Availability of Data for Greenhouse Gas Emission Calculation in Kenya's Transport Sector

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TraCS project is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and funded by the International Climate Initiative of the German Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The project supports the State Department of Transport in Kenya in systematically assessing greenhouse gas emissions from the transport sector, analysing emission reduction potentials and in optimising the sector's contribution to the mitigation target in the NDC.

This report, '**Availability of Data for Greenhouse Gas Emission Calculation in Kenya's Transport Sector'** is produced in view of the sector efforts to meet the annual reporting requirements of their sectoral greenhouse gas emissions and their climate change actions. This stock take is an essential first step towards development of the inventory.

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List of abbreviations and acronyms

AFOLU	Agriculture Forestry and other Land use
EEA	European Environmental Agency
EMAP	Environmental Monitoring and Assessment Programme
EMEP	European Monitoring and Evaluation Programme
EPA	Environmental Protection Agency
ERC	Energy Regulatory Commission
EU	European Union
GESIP	Green Economy Strategy and Implementation Plan
GHG	Greenhouse Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPS	Global Positioning System
HBEFA	Handbook of Emission Factors for Road Transport
HFO	Heavy Fuel Oil
ICAO	International Civil Aviation Organisation
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency

KAA	Kenya Airports Authority
KARA	Kenya Alliance of Residence Associations
KCAA	Kenya Civil Aviation Authority
KEBS	Kenya Bureau of Standards
KMA	Kenya Maritime Authority
KNBS	Kenya National Bureau of Statistics
KPA	Kenya Ports Authority
KRA	Kenya Revenue Authority
KURA	Kenya Urban Roads Authority
LTO	Landing and Take Off
MENR	Ministry of Environment and Natural Resources
MGR	Metre Gauge Railway
NCCAP	National Climate Change Action Plan
NCV	Net Calorific Value
NDC	Nationally Determined Contribution
NEMA	National Environmental Management Authority
NMT	Non-Motorised Transport
NTSA	National Transport and Safety Authority
SGR	Standard Gauge Railway
TEU	Twenty-foot Equivalent Unit
TJ	Terra Joules
UN	United Nations
UNEP	United Nations Environmental Program
UNFCCC	United Framework Convention on Climate Change
VKT	Vehicle Kilometres Travelled

1 Data Sources, policy and legal framework in Kenya's transport sector

Data from unofficial sources is varied and scattered. These include numerous reports developed by development partner agencies (including GIZ and JICA), as well as research papers from Universities (including University of Nairobi and Technical University of Kenya). Unofficial data however tend to be localized to a town/city or region within the country, with very few done on a national scale.

Transport activity is expected to grow robustly over the next several decades[1]. Transport activity is rapidly growing across the world particularly the fast-growing economies. The movement of passengers and freight is an essential element of social and economic activity, which increases along with economic growth. Thus, transport infrastructure that does not deliver the right kind of transport at the right place and time at affordable prices will hamper economic development and cause damage to the population's health, safety and the environment (Bongardt et al. 2016). In Kenya, major construction projects in the past decade have seen the robust growth of the country's road network including rehabilitation of the Nairobi-Kisumu-Eldoret network, and completion of by-passes and missing link roads in major cities. Today the classified road network stands at 63,575 km.[2] In the past five years, the Government completed the Standard Gauge Railway between Nairobi and Mombasa opening up significant movement of passenger and freight travel from road to rail. Current works are on-going to extend the line from Nairobi to Naivasha and Kisumu.

As Kenya strives to become an industrialized middle-income country by the year 2030, infrastructure projects are considered important in reaching this target. In Kenya, road transport accounts for 99% of the GHG emission from the transport sector according to the National Climate Change Action Plan (NCCAP 2013-2017). Given the importance of the transport sector in Kenya's socio-economic development, it is important to implement measures that enhance sustainable development within the sector. Additionally, the Kenya Government is party to the UN Framework Convention on Climate Change (UNFCCC) and is also party to the Paris Agreement where all members agreed to make effort to keep global warming below two degrees Celsius. This report focusses on the analysis of the currently available data and data gaps for the calculation of the total fuel consumption and emissions of the transport sector and its sub-sectors.

1.1 Data Sources

In the context of greenhouse gas (GHG) inventories, two data sources are typically available:

1. Official data sources available from relevant government agencies.
2. Unofficial sources made available from non-government actors including academia, the private sector and international agencies.

In Kenya the primary sources for official statistical data is the Kenya National Bureau of Statistics (KNBS). Key data relevant to the transport sector is compiled in the annual KNBS Economic Survey. These include fuel consumption (top-down), vehicle registration, rail passenger and freight transport, among others. Official data can also be sourced on request from the National Transport

[1]Source: OECD/ITF (2017), ITF Transport Outlook 2017, OECD Publishing, Paris
[2]Source: Kenya National Highways Authority

Safety Authority (NTSA), whose data on vehicle registration is more detailed. This data, however, is generally not publicly available.

1.2 Legal and Policy Frameworks

The legal and policy framework covering the transport sector is spread across a wide array of government agencies. These primarily include relevant government ministries (including the Ministry of Transport and Infrastructure; Ministry of Environment and Mineral Resources; Ministry of Road and Public Works) and state agencies (including the National Transport Safety Authority, National Environmental Management Agency, Energy Regulatory Commission, Kenya Bureau of Standards). The key legal and policy documents and the areas they address in transport are summarized in Table 1.1.

Table 1.1 Summary of Policies related to Transport in Kenya

A=Act of Parliament B=Bill P=Policy R= Regulation S=Standard T=Document Type

Institution	Title of Document	T	What Policy is addressing in relation to Transport
Ministry of Transport	Integrated National Transport Policy 2009	P	Transport sector is a key pillar and a critical enabler for achieving vision 2030. The policy paper identifies key challenges inhibiting transport sector from its facilitative role in respect to national and regional economies. These include adherence to environmental requirements, and environmental degradation from transport. The policy proposes strategies to deal with the problems experienced in the PSVs. It also encourages non- transport interventions to mitigate the adverse environmental effects of transport and also recommends regular inspection of motor vehicles to ensure control of noxious gaseous emissions.
Kenya Shippers Council	Policy position on transport and logistics chain in Kenya	P	This policy document addresses key concerns among shippers and demands for a number of actions that the Government, service providers and regulatory institutions should undertake to improve transport and logistics infrastructure
UN Environment in collaboration with Nairobi County	Nairobi City County Non- Motorized Transport Policy 2015	P	The objective of this policy is to provide a harmonized framework for, prioritization and coordination of non-motorized transport infrastructure, facility development and maintenance in Nairobi. The policy strives to facilitate a mobility environment where all transport modes are of equal importance particularly in the efforts to include NMT within the integrated transport system. The policy was developed in partnership with UN Environment and Kenya Alliance of Residence Associations (KARA).
Ministry of Roads and Public Works (at the time)	The Development & Management of the roads sub-sector for sustainable economic growth. Sessional paper of May 2006	P	This policy aims to attain an efficient road sector that supports and promotes economic growth through cost effective provision & maintenance of infrastructure & reliable transport with key objectives being: - To reduce travel costs and travel time, increase accessibility, optimize use of available resources, increase resources for investment in the road sector, enhance road safety and achieve optimal institutional framework for effective implementation
National Environment and Management Authority (NEMA)	Fossil Fuel Emission Control Regulations 2006	R	These Regulations set out emission standards for internal combustion engines, provide for the licensing of persons who treat fuel and for the appointment of environmental inspectors for purposes of emission inspection and authorizes the National Environment Management Authority to enter into partnerships for purposes of emission inspection.
Ministry of Transport	Kenya Roads Bill 2015	B	The bill provides for the classification, management, construction & department responsible for matters relating to transport

Institution	Title of Document	T	What Policy is addressing in relation to Transport
Ministry of Transport	The Kenya Roads Act, 2007	A	The enactment of this Act, established among others, three autonomous road authorities namely the Kenya National Highways Authority, Kenya Rural Roads Authority, and Kenya Urban Roads Authority (KURA). The authorities are responsible for the management, development, rehabilitation and maintenance of roads under their control.
Ministry of Transport	Traffic Amendment Act 2017	A	The Act is an amendment of the Traffic (cap 403) which outlines road safety measures near schools and also promote child safety in motor vehicles around learning institutions or when using school transport
National Transport Safety Authority (NTSA)	National Transport Authority Licensing Act	A	The Act No. 33 of 2012, which was revised in 2014 provides for the establishment of the National Transport and Safety Authority; its powers and functions of the authority
NTSA	Traffic Act Chapter 403, Revised 2012 (2010)	A	The Act consolidates the law relating to traffic on the roads. It further stipulates requirement and procedures to be followed during registration and in licensing of vehicles. It also provides for the inspection of commercial vehicles.
NTSA	NTSA operation of Motorcycles	R	Regulations 2014. The regulations outline guidelines on the use and the responsibilities of those operating motorcycles and their areas of operations (Draft)
NTSA	NTSA operations of commercial service vehicles	R	Regulations 2017. The regulations outline guidelines on the use and the responsibilities of those operating commercial vehicles and their areas of operations (Draft)
NTSA	NTSA operations of Public service vehicles	R	Regulations 2013. Gives guidelines on the criteria of the drivers, the use and operations of Public service vehicles, the responsibilities of the vehicle owners (Draft)
NTSA	NTSA operations of Tourist vehicles	R	Regulations 2014. The regulations outline guidelines on the use and the responsibilities of those operating tourist service vehicles (Draft)
Energy Regulatory Commission	Waste Management Regulations, 2006	R	The Regulations are meant to streamline handling of, transportation and disposal of various types of wastes. The aim being to protect human health and the environment
NEMA	Environmental Management& Coordination Act; Air Quality Regulations, 2014	A/R	The Regulations provide for the prevention, control and abatement of air pollution to ensure clean and healthy ambient air. It also provides for the establishment of emission standards for various sources such as mobile sources (e.g. motor vehicles) and stationary sources (e.g. industries) as outlined in the Environmental Management and Coordination Act, 1999.
Kenya Bureau of Standards	Standards Act, Cap 496	A	The Act strives to promote the standardization of the specification of commodities, and provides for the standardization of commodities and codes of practice, Code of practice for inspection of road vehicles, Motor gasoline specification, diesel fuels specification and engine oils.

Institution	Title of Document	T	What Policy is addressing in relation to Transport
Ministry of Transport	Transport Licensing Act, Revised 2014 (2012)]	A	Provides for the establishment of the NTSA
Energy Regulatory Commission	Energy Act No.12 of 2006	A	This part addresses the regulations on licensing, importation, refining, exportation, wholesale, retail, storage or transportation of petroleum, or sale of adulterated petroleum, inspection of petroleum with prescribed apparatus as well as policy initiatives in the Energy Sector that are critical to the realization of reduced vehicular emissions.
KEBS	KS 1515:2000 – Code of practice for inspection of road Vehicles	S	The Standards were formulated to regulate the quality and condition of road vehicles for safety, environmental and economic reasons whereby clause 1.2.2 applies to inspection of motor vehicles as per the Traffic Act; clause 2, addresses inspection of all road vehicles immediately before importation; and clause 2.5, addresses the age Limit of all motor vehicles allowed for importation and the difference between the date of registration and the date of manufacture.
Ministry of Devolution and Planning	Vision 2030	P	The Kenya's national planning strategy is based on 3 pillars; economic, social and political to ensure that Kenya is transformed into an industrialized middle-income country by 2030. It is implemented in 5-year mid-term plans. The pillars are anchored in various foundations including infrastructure where it is aimed that by the year 2030 the country will have firmly been connected through a network of roads, railways, ports, airports.
Ministry of Transport and Infrastructure	Sector Plan for infrastructure 2013 - 2017	P	The plan is part of the government's commitment towards ensuring the country's stock of infrastructure facilitates anchors sustainable growth and development. The plan covers transport, roads, energy buildings and other public works sub-sectors
Ministry of Environment and Natural Resources (MENR) (At the time)	Kenya's Nationally Determined Contributions	P	The transport sector's contribution to GHG emissions is recognized by the Kenya's INDC. In this regard it is one of the sectors covered by the contribution, others being energy, industrial processes, agriculture, forestry and other land use (AFOLU) and the waste sector.
MENR	National Climate Change Action plan 2013 - 2017	P	The plan addresses the options for low carbon climate resilient development pathway as Kenya adapts to climate change impacts and mitigates growing emissions
MENR	The Green Economy Strategy and Implementation plan (2016-2030)	P	One of the objectives of the GESIP thematic area 1 on promoting sustainable infrastructure is to enhance sustainable mobility through reduction of vehicular emissions through legal and fiscal measures
Kenya Civil Aviation Authority	Kenya's Action Plan for the reduction of co_2 gas emissions in aviation sector	P	The plan focuses on domestic and international civil aviation and is being supported by ICAO- EU assistance project on capacity building for co2 mitigation from international aviation.

2 Data inventory and gaps by sub-sector

This chapter looks at the availability of data for both top-down and bottom-up approaches in the different transport sub sectors

2.1 Road sub-sector

The road transport sector initially selected a top-down approach for emission calculation based on official available data. A bottom-up approach would require calculation of total fuel consumption by multiplying the total number of in-service vehicles, the vehicle kilometres travelled (VKT) per year, and the average specific fuel consumption per vehicle type, all of which are not currently available through official data.

Additional work using unofficial data sources was needed to carry out a bottom-up approach.

2.1.1 Boundaries

The Boundary for the study was national. The emission calculation for the road transport sub-sector included all types of vehicles, such as passenger cars, light trucks, heavy trucks, buses and on-road motorcycles and three wheelers. There are two primary fuel types: petrol and diesel. The analysis does not include mobile machinery used for agricultural activity.

2.1.2 Top-down approach: Availability of fuel consumption data

Tier 1 approaches make use of available national and international statistics, combined with default emission factors. A top-down GHG inventory from historical data covering the period 2006 to 2017 using Tier 1 approaches was carried out.[3]

Vehicles covered under *road transport* include personal cars, public passenger transport (buses, *matatus, tuk-tuks*), public freight transport and motorcycles. Based on the *2006 IPCC Guidelines for Conducting Emission Inventories*, emissions from mobile sources can be estimated from the Equation (1):

$$\text{Emissions}_{GHG,a,b} = \sum_{GHG,a,b} \text{Fuel Consumption}_{a,b} \times \text{Emission Factor}_{GHG,a,b} \quad (1)$$

where

$\text{Emissions}_{GHG,a,b}$	is emissions of a given GHG by fuel type (kg GHG)
$\text{Fuel Consumption}_{a,b}$	is fuel sold (TJ)
$\text{Emission Factor}_{GHG,a,b}$	is default emission factor of a given GHG by type of fuel (kg gas/TJ)
a	is type of fuel (e.g. gasoline, diesel, etc)
b	is type of vehicle or mode of transportation (on-road, marine, aviation)

The data for on-road fuel consumption is available from the annual economic surveys produced by the Kenya National Bureau of Statistics. For this report, the period 2006-2017 was considered using the Kenya Economic Surveys 2011, 2012, 2013, 2014, 2015, 2016 and 2017.[4] The significant overlap in data between the volumes enabled detection and correction of any typographical errors that may have occurred in any volume and accounting for revisions. It is important to note that these figures provide a reasonable estimate. Variations occur from the actual consumption in the road sector as petroleum products may be purchased at road-side petrol stations for non-transport uses including powering electric generators, water-pumps, lawn mowers, etc. This may

[3]Potential for public programmes in Kenya to encourage private sector entities to reduce emissions from mobile and stationary sources, *University of Nairobi Technical Report MME-2016-001* (UNEP Sponsored study)

[4]Kenya National Bureau of Statistics (KNBS), *Economic Survey 2011; Economic Survey 2012; Economic Survey 2013; Economic Survey 2014; Economic Survey 2015; Economic Survey 2016; Economic Survey 2017; Economic Survey 2018*

also lead to overestimating the fuel consumption of the transport sector based on top-down data, in particular in the case of diesel. The diesel estimates are calculated by subtracting total petrol demand from retail pump outlet sales. The consumption provided in tonnes was converted to cubic meters as presented in Table 2.1.

Table 2.1 Petrol and diesel consumption in Kenya from road transport between 2006 and 2017

	2006	2007	2008	2009	2010	2011
Diesel Consumption (tonnes)	1,184,200	1,203,300	1,228,000	1,592,800	1,765,300	1,597,400
Diesel Cons. (Converted) m^3	1,273,788	1,373,295	1,403,553	1,741,803	1,866,279	1,810,314
Petrol Consumption (tonnes)	358,200	367,100	381,300	461,700	597,200	562,100
Petrol Consumption (m^3)	494,316	506,598	526,194	637,146	824,136	775,698
Overall Consumption (m^3)	1,950,882	1,986,657	2,036,634	2,596,290	2,995,455	2,740,500
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
Diesel Consumption (tonnes)	1,616,200	1,799,200	1,887,200	2,307,700	2,490,400	2,273,800
Diesel Cons. (Converted) m^3	1,828,149	1,969,476	2,117,322	2,559,507	2,851,509	2,566,026
Petrol Consumption (tonnes)	618,500	774,500	903,800	1,107,000	1,227,200	1,267,400
Petrol Consumption (m^3)	853,530	1,068,810	1,247,244	1,527,600	1,693,536	1,749,012
Overall Consumption (m^3)	2,841,456	3,281,826	3,568,500	4,366,131	4,756,728	4,545,786

Source: Calculated from Data Compiled from Kenya National Economic Surveys 2011 through 2018

The conversion factors used for diesel and petrol was 1.23 m^3/tonne and 1.38 m^3/tonne, respectively.[5] A summary of the conversion factors used are presented in Table 2.2.

Table 2.2 Summary of conversion factors used.

Conversion From:	Conversion to:	Conversion Factor:
Diesel: Tonnes	Cubic metres	1.23
Petrol: Tonnes	Cubic metres	1.38
Diesel: Cubic metres	Tera Joules	38.68 x 10-3
Diesel: Cubic metres	Tera Joules	34.66 x 10-3

The default *emission factors* from the 2006 IPCC guidelines for Tier 1 GHG CO_2e estimation are 74,100 kg gas/TJ and 69,300 kg gas/TJ for diesel and petrol, respectively. In addition, the conversion factors from m^3 to Tera Joules (TJ) for diesel and petrol used were 38.68 x 10^{-3} TJ/m^3 and 34.66 x 10^{-3} TJ/m^3, respectively.[6] Energy content for diesel and petrol consumed over the period is presented in Table 2.3.

[5] *International Recommendations for Energy Statistics* (IRES), 2011
[6] ibid

Table 2.3 Energy Content for the Petrol and Diesel Consumed in Kenya for road transport between 2006 and 2017

	2006	2007	2008	2009	2010	2011
Diesel Consumption (TJ)	56,340	57,249	58,424	75,780	83,987	75,999
Petrol Consumption (TJ)	17,133	17,559	18,238	22,083	28,565	26,886
	2013	**2013**	**2014**	**2015**	**2016**	**2017**
Diesel Consumption (TJ)	76,893	85,599	89,786	109,792	118,484	108,179
Petrol Consumption (TJ)	29,583	37,045	43,229	52,949	58,698	60,621

Using the data from Table 2.3, the estimated emissions from road transport for the period 2006 to 2017 were calculated using Equation (1) and are presented in Megatonnes (Mt) CO_2e in Table 2.4. As can be seen from the tables, the emission of CO_2e from diesel is significantly more than that from petrol due to both higher diesel fuel consumption as well as higher energy content per litre of diesel (38.68×10^{-6} TJ/m^3) than petrol (34.66×10^{-6} TJ/m^3), coupled with more emissions per TJ from diesel (74,100 kg gas/TJ) than from petrol (69,300 kg gas/TJ). In 2017, emissions from road transport is estimated to have been 11.82 Mt CO_2e, experiencing a slight decline from 2016 where it is estimated to have been 12.5 Mt CO_2e.

Table 2.4 CO_2e Emission in Megatonnes from Petrol and Diesel Consumed in Kenya for road transport between 2006 and 2017

	2006	2007	2008	2009	2010	2011
From Diesel (Mt)	4.175	4.242	4.329	5.615	6.223	5.631
From Petrol (Mt)	1.187	1.217	1.264	1.530	1.980	1.863
Overall (Mt)	5.36	5.46	5.59	7.15	8.20	7.49
	2013	**2013**	**2014**	**2015**	**2016**	**2017**
From Diesel (Mt)	5.698	6.343	6.653	8.136	8.780	8.016
From Petrol (Mt)	2.050	2.567	2.996	3.669	4.068	4.201
Overall (Mt)	7.75	8.91	9.65	11.80	12.85	12.22

2.1.2.1 Conclusions and Recommendations top-down approach

The road sector has several uncertainties with regard to variables required to conduct an accurate top-down approach. These include:

(a) Variations in official data provided for fuel consumption as reported in the KNBS Economic Surveys, as compared to non-official sources such as the Petroleum Institute

(b) Global average energy content for fuel is used as local data is not available

(c) Uncertainties in consumption arising from fuel assumed to be used for road transport actually used for household generators, water pumps, etc.

2.1.3 Bottom-up approach: Availability of vehicle and travel activity data

Higher tier approach that makes use of disaggregated transport activity data.

2.1.3.1 Data Requirements

The bottom-up approach for the road sector requires the following information (preferably on the level of vehicle type):

- In-use vehicle population disaggregated by vehicle type, vehicle size classes, fuel type, technology (Euro-Standard)
- Annual average vehicle kilometres travelled (VKT) per vehicle type and size class
- Specific fuel consumption per vehicle size classes, fuel type, technology (Euro-Standard)
- GHG emission factors

2.1.3.2 Data availability

The total **number of newly registered vehicles** per vehicle type (passenger cars, light duty trucks, heavy duty trucks and buses) is reported annually by the Kenya National Bureau of Statistics. More detailed data on vehicle population of passenger cars, light duty trucks, heavy-duty trucks and buses, such as the fuel type is available from the Kenya National Transport Safety Authority (NTSA) data base.

In Kenya, there is uncertainty on how many of the registered vehicles are in use. Vehicles are registered once, and there is no system of de-registration. Public service vehicles, light duty trucks and heavy-duty trucks, and buses, however, are required to go through an annual inspection, providing good estimate of their in-use numbers.

In addition, there is no official data available on vehicle kilometre travelled (VKT). There are no reliable and categorized data from the academic literature or other academic sources. A key challenge in determining annual VKT is that the majority of vehicles are imported as used vehicles. Averaging the total kilometres travelled by the age based on year of manufacture or year of first registration would thus combine driving habits pre- and post-import into Kenya. In addition, reporting on kilometres travelled is not required. Further, there have been no country specific values on GHG emission factors for road transport available primarily due to data on vehicle activity not being available. This includes share of average VKT by road type, average speed class or traffic condition (free flow, congestion, etc.), and road gradient. This has since been done through a parallel study, and whose results are presented in *Characteristics of the in-service vehicle fleet in Kenya* Report, 2018.

2.1.3.3 Further data sources for validation

For validation purposes, the following data is of relevance:

(a) Total transport performance per vehicle category/type and year (passenger car, truck, bus, motorcycle) (Passenger- and tonnes-kilometre)

(b) Average load (occupancy rate, average capacity) to calculate total transport performance bottom-up from vehicle population and VKT

(c) Modal Split (passenger car, truck, bus, motorcycle)

Refer to table 2.5 for an elaborated analysis of status of availability of each of the above data sets.

2.1.3.4 Conclusions and recommendations bottom-up approach

The road sector has several uncertainties with regard to variables required to conduct an accurate bottom-up approach. There are no requirements for official reporting of bottom-up data for the national GHG inventory. However, in order to inform policy making and evaluate different policies regarding their potential to reduce transport demand, fuel consumption and emissions bottom-up data are required. Uncertainties of bottom-up data include:

(a) There is no official information of in-use vehicles on the roads for all categories of vehicles, as this information is not collected. An estimate can be made on buses, light and heavy-duty trucks, as they are all expected to undergo an annual mechanical inspection. There is no similar regime at present for private passenger vehicles, motorcycles and three wheeled vehicles (*tuk-tuks*); here general assumptions on the average vehicle lifetime per mode are necessary to defer the current fleet. This situation will, however, be improved in the near term as the National Transport Safety Authority moves towards comprehensive inspection of all motor vehicles. Motorcycles, however, will still be excluded.

(b) There is no available data on vehicle kilometres travelled, save for a few dated publications focussed on Nairobi. This information can be improved through a combination of activities including taking the odometer readings from public service vehicles as they go for mechanical inspection (later extending to passenger vehicles when they are brought into the inspection regime), and periodic (may be annual) national surveys.

(c) There is limited information on average traffic speeds and flow conditions. The few studies available are only for the Nairobi Metropolitan Area, for example one conducted by Japanese International Cooperation Agency.

(d) No real-world average fuel consumption of road vehicles has been done in Kenya. As a result, one is restricted to the use of international default values.

(e) Finally. at the time of writing, Kenya, like most African countries, has no official specific emission factors for the road and other sectors. As a result, generic default values have been used from international sources, specifically, IPCC Tier 1 values. In the short-term term, other international sources such as the HBEFA (Handbook Emission Factors for Road Transport)[7] can be adapted to the Kenyan traffic situation. This has since been done. The results are available in the GIZ changing transport website through this link.

[7] HBEFA is a joint effort of different European countries that provides emission factors for all current vehicle categories for a wide variety of traffic situations. Emission factors are weighted average values for the countries Germany, Austria, Switzerland, France, Norway and Sweden.

Table 2.5 Summary on Road Sub-Sector

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
For a top-down calculation					
Total fuel consumption (diesel, motor gasoline) of road vehicles	▪ Information available of petroleum fuel consumed for the road sub-sector ▪ There is some uncertainty due to potential use of fuel for non-road transport uses including electricity generators, and water pumps	N/A	**Medium**	**Low**	▪ Supplement information through National Surveys conducted by NTSA
Net Energy Content/ Calorific Value for diesel and gasoline	▪ No country-specific values available ▪ Values used should match country fuel inventory	▪ Default values from IPCC guidelines 2006	**Low**	**Low**	▪ Country specific values can be obtained through periodic testing coordinated/conducted by the Energy Regulatory Commission (ERC)
GHG emission factors for diesel and gasoline (Tier 1)	▪ No country-specific values available ▪ Current work facilitated by the Ministry of Transport has developed an initial set ▪ GHG emission factors should match data used in official inventory	▪ Default values from IPCC guidelines 2006	**Low** **Medium**	**Low** **Medium**	▪ Country specific values should be refined further and facilitated by the Ministry of Transport
Data required for a bottom-up calculation					
Annual In-service vehicle population disaggregated by vehicle type, vehicle size classes, fuel type, technology	▪ There is currently no data on total number of vehicles in operation per vehicle type (passenger cars, light duty trucks, heavy duty trucks and buses) ▪ There is no information of number	▪ Most government reports currently use new registration data, with expert estimates of those	**High**	**High**	▪ Estimates can be made through national vehicle survey to establish survival curves for each vehicle category ▪ Curves cross referenced against registration data to provide in-

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
(Euro-Standard)	of in-use Motorcycles (2- and 3-Wheelers). ▪ Motor vehicles and motorcycles are registered only once with no system for de-registration. ▪ Current work facilitated by Ministry of transport has provided initial estimates	still in service			service population estimate.
Annual average driven mileage per vehicle type and size class (km/vehicle/year)	▪ There is no official data available on the annual mileage of road vehicles yet. ▪ Current work facilitated by Ministry of transport has provided initial estimates	▪ Minimal literature sources available, very dated and confined to Nairobi	**High**	**High**	▪ All public sector vehicles under go annual mechanical inspection. Part of that should include recording of odometer reading ▪ Annual national survey of all motor vehicles to obtain odometer readings as well as information form owners on fuel consumption and vehicle use. This would capture motor vehicles and motorcycles (2- and 3-wheelers)
Specific fuel consumption per vehicle size classes, fuel type, technology (Euro-Standard) (l/100km)	▪ No availability of real-world fuel consumption for all vehicle types for Kenya ▪ Current work facilitated by Ministry of transport has provided initial estimates	▪ Default values can be taken for all vehicle types and sizes from EMAP/EEA 2016	**Medium to high**	**Medium to high**	▪ Average fuel consumption could be also collected based on surveys; as real-world fuel consumption testing are very costly
GHG emission factors	▪ There are no country specific values on GHG emission factors available. ▪ Availability of information on traffic situations, such as the distinction between urban/rural; road types: e.g. motorway, trunk road; speed limits and levels of services (e.g. free flow,	▪ Use of international Tier 1 default values of IPCC Guidelines 2006	**Medium**	**Medium**	▪ Collection of country specific parameters required for development of emission factors for Kenya. This includes traffic situations, ▪ To upgrade to country specific emission factors based on collected Kenyan traffic parameters.

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
	heavy traffic, saturated, stop & go) enabling more than Tier 1 emission factors to be used				
Data required for validation					
Total Kilometres travelled	▪ There are preliminary estimates on total kilometres travelled. ▪ Most vehicles on the roads were imported as used vehicles. Odometer reading, therefore does not provide the actual kilometres travelled in Kenya. Data is not collected on odometer readings as part of registration process by NTSA	▪ There is no default data available for use as a substitute	**High**	**High**	▪ NTSA is planning to include odometer readings as part of registration process and odometer readings during current public service vehicle inspections, and as part of planned private vehicle inspections. This will provide annual total kilometres travelled for all vehicles
Total transport performance (Passenger- and tonnes-kilometer)	▪ Transport performance is currently evaluated based on economic outputs ▪ There is no official data available on this level of detail for road transport performance. The same however exists for rail transport.	N/A	**N/A**	**Low**	▪ Data collection for other parameters mentioned above may take precedence over putting in systems in the near future to collect performance data
Input load (occupancy rate, average load)	▪ There is not data available	N/A	**N/A**	**Low**	▪ In case of conducting surveys (e.g. on mileage), indicators for measurement of load/ occupancy should be included to improve assumptions
Modal Split (passenger car, truck, bus, motorcycle)	▪ There is data available on mode split by numbers from 2014 Kenya Roads Board Traffic Survey. This was a one-off project	▪ The data provides a snapshot nationwide	**High**	**Medium**	▪ Carrying out of the surveys should be institutionalised and carried out at regular intervals

2.2 Railway sub-sector

The rail sub-sector has applied a top-down approach for emission calculation based on official available data.

2.2.1 Background

Rail transport is generally operated by Kenya Railways, which is a state corporation. The total length of the rail network in the country is 2778 km of Metre Gauge Rail (MGR) network, consisting of 1083 km mainline, 346 km principle lines, 490 km minor/branch lines and 859 km private lines and sidings.

Nairobi Commuter Services operate the following:

Table 2.6 Nairobi Commuter Services operations

Route	Distance (km)	No. of services per day
Nairobi-Ruiru	31	2
Nairobi-Kahawa	24	2
Nairobi-Embakasi Village	15	3
Nairobi-Kikuyu	31	2
Nairobi-Syokimau	19	4
Nairobi-Nairobi Terminal	16	4

Other railway operations are:

- Tata Chemicals-Magadi, (Konza-Magadi) 130km in length
- Standard Gauge Railways, (Nairobi-Mombasa) 471 km in length. In the first one year, the service carried about 1.3 million passengers (with two return trips per day) and over 600,000 tonnes of cargo.

2.2.2 Boundaries

From the IPCC 2006 guidelines, emissions from the railway sector include emissions from railway transport for both freight and passenger traffic routes. This includes diesel-propelled locomotives for freight and passenger traffic, as well as the movements of locomotives for rolling stock management. Kenya does not have electricity powered railway systems.

2.2.3 Top-down approach: Availability of fuel consumption data

Top down approaches make use of available national and international statistics, combined with default emission factors. A top-down GHG inventory from historical data covering the period 2006 to 2017 using Tier 1 approaches was carried out.

2.2.3.1 Data Requirements

For the top-down calculation the following data is required:

- Total fuel consumption (diesel)
- Lower heating values/ net calorific value (NCV) (diesel)
- Emission factor (diesel)

2.2.3.2 Data Availability

The locomotive fuel data is reported for each locomotive by Kenya Railways on a monthly basis. The locomotives are numbered for identification and their fuel use documented accordingly. The available records are extensive but accessible only for the 60-year-old meter gauge railway. In addition, the available fuel data for locomotives on the standard gauge railways is limited since it has operated for less than one year. While that of Tata-Chemicals is documented by the private company who owns it. All this information is compiled on an annual basis by the Kenya National Bureau of Statistics and released through the annual economic surveys.

There are no country-specific values for emission factors, and therefore default values can be taken from international sources, for example IPCC 2006. Vehicles covered under *rail transport* are on the diesel locomotives. As for road transport and based on the *2006 IPCC Guidelines for Conducting Emission Inventories*, emissions from the rail sector can be estimated from the Equation (2):

$$\text{Emissions}_{GHG,a,b} = \sum_{GHG,a,b} \text{Fuel Consumption}_{a,b} \times \text{Emission Factor}_{GHG,a,b} \quad (2)$$

where

$\text{Emissions}_{GHG,a,b}$	is emissions of a given GHG by fuel type (kg GHG)
$\text{Fuel Consumption}_{a,b}$	is fuel sold (TJ)
$\text{Emission Factor}_{GHG,a,b}$	is default emission factor of a given GHG by type of fuel (kg gas/TJ)
a	is type of fuel (diesel in this case)
b	is type of vehicle or mode of transportation

Using the default emission factors from the 2006 IPCC guidelines for Tier 1 CO_2e estimation as 74,100 kg gas/TJ, the estimated emissions from the rail sub-sector based on a top-down approach for the period 2006-2017 were calculated using Equation (2) and are presented in megatonnes (Mt) CO_2e in Table 2.7, using a conversion factor from m^3 to Tera Joules (TJ) of 38.68×10^{-3} TJ/m^3. In 2017, emissions from rail transport were estimated at 0.042 Mt CO_2e.

Table 2.7 Diesel consumption in Kenya from rail transport between 2006 and 2017

	2006	2007	2008	2009	2010	2011
Diesel Consumption (tonnes)	20,500	16,400	13,500	8,500	200	7,300
Diesel Cons. (converted) m^3	25,215	20,172	16,605	10,455	246	8,979
Emissions (Mt)	0.072	0.058	0.048	0.030	0.001	0.026
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
Diesel Consumption (tonnes)	11,600	14,200	15,600	36,900	43,000	11,800
Diesel Cons. (converted) m^3	14,268	17,466	19,188	45,387	52,890	14,514
Emissions (Mt)	0.041	0.050	0.055	0.130	0.152	0.042

Source: Calculated from data compiled from Kenya National Economic Surveys 2011 through 2018

2.2.4 Bottom-up approach: Availability of vehicle and travel activity data

Higher tier approach that makes use of disaggregated transport activity data.

2.2.4.1 Data Requirements

There are several bottom-up approaches to determine the fuel consumption in the rail sub-sector, from which emissions can be calculated. For example, the "vehicle population approach", commonly used for non-road transport emission inventories, for example in the EMEP/EEA guidebook 2016, is based on the following formula:

Domestic fuel consumption (kg) = vehicle population (-) x average operating time (h/year) x average engine power (kW) x engine load factor (-) x engine specific fuel consumption (kg/kWh)

It takes into consideration the following indicators (to be collected for each locomotive or train category):

- Vehicle population at the end of the year (by vehicle type/train category, vehicle age)
- Average operating hours (hours per train per year)
- Average train (total) engine power (kW)
- Engine Load factor (% of rated engine power used in average)
- Engine specific fuel consumption (kg fuel/kWh)

In Kenya, however, there is primarily a single operator of railways, over a limited number of routes. Actual fuel consumption per engine is already being compiled and the data is available. This may negate the need to use the above and similar approaches to estimate fuel consumption.

2.2.4.2 Data availability

The data on fuel consumption in the rail sector can be made available by Kenya Railways, and the Tata Chemicals line. They already report on an annual basis to the Kenya National Bureau of Statistics, and that information is publicly available.

2.2.4.3 Further data sources for validation

Passenger and freight performance within the rail sub-sector is available through the Kenya National Bureau of Statistics. It includes:

- Performance of passenger transport (Passenger-km)
- Performance of freight transport (Tonne-km)

Data for the period 2006-2017 is provided in Table 2.7.

2.2.5 Conclusions and recommendations

The railway sub-sector officially reports top-down data to the Kenya National Bureau of Statistics. This is done on an annual basis. There are no requirements for official reporting of bottom-up data. Between 2006 and 2010, there was large decline in the sub-sector as Kenya Railways operations virtually ground to a halt. A concession to Rift Valley Railways begun to see a re-birth of the sub-sector. The cancellation of the concession in 2017, coupled with the completion of the standard gauge railway between Mombasa and Nairobi in 2017, should see a resurgence in the sector, and a

significant increase in passenger and freight transport. This is expected to further increase in the next few years, once the SGR to Kisumu and Malaba on the Uganda Border is complete.

Table 2.8 Railway sub-sector performance between 2006 and 2017

	2006	2007	2008	2009	2010	2011
Tonne-km (millions)	1,313	5,606	1,109	1,060	1,105	1,135
Passenger-km (millions)	369	148	105	389	270	283
	2012	**2013**	**2014**	**2015**	**2016**	**2017**
Tonne-km (millions)	1,139	862	1,169	1,283	1,141	857
Passenger-km (millions)	221	194	176	99	113	120

Source: Compiled from Kenya National Economic Surveys 2011 through 2018

Table 2.9 Summary on Rail Sub-Sector

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
Data required for top-Down calculation (as proposed in the GHG calculation tool)					
Total fuel consumption (diesel)	▪ Data on each locomotive and total consumption is reported by Kenya Railways and Tata Chemical	-	**Low**	**Low**	
Lower heating values/ net calorific value (NCV) for diesel	▪ No country-specific values available ▪ Values may be available in the harmonised East African Fuel Standards	▪ Default values from IPCC guidelines 2006	**Low**	**Low**	▪ Energy Regulatory Commission can periodically confirm if NCV of actual supplied diesel matches the EA Fuel Standards
GHG emission factors (for diesel)	▪ No country-specific values available	▪ Use default values from IPCC guidelines 2006	**Low**	**Low**	▪ There is likely to be little difference with other countries default values.
Data required for a future bottom-up calculation for validation (requires information on each locomotive type or locomotive)					
Vehicle population at the end of the year (by type/train category, Vehicle age)	Detailed information on the vehicle stock (engine power, vehicle age, fuel type) is not reported, but can be requested from Kenya Railways	-	**Low**	**Low**	▪ This should be included in the official statistical system to ensure continuous and complete data provision.

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
Average operating hours (hours per year)	▪ No data available	▪ First assumptions can be made based on experts judgement and consultation with Kenya Railways	**Medium**	**Low**	▪ Put in place mechanisms to require Kenya Railways to report this information
Average train (total) engine power (kW)	▪ Detailed information on vehicle stock (engine power, vehicle age, fuel type) is reported by Kenya Railways		**Low**	**Low**	▪ Put in place mechanisms to require Kenya Railways to report this information
Engine Load factor (%)	▪ Data is not yet reported.	▪ First assumptions can be made based on experts judgement, based on other countries' experiences (literature)	**Medium**	**Low**	▪ MoT can conduct periodic survey of Kenya Railways for the information
Engine specific fuel consumption (g/kWh)	▪ Data not yet available	▪ First assumptions can be made based on experts judgement, based on other countries' experiences (literature)	**Low**	**Low**	▪ Typical best values and range are available in literature
Emission factors (for diesel)	▪ No country-specific values available	▪ Values can be taken from IPCC 2006.	**Low**	**Low**	▪ Value will probably not differ very much from international default values.
Data required for validation (as proposed in the GHG calculation tool)					
Total transport	▪ This data is available as part of	-	**Low**	**None**	- ??

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
performance of passenger transport (passenger-kilometre)	Kenya National Bureau of Statistics Annual Economic Surveys				
Total transport performance of freight transport (tonnes-kilometre)	▪ This data is available as part of Kenya National Bureau of Statistics Annual Economic Surveys	-	**Low**	**None**	- ??

2.3 Maritime

The Maritime and shipping sub-sector has not disaggregated data to levels that would allow for emission calculations using a top-down approach.

2.3.1 Boundaries

Water-borne navigation as defined by the IPCC (2006) distinguishes between international and domestic navigation (see Table 2.9). Domestic navigation can be furthermore divided into "Maritime" managed by the Kenya Maritime Authority (KMA) and "Inland Waterways." The KMA was established in June 2004 to be in charge of regulatory oversight over the Kenyan maritime industry, with maritime safety and security as a couple of its core functions. In addition, the Kenya Ports Authority (KPA) is mandated to maintain, operate, improve and regulate all sea and inland waterway ports in Kenya.

According to IPCC (2006), emissions from domestic navigation includes emissions from fuels used by vessels of all flags that depart and arrive in the same country, excluding fishing and military vessels. Emissions from fishing vessels is accounted for under the Ministry of Agriculture.

Table 2.10 Segregation of water-borne navigation (based on IPCC 2006 Volume 2: Energy, p. 3.8)

Name	Explanation
Water-borne Navigation	Emissions from fuels used to propel water-borne vessels, including hovercraft and hydrofoils but excluding fishing vessels. Domestic split should be determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.
International water-borne navigation (international bunkers)	Emissions from fuels used by vessels of all flags that are engaged in international water-borne navigation. The international navigation may take place at sea, on inland lakes and waterway in coastal waters. Includes emissions from journeys that depart in one country and arrive in a different country. Exclude consumption by fishing vessels. Emissions from international military water-borne navigation can be included as a subcategory of international water-borne navigation provided that the same definition distinction is applied and data are available to support the definition.
Domestic waterborne Navigation	Emissions from fuels used by vessels of all lags that depart and arrive in the same country (exclude fishing and military). Note that this might include journeys of considerable length between two ports in a country.

2.3.2 Top-down approach: Availability of fuel consumption data

The data required for a top-down approach for maritime shipping is not available. Although the Kenya National Bureau of Statistics annual economic survey provides net domestic sales for petroleum products that can be allocated to the sub-sector, it does not differentiate between diesel and heavy fuel oil (HFO). It is therefore not possible to determine the amount of diesel consumed nor the amount of HFO. For the sub-sector, a top-down calculation would require for both diesel and HFO:

- Total domestic fuel consumption, and
- Lower heating values/ net calorific value (NCV)

In the absence of a breakdown between diesel and HFO in the shipping sector in national statistics it would be possible to make an educated guess at the split between diesel and HFO based on interviews with industry experts.

2.3.3 Bottom-up approach: Availability of vehicle and travel activity data

Higher tier approach that makes use of disaggregated transport activity data.

2.3.3.1 Data requirements

A simplified bottom-up approach could use the following formula:

Domestic fuel consumption (kg) = transport volume (tonnes, passenger, TEU) x average trip distance (km) x average specific fuel consumption (kg/Tkm, Pkm, TEUkm)

Where TEU is 20-foot container equivalent. Freight and passenger volumes could be obtained from the Kenya Ports Authority and the Kenya Revenue Authority. Current publicly available data include annual container traffic (TEUs) and goods handled (tonnes). Other data as per formula (3) above are not available, not generally reported. Kenya has only a single major Port, Mombasa, from which most of this data is captured. There is little or no reporting on activities in the inland waterways, especially around Lake Victoria.

2.3.3.2 Data availability

The required data for a bottom up approach is not available, nor is there a reporting system in place to collect the same.

2.3.4 Conclusions and recommendations

Data for emissions in the maritime sector is wanting. There is little available data for either a top-down or a bottom-up approach, nor are there systems in place to collect the same. To provide reasonable estimates for emissions in the sub-sector, structures should be put in place to systematically and regularly capture this information.

Table 2.11 Summary of Maritime Sub-Sector

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
Data required for top-down calculation (not selected for calculation)					
Total fuel consumption (diesel and HFO)	▪ Available data does not distinguish between international and domestic use	-	**N/A**	**N/A**	▪ Data from the sector should be disaggregated between domestic and international
Lower heating values/ net calorific value (NCV) for diesel and HFO	▪ No country specific value available ▪ May be available in the harmonized East African fuel standards	▪ Default values from IPCC guidelines 2006	**Low**	**Low**	▪ Periodic testing for by Energy Regulatory Council
GHG emission factors (for diesel and Heavy fuel oil)	▪ No country-specific values available	▪ Default values from IPCC 2006 guidelines (Note: For waterborne navigation, IPCC does not offer a value for CH_4, N_2O of diesel, so HFO values can be used.)	**Low**	**Low**	▪ Domestic emission factors are not expected to be very different from international values
Data required for a detailed bottom-up calculation					
Vehicle population at the end of the year (divided by some of its technical parameters (main engine size class,	▪ There is no data available of vehicle population, fuel types, types of vessels, class, dead weight and tonnage	-	**N/A**	**Low**	▪ Official reporting systems should include collection of data on types of fuel, engine size, class gross tonnage, etc.

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
fuel type, gross tonnage, dead weight, main engine capacity)					
Average operating hours (hours per year/ vessel type)	▪ No data available yet. ▪ Data available is of vessel calls and port days	-	**N/A**	**Medium**	▪ Through the Kenya Maritime Authority carry out surveys to collect estimates of operating hours
Average speed (per vessel type)	▪ No data available yet.	▪ First assumptions can be made based on experts judgement, based on other countries' experiences (literature)	**High**	**Medium**	▪ Through the Kenya Maritime Authority carry out surveys to collect estimates of average speeds. ▪ This can also be done through reporting on travel time taken and distance between Ports
Engine Load factor (%) (per vessel type)	▪ No data available yet.	▪ First assumptions can be made based on experts judgement, based on other countries' experiences (literature)	**High**	**Medium**	▪ Through the Kenya Maritime Authority carry out surveys to collect estimates of engine load factors
Occupancy rate (per vessel type)	▪ No data available yet.	▪ First assumptions can be made based on experts judgement, based on other countries' experiences (literature)	**High**	**Medium**	▪ Through the Kenya Maritime Authority carry out surveys to collect estimates of occupancy rate
Engine specific fuel consumption (g/kWh) (per vessel	▪ No data available yet.	▪ First assumptions can be made based on experts judgement, based on other	**Medium**	**Medium**	▪ Through the Kenya Maritime Authority carry out surveys to collect estimates of specific fuel

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
type)		countries' experiences (literature)			consumption
Share of domestic fleet (per vessel type)	▪ No data available yet.	▪ First assumptions can be made based on experts' judgement.	**High**	**Medium**	▪ Through the Kenya Maritime Authority carry out surveys to collect estimates of share of domestic fleet
Emission factors (for HFO and diesel)	▪ No country-specific values available	▪ Values can be taken from IPCC 2006.	**Low**	**Low**	▪ Value will probably not differ very much from international default values.

2.4 Inland Waterways

2.4.1.1 Boundaries

In Kenya, there is minimal transport on the inland waterways. Kisumu City on Lake Victoria provides the largest potential for inland waterway transport, but this has been greatly neglected. The port infrastructure is a bad state of repair, with negligible commercial activity. Small ferry services do exist, but their contribution would be negligible. As expected, there is no data for the sub-sector. However, until the level of activity significantly increases, there may be no value in establishing data collection systems for either a bottom-up or top down approach.

2.5 Aviation sub-sector

Regulation and oversight of the aviation sub-sector safety and security is provided by Kenya Civil Aviation Authority (KCAA). KCAA was established on 24th October 2002 by the Civil Aviation (Amendment) Act, 2002 to take over the functions of the defunct Directorate of Civil Aviation and the Civil Aviation Board in the Ministry of Transport. The Authority is mandated to carry out four primary functions: Regulation and oversight of aviation safety and security, Economic regulation of air services and development of civil aviation, Provision of air navigation services, and Training of aviation personnel.

The Kenya Airports Authority is an autonomous body established in 1991 through an Act of Parliament and is charged with an umbrella responsibility of providing and managing a coordinated system of airports in the country.

2.5.1 Boundaries

GHG emission inventory for aviation is based on domestic flights only (see Table 2.12) and does not include military aircraft.

Table 2.12 Sector spilt for aviation sector (based on IPCC 2006 Volume 2: Energy, p. 3.8)

Name	Explanation
Civil Aviation	Emissions from international and domestic civil aviation and domestic air transport, including take-offs and landings. Comprises civil commercial use of airplanes; including scheduled and chartered traffic for passenger and freight, air taxing, and general aviation. Excludes use of fuel at airports for ground transport, which is reported under 1 A3 e ("Other transportation").
International aviation	Emissions from flights that depart in one country and arrive in a different country. Include take-offs and landings for these flight stages.
(International Bunkers)	Emissions which relate to fuel use for international civil aviation. Note that these emissions are to be excluded from national totals but should be reported separately. For the purpose of greenhouse gas emission inventories, fuel used during landing and take-off in an international flight stage is considered part of international bunkers fuel use. Not included in national totals.
Domestic aviation	Emissions from civil domestic passenger and freight traffic that departs and arrives in the same country (commercial, private, agriculture, etc.), including take-offs and landings for these flight stages. Note that this may include journeys of considerable length between two airports in a country

2.5.2 Top-down approach

For the top down approach data on fuel consumption by fuel type (i.e. jet kerosene, aviation gasoline) for domestic flights is required, i.e.

- Total domestic aviation fuel consumption
- Lower heating values/net calorific value
- GHG emission factors

Current total aviation fuel supplied is available through the Kenya National Bureau of Statistics Annual Economic Survey. The data does not distinguish between domestic and international flights, however, expert

estimates from a feasibility study on biofuels by ICAO estimate that 7 percent of the total aviation fuel requirement can be attributed to domestic operations[8].

2.5.3 Bottom-up approach

Higher tier approach that makes use of disaggregated transport activity data.

2.5.3.1 Data requirements and availability

Domestic fuel consumption can be determined using various approaches. For example, it can be calculated from (EMEP/EPA Guidebook 2006):

$$\textit{Domestic fuel consumption (kg)} = \textit{number of take-offs} \times \textit{specific fuel consumption (kg)} \qquad (3)$$

The data required, by type/sub-type of aircraft, would thus include:

- Number of domestic take-offs (Available in the Aviation Action Plan of 2015)
- Average fuel consumption (by type, distance class, flight cycles)
- Emission factors for jet kerosene

There is data available from the Kenya National Bureau of Statistics on annual take-offs and landings, but the data is not segregated by aircraft type, nor by domestic and international flights. The segregated data can be requested through KCAA as the regulating agency for the industry.

[8] Feasibility Study on the Use of Sustainable Aviation Fuels in Kenya, ICAO, 2018

Table 2.13 Summary on Aviation Sub-Sector

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
For a top-down calculation (not selected for calculation)					
Total fuel consumption of domestic flights	▪ Information is available on annual total fuel consumption for the sub-sector. ▪ Not segregated by fuel type nor by domestic and international flights	N/A	**N/A**	**High**	▪ Requirements for airlines to report fuel consumption per aircraft type, fuel type and domestic or international
Net Energy Content/ Calorific Value for diesel and gasoline	▪ No country-specific values available ▪ Values used should match country fuel inventory	▪ Default values from IPCC guidelines 2006	**Low**	**Low**	▪ Country specific values can be obtained through periodic testing coordinated/conducted by the Energy Regulatory Commission (ERC)
GHG emission factors for jet and aviation gasoline	▪ No country-specific values available ▪ GHG emission factors should match data used in official inventory	▪ Default values from IPCC guidelines 2006	**Low**	**Low**	▪ Country specific values can be established facilitated by the Ministry of Energy
Data required for a bottom-up calculation – required for each aircraft type					
Vehicle population by aircraft type	▪ This data is available with the Kenya Civil Aviation Authority (KCAA) ▪ There is data available on flight distance/distance class per aircraft type ▪ There is no data on fuel use	-	**Low**	**Low**	▪ Making data available, including manufacturer, model, age.
Flight distances	▪ There is data on flight distance/distance class per aircraft	-	**Low**	**Low**	▪ Provide a systemic approach to the collection of flight distance disaggregated

Indicator	Data availability (accessibility and uncertainty)	Default data/ assumptions to replace real data	Uncertainty	Urgency of action to improve data	Potential for future improvements
between airports	type from KCAA				by aircraft type.
Number of take-offs	▪ This data is available through KNBS ▪ Disaggregated data by aircraft type, as well as domestic and international flights can be obtained from KCAA	-	**Low**	**Low**	▪ Put system in place to collect disaggregated data
GHG emission factors	▪ There are no country specific values on GHG emission factors available.	▪ Can use values from EMAP/EEA Guidebook 2016	**Low**	**Low**	▪ Values may not differ considerably from default international values
Specific Fuel Consumption	▪ There are no country specific values available	▪ Can use values for Landing and Take Off (LTO) and Cruise from EMAP/EEA Guidebook 2016	**Low**	**Low**	▪ This data should be collected by aircraft type and flight distance.

3 Conclusions and recommendations for data collection

Status of availability of data for the five sub-sectors has been elaborated in the previous chapters. High uncertainty still exists particularly with the bottom-up approach in road transport. It is however possible to use the top down approach with a reasonable level of certainty as total fuel sales/consumption is annually reported by the Kenya National Bureau of statistics. Uncertainty mainly exists when it comes to diesel fuel consumption in the road sector, as well as the maritime and aviation sub-sectors as the reported data is not differentiated between domestic and international consumption. Disaggregation of this data, during this annual reporting is therefore of high importance to the inventory development process.

3.1 Data collection priorities

In the past, data collection within the transport sector has not been in support of calculation of GHG emissions, but rather in support of other national priorities. With Kenya's commitments to reduction in GHG emissions, the need for robust data collection processes and guidelines from all transport sectors shall be essential in providing key data in support of carrying out regular top-down and bottom-up calculations. The processes and guidelines should be agreed upon by all stakeholders and be in line with international best practices and standards.

The State Department of Transport has made efforts towards establishment of a long-standing Transport Data Centre. This is supported by previously commissioned research on relevant transport indicators (Transport Sector Indicator Framework). The Data centre is expected to be the main repository for national and regional transport data collected from agencies within the Ministry of Transport. Expediting operationalisation of such a set up through capacity enhancement and financial allocation, is of high importance in easing the challenges experience in inventory development.