ferries and off-road vehicles and boats, while jet kerosene was used in the aviation sector. The total energy use is estimated at 44,853 TJ. The distribution of energy consumption in the transport sector is, by road transport, aviation and other including rail and navigation 83.7%, 11% and 5.3%, respectively. The gasoline and diesel consumption are 19,491 TJ and 20,631 TJ, respectively, while jet kerosene was 4,708 TJ.

2.2.2.1. Road transport

In the base year, the road transport is 71,000 million passenger-kilometre and 12,993 million tonne-kilometre. The passenger travels are mostly by minibuses, buses and motorcycles (Figure 2.4).

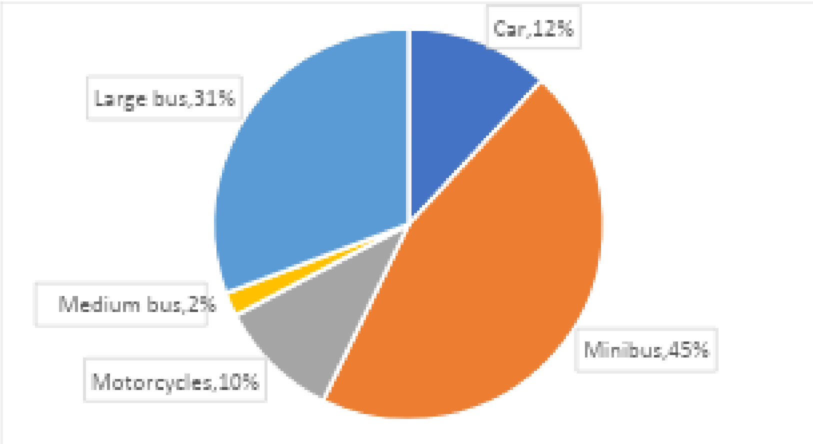

Figure 2.4: The distribution of passenger km-based category of modes of transport.

Although motorcycles are used both urban and rural areas because they can access hard to reach areas and quicker means of transport, minibuses have highest passenger-kilometre (45%), because it is cheaper and safer than motorcycle transport. Cars are used for short distances, while buses are operated for long routes. The energy consumption in road transport is 37,320 TJ.

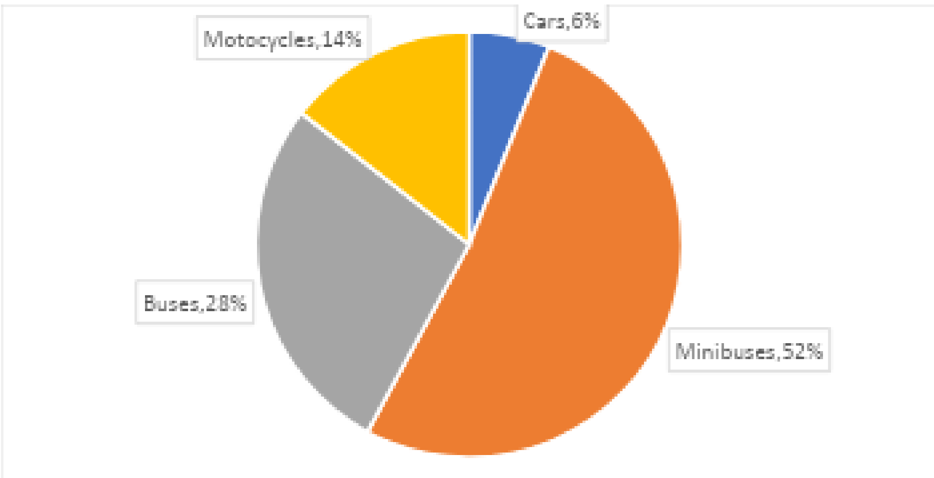

Figure 2.5: The composition of passenger-kilometre by type of vehicles.

Freight is dominated by lorries with capacities less than less than 10 tonnes (Figure 2.6). It followed by trucks with capacities more than 10 tonnes. Pickups are used for low-capacity sort distance freight transport. The energy consumption on road freight is 4,334 TJ.

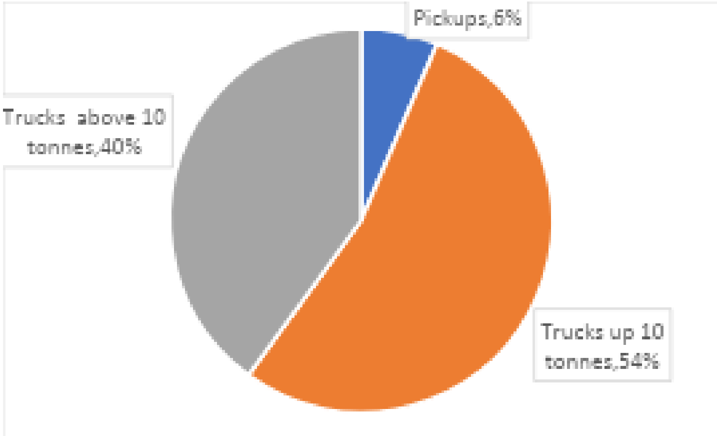

Figure 2.6: The distribution of road freight tonne-km.

2.2.2.2. Off Road vehicles

All off-road vehicles use diesel fuel. The off-road vehicles include tractors, engineering equipment, nom categorised vehicles. Tractors energy consumption is 1,254 TJ, while for engineering equipment and non-Categorised vehicles are estimated at 125TJ and 250 TJ respectively. In the literature, off road vehicles falls under freight transport. All off road vehicles consumption is 1629 TJ

2.2.2.3. Ferries

Most of the ferry services in Uganda are being operated by UNRA. Other ferry operators include the Uganda Railways Corporation (URC), Uganda Wildlife Authority (UWA), the Ministry of Works and Transport (MoWT). Those ferries operated by UNRA are working as road bridges. In 2015, there were

nine ferries UNRA. The energy consumption by UNRA ferries was 357,361 TJ. The UNRA ferries travels an average of 6.67 km. There are private operators such as MV-Kasese, UWA and Pearl which travel over 100 km. All the ferries and Marine vessel use diesel.

MV Kaawa is operated by URC and has 2 CAT D339 Engines. MV Kaawa is used for freight and passenger transport between Port Bell and Mwanza in Tanzania. On average it travels 28,808 Nautical Miles Per year. The type of the Engine and Fuel Type: Vessel Engine :2 CAT D339 and Gensets: 2 CAT 3306. The type of fuel is diesel. The fuel consumption: 49 litres /Nautical Mile and the average fuel consumption for Locomotives in Gross Tonne -km per Litre = 66.7 GTK/litres. The energy consumption was 53.2 TJ. The energy consumption by all marine vehicles is 1,254 TJ

2.2.2.4. Boats

The water transport is dominated by informal services are provided on the lakes and rivers by private operators in motorised canoes, mostly open boats of about 15-passenger capacity, carrying passengers, livestock and goods. There are other uses of boats in water bodies. The recent survey was made to establish the number of boats in major water bodies in Uganda. It was established that over 95% of the boats use petrol. The initial data for boats was obtained from the Initial National Communication (Table 2.12). The data from the Initial National Communication shows fuel economy and distance travelled per day, and the resent survey by Ministry of Agriculture, Animal Industry and Fisheries (Table 2.13).

Table 2.12: Boats fuel consumption and distance travelled par day[7]

HP	Average Consumption km/litre	No of Boats	Distance travelled per day
1 to 15	6	1378	18
16-30	5	327	36
31-60	4	80	72
61-85	3	28	120

Table 2.13: The number of boats in the main water bodies[8].

Main Water body	Number of Boat using Engines	Year recorded
Victoria	17,075	2021
Albert	2,734	2018
Edward, George & Kazinga channel	341	2018
Kyoga	6,732	2019

Boats are widely used in the waterways, they are used for different proposes, but mostly are used for fishing and transport. There however few boats used for leisure, renting and other

[7] *Source: Initial National Communication, 2002*

[8] *Source: MAAIF, 2021,*

purposes. Commercial fishing is one of the main activities in water bodies followed by transport. Limited number of boats are used for other activities such as leisure and rental. The use of boats for different purpose is as seen in Table 2.14.

Table 2.14: The purpose of boats[9]

Purpose	Leisure	Commercial passenger	Commercial fishing	Rental	Other
Number	368	1500	18124	16	764

The estimated data of boats for 2015 was based these two sets, thus the Initial National communication and the survey made by Ministry of Agriculture, Animal Industry and Fisheries. A relationship based on the growth rate was used to estimate the number of boats in the main water bodies, as illustrated in Table 2.15. A similar approach was used to estimate the number of boats used in transport sector is used to establish the number of boats practicing commercial fishing 2015 is as seen in Table 2.16. The estimated energy consumption in passenger transport is 33.2 TJ. The estimated energy consumption by fishing boat is assumed to be as freight. They're very few boats that use diesel. The energy consumption for freight boat is estimated at 1,242.5 TJ. The energy balance data is 1,254 TJ.

Table 2.15: Estimated number of boats for passenger transport in 2015

Number	Load factor	Average distance	Boat-kilometre (million)	Person-km(million)	Litres (million)
780	12	36	9.828	117.936	1.638

Table 2.16: Estimated number of fishing boats 2015.

The Base Year	2015				Fuel
Number	Load (kg)	Distance day	Annual(km)	Tonne-km (million)	Million litres)
11,442	300	36	12,600	72.09	12.01

2.2.2.5. Railways

Rail transport has remained on a downward trend for several decades. The locomotives are over 40 years old. Originally, the total railway length in

[9] Source: MAAIF, 2021.

Uganda was 1,266 Km. By 2006, the active rail section had reduced to 330 Km. The 25-year concession that was given to Rift Valley Railways (RVR) in 2006 was terminated in 2017 due to poor performance. Most the railway is used for freight transport. There is limited use passenger transport around Greater Kampala Metropolitan Area.

Rail passenger transport demand relates to the commuter passenger train service being operated between Kampala and Namanve by the Government of Uganda through Kampala Capital City Authority (KCCA). It is now under the URC. The train travels 12km between Kampala and Namanve along the Eastern Line and makes four scheduled trips per day. The estimated number of passengers 3,000 per day. Transport by rail is estimated at 36. million passenger-kilometres. The energy consumption is 18.8 TJ.

The railway transport is largely focused on the freight transport in 2015. The freight was 173.8 million tonnes -kilometres. The total energy consumption was 262.1 TJ.

2.2.2.6. Civil Aviation

This sub-section presents data on the movement of commercial aircrafts, passengers and cargo through Entebbe International Airport. Aviation sectors in one of the most important means of transport. Most of the passengers are from overseas. The domestic passengers are recorded but there but there is information on consumption of fuel. The volume of unloaded and loaded cargo realised an increase so is the number of passengers as seen in Table 2.17. The energy consumption in the aviation sector was 4,708.8 TJ.

Table 2.17: Aviation Transport Statistics 2010 to 2015[10].

	2010	2011	2012	2013	2014	2015
Movements	23320	24506	30259	30364	26886	27382
International	1023437	1085609	1238536	1343963	1332499	1375144
Domestic	11879	9508	13780	25458	22789	14934
Import (ton)	21344	20611	22131	21824	20644	21789
Exports (ton)	27752	28025	33821	34130	32197	32660
Fuel uplift (L)	117,265,785	117,265,785	138,251,523	133,194,700	147,215,102	130,373,060

2.2.3. Base year greenhouse gas emissions

The total emissions for the transport sector in the base year is 3.39 million metric tonnes of

[10] *Source: Civil Aviation Authority*

CO_2 equivalent. The road sectors in the leading source of emissions followed by aviation sector and navigation. The cause of emissions in the increasing importation of used vehicles and poor maintenance culture in Uganda. In the updated NDC, the emission in the transport sector was 4.2 million tonnes CO_2 eq, which is higher. The sources of emissions and their sources are as shown in Figure 2.7.

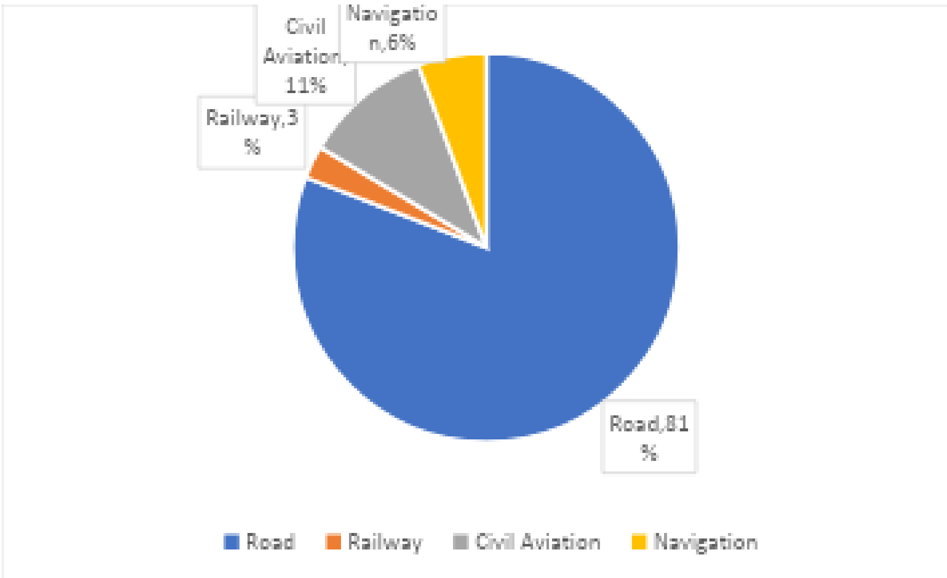

Figure 2.7: The main sources of Emissions

2.3. Business as Usual Greenhouse Gas emission projections

2.3.1. The major drives and assumptions

Economic development has been the key driver for Uganda's petroleum fuels from 2015 to the present. The average GDP growth from 2005 to 2015 was 6.8 % per annum (UBOS, 2006,2016). In this study a growth rate of 7% was assumed to be main driver. There has been slow development in the growth of oil and gas products during this period. All indications point to continued rapid petroleum consumption from now to 2030. It is envisaged that there will be continued growth in Uganda's GDP through 2030. As Uganda's economy improves, more efficient motor vehicles will be purchased, thereby improving Uganda's fuel economy.

The Emission Projection

Total emissions from Uganda's transport sector in the base year was 3.214 million metric tonnes C02 equivalent. The period 2005 to 2014 was a period of significant historical growth of GHG emissions attributable to the transport sector. Emissions from transport during the base year were close to the transport sector emissions to the national energy balance for the year 2015. The road transport sector is the major source of GHG emissions and will continue to grow as Uganda's economy grows. The overall baseline projections for the transport sector are shown in Figure 2.8 with more detail and assumptions described below.

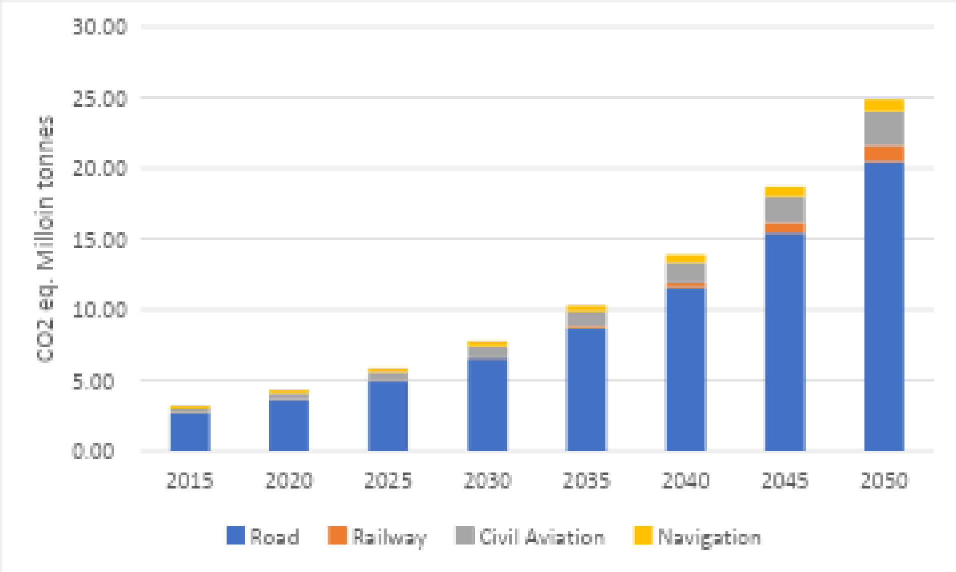

Figure 2.8:: The projected emissions in the transport sector.

Road transport will continue to be the main means of transport for goods and services until 2030 and beyond. Emissions in the railway subsector will grow more quickly than in the past two decades as Government invests substantially in railway rehabilitation, procurement of new locomotives coupled with the expansion of new railway lines and improvement in existing railway infrastructure. Petroleum fuel consumption will continue to increase in international and domestic aviation as airport rehabilitation and new construction takes place.

2.3.2. Transport sector baseline emission projection

The demand for mobility for both passengers and freight will increase as Uganda develops. As it can be seen in the period 2005 to 2015, there is general increase in all types of vehicles. The year 2005, was used based on the Second National Communication as a reference year. Consequently, the passenger- kilometres and tonne-kilometres will increase proportionately. From the year 2015 to 2025, It is assumed that the passenger- kilometres and tonne-kilometres will increase at 7 % per annum. As outlined in the National Transport Master Plan, the dominant growth will be in the road sector, where traffic is expected to reflect economic growth and lead to a growth in traffic of about 7% until 2025 when growth reduces to 6%[11]. Thereafter it will decrease to 6% by 2050. The trends of emissions in

[11] https://www.researchgate.net/publication/285766191_Energy_Report_for_Uganda_A_100_Renewable_Energy_Future_by_2050

transport sector are shown in Table 2.18.

Table 2.18: The emissions in the transport sectors, CO_2eq (million tonnes)

	2015	2020	2025	2030	2035	2040	2045	2050
	2015	2020	2025	2030	2035	2040	2045	2050
Civil Aviation	0.345	0.450	0.589	0.788	1.054	1.411	1.870	2.387
Off Road	0.120	0.140	0.164	0.192	0.224	0.262	0.307	0.359
Navigation	0.183	0.228	0.284	0.355	0.443	0.553	0.691	0.865
Road	2.545	3.479	4.803	6.377	8.472	11.329	15.122	20.112
Railway	0.021	0.027	0.035	0.055	0.131	0.319	0.720	1.156
Total	3.214	4.325	5.874	7.766	10.324	13.874	18.710	24.878

The overall increment based on the baseline is about seven folds. Most of the increment will in the railway sector in general and freight in particular. It is the sector which was in the downward trends.

2.3.3. Road transport projections

The road sector has passenger and freight subsectors. Minibus is the most common means of transport inn Uganda. Some are very old, but there new second plying long distances. The trend of emissions in the road sectors are as seen in Table 2.19.

Table 2.19: Road sector baseline projections ($CO_2eq.$ million tonnes)

	2015	2020	2025	2030	2035	2040	2045	2050
Pick- Petrol and diesel	0.088	0.116	0.150	0.194	0.249	0.333	0.439	0.565
Freight\Lorries\Lorries Less than 10 tonnes	0.181	0.228	0.286	0.358	0.451	0.595	0.782	0.998
Freight\Lorries\Lorries_above_10_tonnes	0.209	0.240	0.306	0.390	0.498	0.667	0.875	1.117
Passenger\Cars\Diesel	0.066	0.093	0.131	0.175	0.234	0.313	0.419	0.561
Passenger\Cars\Petrol	0.513	0.719	1.009	1.350	1.807	2.418	3.235	4.330

Passenger\Large Buses\Diesel	0.346	0.470	0.659	0.882	1.180	1.580	2.114	2.829
Passenger\Medium Buses\Diesel	0.038	0.064	0.089	0.119	0.160	0.214	0.286	0.383
Passenger\Minibuses\Diesel	0.433	0.608	0.852	1.140	1.526	2.042	2.733	3.657
Passenger\Minibuses\Petrol	0.412	0.578	0.810	1.084	1.451	1.942	2.599	3.477
Passenger\Motorcycles\Petrol	0.260	0.364	0.511	0.684	0.915	1.225	1.639	2.194
Total	2.545	3.479	4.803	6.377	8.472	11.329	15.122	20.112

2.3.4. Railway projections

The railway sector had a lot of challenges in the period 2005 to 2016, it was under performing when it was under concession arrangement with Uganda Rift Valley. There were few improvements, the estimate growth was about 3% and will increase gradually as the infrastructure is under repair. The rehabilitation of the railway infrastructure is ongoing. The estimated growth rates in terms are freight and passenger is about 5% and 6% respectively for the period 2015-2025. The period 2025-2030 by 50%, and thereafter 4% to the 2050. Projected emissions are shown in Table 2.20. It should be noted that the locomotives are very old. It should be well maintained and could serve short distances.

Table 2.20: Baseline projections for railway sector (CO2eq. million tonnes)

Branch	2015	2020	2025	2030	2035	2040	2045	2050
Freight\Diesel	0.009	0.011	0.012	0.015	0.017	0.020	0.023	0.027
Passenger\Diesel	0.092	0.107	0.124	0.144	0.167	0.193	0.224	0.260
Total	0.018	0.022	0.027	0.033	0.040	0.049	0.060	0.073

2.3.5. *Off-Road vehicles projections*

The off-road vehicles which include tractors, engineering plants and uncategorised vehicles is assumed to increases 4% per annum. This sector is considered under freight transport and largely depends on the diesel fuel. Projected emissions are shown in Table 2.21.

Table 2.21: Projected emissions for off-road vehicles, CO_2eq (million tonnes)

Branch	2015	2020	2025	2030	2035	2040	2045	2050
Engineering Equipment\Diesel	0.009	0.011	0.012	0.015	0.017	0.020	0.023	0.027
Tractors\Diesel	0.092	0.107	0.124	0.144	0.167	0.193	0.224	0.260
Uncategorised\Diesel	0.018	0.022	0.027	0.033	0.040	0.049	0.060	0.073
Total	0.120	0.140	0.164	0.192	0.224	0.262	0.307	0.359

2.3.6. *Navigation / Waterways transport projections*

The number of small boats is on the increase. Most of them are fishing boats. These estimates are based on the linear interpolation. The estimated growth rates are 4% per year for both fishing and transport boats. The other boats are estimated to grow at 4 % per annum. The ferries carry both cargo and passengers, the number of ferries and other marine vessels are expected to increase at rated of 3% over the period 2015 to 2025 and 4% thereafter. Projected emissions are shown in Table 2.22.

Table 2.22: Navigation/Waterways projected emissions CO_2eq (million tonnes)

Branch	2015	2020	2025	2030	2035	2040	2045	2050
Boats Fishing\Gasoline	0.091	0.111	0.135	0.165	0.200	0.244	0.297	0.361

Marine Vessels\Diesel	0.091	0.117	0.149	0.190	0.242	0.309	0.395	0.504
UNRA Ferries\Diesel	0.001	0.001	0.002	0.002	0.003	0.003	0.004	0.006
Total	0.184	0.229	0.286	0.357	0.445	0.557	0.696	0.870

2.3.7. Aviation projections

Uganda's Aviation sector is expected to increase by 5% up to 2025. Thereafter, it should increase by 6% p.a. to 2035 and 5% p.a. to 2050. Uganda is expected to have a population growth rate of about 5.5% for passenger travel, and 6% for cargo per year through 2029 air transport. Projected emissions are provided in Table 2.23.

Table 2.23: Domestic and international aviation projections CO_2eq (million tonnes)

	2015	2020	2025	2030	2035	2040	2045	2050
Domestic (Avgas)	-	-	-	-	-	-	-	-
International (Jet kerosene)	0.345	0.450	0.589	0.788	1.054	1.411	1.870	2.387
Total								

2.4. Mitigation measure impacts

There are four main options which Uganda can emphasize to reduce GHG emissions in the transport sector are to.

a) Promote the use of efficient motor vehicles:

b) Fuel switch from fossil fuels to cleaner fuels such as electricity, ethanol blending and biodiesel;

c) Use mass transit, such as buses and trains in town service; and,

d) Shifting freight from lorries to railways and water ways.

Out of the four mitigation options, improved fuel economy is the most appropriate for Uganda. Most of the vehicles currently imported are second-hand, with poorer fuel efficiency than new car imports. When coupled with poor maintenance culture, and quality of the infrastructure in Uganda, the lifetime for vehicles is about 16 years. The fuel economy is lower than international standards.

It is estimated as 13.5 l/100 Km. The GoU would like to achieve an average vehicle fuel economy of 4.2 litre/100 km by 2030. This implies more than a tripling of vehicle fuel economy by 2030. The GoU has few options to reduce the emissions, given the fact that Uganda is a poor country, most people who purchase vehicles cannot afford new vehicles.

This makes increasing fuel economy per vehicle (and in total for road transport) very difficult under current economic conditions. It is estimated, that given current economic projections, Uganda will continue to rely on the import of second-hand vehicles and vehicles with less fuel efficiency than new vehicles in the coming 20 years. It will take time to achieve that. The Government put restrictions on importing old vehicles so that we can achieve 4.2 litres/100 km for low-capacity vehicles, but not for all vehicles. Uganda does have the sufficient infrastructure such as good roads.

The Mitigation Policy Impact

Over the years, Uganda has developed very good economic policies. It needs support from international development agencies and experts to improve estimates for forecasts/estimate for Uganda's future transport energy efficiency, hence, reduced estimates of GHG emissions for Uganda over the next 25 years. There are potentially many mitigation policies, out of which one is chosen for this conservative analysis. As part of the efforts to mitigate climate change, fuel economy is one the best measures considered because it is one of the "low hanging fruits" whereby Government can utilise without government making high investments.

The statement can be analysed through different mitigation pathways. The capacity of vehicles which have the fuel economy 13.5L/100 km, typically it is a car running on petrol engine, with capacity within a range of 3001_3500 CC.

Initial assessment using the GFEI approach, the fuel economy-based CDP is 20% in the year 2030, while under WAM. the fuel economy will be reduced to 35% in 2040 and 50% by 2050. Based on these initial findings such vehicles can attain the required 4.2 L/100 km it is possible for vehicles of lower than 2500 CC.

Assumptions.

- The capacity of cars in Uganda varies between 500 CC and 3,500C. A car average capacity 1501_2000 CC running on petrol has an average fuel economy of 8.3 L/100 km in the base year.
- It is most likely that such vehicles can achieve 15% reduction in fuel economy by 2030, thereafter 30% in 2040 and finally 50% in 2050 as stated in GFEI.
- In the base year cars contribute 12.5% of the estimated 71,000 million – person kilometres are cars, out of which 30% are of average capacity 1501_2000 CC.

- The growth rates in the number of vehicle-kilometres will start with 7% and then reduce to 6% per annum by 2050.
- The fuel use, 90% of the cars use petrol, while10% diesel.

Uganda can attain low fuel economy under three scenarios namely, Current Development Policy (CDP): includes mitigation measures that have been in place since 2015, While with Additional Measures (WAM): includes additional mitigation measures

Most of the cars have average capacity of 1501_2000CC. The most popular vehicles consume petrol. In the BAU Scenario the emission will increase from 153.8 to 1286.5 thousand metric tonnes in 2050. That is about and 8 folds increase in GHG emissions due to transport vehicles (Figure 2.9).

Under the CDP and WAM scenarios, the emissions increase from 153.8 to 873 and 643.2 thousand metric tonnes respectively, thus 5.7 and 4.2 folds respectively.

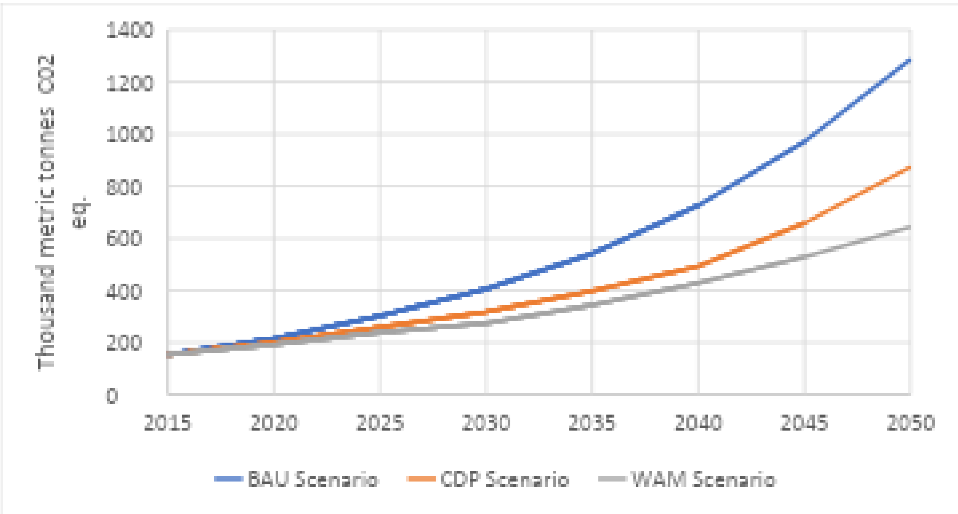

Figure 2.9: Projections for car emissions if fuel economy policies are implemented.

1. Increase the importation of new, higher fuel efficiency vehicles and limit the importation of old, inefficient vehicles;
2. Improve the country's road infrastructure and associated road infrastructure which will make travel on such roads more efficient than current roads due to a number of factors, primarily polities that that will reduce road traffic congestion;
3. Reduce energy intensity for travel per passenger and tonne-kilometre through the rapid deployment of higher efficiency vehicles, thereby enabling the GOU to achieve a transport fuel economy of 4.2 litre/100 km by 2030.

4. The private sector is interested in seeing policies that are longer-term than is currently the case, i.e. to see transport policy. One policy example to help achieve this would be to reduce vehicle duties by 25% on imports every year for the next 5-6 years. More road discipline in terms of following and enforcing speed limits, load limits (particularly mini-bus, and other people transporting vehicles) which have been shown, both in Uganda, but all over the world to have significantly rapid positive fuel efficiency effects (e.g., increasing fuel efficiency by 50% per passenger kilometre within a year). Improving over transport discipline, including enforcing speed limits, policing traffic to reduce traffic jam, reducing vehicle loads to those loads specific vehicles were designed to carry, as have been set out in Uganda's Transport NAMA (Nationally Appropriate Mitigation Actions):

2.5. Recommendations for improving data collection for transport baselines and projections

2.5.1 Data Collection

The climate change related data need more transparency than any time before. Data collection is key challenge in the transport sector. There are the four modes of transport and additionally the fifth mode, pipeline is under construction. This study made an attempt to improve on the data collection through interaction with the key stakeholders and developing tools for data collection.

Road Transport: The classification of the types of vehicles under the MoWT are cars, minibus, motorcycle, bus, lorries and three wheelers. The MoWT has annual registry of new vehicles, but there is no data on the fleet. There are vehicles which are no longer on the road. There is no institutional arrangement in place that can track those vehicles. The MoWT should pursue annual vehicle inspection, where valuable information such as the vehicle travel (vehicle-kilometre), the fleet and road worthiness will be captured during the process. Although the police have data on the vehicles written off, there could be some which are not recorded by the police. It is recommended that the MoWT should work closely with the police and possibly the insurance companies to track the number of vehicles which are written off and their capacities (CC), and share the data with UBOS.

Civil Aviation: The data provided is in aggregated form, example the fuel used in the civil aviation sector is jet kerosene. The aviation gasoline is used small air crafts, should be separated from the jet kerosene. The aviation sector is one the sectors which can move from Tier 1 to Tier 2. It is possible to capture data on landing and take-off and cruising. There may be a need for capacity building. All the national air ports in respect of their size should be able to capture on fuel consumption by type and amount in litres. The UCCA can also provide data cargo and passenger air craft separably. UCCA can also explore and provide data on passenger-kilometre and tonne-kilometre for cargo. The data should share with CCD at annul basis.

Marines. There is very limited information about marines/water ways travel. Limited data was available in the Initial National Communication, thereafter along break. The study carried MAAIF few years back (2018-2021) gave more light on the boats in the lakes and water ways. Nearly all the boats in the lakes are private. There are also ferries and other marine vessels operated by UNRA and private sector which are increasing in numbers. There are many valuable data that should to be shared with the key stakeholders namely, UBOs, MoWT, MAAIF and MEMD. The information on vehicles should include the purpose, the capacity in terms of cargo, passengers. The capacity of the engine in CC and most important is the annual fuel consumption by type of diesel and petrol. The data should be shared by all key stakeholders.

Railways: URC has a good data about locomotive, their age and fuel consumption. Most the locomotives are more than 40 years old. The tonne-kilometres are provided for each type of locomotives. Even though there were breaks in data in the last decades, URC has improved on data collection. It is envisaged that URC will be able procure new locomotives which are more efficient and haulage is expected to increase in the near foreseeable future. With improvement in data presentation, URC will be a good candidate for Tier 2. Data given to key stakeholders should be verified internally before publishing.

The pipeline: The proposals for construction of pipelines to reduce the cost of petroleum transportation have been on table for several decades. There is a new pipeline under construction to transport crude oil to Tanga in Tanzania for export. There will be a need for data on the amount of oil pumped, the energy use, and fugitive emissions. As Uganda is also planning for refinery, there will be additional pipelines for other petroleum products. Although it could not be part of transport CCD will need information about emissions along the gas and petroleum value chain.

Since Uganda is phase of transparency, there is need of capacity building in transport value chain. Data compilers should be supported, so they can provide extra information about the data such as the uncertainty, the source of uncertainty, how the uncertainty can be improved and any other relevant information. There are at times different data from same institution quoted the same refence source. There should be an institutional arrangement whereby data can be shared and published to void such occurrences. The key stakeholders CCD, UBOs, MoWT, MAAIF and MEMD should work together.

Data challenges in Transport Sector

- There is general lack of historical data, that is partly due loss of institutional memory and poor archiving
- In some cases, data sharing is a challenge, it is personalised

- The data are captured based on the needs of an institution, such as statists only, energy data are not published.
- In some cases, data seems not undergo under internal quality assurance
- Some institutions give data in their own format, the extra data may need to extracted, it may take long time.
- At times data may not be given, speciality by the private sector.
- There is a need of a joint meeting during data collection with the member of Climate Change Department, MDA and Consultant.

Improvement on how these gaps could be filled.

- Data should be archived in all institutions and not limited to persons, preferably the GoU can set data centre, which is accessible.
- The request of data once it is made at the registry, it should be accessed
- There is need for institution to work together, example UBOS, conducts household survey, but the MEMD and CCD need the amount of energy be in kilogram of litres, such data can be collected by UBOS during household survey.
- The data should go through quality assurance before published
- Institution requesting for data should explain what they need and the format should be simplified.

Recommendation

- MoWT should develop a national database on vehicle fleet, fuel consumption and efficiency.
- MoWT and MEMD should develop of fuel efficiency policy and standards have benchmark/target on consumption for light, medium and heavy-duty vehicles being imported into the country
- It is recommended that the MoWT work closely with police and possibly the insurance companies to track the number of vehicles written off and their capacities (CC) share with stakeholders.
- The CCD and MoWT, with should form a small group personnel members who can be assisted to go into the details of the LEAP. The participants should be trained how to ingrate LEAP with other tools
- The UCCA should be able to provide data fuel during landing and take-off, also provide data cargo and passenger air craft separably. Separate data of aviation gasoline from jet kerosene. UCAA provide data on passenger-kilometre and tonne-kilometre for cargo. The data should be shared with CCD at annul basis.
- On water ways /navigation, MoWT and MAAIF to provide the following information to CCD, the type of vessel, cargo (tonnes), passengers. The capacity of the engine in CC annual fuel consumption by type diesel and petrol. Additional in terms of passenger-kilometres and tonne-kilometre should be provided.
- URC to provide data on fuel, consumption and freight (tonnes). The data be presented in form of passenger-kilometres and tonne-kilometres. The data should in summary form and not for each locomotive type.

- There should be an institutional arrangement whereby data in shared and published to void such as occurrences in consistence. Key stakeholders UBOs, MoWT, MAAIF, MEMD and CCD
- In cases of missing gaps in data series, the compilers should able to fill in the gaps and explain how it was filling was done e.g., splicing technique, interpolation, surrogate data etc.
- Data compilers should be supported, so they can provide extra information about the data such as the uncertainty in the data, the source of uncertainty, how the uncertainty can be improved and any other relevant information.
- The oil and gas sector should plan for data on the amount of oil pumped, the charteristics of oil the energy use and fugitive emissions.
- CCD should work closely with MoWT to look at possibility getting data from bulk users such marine vessel in terms of passenger-kilometres and tonne-kilometres.
- CCD should work closely with other MDAs to look at possibility getting data, which could be one of the items needed for their operation licences. Some data like fuel consumption could straight forward, other will need confidentiality such as production.
- All MDAs should budget for data collection. By 2026 all MDAs should prepare their sectoral inventories and share it with CCD.

2.5.2 Policy impact Projection

The gaps in data required for doing projections

- When there are missing gaps in data series, the compilers should able to fill in the gaps and explain how it was fillings are done e.g., splicing technique, interpolation, surrogate data etc. It would be good for the data compliers to identify the drivers of the activity example population, GDP, institutional projections etc.

- There should a data provision policy, where is should made mandatory. There is close where budget could cannot be passed without item on climate change. Licensing marine vessels should be subjected to provsion of data on capacity (CC), cargo and passengers and fuel consumption annual by the private operators to the key stakeholders.

The software Applicable in Transport sector for policy analysis

- Greenhouse gas abatement cost model (GACMO)
- Advantages include is a good tool for cost analysis, it need minimum training and easy to navigate.
- It can also provide data on emission.
- It generally focuses on energy and limited input in waste sector.

- Data input requirements are low.
- It works very well with mitigation.

Disadvantages include

- Requires a good energy balance data for energy sector.
- The calculations based on the inventory and growth factor.
- The data entre period are fixed. It has no sectorial linkages.
- It does assess SD impacts.
- It was left out of this study due its limited applications.

Low Emissions Analysis Platform (LEAP)

Advantages

- Does require a licence but Uganda government and education institutions should be able to get it for free
- A lot of support materials
- Easy to navigate
- High granularity output - detailed outputs and graphics
- Can be operated at different levels depending on data availability
- Can be linked with the TRACE model
- Does also include a cost analysis

Disadvantages

- Sectors other than energy need to be modelled outside of LEAP, though the updated versions have non energy components, it needs training
- Depending on level of data available it could require a bit of time to input data
- Calculation transparency is medium.
- It is not a free software for consultants

Recommendations.

- Government of Uganda
- strengthen regulation limiting the age of imported vehicles (compliance linked to pre-shipment inspection)
- Promotion of cleaner fuels and setting of fuel standards.
- Design of a vehicle inspection and maintenance system, including certification programme, standards for inspections and establishment of vehicle inspection centres.
- Development of tax incentives to encourage acquisition of more fuel-efficient vehicles.
- Establishment of a financial incentives scheme for vehicle replacement.
- Public information and awareness campaign for improving on the fuel economy
- Uganda should keep improve of infrastructure development as a support to policy in fuel economy.
- There is a need for policy analysis to carry due diligence before policy on fuel economy become public.

3. Waste sector

3.1. Methodology

To develop the baseline and policy impact projections, data for the greenhouse gas (GHG) emission inventory were obtained from the waste sector database of inventory activity data on:

- Solid waste disposal sites (SWDS) of different subcategories (managed or unmanaged, and shallow or deep),
- Biological Treatment of solid wastes (composting and anaerobic digestion),
- Incineration and Open Burning,
- Wastewater (domestic and industrial)

A baseline projection scenario represents the future situation without interventions or new policies, that is, Business as usual (BAU). The base year for this study is 2015, the year serving as a starting point to measure emission changes with time (yrs.) as we progress BAU or with interventions (mitigations). The waste sector database are the basic facts or values on wastes consisting of solid wastes and wastewaters (amount of waste generated and disposed, management technology and greenhouse gas emissions).

The Waste sector has the solid waste and the wastewater (domestic and industrial) as subsectors important in the greenhouse gas (GHG) emissions estimates. The waste sector assessment was done by building different scenarios: Business as usual – BAU, with existing measures (WEM) and with current development plans. These emission scenarios were modelled from the 2015 base year, and were defined as follows[12]:

- **Baseline / Business-as-usual:** A scenario that ignores existing measures, and just forecasts future GHG emissions based on expected trends.
- **'With Existing Measures' (WEM):** Includes mitigation measures that were in place up to 2015 (the base year).
- **Current Development Policy (CDP):** Includes mitigation measures that have been in place since 2015, but also include planned measures and/or targets and commitments that have not yet been implemented.
- **With Additional Measures (WAM):** Includes additional mitigation measures or measures in earlier scenarios implemented to a higher degree of ambition.

For waste data analysis and the BAU and mitigation/policy trajectories, the IPCC inventory software and the associated Excel (2016) based IPCC worksheets were used. For additional model testing, the GACMO version 206 model was used to compare with the IPCC approach. Mitigation options assessed with IPPC based Excel worksheets included: i) Green cities waste management and ii) NAMA- Schools bio-latrines. The GACMO model assessed the mitigation

[12] *Uganda Climate Promise Project (2021). Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. Version 1.0.*

options for: i) Composting Municipal Solid Waste, ii) Incineration plants, and iii) Recycling of plastics[13].

3.2. Baseline Scenarios and Assumptions for the Waste Sector

The waste sector (solid waste and wastewater) is rapidly increasing in volumes and changing in composition, particularly in ban areas. The rapid increase in urban population and changing lifestyle demands have caused these observed changes. The percentage of solid waste generated that is disposed to solid waste disposal sites is low (10-55%) varying among the urban areas. The composition of solid waste varies little among the urban areas of the country and the average distribution by weight % are: food (18%), garden and yard (46.3%), paper (7%), wood (2%), textile (1%), plastics and others (25%)[14]. Plastics and hazardous substances have become significant contents of solid wastes while biodegradable contents are decreasing. These changes demand putting in place more robust waste management systems. The fraction of households that are connected to the municipal sewage system in the cities is estimated to be only 21% with a projected growth to 30% in the next decade[15].

National population data are important for the estimation of GHG emissions from waste because waste is generated from human activities. Uganda population numbers in 2015 were 13,166,100 urban, 22,333,000 rural and 35,499,100 total population[16]. The national population growth rate between 2014 and 2024 was 2.9%, while earlier projections were at 3.0%[17]. The rate of urbanization and the population socio-economic characteristics have some influence on the nature and quantities of the municipal solid wastes generated. Uganda's municipal solid waste (MSW) average generation rate is 0.55 kg/cap/day[18,19].

3.2.1. Base Year Greenhouse Gas Emissions

Total GHG emissions for the base year 2015 was 2,606.8 Gg CO_2eq arising from source categories: SWDS (1,370.8 Gg CO_2eq), Biological Treatment (94.9Gg CO_2eq), Domestic wastewater (1,078.7 Gg CO_2eq), Industrial wastewater (53.6 Gg CO_2eq), Incineration and

[13] GACMO –version 206 modelling software
[14] NEMA, 2024 unpublished data
[15] Uganda Climate Promise Project (2021). Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. Version 1.0.
[16] UBOS. Rural-Urban Population for 146 Districts in Uganda. Excel Sheets. For all population data used (2015-2030). Projections were made using 3% annual population growth rate.
[17] National Census Report-Draft 2024
[18] J.Okot-Okumu and R. Nynje. 2011. Municipal Solid waste management under decentralization in Uganda. Habitat. Int.
[19] Updated Nationally Determined Contributions (NDC), 2022. Ministry of Water and Environment.

Open Burning (8.8 Gg CO_2eq) shown below in Figure 3.1.

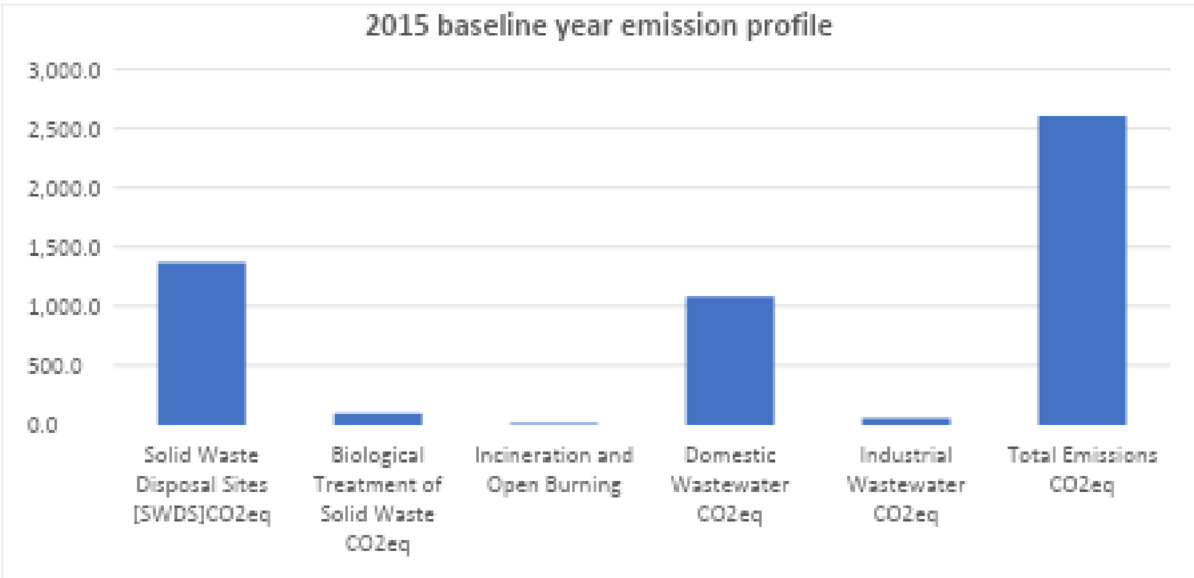

Figure 3.1: Greenhous gas emissions for base year 2015

Updated data obtained during this study show growing emissions levels[20]. The total GHG emissions characteristics for the waste sector is similar among the years considered for assessment. Two thirds of the emissions were from SWDS (CH_4 emissions from managed and unmanaged disposal sites) and the remainder mostly from wastewaters (about 33%).

3.3. Greenhouse Gas Baseline Emission Projections

3.3.1. Assumptions

The waste sector key drivers of GHGs emissions are population numbers, income level and the available waste management technology. These are the activity data that are used in the estimation of GHG emissions from the different waste management practices. To construct the GHG emissions trajectories, assumptions are made on the characteristics of the

[20] *Uganda Climate Promise Project. Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. (2021). Version 1.0.*

determinants of GHG emissions from wastes such as the waste composition, waste generation rates, management technologies and waste parameters among others.

3.3.1.1. Solid waste

For emissions from solid wastes, it was assumed that the population that are served with waste management services grow in line with the national total population growth. It was also assumed that those generating MSW that end in SWDS are mostly the urban population. The national projected population numbers (3.0% growth rate) are shown below (Table 3.1). Specific assumptions for SWDS are shown Table 3.1[21].

Table 3.1: Specific assumptions on solid waste generation and disposal

Solid waste generation and disposal	
Baseline description	Population consumption pattern, waste generation and solid waste management practices remain the same over the projected period (2015 -2050). Population served with waste management services grows in line with national population growth.
Drivers and Assumptions	
Population served by MSW services	Urban population grows in line with national population growth rate (see Fig 2 below). National population data from UBOS
Management technologies	Remained constant during the period on assess (30% unmanaged shallow & 55% managed) for BAU
Management technologies	Adopted the NDC mitigations and will be continued guided by 2006 IPCC Guidelines
Degradable Organic carbon fraction	Remains constant for all degradable for the period of projections
Waste per capita	Remains constant and the same as 2018 to 2022 value (200.8 kg/cap/yr.)
Amount of MSW	Increases in line with urban population growth
% of waste to SWDS	Remains constant and the same as 2015 value (55%)[22]
MSW to Biological treatment,	Increase in line with urban population growth and will maintain the same ratios compared to SWDS throughout the projection period (2015-2050)

[21] *Uganda Climate Promise Project. Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. (2021). Version 1.0., with some changes.*
[22] *Information obtained from NEMA , 2024*

Incineration, Open burning	
Waste categorization	Remains constant from 2018 to 2022 values (food (18%), garden & yard (46.3%, paper (7%), wood (2%), textile (1%), plastics and others (25%)[23]
Sludge to SWDS	Remains constant and the same as 2018 value (0%)
Amount of methane recovered	Remains constant at 2018 value (0 kg)

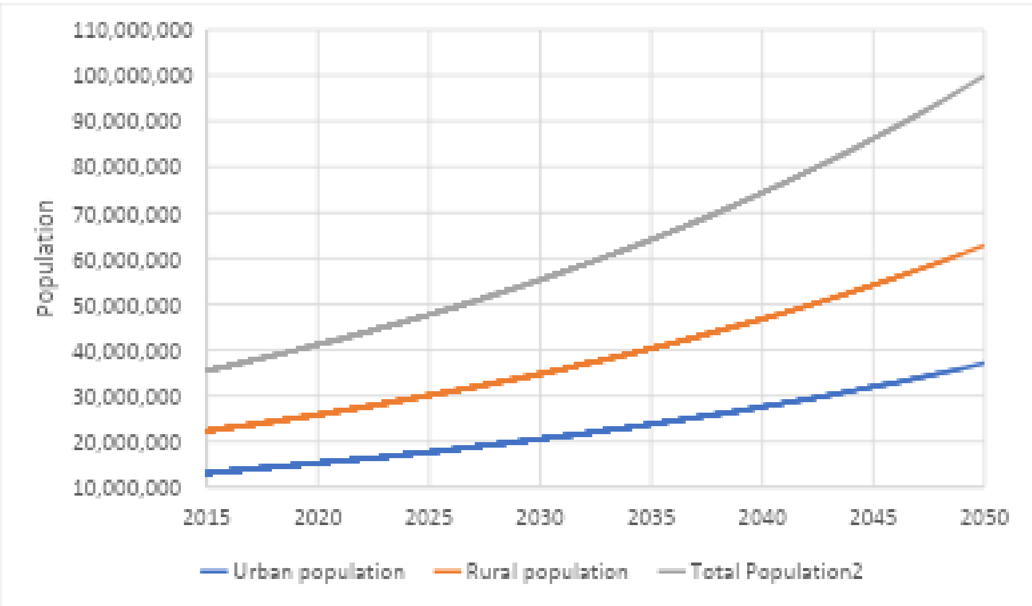

Figure 3.2: Population projections

3.3.1.2. Wastewater

For domestic wastewater treatment and discharge, it was assumed that connection to sewage system, wastewater generated 21% with a projected growth to 30% in the next decade and treatment practices remain the same over the projected period (2015 - 2050), while volumes of wastewater generated grow in line with national urban population growth

[23] *Information obtained from NEMA , 2024*

for domestic wastewater[24,25]. For industrial wastewater treatment and discharge, it was assumed that wastewater generated and discharged increase in volumes in line with annual Gross Domestic Product (GDP). For latrines and septic systems, it was assumed that the waste generated grow in line with rural population growth. Specific assumptions on wastewater treatment and discharge are in a technical report on enhanced mitigation and adaptation targets (Table 2)[26].

Table 3.2: Specific assumptions on wastewater treatment and discharge

Wastewater Treatment and Discharge	
Domestic Wastewater Treatment and Discharge	
Baseline description	Population consumption pattern, wastewater generation and treatment practices remain the same over the projection period. Wastewater generation grows in line with national population growth.
Drivers and Assumptions	
Population served by wastewater treatment systems	Urban population served grows in line with NWSC water connection growth (about 1.2 million in 2015 and expected to grow by to 30% in the next decade).[27] Data on population served by conventional WWT and lagoons – NWSC quarterly reports. For latrines rural population data were used.
Degradable Organic component	Use of the default value from 2006 IPCC guidelines. Default value remains constant during the projection period
Correction factor for industrial BOD	Remains at default value for collected wastewater. 2006 IPCC guidelines
Types of treatment and discharge	Remains constant as of 2015 to 2024 (centralised conventional WWTP, anaerobic deep lagoons; shallow lagoons, septic tank and latrine)
Fraction of population using different treatments	Assumed to remain constant during the period of projections

[24] *Uganda Climate Promise Project. Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. (2021). Version 1.0., with some changes.*

[25] *Updated Nationally Determined Contributions (NDC), 2022. Ministry of Water and Environment.*

[26] *Uganda Climate Promise Project. Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. (2021). Version 1.0., with some changes.*

[27] *Uganda Climate Promise Project. Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. (2021). Version 1.0., with some changes*

Degree of technology utilization	Assumed to remain constant during the period of projections. 2006 IPCC default values were used
Per capita protein consumption	Default value used and assumed remains constant as of 2015 (17.888 kg/person/year)
Daily per capita pit latrine sludge BOD_5	Default value used and assumed to remain constant during the projections period[28]
Industrial Wastewater Treatment and Discharge	
Baseline description	Industries production growth, wastewater generation and treatment practices remain the same over the projection period. Wastewater generation grows in line with industries production growth (e.g. Breweries & Malt, Beverages, Fish processing, Sugar refining, Alcohol refining).
Drivers and Assumptions	
Activity and emissions growth rate	Industry production in tons per year was assumed to determine the volumes m^3 of wastewater discharge. Extrapolation was based on annual industrial production growth rate based on the 2018 to 2022 growth.
Wastewater treatment technologies	It was assumed that the wastewater treatment technologies (UASB/anaerobic, aerobic, lagoons, etc) remain the same during the projections period.

3.3.2. Business as Usual Greenhouse Gas emissions projections

Following the assumptions outlined above, the business (BAU) as usual emissions projections from the waste sector are as shown in Figure 3.3. Total GHG emissions is projected to reach 3261 Gg CO_2e and 5889 Gg CO_2e by 2030 and 2050 respectively.

[28] *Eawag, Sandec Training Tool 1.0-Module 5, 2008. Faecal Sludge Management and Martin Strauss.*

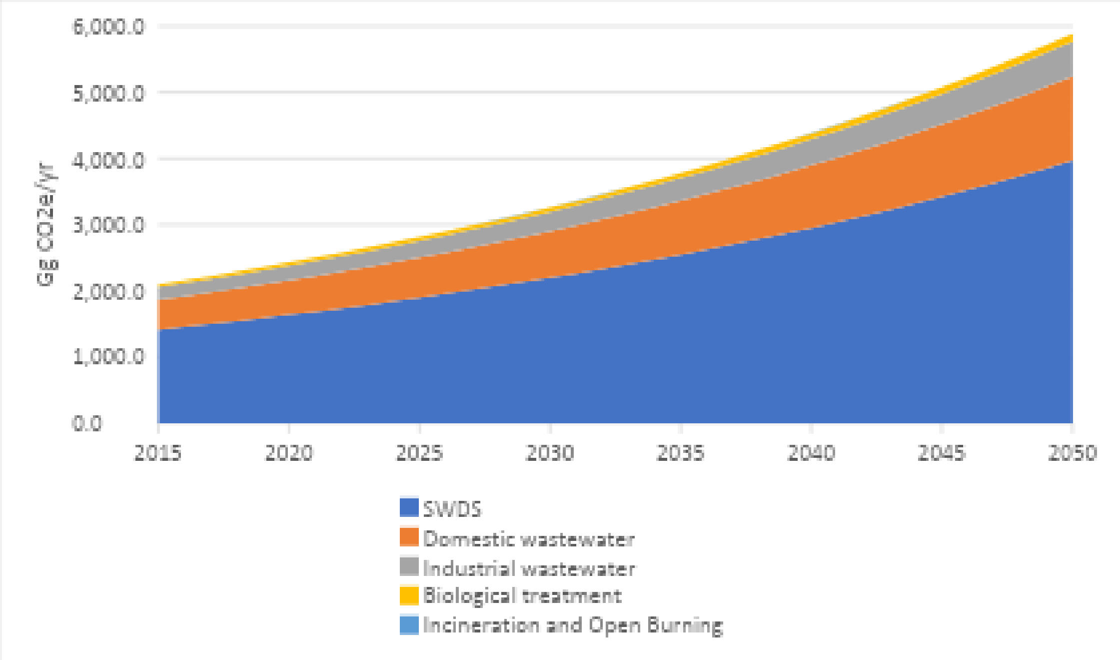

Figure 3.3: Baseline GHG emissions from the waste sector under business-as-usual scenario

It is important to note that data compilation for SWDS relied on data from few Cities and Municipalities that do not cover the entire country and the categorization of SWDS systems for the emission estimation were based on expert judgement. There are still gaps in data on the waste sector and for the data collected uncertainties considerations are based on the 2006 IPCC Guidelines[29].

The BAU trajectories constructed with IPCC model and GACMO are comparable (Figure 3.4). The BAU trajectories generated by IPCC and GACMO trajectory are comparable to WEM from 2015 onwards since WEM only includes mitigation measures that were in place up to 2015 (the base year). The existing measures are the Green city and school bio-latrines that are measures that have been in place up to 2015.

[29] *2006 IPCC Guidelines, Vol.5- Waste Sector.*

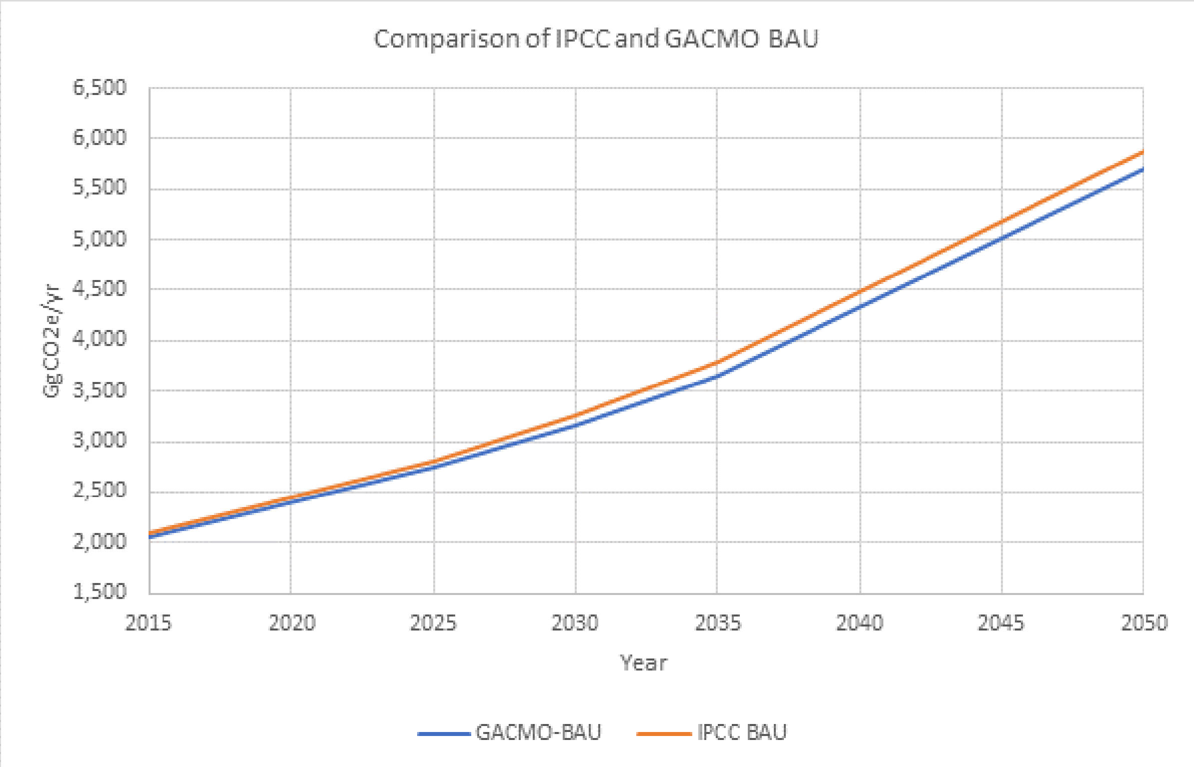

Figure 3.4: Comparison of the business-as-usual projections.

3.4. Mitigation projections

The mitigation projections based on NDC are: Green cities waste management and School bio-latrines. The impacts of these mitigation measure are however, not quantified yet though the target was 34.8% GHG emissions reduction by 2030.

Green cities waste management measure is targeting green development in the large urban areas. It is designed to support comprehensive physical planning and efficient waste management (both solid and wastewater) for at least five cities and 15 municipalities (National Planning Authority, 2017)[30]. The water management elements (increased water harvesting and efficient water utilization) are estimated to deliver savings equivalent to 1.1 MtCO2e by 2030. However, there is no data on progress made so far to proceed with assessment of the mitigation impact.

School bio-latrines mitigation measures include relevant elements of a Nationally Appropriate Mitigation Action (NAMA) for improving cooking and sanitation conditions of schools. It involves the installation of biogas cook stoves fed by biogas from bio-latrines with

[30] *NPA (2017) The Uganda Green Growth Development Strategy 2017/18 – 2030/31*

bio-digesters (Ministry of Energy and Mineral Development, 2016)[31]. The NAMA is based on 5% of schools, or 1,100 having the measures installed. However, there is no data on progress made so far to proceed with assessment of the mitigation impact.

GACMO-version 206 software based GHG emissions assessment was only possible for solid waste (SW) and the mitigation options relevant to Uganda selected include: Composting of MSW, incineration plant, recycling of plastics.

The Green Cities Plan forms part of the Green Growth Development Strategy[32]. While the school bio-latrine measure is already captured within an existing NAMA. Table 3.3 below describes the assumptions made for each measure for the three mitigation scenarios[33,34]. These are assumptions that are in NDC and used by technical reports on mitigation and adaptations (MWE 2021)[35,36].

The resulting GHG emissions projections based on the assumptions described in Table 3 are presented hereafter. For the existing mitigation options reported for the NDC and update are described by the IPCC Excel model and GACMO model BAU trajectories. However, with added mitigations based on expert judgement emissions reductions could be between 10% and 30% depending on the extent of the different activities within the mitigation measure. For this type of mitigation measures, if not comprehensively implemented emissions reductions may be as low as between 2% and 10% during the period 2015 to 2050. However, it is anticipated that it will be a reduction of 1.1MtCO2e between 2018 and 2030[37].

Table 3.3: Mitigation options and assumptions

Measure	BAU	WEM	CDP	WAM	Notes

[31] *Nationally Appropriate Mitigation Action on Integrated Sustainable Energy Systems for Schools in Uganda. Accessed from: https://www.ndcs.undp.org/content/dam/LECB/docs/pubs-namas/undp-lecb-Uganda-Green-School-NAMA-2016.pdf?download*
[32] *NPA (2017) The Uganda Green Growth Development Strategy 2017/18 – 2030/31*
[33] *Development of Uganda's Long-Term Climate Change Strategy Technical Annex: Mitigation elements. Report for the Uganda Ministry of Water and Environment (MWE), Climate Change Department (CCD) and the German Development Cooperation (GIZ), 2021.*
[34] *Uganda Climate Promise Project Technical Report on Enhanced Mitigation and Adaptation Targets Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP, 2021.*
[35] *Ministry of Water and Environment (2022). Updated Nationally Determined Contribution (NDC).*

[36] *Uganda Climate Promise Project (2021). Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. Version 1.0*

[37] *NPA (2017) The Uganda Green Growth Development Strategy 2017/18 – 2030/31*

Green Cities Waste management	Waste generation based on population growth.	Includes mitigation measures that were in place up to 2015 (the base year). Assumed same as BAU	Support comprehensive physical planning and efficient waste management (solid and wastewater) for at least five cities and 15 municipalities.	Extend this to other municipalities that generate about 50% of the waste generated in the five cities and the 15 municipalities.	Green Growth Development Plan only includes CO2 savings estimate for the water management element, so saving will be underestimated.
School bio latrines	Waste generation based on per capita rates. Targeting schools.	Includes mitigation measures that were in place up to 2015 (the base year). Assumed same as BAU	1,100 schools with bio latrines with bio digesters.	Continuation of rate of installation to 2050	CO2 savings from the measures are not estimated in the NAMA.

For school bio latrines where cooking fuel is substituted with biogas from the biodigesters, the implementation can achieve a reduction of between 10% and 30% in mitigating of CH_4 emissions from open latrines based on expert judgement. In this case Excel model was used to do the projections the assumption that emission reduction will be between 10% and 40% based on expert judgement. Because of lack of data, it is taken that the mitigation measures are being implemented from 2015 to 2050 period. When fully implemented, the main mitigation measures and policies are projected to reduce the 2030 emissions by 34.8% to 2.09 MtCO2e[38]. So, the mitigation reduction levels were raised to 40% by 2050 to construct the trajectories. The mitigation trajectories presented below are based on the IPCC model. Since the GACMO model only works well when energy data are included, it was not possible to generate any useful mitigation trajectories with it. The mitigation trajectories are compared in Figure 3.5.

[38] *Uganda Climate Promise Project Technical Report on Enhanced Mitigation and Adaptation Targets Updating*

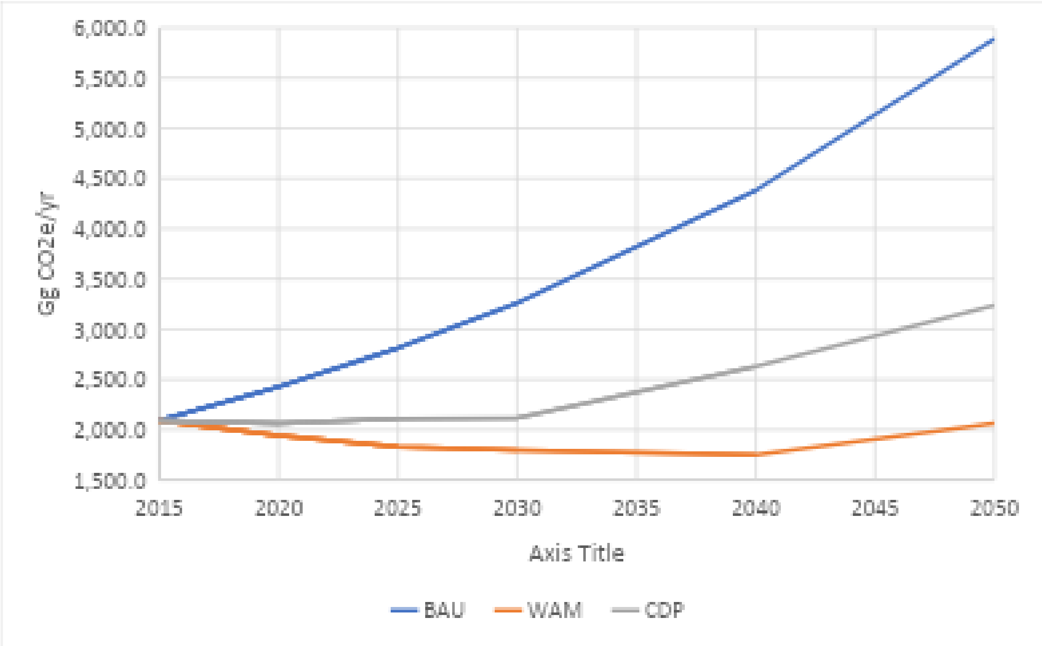

Figure 3.5: Mitigation projections 2015-2050

The trajectories described in this report display higher percentage emissions reduction levels compared to other reports[39,40]. Additional mitigation measures that were assessed include: composting, plastics recycling and solid waste incineration (Figure 3.6). So, the additional measures of composting, plastics recycling and solid waste incineration show additional emission reductions when you compare to the WAM in Figure. The targets were set based on expert judgement. Aggregated mitigation trajectory is shown in Figure 3.7. So, when the mitigation measures are considered separately the resultant emissions reduction are comparable to the WAM and CDP described above. When the mitigation measures are aggregated the emissions reduction is more than WAM and CDP (Figure 3.7).

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[39] *Ministry of Water and Environment (2022). Updated Nationally Determined Contribution (NDC).*

[40] *Uganda Climate Promise Project (2021). Technical Report on Enhanced Mitigation and Adaptation Targets. Updating Uganda's Nationally Determined Contribution (NDC). Government of Uganda & UNDP. Version 1.0.*

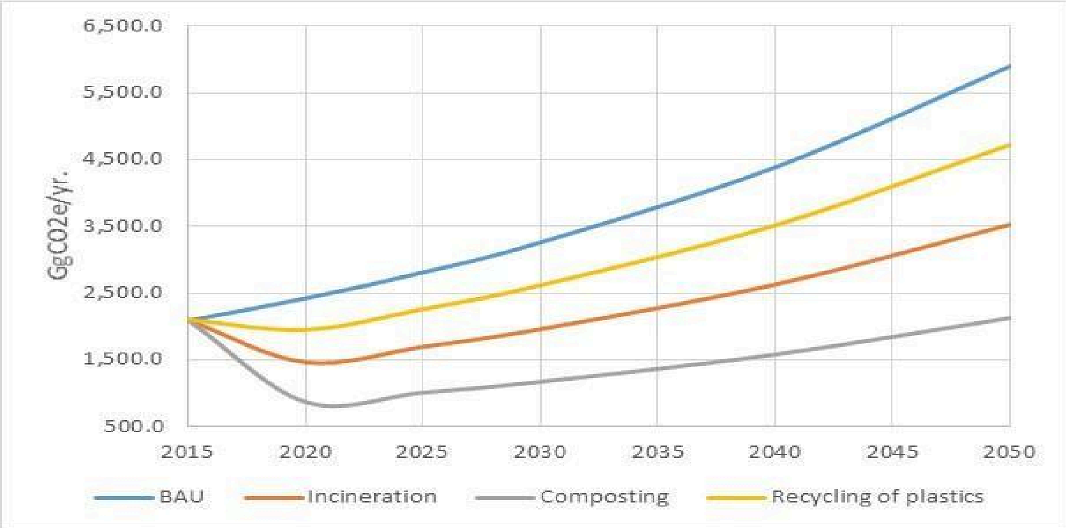

Figure 3.6: Comparison of the impacts of the additional mitigation measures

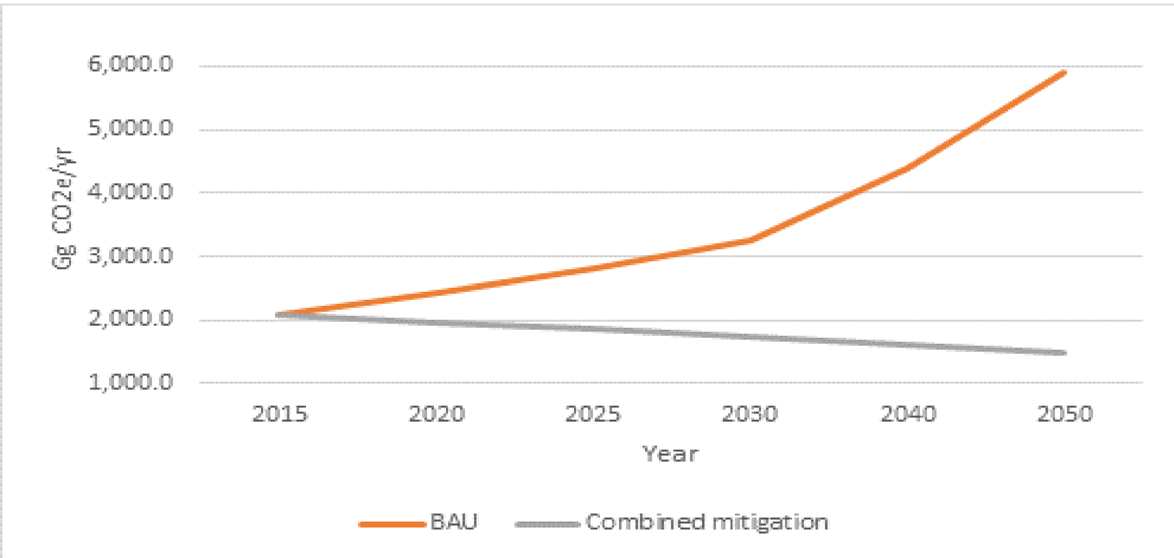

Figure 3.7: Aggregated impact of the mitigations

3.5. Tracking NDC

The IPCC inventory software has traditionally been used with the 2006 IPCC Guidelines to estimate greenhouse gas emissions for all the sectors. The IPCC inventory software provides for emissions determination from all the waste sector categories. For the waste sector the guidelines are provided for in Volume 5-Waste (Chapters 1-6) including annex 1-worksheets. The worksheets are designed for each waste subcategory emissions determinations. So, they are usually used with the inventory software. In using IPCC model, the disaggregated data inputs are manipulated to generate aggregated outputs that can be displayed as tables or graphs. The IPCC model is versatile and can analyse the waste sector alone in isolation from the other GHG emission sectors with good outputs. The worksheets together with the inventory software form a robust working system for the waste sector GHG emissions determinations/estimates that is useful for tracking progress in implementing and achieving the Nationally Determined Contributions (NDC). The following: IPCC inventory software, the *IPCC_waste_model.xls.Excel (for SWDS only), 4_Waste_blanks.xls.Excel -for the rest of waste categories* are available from the IPCC website for free.

The ICAT project introduced the GACMO model that is used for GHG emissions. GACMO can be used for tracking the progress in implementing and achieving the Nationally Determined Contributions (NDC)[41]. The GAMCO tool can be used at both national level (country level) but can also be adapted to be used at the sub-national level (region or city). It is a tool used to estimate aggregated GHG emissions and develop the corresponding baseline scenario, as well as one (or more) mitigation scenarios based on specific mitigation options. For the GACMO tool however, it was not possible to do a comprehensive assessment of the waste sector GHG emissions in isolation from the energy sector which is the main focus of this model. However, GACMO can be used for BAU and WEM trajectories together with the IPCC worksheets.

3.6. Recommendations

Improving capacity for greenhouse gas (GHG) emission inventory, projections, and mitigation analysis modelling for the waste sector can significantly contribute to the enhancement of tracking and reporting of Nationally Determined Contributions (NDCs). The recommendations provided in this document are guided by international obligations such as for UNFCCC – non-Annex 1 countries and Paris agreement reporting requirements, and national obligations as per the provisions in the National Environment Act No.5 of 2019, the Climate Change Act 2021, the National Environment (Waste Management) Regulations,

[41] *Initiative for Climate Action Transparency - ICAT - Guidance to the Greenhouse Gas Abatement Cost Model (GACMO). 2023.*

2020, and the Petroleum (waste Management) Regulations, 2019 among others. The national laws explicitly show the roles and responsibilities of stakeholders in the waste sector. The key stakeholders include the Ministry of Water and Environment with relevant department such as CCD, the National Environment Management Authority (NEMA), Urban Councils, District Councils, and other Lead Agencies- Public and Private sector.

A publication exists on a study prepared for to support the preparation of GHG inventories in the waste sector through good practice examples which can be adopted in other countries[42].

Persons involved in the compilation of GHG inventories and data management for the waste sector should use the Good Practice in GHG Inventories for the waste sector and the IPCC Guidelines Chapters for the waste sector to implement good practice. Below are recommendations to achieve sustainably in data collection, analysis and management including dissemination of relevant information guided by national laws.

3.6.1. Strengthen Data Collection and Management Systems

1. **Improve data collection.**
   i. It is good practice to continue conducting key source analysis to identify those source categories which contribute most to the absolute emissions in the waste sector. This will allow focusing of resources for inventories on key source categories
   ii. Use of the data collection template: For consistency, the data collection templates prepared by the ICAT project should be used by all persons involved in the compilation of GHG inventories and data management for the waste sector
   iii. To improve data collection, enhance data collection systems to capture accurate and comprehensive information by forming a team for data collection, and storage including QA and QC.
   iv. Incorporate new data sources such as satellite imagery, sensor, GPS among others to improve accuracy and emissions estimates.
2. **Improve data and management**
   i. Develop a centralized waste sector database: A national database centre and system to aggregate, manage, and update data on waste generation, composition, treatment, and disposal should be established.

[42] Partnership on transparency in the Paris agreement. Good Practices in GHG Inventories for the Waste Sector. GIZ 2022

ii. Task waste sector stakeholders to collect and submit data to the national database centre quarterly.
iii. The national database centre should use nationally selected models to analyse and prepare BAU and Mitigation projections including emerging policy impacts.

3. **Adopt standardized methodologies**:
    iv. Use internationally recognized protocols such as the IPCC Guidelines for National Greenhouse Gas Inventories to ensure consistency.
    v. When a national database and system are established upgrade the waste data analysis methodology from Tier 1 to Tier 2.
    vi. Use national selected models to analyse waste data and develop scenario-based projections
    vii. Evaluate policy and technology options.

4. **Enhance Capacity**:
    i. Develop capacity of persons involved in the compilation of GHG inventories and data management: waste data collection [generation, composition, management practices and to estimate emissions and project future scenarios]
    ii. Train Urban, District and Lead Agencies on the use of the data collection Templates, data analysis, data storage, use of models for analysis, and estimate of GHG emissions and future scenarios projections. Engage these agencies to develop a national waste GHG model and to be able to use digital tools to monitor waste management activities in real time.
    iii. Engage other stakeholders: Train private sector players, and community groups to provide accurate and reliable data.

5. **Enhance Technical Modelling and Analytical Capacity**
    i. Invest in advanced modelling tools: to complement IPCC acquire software such as GACMO, Waste Reduction Model (WARM) or LEAP (Long-range Energy Alternatives Planning) for more precise projections and scenario analysis.
    ii. Build local expertise through capacity-building programs for government agencies, researchers, and waste managers on GHG inventory and projection techniques.

   iii. Regularly review and update inventory approaches to align with new IPCC guidelines and emerging technologies.

6. **Strengthen Monitoring, Reporting, and Verification (MRV) Frameworks**
   i. Develop a robust MRV system: the MWE through its relevant departments should promote activities that enhance the designated institutional responsibilities and workflows for tracking mitigation actions.
   ii. Incorporate transparency tools in data collection, analysis, management and dissemination guided by national laws: Use available national and international platforms for accountability in waste sector GHG emission reporting by ensuring that data is accurate, complete and accessible, to enhance public and international confidence in waste sector GHG emission data.
   iii. Conduct regular third-party audits: Validate inventory data and ensure compliance with NDC targets.
7. **Mobilize Resources and Establish Partnerships**
   i. Seek funding through mechanisms such as the Green Climate Fund (GCF) or Global Environment Facility (GEF) to support inventory and mitigation activities.
   ii. Establish collaborate/partnerships with academia and NGOs to address data completeness issues including technical and data gaps.
   iii. Work with the private operators in initiatives that improved waste collection and treatment for emission reduction
8. **Incorporate Future-Proof Measures**
   i. Encourage policy innovation that advocate for regulations that promotes and rewards waste valorisation and low-emission practices and technologies in the waste sector.
   ii. Design and implement climate proofing measures for the waste sector.

These recommendations will not only improve GHG tracking and NDC reporting but also promote sustainable waste management, reducing overall sectoral emissions and promoting environmental and socio-economic co-benefits.

4. References

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