REPORT ON THE TOOL FOR THE ESTIMATION OF GREENHOUSE GAS INVENTORY FOR NORTHERN AND CENTRAL CORRIDORS

2018 BASELINE

JULY 2020

NORTHERN CORRIDOR
TRANSIT AND TRANSPORT
COORDINATION AUTHORITY

TRADE MARK EAST AFRICA
Growing Prosperity Through Trade

CENTRAL CORRIDOR
TRANSIT AND TRANSPORT FACILITATION AGENCY

BURUNDI | DEMOCRATIC REPUBLIC OF CONGO | KENYA | RWANDA | SOUTH SUDAN | TANZANIA | UGANDA

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ACKNOWLEDGEMENT

At the outset, ClimateCare (CC) and Meghraj Capital Limited (MCL) would like to thank TradeMark East Africa (TMEA) for providing the opportunity to work on this distinct project. CC and MCL team is grateful to Mr. Mikko Leppanen and Mr. Denis Maina from TMEA for their support, co-ordination, and timely feedback.

Profound appreciation also goes to UNCTAD for their contribution and support to Northern Corridor that laid a foundation for this report.

We would like to acknowledge the kind support, valuable inputs and co-ordination extended by Northern Corridor Transit and Transport Coordination Authority (NCTTCA) team, especially, Mr. Aloys Rusagara, Mr. Fred Paul Babalanda and Mr. Gideon Chikamai.

We are grateful to Central Corridor Transit Transport Facilitation Agency (CCTTFA) team especially, Mr Melchior Barantandikiye, Mr Ally Hamud Kakomile and Mr Faraji Y. Kondo for the support, co-ordination and feedback.

The report would not have been possible without the valuable technical inputs, guidance and suggestions received from many key stakeholders such as Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Kenya, Ministry of Works, Transport and Communications and National Environment Management Council, Tanzania; Ministry of Transport, Posts & Telecommunications and Ministry of Environment, Land Management & Public Works, Burundi; Ministry of Infrastructure and Ministry of Environment, Rwanda; Ministry of works & Transport and Ministry of Water and Environment, Uganda and Super Star Forwarders Limited, Part of the Superdoll Group.

ClimateCare and Meghraj Capital Limited
Kenya

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GLOSSARY

Annual average daily traffic (AADT)

Annual average daily traffic, abbreviated AADT, is a measure used primarily in transportation planning, transportation engineering and retail location selection.

Base year

A historical datum (e.g., year) against which a company's emissions are tracked over time.

Base year emissions

GHG emissions occurred in the base year.

CO_2 equivalent (CO_2e)

The universal unit of measurement to indicate the global warming potential (GWP) of each greenhouse gas, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate releasing (or avoiding releasing) different greenhouse gases against a common basis.

Commercial vehicle

The commercial vehicle sector can be broadly classified as Light Commercial Vehicles (LCV), Medium Commercial Vehicles (MCV) and Heavy Commercial/ Goods Vehicle (HGV/HCV) based on the gross vehicle weight (GVW) of the vehicle. According to the East African Community (EAC) vehicle load control act, the commercial vehicle segment can be further classified into three segments based on gross vehicle weight as follows –

Emission factor

A factor that converts activity data into GHG emissions data (e.g., kg CO_2e emitted per litre of fuel consumed, kg CO_2e emitted per kilometer travelled, etc.)

Global warming potential (GWP)

A factor describing the radiative forcing impact (degree of harm to the atmosphere) of one unit of a given GHG relative to one unit of CO_2.

Greenhouse gases (GHG)

Greenhouse gases are gases in the atmosphere such as water vapour, carbon dioxide, methane and nitrous oxide that can absorb infrared radiation, trapping heat in the atmosphere. This greenhouse effect means that emissions of greenhouse gases due to human activity cause global warming. GHGs are the six gases covered by the UNFCCC: Carbon Dioxide (CO_2); Methane (CH_4); Nitrous Oxide (N_2O); Hydrofluorocarbons (HFCs); Perfluorocarbons (PFCs); and Sulphur Hexafluoride (SF_6).

Indirect emissions

Emissions that are a consequence of the activities of the reporting process

Primary data

Data from specific activities within the process

Reporting year

The year for which emissions are reported.

Table 1: Commercial Vehicle Categorisation

Number of types on axle	Commercial vehicle category	Permissible gross vehicle weight (metric tonnes)
2	LCV	18
3	MCV	26
4	MCV	32
5	HGV	42
6 (Lift able axle)	HGV	47.75
7 (Double Differential)	HGV	50
8	HGV	56
9	HGV	56
10	HGV	56

Direct emissions

Emissions from sources that are controlled by the reporting process.

Vehicle Kilometre Travelled

The unit of transportation measurement describes the unit of measurement used to measure the quantity and traffic of transportation used in transportation statistics, planning, and related fields.

ABBREVIATIONS AND ACRONYMS

CCTTFA	Central Corridor Transit Transport Facilitation Agency
CH_4	Methane
CO_2	Carbon Dioxide
CO	Carbon Monoxide
EMEP EEA	European Monitoring and Evaluation Programme European Environment Agency
EAC	East African Community
EU	European Union
GHG	Greenhouse Gases
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GOB	Government of Burundi
GODRC	Government of Democratic Republic of Congo
GOK	Government of Kenya
GOR	Government of Rwanda
GOSS	Government of South Sudan
GOT	Government of Tanzania (United Republic of Tanzania)
GOU	Government of Uganda
GPG 2000	Good Practice Governance 2000
GWP	Global Warming Potential
HBEFA 3.3	Handbook Emission Factors for Road Transport
HGV	Heavy Goods Vehicle
IPCC	Intergovernmental Panel on Climate Change
JKUAT	Jomo Kenyatta University of Agriculture and Technology

LCV	Light Commercial Vehicle
MCV	Medium Commercial Vehicle
MoTIHUD	Ministry of Transport, Infrastructure, Housing and Urban Development
NATCOM	National Communication to the United Nations Framework Convention on climate change
NCTTCA	Northern Corridor Transit and Transport Coordination Authority
NIT	National Institute of Transport
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxides
NMVOC	Non-Methane Volatile Organic Compounds
NTSA	National Transport and Safety Authority
PM	Particulate Matter
QA/QC	Quality Assurance and Quality Control
SO_2	Sulphur Dioxide
TMEA	TradeMark East Africa
TOR	Terms of Reference
TPA	Tanzania Port Authorities
TRACS	Advancing Transport Climate Strategies
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNCTAD	United Nations Conference on Trade and Development
VOC	Volatile Organic Compound
$MMtCO_2e$	Million Metric tonnes of Carbon dioxide equivalent

EXECUTIVE SUMMARY

According to the Intergovernmental Panel on Climate Change (IPCC), globally, the transport emissions on a business-as-usual basis could reach 12 billion tonnes of CO_2 by 2050 (Intergovernmental Panel on Climate Change (IPCC) 2014). The transport sector faces a daunting climate change challenge in the next few decades in terms of contribution to the goal of keeping the temperature rise well below 2°C. This presents a formidable challenge for planning and managing transport systems. The task is even harder for freight transport because its share of total transport emissions is projected to rise from 42% in 2010 to 60% by 2050 (Organization for Economic Co-operation and Development (OECD)/ International Transport Forum (ITF) 2015). Freight transport has been identified as one of the hardest socio-economic activities to decarbonise.

In this context, governments and companies are taking many initiatives to reduce the carbon intensity of freight transport operations. In 2011, the European Commission set a target to cut total CO_2 emissions from passenger and freight transport for the 27 EU countries by 60% between 1990 and 2050. In December 2019, the European Commission unveiled a 'climate law' to commit the 27-nation EU to reduce its GHG emissions to zero by 2050 (European Commission 2019). In other parts of the world, the projected growth in freight movement is much higher, pressing governments and businesses to find ways to decrease GHG emissions per tonne-kilometre. For example, the International Transport Forum (ITF) expects the rate of increase in total tonne-kilometres between 2010 and 2050 to be three times higher in emerging economies and developing countries, like East Africa, than in the EU and North America (McKinnon 2016).

TradeMark East Africa (TMEA) is a not -for-profit aid for trade organisation, working with East African Community (EAC) to support growth through trade. TMEA seeks to increase trade in East African countries and region by unlocking economic potential through reduced barriers to trade and improved business competitiveness. One of the focus areas of TMEA is the sustainable and inclusive trade in the region. TMEA works with the regional freight transport system in East Africa.

TMEA has been supporting Northern Corridor Transit and Transport Coordination Authority (NCTTCA) and Central Corridor Transit Transport Facilitation Agency (CCTTFA) to set up corridor transport observatory systems. TMEA has conducted this study to understand the climate change impacts of the corridors, among other related issues, and has set out a programme to:

1. Develop a tool for estimating the greenhouse gas (GHG) emissions associated with the two major corridors.

2. Support the corridor transport observatory systems to establish a system of collecting and apply the relevant data using the tool to regularly report on the performance of the corridors with respect to GHG emissions.

3. Identify GHG emission reduction potential in possible climate change mitigation projects of the corridors

Considering the above aspects, TMEA commissioned ClimateCare along with Meghraj Capital Limited to carry out a study to understand GHG emissions from Northern and Central corridors. To estimate GHG emissions, a flexible Excel based model has been developed which will, ultimately, help to identify climate change mitigation projects along the regional transit corridors which, in turn, will reduce the carbon intensity of freight transport operations leading to lower grams of CO_2 emitted per tonne-kilometre.

For estimating GHG emissions for Northern and Central Corridors, three GHG emission models for freight transport - GIZ emission model for Kenya, United Nations Framework Convention On Climate Change (UNFCCC) GHG emission framework, and the United Nations Environment Programme (UNEP) and United Nations Conference on Trade and Development (UNCTAD) facilitated Northern Corridor GHG Emission Model (NCEM) were comprehensively reviewed with respect to approach, and methodology, GHG emission calculations, data requirements, robustness, transparency, comprehensiveness and compliance to international standards. As Northern Corridor Emission Model (NCEM) is based on internationally accepted IPCC framework and is more robust, NCEM was selected as a base framework for developed GHG emission model for estimating GHG emissions.

A consultative and inclusive approach was adapted for the study, extensive site visits, series of consultations, and in depth discussions were carried out with key stakeholders such as TMEA, the secretariats of the NCTTCA and CCTTFA and, the governments of the respective member countries (Kenya, Uganda, Tanzania, Rwanda, and Burundi). Moreover, other key stakeholders like transporters and those who have been involved in previous works, such as GIZ's Advancing Transport Climate Strategies (TraCS) project were also consulted.

The approach adopted for the study is a first of its kind in the East African region, for estimating GHG emissions from freight transport. Currently, the top-down approach (estimating GHG emissions by using fuel consumption) is adopted by governments of member countries (Kenya, Uganda, Tanzania, Rwanda, Burundi, DRC and South Sudan) for estimating GHG emissions from the freight transport sector. The present study uses a bottom-up approach for estimating GHG emissions from freight transport. In the bottom-up approach, critical data like truck traffic, the actual weight of the truck, fuel efficiency of the truck, and percentage of empty trips are collected from the ground (either monitored at ground level through corridor observatory or through a survey) for estimating GHG emissions. The results of the study would be highly useful not only for NCTTCA and CCTTFA but also the governments of member countries for developing climate goals and action plans to achieve the goals.

The present study found that for 2018, GHG emissions of Northern Corridor are 1.73 MMtCO_2e, out of which CO_2 emissions account for about 98.75 % of total GHG emissions, followed by N_2O emissions and CH_4 emissions which are comparatively very small.

And the total estimated GHG emissions of Central Corridor are 1.23 MMtCO_2e, wherein CO_2 emissions account for about 99 % followed by N_2O, and CH_4 emissions, which are comparatively minimal. In both corridors, CO_2 emissions accounted for major emissions compared to other GHGs. Hence, the climate change mitigation measures which need to be planned for the corridors need to focus mainly on reducing CO_2 emissions.

GHG emissions of the entire corridor as well as emissions from route wise / section wise were calculated in order to identify the GHG intensive routes/ sections of the corridors.

After identifying, GHG intensive routes / sections, corridors can prioritize the identification and implementation of climate change mitigation actions in these GHG intensive routes/sections.

In the Northern Corridor, the top 10 GHG emission intensive routes are Mombasa-Malaba, Mombasa-Nairobi, Mombasa-Busia, Nairobi-Busia, Busitema-Kampala, Luwero-Elegu, Luwero-Goli, Mbale-Goli, Mubende - Kasindi, and Mbale - Elegu. Out of 25 routes in the Northern Corridor, these 10 routes constituted 86 % of estimated total GHG emissions of the corridor. Hence these routes are priority routes where climate change mitigation actions can be identified and implemented for reducing GHG emissions in the corridor.

In the Central Corridor, the top 5 GHG emission intensive routes are: Morogoro – Isaka, Dar es Salaam – Morogoro, Isaka - Rusumo, Isaka – Mwanza, Isaka - Kabanga.

Out of 11 routes in Central Corridor, these 5 routes constituted 94 % of estimated total GHG emissions of the corridor.

The estimated total GHG emissions of the corridors have been further analysed based on vehicle categories, i.e. Light Commercial Vehicles (LCV), Medium Commercial Vehicles (MCV) and Heavy Goods Vehicles (HGV). In the Northern Corridor, the LCV's contributed around 17% (0.32MMtCO_2e) of the total estimated emissions; HGVs contributed 25% (0.41 MMtCO_2e) of the total emissions and MCVs contributed around 58% (1 MMtCO_2e) of the total emissions.

In the Central Corridor out of total emissions, the HGV's contributed around 100 % (1.23 MMtCO_2e) of the total emissions.

In the Northern Corridor, vehicle fuel efficiency improvement related interventions such as training of drivers and, improvement in vehicle aerodynamics can be focused on MCVs and similarly such initiatives can be focused on HGVs in the Central Corridor.

The GHG emissions for onward journeys (port city to capital or major city) and return trip (capital or major city to port city) were analysed. It has to be noted that in both the corridors, the export trips are only 14% of the total trade; hence a higher proportion of empty return trips is anticipated.

In the Northern Corridor, it was observed that onward journey constituted 58% (1 MMtCO_2e) of total estimated GHG emission and return journey constituted 42% (0.73 MMtCO_2e) of the total estimated GHG emission. In the return journey, the empty trips contributed 59% (0.43 MMtCO_2e) of the total estimated GHG emission of return journey, and loaded trips contributed 41% (0.30 MMtCO_2e) of the total GHG emission of the return journeys.

In the Central Corridor, it was observed that the onward journey constituted 59% (0.73 $MMtCO_2e$) of total estimated GHG emissions and return journeys constituted 41% (0.51 $MMtCO_2e$) of the total estimated GHG emissions. In the return journey, the empty trips contributed 57% (0.29 $MMtCO_2e$) of the total estimated GHG emission of return journey, and loaded trips contributed 43% (0.22 $MMtCO_2e$) of the total GHG emission of the return journey.

In both the corridors, it was observed that empty trips constituted the major portion of the total estimated GHG emissions of return journey. It has to be noted that GHGs are emitted during both trips - empty and loaded trips. However, during empty trips, fuel is consumed, and subsequently, GHGs are emitted without carrying out any useful work (no goods are transported). Hence, empty trips not only cause climate issues but also affect or increase the logistics cost substantially. Therefore, corridors, along with truck operators, need to take initiatives like route optimisation, reverse logistics, truck aggregation (similar to cab aggregation models of Uber) etc., to reduce empty return trips.

The GHG emissions from the Northern Corridor sections / routes in Kenya and Uganda constituted 95 % of total estimated GHG emissions of the Northern Corridor. In a similar manner, the GHG emissions from the Central Corridor sections/routes in Tanzania and Rwanda comprised 98 % of total estimated GHG emissions of the Central Corridor. Hence the climate change related policies / programs (such as the NDCs, National Communications and Biannual Update Reports, National Climate Change Action plans etc.,) of these four countries (Kenya, Uganda, Tanzania and, Rwanda) were reviewed comprehensively.

The below table provides a comparison between the total GHG emissions from freight transportation of the selected countries and GHG emissions from the corridor sections / routes of the selected countries. It also provides the GHG emission reduction targets in the transport sector of the selected countries.

Table 2: GHG emissions from freight transportation of selected countries vs GHG emissions from sections/routes of Northern/ Central Corridor in these selected countries

Country	GHG emissions from routes / sections of Northern Corridor ($MMtCO_2e$)	GHG emissions from routes / sections of Central Corridor ($MMtCO_2e$)	GHG emissions from freight transportation of the country ($MMtCO_2e$)	GHG emission from Northern/ Central Corridor in selected countries as a percentage of total freight transport emission of respective countries ($MMtCO_2e$)	Climate change targets (GHG emission reduction targets as a percentage of BAU transport emissions)
Kenya	1.24	-	2.56	48%	14%
Uganda	0.48	0.01	0.51	97%	23%
Tanzania	-	1.16	1.5	78 %	10-20%
Rwanda	0.006	0.04	0.09	51%	24%

Source: (Kenya's National Climate Change Action Plan- Mitigation Technical Analysis Report 2018)(Uganda's First Biennial Update Report to the United Nations Framework Convention on Climate Change 2019)(Rwanda's Third National Communication under the United Nations Framework Convention on Climate Change 2018)

The above table purports that GHG emissions from the Northern / Central Corridors of selected countries constitute a significant portion (48-97%) of total GHG emissions from freight transportation of the respective countries. Hence any reduction in GHG emissions in the Northern / Central Corridors would lead to GHG emission reductions in the transport sector of the country and would positively contribute in meeting climate change targets of these countries.

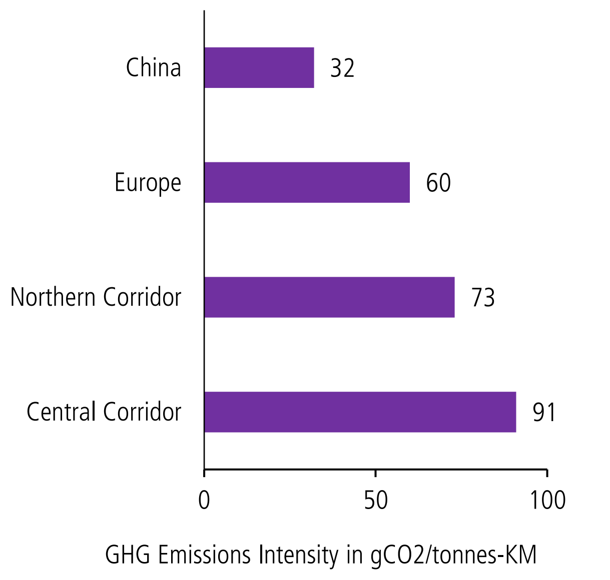
It can be inferred from the above table that GHG emission reduction target in the transport sector of the selected countries ranged from 10-24 % (as compared to BAU GHG emission scenario).

The above analysis indicates that actions taken in the corridors can significantly help the countries to achieve these targets.

In order to assess the GHG emission reduction potential in the corridors, a comparative analysis (as depicted below) of GHG intensity of Northern and Central Corridor with the freight corridors in China and Europe was carried out.

Based on the analysis, the GHG intensity of Northern Corridor was 2.3 times more than the GHG intensity of similar corridors in China, and the GHG intensity of Northern Corridor was 1.22 times more than the GHG intensity of freight corridors in Europe.

Figure 1: Comparative GHG intensity across corridors in the world (Lynn H Kaack 2018)



Similarly, the GHG intensity of the Central Corridor was 2.84 times more than the GHG intensity of similar corridors in China, and the GHG intensity of Central Corridor was 1.52 times more than the GHG intensity of freight corridors in Europe.

The above analysis clearly shows that substantial GHG emission reduction potential exists in both the corridors.

NCTTCA under the Northern Corridor Green Freight Programme has already developed climate goals for the five year period (2017-2021), and one of the critical climate goals is to reduce CO_2 emission intensity by 10% by 2021 (considering 2016 as baseline).

The GHG intensity of the Northern Corridor in 2018 was 73 gCO_2/tonne-km which is 3% lesser than the baseline GHG intensity (75 gCO_2/tonne-km). This demonstrates that there is a reduction in GHG intensity of the Northern Corridor, and it seems that the Northern Corridor is in the right direction towards achieving the GHG intensity reduction target.

Considering the country level climate targets, GHG emission reduction potential and GHG intensity reduction trends, the following climate targets (GHG intensity reduction) targets are suggested for the corridors.

- Central Corridor: Reduction of CO_2 emission intensity grams per tonne-km by 20% by 2030 considering CO_2 emission intensity in 2020 as baseline.
- Northern Corridor: Reduction of CO_2 emission intensity grams per tonne-km by 15% by 2030 considering the CO_2 emission intensity in 2021 as baseline.

In order to meet the proposed GHG intensity targets, the corridors can consider the following three broad climate mitigation interventions:

1. Climate mitigation interventions through implementing infrastructure projects

   a. Modal shift

      It has been observed in both the corridors that majority of goods are transported through roadways. Substantial GHG emission reduction potential exists in modal shift (roadways to railways / inland waterways). Countries like Kenya, Rwanda have taken national-level climate targets for modal shift from roadways to railways for freight transportation.

b. Improving road conditions

The poor road condition impacts vehicle speed, which increases fuel consumption and ultimately, increases GHG emission. There is good scope for improvement of road conditions in both the corridors. During the study, the GHG intensive routes or sections were identified in both corridors. It is suggested to carry out road condition improvement projects (improving roughness index) in these GHG intensive routes to help in reducing GHG intensity in both the corridors.

1. Climate mitigation interventions through capacity building and institutional mechanisms

a. Capacity building of truck drivers on eco-driving practices

Efficient driving practices can reduce fuel consumption, significantly reducing vehicular emissions. NCTTCA and CCTTFA can run a capacity-building programme for the truck drivers on fuel-efficient driving techniques.

b. Reduction in empty return trips through smart practices like route optimisation, aggregator model.

In both the corridors, it was observed that empty trips constituted a significant portion of total estimated GHG emission of the return journey, thereby increasing the GHG intensity of the corridors. Therefore, corridors, along with truck operators, need to take initiatives like route optimisation, reverse logistics, truck aggregator model (similar to cab aggregator model of Uber) etc., to reduce empty return trips.

c. Green leadership programme for truck operators/ fleet owners

Green leadership programme may be developed for truck operators/ fleet owners under which truck operators can take voluntary climate targets like improvement in fuel efficiency, reduction in pollutants, among others. The truck operators/ fleet owners who achieve the climate targets be incentivised by providing concessional toll rates, reduction in road tax, and priority clearance in port or customs area among others.

3. Vehicle efficiency improvement projects

As the freight transport accounts for the majority of fuel use and emissions, it is recommended to assess the vehicle characteristics. After engine losses, a majority of energy losses are due to aerodynamic drag. The corridors can collaborate with national automobile research institutes and truck manufacturers to standardize aerodynamic features of the trucks.

In the case of Northern Corridor, vehicle fuel efficiency improvement related interventions can be focused more on MCVs and similarly, such initiatives can be focused more on HGVs in Central Corridor.


PORT OF DAR ES SALAAM


PORT OF MOMBASA

CHAPTER ONE: PROJECT OVERVIEW

1.1 Project Background

1.1.1 Project Context

This report covers the development and future application of a tool for the estimation of greenhouse gas (GHG) emissions from the freight subsector of the Northern and Central Transit and Transport Corridors of the Eastern Africa region. The development of the tool was commissioned by TradeMark East Africa (TMEA) on behalf of the corridors and regional governments who are members of the corridors.

TMEA is an aid-for-trade organisation that was established with the aim of growing prosperity in East Africa through increased trade. With funding from various development agencies, TMEA operates on a not-for-profit basis covering Kenya, Tanzania, Uganda, Rwanda, Burundi, South Sudan, the Democratic Republic of Congo (DRC) and Ethiopia. It also works closely with the East African Community (EAC) institutions, national governments, the private sector and civil society organisations.

TMEA seeks to increase trade in these target countries and region by unlocking economic potential through reduced barriers to trade and improved business competitiveness. One of the focus areas of TMEA is the freight transport sector in the region, and TMEA works with the regional freight transit corridors (mainly Northern Corridor Transit and Transport Coordination Authority (NCTTCA) and Central Corridor Transit Transport Facilitation Agency (CCTTFA), among others.

TMEA has been supporting these two corridor management institutions to set up corridor transport observatory systems (Corridor Performance Monitoring Tool). The observatory systems track the indicators using raw data collected from the stakeholders in all the member states. The indicators provide clear information, enabling the identification of the bottlenecks that need to be resolved to improve on the efficiency and, eventually, the trade and operations along the corridor.

At the same time, TMEA would like to understand the climate change impacts of the corridors, among other related issues, and has set out a programme to:

i. Develop a tool for estimating the greenhouse gas (GHG) emissions associated with the two major corridors.

ii. Support the corridor transport observatory systems to establish a system of collecting and apply the relevant data using the tool to regularly report on the performance of the corridors with respect to GHG emissions.

iii. Identify GHG emission reduction potential in possible climate change mitigation projects of the corridors

Ultimately, this work will help identify projects along the regional transit corridors which reduce the carbon intensity of freight transport operations leading to lower grams of CO_2 emitted per tonne-kilometre. This is particularly important considering that in the freight transport sub-sector, the total tonne-kilometres delivered is expected to increase three-fold between 2010 and 2050 in emerging economies and developing countries like those in the East African region (ITF 2019). Without an accurate assessment of the corridors' GHG emissions, it will be difficult to plan effective policies to reduce the carbon intensity of the regional freight section sub-sector as well as benefit from international programs to reduce emissions.

To support the development of the GHG estimation tool, together with the identification and capture of the associated data, TMEA contracted ClimateCare Limited (https://climatecare.org/), in a joint venture with Land Trees and Sustainability (LTS) Africa (https://www.ltsi.co.uk/location/lts-africa-ltd-kenya) and Meghraj Capital Limited (https://www.meghraj.com) to provide the necessary consultancy support.

This report covers the approach and methodology adopted, some key decisions made during the process and the key features of the corridor GHG Estimation tool, including the data required for the tool together with the key assumptions made in the development of the tool

1.1.2 About the Project

Countries and infrastructure in the EAC region are at high risk of facing climate change related issues as these economies are highly dependent on climate-sensitive sectors such as agriculture. TMEA has proposed TMEA Climate Change Strategy (2018-2022), along with Corporate Strategy 2018-2023. To support partners including EAC, NCTTCA and, CCTTFA, TMEA has been mainstreaming climate change through following key initiatives into existing TMEA's projects(Trademark East Africa 2018)

1. To support key TMEA's GHG mitigation projects in estimating GHG emissions.
2. To support both Central and Northern Corridors' authorities in developing observatories programmes for collection of GHG emission and other climate change-related data.
3. To report the results and establish baseline and monitoring framework for continuous monitoring.

The objectives of the study, as stated in the Terms of Reference (ToR), were to support:

1. The Northern and Central Corridors in collection of data and calculating GHG estimates on freight transport (road) for the corridors
2. The identification of TMEA's key climate change relevant projects and estimating the associated GHG emission reductions.

This report addresses the first objective of estimating GHG emissions of freight transport for the corridors. The second objective of the project of identifying TMEA's key climate change relevant projects is covered comprehensively in a separate report. The main beneficiaries of this work will be TMEA and the secretariats of the Northern and Central Corridors, together with the border agencies of Kenya, Tanzania, Uganda, Rwanda, Burundi, South Sudan, the Democratic Republic of Congo (DRC), and the regional governments at large.

1.1.3 The Transit and Transport Corridors

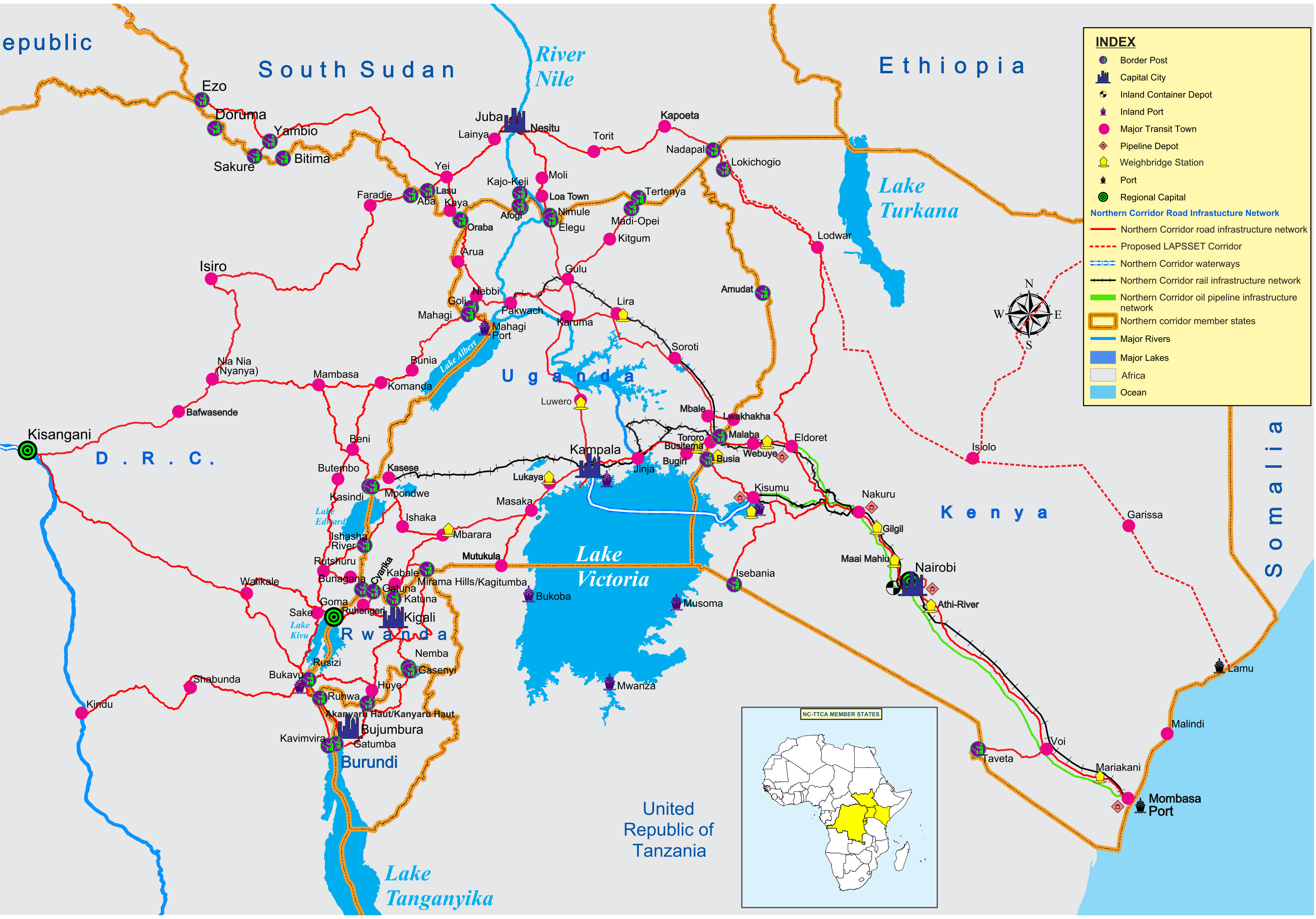
The Eastern Africa regional transport system has two main transit corridors:

1. The Northern Corridor from the Port of Mombasa
2. The Central Corridor from the Port of Dar es Salaam.

There are other corridors as well in the region; however, this report focuses on GHG emission calculation of Northern Corridor and Central Corridor.

The Northern Corridor is a multimodal trade route encompassing road, rail, pipeline and inland waterways transport, linking the landlocked countries of the Great Lakes Region with the Kenyan maritime seaport of Mombasa. Its presence has enhanced trade among the landlocked countries and the outside world (See Figure 2: Northern Corridor Map). The Northern Corridor Transit and Transport Agreement (NCTTA) is a treaty coupled with 11 protocols signed in 1985 and revised in 2007 for regional cooperation to facilitate interstate and transit trade, between the Member States of Burundi, Democratic Republic of Congo (DRC), Kenya, Rwanda, Uganda and South Sudan, which acceded to the agreement in 2012.

Figure 2: Northern Corridor map (Source: NCTTCA)



The agreement aims to achieve sustainable transport through the promotion of efficient and competitive transport, fostering inclusive transport and the establishment of a green freight transport system.

The Northern Corridor Transit and Transport Coordination Authority (NCTTCA) was established and mandated by the member states to oversee the implementation of the agreement, to monitor its performance and to transform the Northern trade route into an economic development corridor, making the corridor seamless, efficient, smart and green.

The Northern Corridor road network in all six member states is approximately 14,108 km in length (463 km in Burundi, 5,176 km in DRC, 1,710 km in Kenya, 781 km in Rwanda, 3,691 km in South Sudan and 2,287 km in Uganda). The key transit transport routes within the corridor are from Mombasa to Bujumbura (the South-West terminus) covering about 2,000 km of road distance, and the Mombasa - Kisangani route which stretches for about 3,000 km. The bulk of imports and exports destined to and from countries in the corridor are transported through either of these transit routes.

The Northern Corridor handles a substantial volume of trade including intra-regional trade that, as an illustration, reached over 30.8 million tonnes in 2018. (Northern Corridor Transit and Transport coordination Authority June 2019) The daily traffic volume for heavy trucks (both outbound and inbound) at Mariakani weighbridge (located 35 km from Mombasa Port), for example, is around 5,000 trucks. (Northern Corridor Transit and Transport coordination Authority June 2019)

According to NCTTCA, only 28.4% of the road network is in good condition, and 63.6% is in bad condition (Northern Corridor Transit and Transport Coordination Authority n.d.)

However, the main trunk road which carries more than 90% of traffic is in good condition. Improvement of the road networks within the corridor will not only help in increasing the regional trade and investments but also help in improving the regional freight sub-sector performance, logistics costs and environmental impacts, which are expected to increase on a business-as-usual scenario. (Northern Corridor Transit and Transport Coordination Authority n.d.)

Table 3: Road condition of Northern Corridor

Country	Excellent	Good	Fair	Poor	Total (km)
Kenya	38%	37%	8%	17%	1,201
DRC	0%	31%	47%	21%	4,162
Burundi	0%	52%	27%	21%	516
Rwanda	46%	34%	20%	0%	977
South Sudan	0%	0%	5%	95%	3,351
Uganda	23%	19%	35%	23%	2,163

Source: 2018 Estimate (Northern Corridor Transport Observatory n.d.)

Since the implementation of the agreement and establishment of the authority, various initiatives have been undertaken, which has resulted in a considerable improvement in trade facilitation in the region.

Apart from providing sustainable and steadfast transport infrastructure, the secretariat is also keen on reducing greenhouse gases emissions along the corridor in an attempt to safeguard the environment. To this end, the secretariat has decided to include indicators on environmental performance of the corridor hence the need for the GHG estimation tool.

The Central Corridor connects the Port of Dar es Salaam by road, rail and inland waterways to landlocked countries of Burundi, Rwanda, Uganda and Eastern part of the Democratic Republic of Congo (DRC) and all of central and northern-western Tanzania itself (Figure 2: Central Corridor Map). The corridor forms part of the backbone of the regional transportation system in East and Eastern Central Africa carrying the import and export of the five countries with a population of more than 120 million people. Specifically, the transit routes and facilities of the Central Corridor as defined by the agreement cover the cargo and passenger transport utilising rail, road and inland waterways.

The cargo is distributed through an integrated rail/ferry system, travelling on rail through Tanzania to the port of Kigoma on Lake Tanganyika (connecting to Bujumbura, Burundi, and to Kalemie and Uvira, DRC) or to the port of

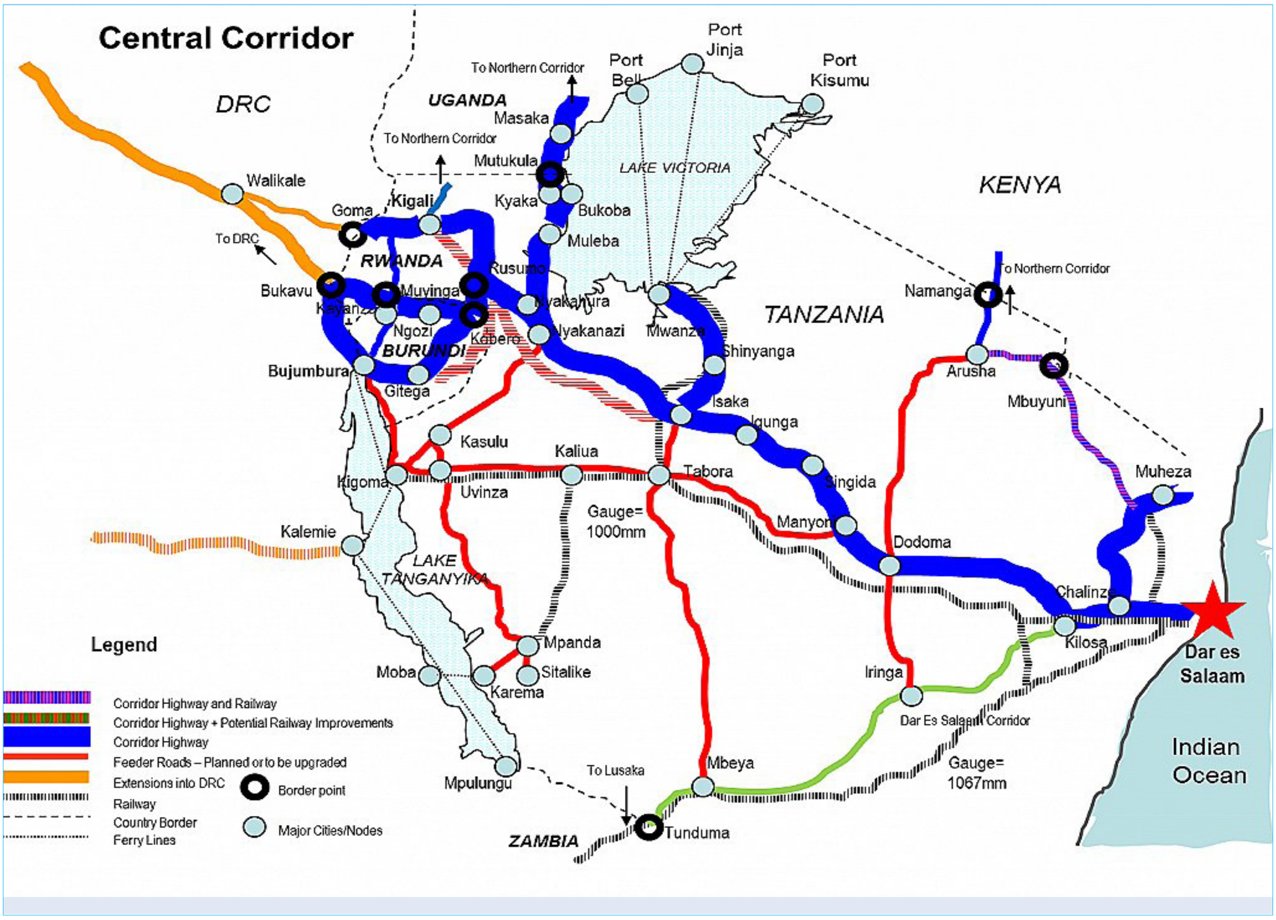
Road condition of a route section along the Northern Corridor

Bulyang'gombe slope along the Central Corridor

Mwanza on Lake Victoria (connecting to Kisumu, Kenya, and Port Bell, Uganda). The corridor has one-stop border posts (OSBPs) in Rusumo/Rusumo (Tanzania-Rwanda), Mutukula/Mutukula (Tanzania-Uganda), and Kabanga/Kobero (Tanzania-Burundi), and one stop inspection stations (OSIS) in Vigwaza (operational), Manyoni and Nyakanazi (under construction).

To track performance and implementation of the various initiatives, each of the corridors has established a transport observatory. Each transport observatory is a monitoring body that tracks more than 36 (Northern Corridor) and 25 (Central Corridor) performance indicators. The indicators are grouped under 7 categories and help track the performance of the ports of Mombasa and Dar es Salaam, as well as the performance of the corridors. NCTTA and CCTTFA have been collaborating with TMEA and signed an agreement for the period of 2018 – 2021 to strengthen and enhance their corridor transport observatories. The development of the corridor GHG inventory tool will enable both NCTTA and CCTTFA not only to estimate the GHG emissions associated with the corridor but also to start collecting the relevant data for the estimation.

Figure 3: Central Corridor map (Source: TTFA)



The corridor is managed by the Central Corridor Transit Transport Facilitation Agency (CCTTFA), a multilateral agency established on 2nd September 2006, formed by an agreement by the five Governments of the Republic of Burundi, DRC, Rwanda, Tanzania and Uganda.

Through co-operation amongst private and public sector stakeholders, the CCTTFA is charged with the promotion of transport utilisation of the Central Corridor, encouraging maintenance, upgrading, improvement and development of infrastructure, and supporting service facilities at the port, rail, lake, road border posts and along the route, to meet user requirements, ensure open competition and reduce the costs of transit transport for land-locked member states.

1.1.4 Approach and Methodology

APPROACH

The consultant has applied a consultative and inclusive approach to the assignment. The key stakeholders have been identified as TMEA, the secretariats of the NCTTCA and CCTTFA and the governments of the respective member countries (Kenya, Uganda, Tanzania, Rwanda, Burundi, DRC and South Sudan), transporters and those who have been involved in previous related work such as TraCS project. In the entire duration of the assignment, TMEA and the secretariats of the NCTTCA, CCTTFA and governments of the regional member countries were extensively consulted. In August 2020, an online validation workshop is proposed in which consultant will present the GHG emission results to all relevant stakeholders (TMEA, NCTTCA, CCTTFA, Ministry officials of member countries) and validate the results and finalise the GHG emission model.

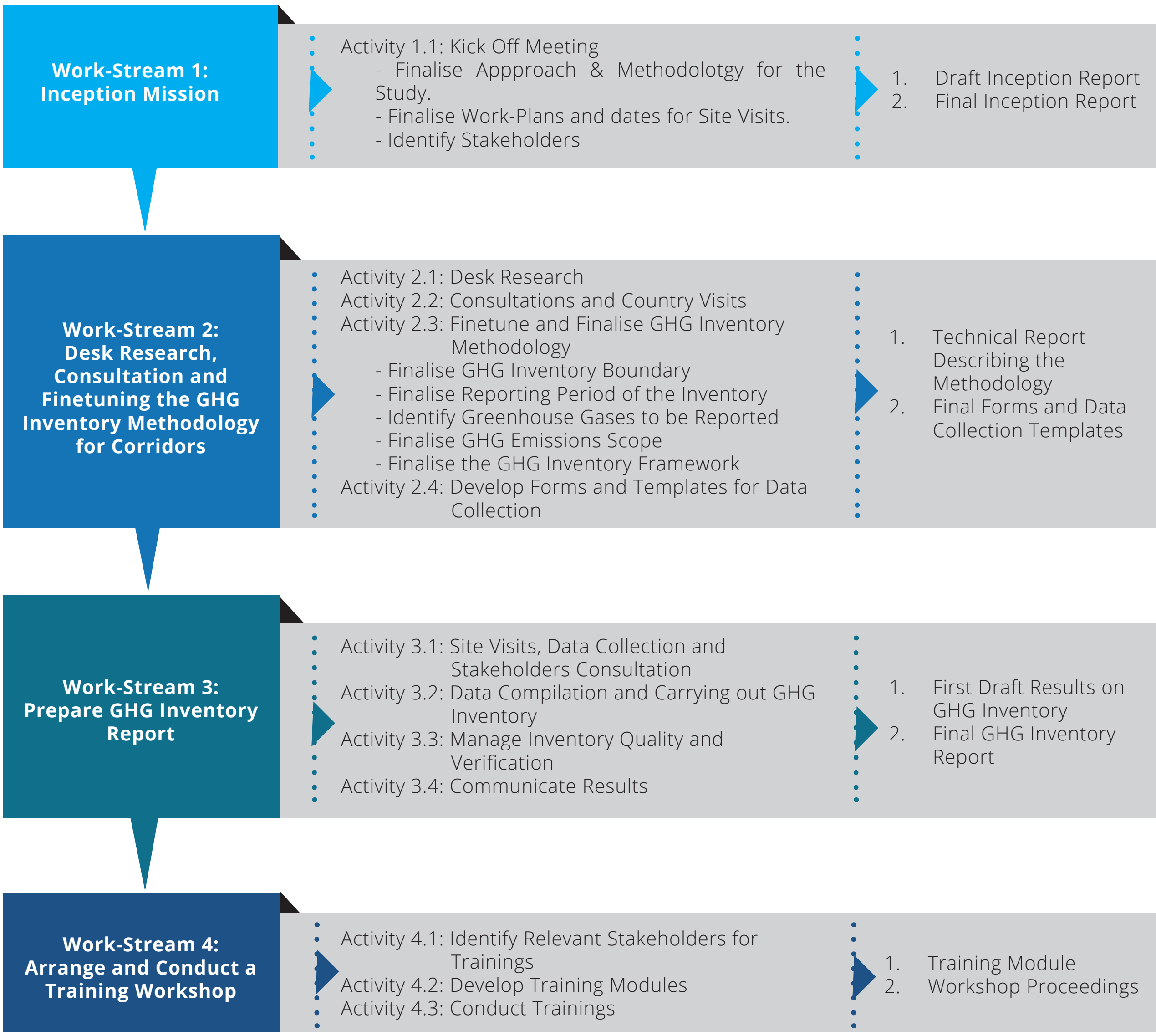
The consultants adopted an extensive consultation approach to ensure the results do not only reflect the feedback of the stakeholders but that of strong and shared ownership of the results is also created among them.

METHODOLOGY

To achieve the first objective and deliver the required outputs, several tasks were undertaken.

Objective: To support the Northern and Central Corridors in collection of data and calculate GHG estimates on freight transport (road) for the corridors.

Figure 4 : Overall work stream framework



Work-Stream 1: Inception Phase

Activity 1: Kick-off meeting at TMEA office, Nairobi

The kick-off meeting for the project was held on 9th September 2019 at TMEA office, Nairobi between consultant from ClimateCare Limited and Meghraj Capital Limited on the one hand, and TMEA on the other. Representatives of the Northern and Central Corridor authorities also attended the kick-off meeting via video conferencing.

Work-Stream 2: Desk Research, Consultations and Fine-tuning the GHG Inventory Methodology for Corridors

Activity 1: Desk Research

The consultant conducted an extensive desk review of TMEA, NCTTCA and CCTTFA documentation and corridor reports, including existing member country documents related to the transport corridors and GHG emissions. The detail of the documents reviewed has been provided in Annexure-VII.

The consultant also reviewed various documents related to GHG accounting protocols with a focus on the transport sector, guidelines and standards which are adopted internationally for GHG accounting, and relevant climate change related documents of the member countries of the Northern and Central Corridors.

The documents were reviewed to understand the following aspects of each GHG protocol and emission model:

1. Approach, methodology and GHG emission calculations
2. Data requirements vis a vis existing or possible-to-get data
3. Expected outputs
4. Robustness, transparency and comprehensiveness of the data and methodology
5. Compliance to international standards

Activity 2: Consultations and Member Country Visits

During this work stream, detailed consultations have been carried out with TMEA, NCTTCA and CCTFA, relevant ministries of member countries (Tanzania, Burundi, Uganda, Rwanda), GIZ (TraCS) team in Nairobi and a major freight transport company in Dar es Salaam (Super Star Forwarders Limited; Part of the Superdoll Group).

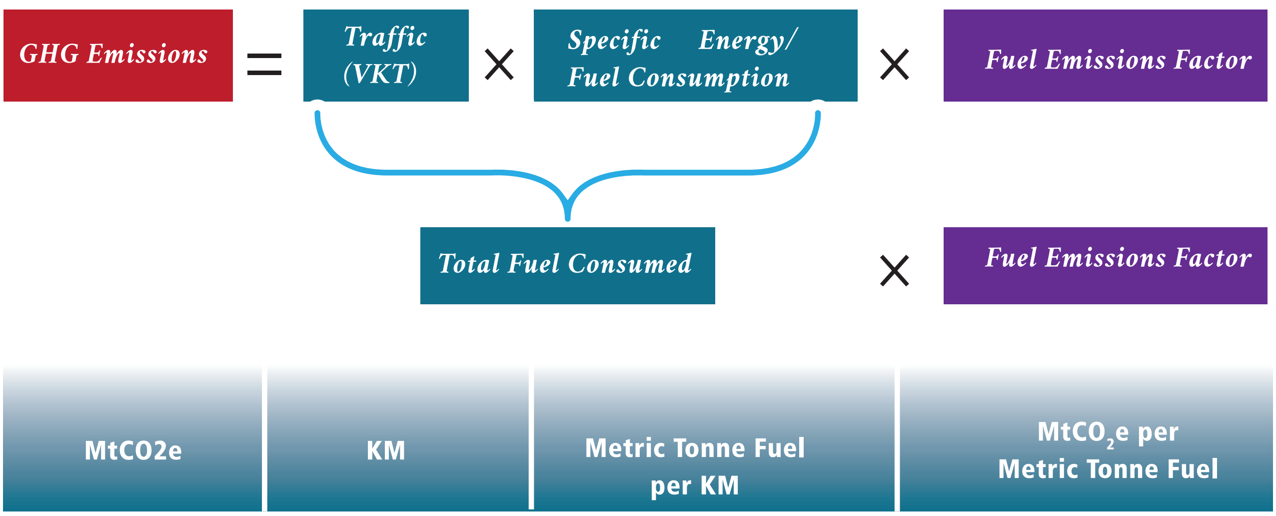
The details of the stakeholder consultation and country visits have been provided in Annexure I.

Review of GHG emission models

The consultant critically reviewed three GHG emission models (GIZ, UNFCCC, Northern Corridor) with respect to approach and methodology followed, GHG emission calculations, data requirements, robustness, transparency, comprehensiveness and compliance to international standards.

GIZ Methodology for Kenya's Transport Sector (2018-2019) GIZ GHG emission model uses the following internationally accepted framework for GHG emission calculations.

Figure 5 : GHG emissions model framework



The GIZ GHG emission model is transparent, comparatively simple and is in compliance with international standards; however, the GIZ GHG emission model has the following limitations with respect to robustness and comprehensiveness:

- The goods vehicles are not categorised (like LCV, MCV, and HGV) in the methodology.
- The model does not account for freight volume which is an essential factor influencing GHG emissions
- The main aim of the GIZ emission model was to develop local emission factors for the transport sector. Although the GIZ study collected much information on fuel consumption, the GIZ team realised that the findings on fuel consumption were not reliable since they were not based on recorded data but estimates. Hence, the GIZ team used fuel consumption and emissions factor data published in the "Handbook Emission Factors for Road Transport (HBEFA 3.3)" and customised to local conditions.

Even though the GIZ GHG emission model uses an internationally accepted framework, considering the above limitations, it was decided to explore other GHG emission models.

UNFCCC GHG Emission Model

United Nations Framework Convention on Climate Change (UNFCCC) is the global apex body for climate change and is an internationally well-recognised organisation working on climate change-related areas.

UNFCCC has developed a methodology to calculate GHG emission for freight transport "Approved small scale methodology, AMS.III.AT (version 02.0); EB 66, for freight vehicles".

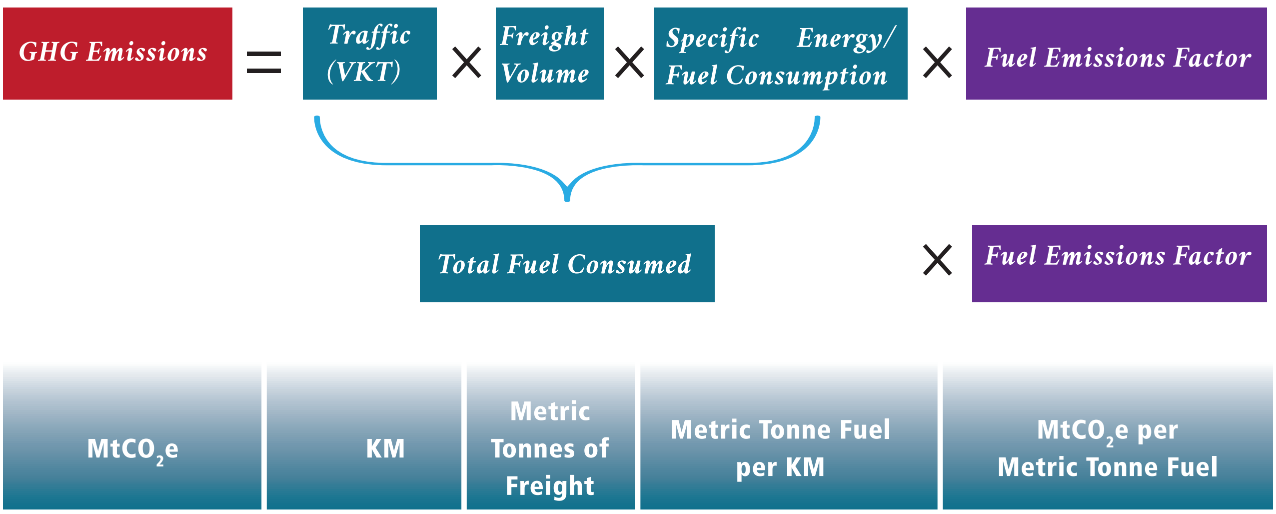
UNFCCC GHG emission model uses the following internationally accepted framework for GHG emission calculations.

The UNFCCC GHG emission model considers freight volume, which is one of the essential factors for calculating GHG emissions. The UNFCCC GHG emission model is very transparent and complies with international standards. The UNFCCC GHG emission model is more comprehensive and robust compared to the GIZ GHG emission model; however, the UNFCCC GHG emission model has the following limitations with respect to comprehensiveness:

- Lack of provision for empty return trips in GHG emission model: Based on discussions with TMEA and the corridor team, all the countries in the EAC import goods from the port. The volume of imported goods is more than exported goods (for example in Northern Corridor, export goods forms only 13% of total traded goods)(Northern Corridor Transit and Transport coordination Authority June 2019) hence during return trip of trucks carrying import goods, the proportion of empty trucks is high. The UNFCCC GHG emission model does not have the provision for empty return trips.

Even though the UNFCCC GHG emission model is more comprehensive and robust as compared to GIZ GHG emission model, considering the above limitation of lack of provision for empty return trips, it was decided to explore other GHG emission models.

Figure 6 : UNFCCC GHG Emission Model Framework

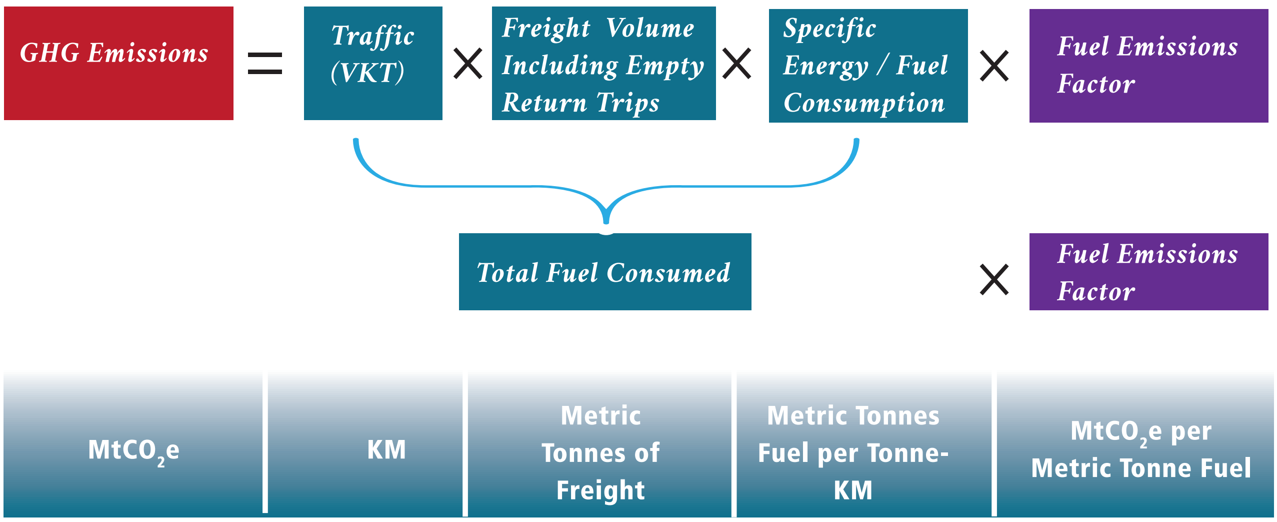


Northern Corridor GHG Emission Model

Northern Corridor GHG Emission Model (NCEM) is based on the following internationally proclaimed framework of IPCC Guidelines for the National Greenhouse Gas inventories, 2006 for GHG emission estimations.

The various components of the GHG model like GHG inventory boundary, reporting period, GHGs to be considered for accounting purpose, GHG emission scope was discussed in detail with TMEA, the corridor teams and was finalised. The details of the components of the GHG model have been provided in Section1.2.

Figure 7 : Northern Corridor GHG Emission Model



Although the Northern Corridor GHG Emission Model (NCEM) is very robust and comprehensive and also, considers categorisation of the vehicle (like LCV, MCV, HGV), freight volume and empty return trips of a goods vehicle, the model does not use local fuel efficiency data and uses the fuel efficiency data sourced from HBEFA 3.3. Even though the model uses global fuel efficiency data, it has been customised to local conditions by considering factors like pavement condition of the road, the average speed of the vehicles, and the number of lanes. The Northern Corridor GHG emission model is based on an internationally accepted IPCC framework and is more robust and comprehensive; hence it was decided to use the Northern Corridor GHG emission model with some customisation. The Northern Corridor GHG emission model is customised for local conditions by using local fuel efficiency value. The data like pavement condition of roads, the average speed of vehicles, and the number of lanes would not be used for GHG emission calculations. However, these data would be used for identifying climate mitigation projects like improving pavement conditions, increasing number of lanes, training or capacity building programs for drivers on optimal vehicle speed which can help in reducing GHG emissions of the corridors.

Activity 3: Develop Forms and Template for Data Collection

The consultant has developed a data collection template and shared with Northern and Central Corridors for data collection. The data collection template is provided in Annexure III, and also a survey questionnaire was developed and shared with the corridor team, which is annexed to this report (Annexure-II).To estimate GHG emissions, the newly developed excel based model requires many data sets which is a combination of on-ground data, observatory data and globally accepted default IPCC values. The corridors have provided the required data from corridor observatory and on-ground survey. The details of the received data are mentioned below:

1. The respective corridor observatories have captured data like import and export data, daily truck traffic, average loading, and loading compliance.
2. During the study, the Northern Corridor has carried out a comprehensive on-ground survey with truck drivers and freight operators covering 4,800 trucks of different categories considering the following aspects:

a. Different truck categories

i. LCV- 2,
ii. MCV- 3 & 4,
iii. HGV- 5,6,7,8,9&10

b. Different routes representing different countries

c. Different vehicle make

d. The gross weight of different category of truck
i. 2 axle -18 to 20 tonnes
ii. 3 axle - 28 to 30 tonnes
iii. 4 axle - 36 to 40 tonnes
iv. 5 axle - 48 to 50 tonnes
v. 6/7/8/9/10 axle – 50 to 54 tonnes

e. Fuel consumption (loaded and empty trips)

f. Average age

g. Average speed

h. Type of load
i. Containerised
ii. Tanker
iii. Tipper
iv. Box body
v. Loose cargo
vi. Special cargo

3. The survey has provided two main results- fuel efficiency and proportion of return loaded and empty trips as given below -

Table 4: Northern Corridor fuel efficiency data obtained from the survey

No. of axle	Fuel efficiency for a loaded vehicle (in km/l)	Fuel efficiency for an empty vehicle (in km/l)
2	3.66	5.4
3	2.12	3.53
4	1.8	3.2
5	1.4	2.65
6	1.35	2.42
7	1.2	1.95
8	1.2	1.95
9	1.2	1.95
10	1.2	1.95

Table 5: Central Corridor fuel efficiency data

No. of axle	Fuel efficiency for a loaded vehicle (in km/l)	Fuel efficiency for an empty vehicle (in km/l)
4	1.8	3.2

As the export is only 14% of the total trade, a higher proportion of empty return trips are estimated. Based on the survey conducted by the Northern Corridor, it was found that during the return journey, nearly 30% of trucks were loaded and 70% of the trucks were empty.

The survey results have been utilised to build a more reliable baseline for the model prepared for the GHG emissions in the corridor for the year 2018.

Work-Stream 3: Prepare the GHG Inventory Report

Activity 1: Data collection and Data compilation

The consultant has worked closely with the corridors on the GHG emission model and in identifying the data requirements for the model. Any data assumptions taken in the model has been discussed in detail with TMEA and corridor teams. In general, preference has been given to local/ national data and the data from publicly available, peer-reviewed and reputable sources like government publications. In the absence of local data, international data sources like IPCC has been used in the model - for data like net calorific value of fuel used in trucks (energy content of fuel/quantity of fuel), CO_2 emission factor of fuel used in trucks ($MtCO_2$/energy content of fuel), the IPCC default values have been applied.

After receiving the comprehensive data from the corridors, the GHG emission model has been updated accordingly.

The details of the data used for calculating GHG emissions of the corridor are provided in section 1.2.

Activity 2: Managing the Inventory Quality and Verification

The GHG emission model requires various data sourced from corridor observatory, ground-level survey, reports and documents. Hence, there is the requirement of carrying out Quality Assurance (QA) and Quality Control (QC) on data acquiring process, acquired data and model in order to have completeness and to make the model more robust.

Two levels of QC checks were conducted by GHG expert and Team lead to ascertain the QA/QC procedure. The details of QA/ QC carried out are provided in Annexure – V.

Verification involves an assessment of the completeness and accuracy of reported data. TMEA may choose to verify the data to demonstrate that calculations are in accordance with the methodology adopted and provide confidence to users that the reported GHG emissions are a fair reflection of a corridor's activities. Verification can be self-verification or can be performed by an independent organisation (third-party verification).

Activity 3: Prepare the GHG Inventory Report

Based on the results of the GHG emission model, the consultant had prepared a GHG accounting report and shared with TMEA, NCTTCA and CCTTFA for review and feedback. Based on their comments, the consultants have finalised the GHG accounting report, GHG emission tool and have shared with TMEA.

Work-stream 4: Conduct Validation workshop on GHG accounting Report

In August 2020, an online validation workshop is proposed in which the consultant team will present the GHG emission results to all relevant stakeholders - TMEA, NCTTCA, CCTTFA, Ministry officials of member countries and validate the results and finalise the GHG emission model. In consultation with TMEA and corridor teams, the consultants will map all the relevant stakeholders for validation workshop and planning of action programme for each participating country and the corridors. The consultant will prepare comprehensive training modules for the workshop to raise awareness and knowledge about the methodological approach towards GHG accounting, the data collection method adopted and the preparation of GHG accounting. The training modules will be handed over to TMEA, NCTTCA and CCTTFA.

1.2. Description of the Methodology

1.2.1. Selection of Inventory Boundary

The geographical boundary of GHG inventory will be the Northern and Central Corridors. Detailed consultations with relevant ministries and departments of member countries like Tanzania, Uganda, Rwanda, Burundi and Kenya were carried out. The consultations did not include visits to DRC and South Sudan. The routes which are currently considered for calculating GHG emissions of corridors are given below and the routes considered were based upon discussion with TMEA and the corridor teams. Based on availability of data, more routes/sections can be considered for GHG emission calculations in future.

Figure 8: Route for Northern Corridor (Northern Corridor Transport Observatory n.d.)

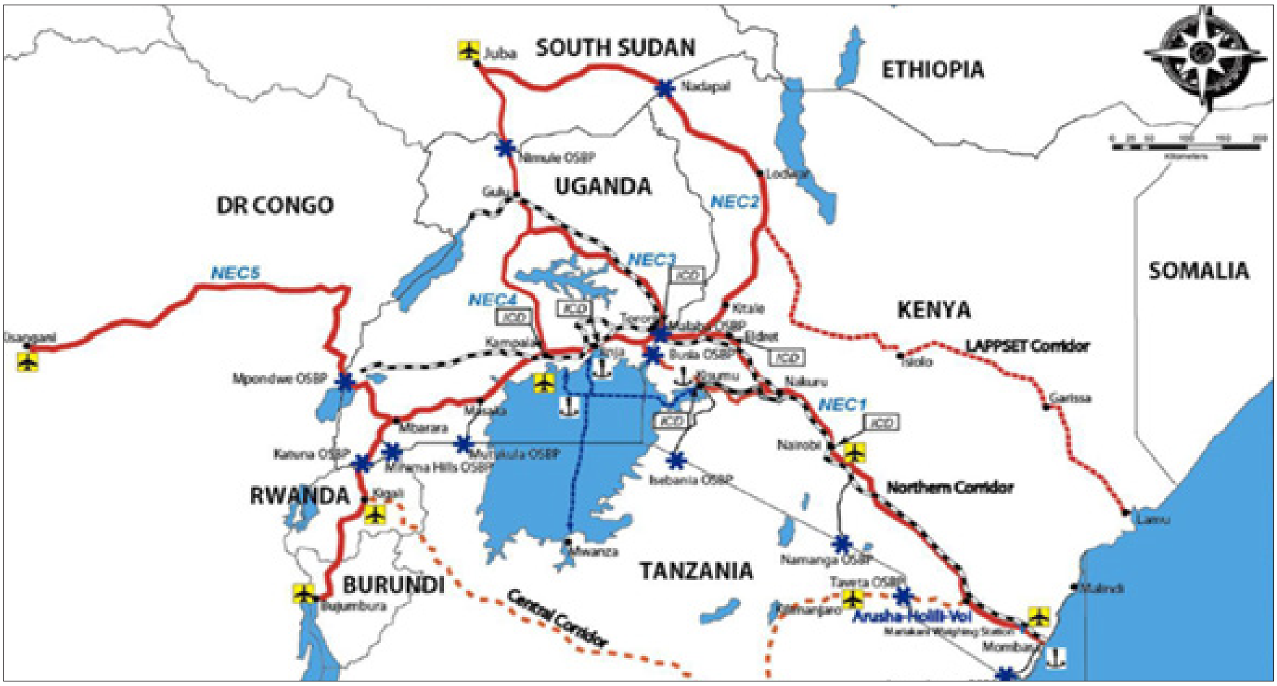


Table 6: Routes of Northern Corridor considered for GHG emission calculations

Sl. No	Routes/Sections		Origin country	Destination country
1.	Mombasa	Nairobi	Kenya	Kenya
2.	Mombasa	Busia	Kenya	Kenya
3.	Mombasa	Malaba	Kenya	Kenya
4.	Nairobi	Busia	Kenya	Kenya
5.	Nairobi	Malaba	Kenya	Kenya
6.	Busitema	Malaba	Uganda	Kenya
7.	Busitema	Busia	Uganda	Kenya
8.	Mbale	Malaba	Uganda	Kenya
9.	Busitema	Kampala	Uganda	Uganda
10.	Kampala	Lukaya	Uganda	Uganda
11.	Lukaya	Mbarara	Uganda	Uganda
12.	Kampala	Luwero	Uganda	Uganda
13.	Kampala	Mupende	Uganda	Uganda

Sl. No	Routes/Sections		Origin country	Destination country
14.	Mbale	Goli	Uganda	Uganda
15.	Mbale	Elegu	Uganda	Uganda
16.	Luwero	Elegu	Uganda	Uganda
17.	Luwero	Goli	Uganda	Uganda
18.	Mubende	Kasindi	Uganda	Uganda
19.	Mbarara	Kasindi	Uganda	Uganda
20.	Mbarara	Gatuna	Uganda	Uganda
21.	Kasindi	Beni	DR Congo	DR Congo
22.	Kasindi	Butombe	DR Congo	DR Congo
23.	Goli	Bunia	DR Congo	DR Congo
24.	Gatuna	Kigali	Rwanda	Rwanda
25.	Elugu	Juba	South Sudan	South Sudan

Figure 9: Route for Central Corridor (Central Corridor Transit Transport Facilitation Agency n.d.)

Table 7: Routes of Central Corridor considered for GHG emission calculations

Sl. No	Routes/Sections		Origin country	Destination country
1.	Dar-es-Salaam	Morogoro	Tanzania	Tanzania
2.	Morogoro	Isaka	Tanzania	Tanzania
3.	Isaka	Rusumo/ Rusumo	Tanzania	Rwanda
4.	Isaka	Kabanga/ Kobero	Tanzania	Burundi
5.	Isaka	Mwanza	Tanzania	Tanzania
6.	Lusahunga	Mutukula	Tanzania	Uganda
7.	Mutukula	Kampala	Uganda	Tanzania
8.	Kabanga	Bujumbura	Tanzania	Burundi
9.	Rusumo	Kigali	Rwanda	Rwanda
10.	Kigali	Goma	Rwanda	DR Congo
11.	Kigali	Bukavu	Rwanda	DR Congo

1.2.2. Reporting Period of the Inventory

Based on the availability of the data, it was suggested that the baseline year to be Jan-2018 to Dec 2018.

1.2.3. Greenhouse Gases Reported

IPCC identifies following GHGs to be reported for GHG accounting purpose:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulfur hexafluoride (SF6)
- Nitrogen trifluoride (NF3)[1]

[1] Nitrogen trifluoride (NF_3) is the seventh GHG to the international accounting and reporting rules under the UNFCCC/Kyoto Protocol as per the added under the Doha amendment to the Kyoto Protocol; applies only from the beginning of the second commitment period i.e. year 2012.

All GHGs (CO_2, CH_4, and N_2O) emitted from freight transport has been considered; however, Carbon Dioxide (CO_2) is the main greenhouse gas. The GHG accounting study provides the total GHG emissions in tonnes of carbon dioxide equivalents ($MtCO_2e$) emitted from Northern and Central Corridors. This includes indirect greenhouse gases like Non-Methane Volatile Organic Compounds (NMVOC), Carbon Monoxide (CO), Nitrogen Oxides (NO_X) and Sulphur Dioxide (SO_2).

1.2.4. GHG Emission Sources Reported

The sectoral boundary of GHG inventory is road freight sector and, it covers three sizes of trucks such as Light Commercial Vehicle (LCV), Medium Commercial Vehicle (MCV) and Heavy Goods Vehicle (HGV).

1.2.5. GHG Emissions Scope and Category

International GHG protocols suggest comprehensive reporting of all GHG emissions attributable to activities taking place within the geographic boundary by categorising the emission sources into in-boundary sources (scope 1, or "territorial"), grid-supplied energy sources (scope 2), and out-of-boundary sources (scope 3).

By applying the same principles to the proposed project, the scopes are as follows:

Table 8: Scope of GHG Accounting

Sl. No	Scope	Definition
1.	Scope 1	GHG emissions from freight transport on the selected boundary
2.	Scope 2	GHG emissions occurring because of the use of grid-supplied electricity for electric vehicles used for freight and plying with the selected boundary
3.	Scope 3	All other GHG emissions that occur outside the boundary because of activities taking place within the selected boundary

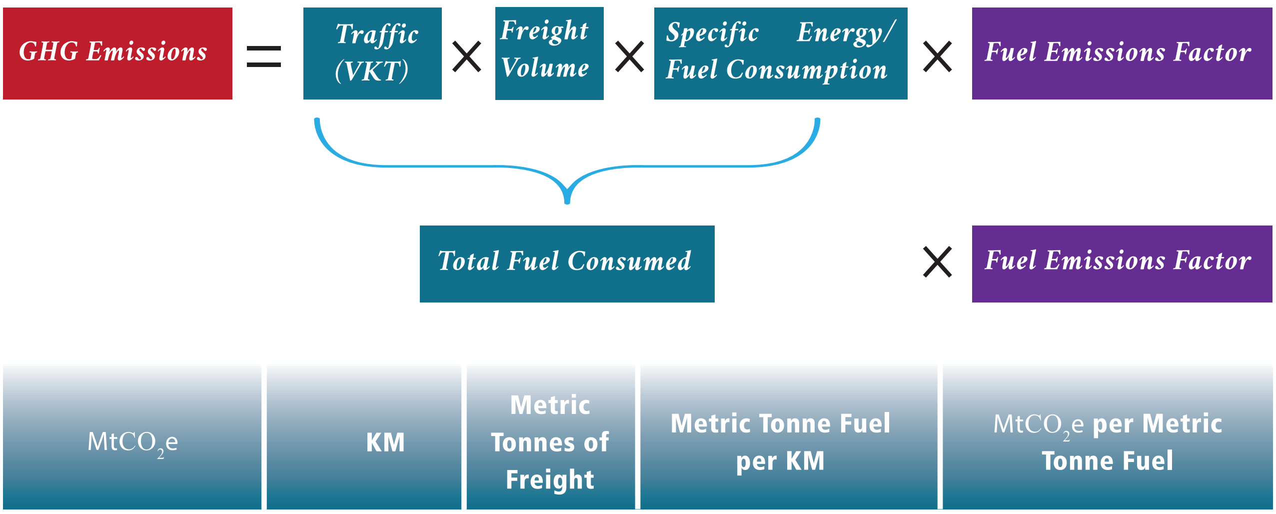
Source: (World Business Council for Sustainable Development (WBCSD), World Resources Institute (WRI) 2004)

Based on discussions it was decided to account for only Scope 1 emissions.

1.2.6. GHG Inventory Reporting Framework

The GHG inventory reporting framework is based on the bottom-up approach in which GHG emissions are calculated based upon the vehicle kilometre travelled, freight volume and fuel efficiency. The framework broadly used to calculate GHG emissions across various vehicle categories in the corridor is as depicted in the figure below:

Figure 10: GHG Accounting Framework (Intergovernmental Panel on Climate Change (IPCC) 2006)



1.3. Data Capture and Calculation Methodology

The GHG emission calculations of the corridors are carried out based on GHG accounting framework (explained in section 1.2.6) and are in line with the IPCC guidelines. Based on the GHG accounting framework, data requirements were identified and discussed with TMEA and corridor teams. The following table provides the details of the data required for GHG emission calculations and its nomenclature and the possible data sources. More details about data requirement and GHG emission calculation methodology is provided in Annexure – III and Annexure – IV of the report, respectively.

Table 9: List of data required for GHG emission model

Data monitored for GHG emissions model	Nomenclature	Source
Vehicle categorisation according to axle	LCV - 2 axles MCV – 3 & 4 axles HGV - 5,6,7,8,9 &10 axles	The vehicles are classified as per the East African Community Vehicle Load Control Act, 2016 and weighbridge data by the corridor observatory
Average annual daily traffic (number of vehicles by category (Light, Medium and Heavy commercial vehicles)	$AADT_{LCV/MCV/HGV}$	The average annual daily traffic is sourced from the corridor observatory
Length of corridor (km)	Length of the corridor	The length of corridor is sourced from corridor observatory
Average weight of trucks by vehicle category (tonnes)	Average weight of LCV/MCV/HGV	The actual weight of the trucks are sourced from a survey conducted by Corridor Transit and Transport Coordination Authority
Fuel efficiency data of trucks by vehicle category (km/litre)	$FE_{LCV/MCV/HGV}$	The actual fuel efficiency of trucks is obtained from the survey conducted by NCTTCA
Net calorific value of the fuel used in trucks (TJ/Gg)	NCV_{Diesel}	Net calorific value of diesel is sourced from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2- chapter 1, (Page 1.18)
GHGs (CO_2, N_2O, CH_4) emission factor of fuel used in trucks ($MtCO_2$/TJ)	EF_{CO_2}, EF_{N_2O}, EF_{CH_4}	CO_2, N_2O & CH_4 emission factor of the fuel is sourced from IPCC guidelines for National Greenhouse Gas Inventories, Volume 2- Energy, Chapter 3 Mobile Combustion (Page no 3.16)
Pollutants (CO, VOC, NOx, PM) emission factor of fuel used in trucks (g/kg of fuel)	EF_{CO}, EF_{VOC}, EF_{NO_x}, EF_{PM}	Pollutants (CO, VOC, NOx, PM) emission factor for fuel is Sourced from EMEP EEA Air Pollutant Emission Inventory Guidebook, 2016, Part B Sectoral guidance chapters, chapter 1 Energy
Global warming potential of CH_4 and N_2O	PRP_{CH_4}, PRP_{N_2O}	The Global warming potential of CH_4 and N_2O are sourced from IPCC Fifth Assessment Climate Change 2013- The Physical Science Basis, Chapter 8

1.3.1. Emission Factors

The IPCC protocol gives importance to the locally available data like local emissions factors. Hence for the study, the consultant had carried out a comprehensive review of various documents like National Communications (NATCOM) report, Nationally Determined Contributions (NDC); National GHG emission reports etc., of member countries and also carried out extensive consultations with ministry of transport and ministry of environment of member countries. Based on the desk research and consultations, it was inferred that country-specific values like emissions factors, net calorific value etc. for fuel was not available. It was also observed that in NATCOM reports, IPCC default value had been considered for fuel emission factor and net calorific value. Hence for GHG emission calculation, the consultant has considered IPCC default values (1996, 2000, 2003, 2006 and 2014) for fuel emission factor and net calorific value.

Table 10: Type of emission factors

Type of emission factor	CO_2 ($MtCO_2$/TJ)	CH_4 (Kg/TJ)	N_2O (Kg/TJ)
Fuel emission factor	74.1	3.9	3.9
Source	IPCC default value	IPCC default value	IPCC default value

Source: (Intergovernmental Panel on Climate Change (IPCC) 2006)

1.3.2. Global Warming Potential

Global warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas to the amount of heat trapped by a similar mass of carbon dioxide.

GWP is an important measure to highlight the effect of an individual gas on the environment compared to a unit emission of CO_2. The GWP of various GHGs is shown in the table below:

Table 11: Global warming potential of GHG's

Gas	Global warming potential (GWP) relative to CO_2	Source
Carbon Dioxide (CO_2)	1	The global warming potential of GHG's are sourced from IPCC Fifth Assessment Climate Change 2013- The Physical Science Basis, Chapter 8
Methane (CH_4)	28	
Nitrous Oxide (N_2O)	265	
Hydro fluorocarbons (HFC-134a)	1,300	
Hydro fluorocarbons (HFC-23)	12,400	
Tetrafluoromethane (CF_4)	6,630	
Hexafluoroethane (C_2F_6)	11,100	
Sulphur Hexafluoride (SF_6)	23,500	

Source: (Intergovernmental Panel on Climate Change (IPCC) 2013)

1.3.3. Activity Data, Emission Factors, and Methodological Tiers Used

Activity data (AD): *"Activity data is a quantitative measure of a level of activity that results in GHG emissions taking place during a given period of time (e.g. volume of gas used, kilometres are driven, tonnes of waste sent to landfill, etc.)"*.(WRI, C40 Cities, ICLEI n.d.)

The activity data used in GHG emission model is provided below:

1. The observatory monitors the annual average daily traffic (AADT) vehicle category wise (Light, Medium and Heavy Commercial Vehicle) covering all the sections listed by NCTTCA and CCTTFA.
2. The observatory is monitoring the length of the route/ section data, and the same has been used in the GHG emission model.
3. The routes considered for calculation of Northern and Central Corridors has been detailed out in the section 1.2.1.
4. The fuel efficiency/consumption data (km/litre) of trucks by vehicle category has been obtained through the survey with Transporters by NCTTCA. Northern Corridor has carried out a comprehensive survey covering 4800 trucks considering the following aspects;

a. Different truck categories
   i. LCV- 2,
   ii. MCV- 3 & 4,
   iii. HGV- 5,6,7,8,9&10
b. Different routes representing different countries.
c. Different vehicle make
d. The gross weight of different category of truck
   i. 2 axle -18 to 20 tonnes
   ii. 3 axle - 28 to 30 tonnes
   iii. 4 axle - 36 to 40 tonnes
   iv. 5 axle - 48 to 50 tonnes
   v. 6/7/8/9/10 axle – 50 to 54 tonnes
e. Fuel consumption (loaded and empty trips)
f. Average age
g. Average speed
h. Type of load
   i. Containerised
   ii. Tanker
   iii. Tipper
   iv. Box body
   v. Loose cargo
   vi. Special cargo

As a quality assurance and quality control procedure, the outcome of the survey- fuel efficiency of the trucks has been compared with fuel efficiency figures of GIZ study and fuel efficiency figures of a study conducted by Jomo Kenyatta University of Agriculture and Technology (X. F. David Odeyo Abiero 2015); and it was found that the fuel efficiency was comparable with both the studies. Hence this data was used for the GHG emission model.

For GHG emission estimations for Central Corridor, the fuel efficiency/consumption data (km/litre) obtained from a survey of Northern Corridor was used.

5. The proportion of empty and loaded return journey by the trucks has been obtained through the survey with transporters by Northern Corridor observatory team and cross-verified from trade (import/ export) related data of corridor observatory. The trade-related data captured by Northern Corridor observatory is given below in the table.

Table 12: Import and export data of Northern Corridor for the year 2018

Country	Imports (weight in metric tonnes)	Exports (weight in metric tonnes)
Uganda	7,417,307	471,812
Burundi	20,610	1,623
Rwanda	219,650	11,084
South Sudan	563,663	170,469
DR Congo	413,249	57,719
Kenya	16,601,544	3,393,894
Total Import/ export	25,236,023	4,106,601
Total Import/ export in percentage	86%	14%
Total Trade		29,342,624

Table 13: Import and export data of Central Corridor for the year 2018

Country	Imports (weight in metric tonnes)	Exports (weight in metric tonnes)
Burundi	366,515	13,189
D.R Congo	1,239,780	539,837
Others	1,575,778	337,917
Rwanda	881,949	29,921
Tanzania	8,307,087	1,144,490
Uganda	188,433	158
Total Import/ export	12,559,542	2,065,512
Total Import/ export in percentage	86%	14%
Total Trade		14,625,054

As the export is only 14% of the total trade, a higher proportion of empty return trips are estimated. Based on the survey conducted by the Northern Corridor, it was found that during the return journey, nearly 30% of trucks were loaded and 70% of the trucks were empty. Considering the facts that during the return journey the trucks travel from different countries and the trucks may not be fully loaded (partially or under loaded), the data (on empty return trips) obtained from the survey found to be more practical and accurate hence used for GHG emission calculations.

Using the above activity data, GHG emission estimates for different sections of the corridors is calculated in the current version of the GHG emission Model. For illustrative purpose, the activity data details of one route in each corridor used in the current version of the GHG emission model are tabulated below. For more details on the data used, please refer to the GHG emission calculation sheets of Northern and Central Corridors.

Table 14: Activity data details Northern Corridor Route- Mbale –Malaba

Data required for GHG emissions model	Northern Corridor: Mbale - Malaba			Source of data/ method for cross check:
Average annual daily traffic of LCV for transporting goods	Onwards – loaded	Return journey (loaded)	Return journey (empty)	Northern Corridor observatory data This data has been sourced by Northern Corridor from weighbridges. Where ever, after the weighbridge the corridor splits into 2-3 routes, expert opinion (from corridor team) was taken to allocate the traffic to different routes.
	26 (2 axle)	8 (2 axle)	18 (2 axle)	
Average annual daily traffic of MCV for transporting goods	Onwards – loaded	Return journey (loaded)	Return journey (empty)	Northern Corridor observatory data This data has been sourced by Northern Corridor from weighbridges. Where ever, after the weighbridge the corridor splits into 2-3 routes, expert opinion (from corridor team) was taken to allocate the traffic to different routes.
	9 (3&4 axle)	3 (3&4 axle)	6 (3&4 axle)	
Average annual daily traffic of HGV for transporting goods	Onwards – loaded	Return journey (loaded)	Return journey (empty)	Northern Corridor observatory data This data has been sourced by Northern Corridor from weighbridges. Where ever, after the weighbridge the corridor splits into 2-3 routes, expert opinion (from corridor team) was taken to allocate the traffic to different routes.
	115 (5,6,7,8,9 &10 axle)	35 (5,6,7,8,9 &10 axle)	81 (5,6,7,8,9 &10 axle)	
Length of corridor (km)	52			The length of corridor is sourced from - Northern Corridor Transport Observatory Report, Chapter 6 Quality of Infrastructure
The average weight of trucks by vehicle category (tonnes)	LCV:	MCV:	HGV:	The actual weight of the trucks are sourced from a survey conducted by Northern Corridor Transit and Transport Coordination Authority
	14	25	44	
Fuel efficiency/ consumption data of trucks by vehicle category (km/litre)	LCV:	MCV:	HGV:	The Fuel efficiency/consumption data (km/litre) of trucks by vehicle category has been sourced through the survey with Transporters by Northern Corridor observatory team
	Loaded: 3.6 Empty: 5.4	Loaded: 2 Empty: 3.3	Loaded: 1.2 Empty: 2.1	
Density of diesel (kg/l)	0.843			HBEFA value
Net calorific value of the fuel used in trucks	43			Net calorific value of diesel is sourced from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2- chapter 1,
Global warming potential CH_4	28			The global warming potential of CH_4 is sourced from IPCC Fifth Assessment Climate Change 2013- The Physical Science Basis, Chapter 8
Global warming potential	265			The global warming potential of N_2O is sourced from IPCC Fifth Assessment Climate Change 2013- The Physical Science Basis, Chapter 8

Table 15: Activity data details Central Corridor- Dar es Salaam-Morogoro

Data required for GHG emissions model	Central Corridor: Dar es Salaam- Morogoro			Source of data/ method for cross check:
Average annual daily traffic of HGV for transporting goods	Onwards – loaded	Return journey (loaded)	Return journey (empty)	Central Corridor Transport Observatory data
	1,048	314	734	
Length of corridor (km)			196	The length of corridor is sourced from Central Corridor Transport Observatory
Average weight of trucks by vehicle category (tonnes)	LCV:	MCV:	HGV:	
	-	-	30	Central Corridor Transport Observatory data
Fuel efficiency/ consumption data of trucks by vehicle category (km/litre)	LCV:	MCV:	HGV:	The Fuel efficiency/consumption data (km/litre) of trucks by vehicle category has been sourced through the survey with Transporters by Northern Corridor observatory team
			Loaded: 1.8 Empty: 3.2	
Density of diesel (kg/l)			0.843	HBEFA value
Net calorific value of the fuel used in trucks			43	Net calorific value of diesel is sourced from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2- chapter 1,
Global warming potential CH_4			28	The global warming potential of CH_4 is sourced from IPCC Fifth Assessment Climate Change 2013- The Physical Science Basis, Chapter 8
Global warming potential			265	The global warming potential of N_2O is sourced from IPCC Fifth Assessment Climate Change 2013- The Physical Science Basis, Chapter 8

Emission factors:

Based on the desk research and consultations, it was inferred that country-specific values like emission factor, net calorific value etc. for fuel was not available. Also, in NATCOM reports, IPCC default value has been considered for fuel emission factor (CO_2, CH_4, and N_2O) and the pollutant (CO, VOC, PM, NO_X) emission factor data has been taken from European Monitoring and Evaluation Programme European Environment Agency (EMEP EEA). Hence for GHG emission calculation, the consultant has considered IPCC default values (1996, 2000, 2003, 2006 and 2014) for fuel emission factor and net calorific value and EMEP EEA for pollutant emission factor.

Table 16: Emission factors for the Corridors

Data required for GHG emissions model Central Corridor:	Values	Source of data/ method for cross check:
CO_2 emission factor for diesel ($MtCO_2$/TJ)	74.1	CO_2 emission factor of the fuel is sourced from IPCC guidelines for National Greenhouse Gas Inventories, Volume 2- Energy, Chapter 3 Mobile Combustion
CH_4 emission factor for diesel (kg/ TJ)	3.9	CH_4 emission factor of the fuel is sourced from IPCC guidelines for National Greenhouse Gas Inventories, Volume 2- Energy, Chapter 3 Mobile Combustion
N_2O emission factor for diesel (kg/ TJ)	3.9	N_2O emission factor of the fuel is sourced from IPCC guidelines for National Greenhouse Gas Inventories, Volume 2- Energy, Chapter 3 Mobile Combustion

Data required for GHG emissions model Central Corridor:	Values	Source of data/ method for cross check:
CO emission factor for diesel (g/kg of fuel)	7.58	EMEP/EEA air pollutant emission inventory guide book 20 Part B Sectoral guidance chapters, chapter 1 Energy
VOC emission factor for diesel (g/kg of fuel)	1.92	EMEP/EEA air pollutant emission inventory guide book 2019, Part B Sectoral guidance chapters, chapter 1 Energy
NO_x emission factor for diesel (g/kg of fuel)	33.37	EMEP/EEA air pollutant emission inventory guide book 2019, Part B Sectoral guidance chapters, chapter 1 Energy
PM emission factor for diesel (g/kg of fuel)	0.94	EMEP/EEA air pollutant emission inventory guide book 2019, Part B Sectoral guidance chapters, chapter 1 Energy

Methodology:

The GHG emission methodology of the corridors is based on the bottom-up approach and is in line with the IPCC guidelines. While selecting the methodology, the principles of relevance, completeness, consistency, transparency and accuracy were considered. More details on the selection of the methodology have been provided in Section 1.1.4.

For a comprehensive, complete, comparable, transparent, and accurate coverage, to the extent capacities permit, the methodology used follows the IPCC Revised Guidelines 1996, supported by the IPCC Good Practice Guidance (GPG) 2000 and 2003.

Quality assurance and quality control procedures:

A QA/QC plan was developed, which took into account the quality data, the cycle of inventory preparation and adherence to that plan. The QC procedure checklist in line with the general inventory level QC procedures of the UNFCCC GPG 2000 and IPCC GPG, 2000 was prepared and is provided in Annexure V. The consultant completed the checklists during the period of data collection and GHG inventory preparation.

Two levels of QC checks were conducted GHG experts; sector expert and team lead to ascertain the QA/QC procedure. The general QA/QC checks for all inventory preparations include cross-checking the reliability of the activity data collected from the primary and secondary sources for proper documentation and record; cross-checking for transcription errors in the activity data; consistency, completeness, and integrity of the database; documentation and reporting of the rationale of assumptions used for activity data; documentation and reporting of gaps in the database; consistency in the labelling of units in ensuing calculations; and completeness checks on the reported data sets for designated years.

CHAPTER TWO: RESULTS

2.1 Greenhouse Gas Emissions

Based on the GHG emission calculation methodology explained in section 1.2 and Annexure – IV, the GHG emissions of the corridors has been calculated, and the summary of results from GHG emission calculation has been provided in this chapter.

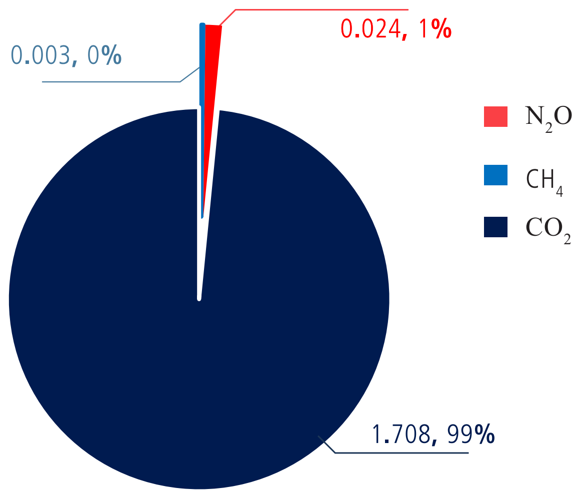
The estimated total GHG emission of the Northern Corridor is 1.734 $MMtCO_2e$ and the estimated total GHG emissions of the Central Corridor is 1.23$MMtCO_2e$. The GHG emission intensity of Northern Corridor is 73 gCO_2/tonne-km, and the Central Corridor is 91 gCO_2/tonne-km.

1. Estimated Total GHG Emissions of the Northern and Central Corridors - Breakup GHG wise (CO_2, CH , and N O)

The estimated total GHG emission comprises of three major GHGs, namely Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O). Among the GHGs, CO_2 contributes the major emissions followed by N_2O and CH_4.

In the Northern Corridor, CO_2 emissions account for about 98.75% (1.708 $MMtCO_2e$) followed by N_2O emissions 1.374% (0.024 $MMtCO_2e$) and CH_4 emissions is comparatively very small. The GHG wise break up of estimated total GHG emission of Northern Corridor is depicted in the below figure.

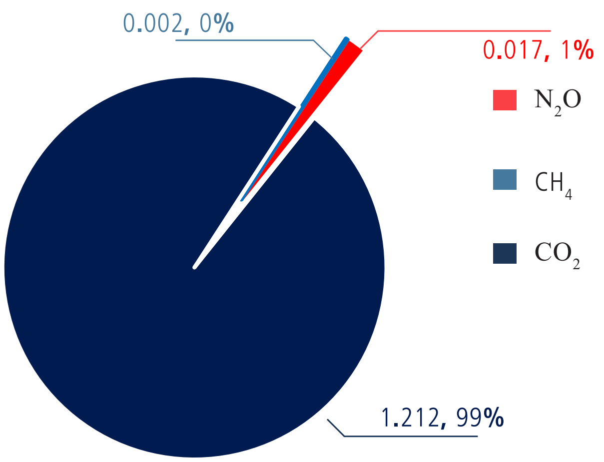
Figure 11: Estimated total GHG emissions of Northern Corridor - Breakup GHG wise (In million tonnes)



A similar trend is observed in the GHG emissions of Central Corridor, wherein CO_2 emissions account for about 99.00% (1.212 $MMtCO_2e$) followed by N_2O which is less than 1% (0.017 $MMtCO_2e$), and CH_4 emissions are comparatively minimal. The GHG wise break up of total estimated GHG emission of the Central Corridor is provided in below figure.

In both corridors CO_2 emissions accounted for significant emissions compared to other GHGs; hence the climate change mitigation measures which need to be planned for the corridors need to focus mainly on reducing CO_2 emissions.

Figure 12: Estimated total GHG emissions of Central Corridor - Breakup GHG wise (In million tonnes)



2. Total Pollutant Emissions of the Corridors- Breakup Pollutant wise (CO, NO_X, and VOC)

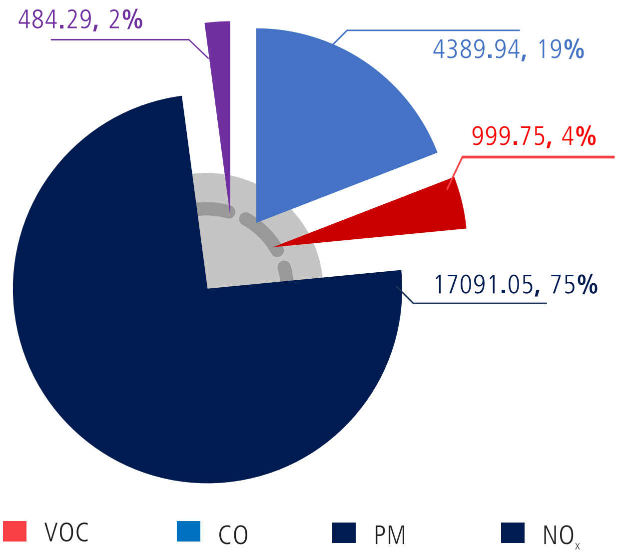
The major pollutants of the corridors are Nitrogen Oxides (NO_X), Particulate Matter (PM), Carbon Monoxide (CO) and Volatile Organic Compounds (VOC).

The estimated total quantity of pollutants in the Northern Corridor is 22,965.03 tonnes, out of which quantity of Nitrogen Oxides constitutes around 75 % (17,091.05 tonnes) of total quantity followed by CO-19% (4389.94 tonnes), VOC - 4% (999.75 tonnes) and PM- 2% (484.29 tonnes).

NCTTCA under Northern Corridor Green Freight Programme has adopted climate goals; one of the climate goals is to reduce Particulate Matter (PM), Black Carbon emissions and Oxides of Nitrogen (NO_X) grams per tonne-km by at least 10% by 2021.

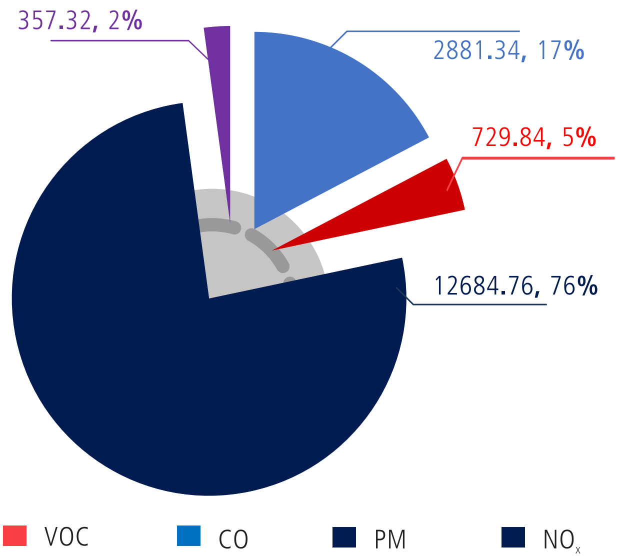
The below analysis would help NCTTCA in reviewing the current scenario of pollutant emissions against the targets.

Figure 13: Estimated total pollutant emissions of Northern Corridor - Pollutant wise



The estimated total quantity of pollutants in the Central Corridor is 16,653.26 tonnes, out of which quantity of Nitrogen Oxides constitutes around 76% (12,684.76 tonnes) of total quantity followed by CO-17% (2,881.34 tonnes), VOC- 5 % (729.84 tonnes) and PM- 2% (357.32 tonnes).

Figure 14: Estimated total pollutant emissions of Central Corridor - Pollutant wise



3. Estimated Total GHG Emissions of the Corridor - Breakup Section-wise (like Mombasa-Kampala, Mombasa – Nairobi etc.)

The details of routes/ sections which are currently considered for calculating GHG emissions of corridors are detailed out in section 1.2.1. Apart from calculating the GHG emissions for the entire corridor, route wise/ section wise GHG emissions were calculated to determine GHG intensive routes/ sections of the corridors.

After identifying, the top 5 or top 10 GHG intensive routes/ sections, corridors can prioritise the identification and implementation of climate change mitigation actions in these GHG intensive routes/sections. Any further studies on climate change mitigation actions or pilot climate change projects can be focused on these GHG intensive routes/ sections. Regular monitoring of GHG emissions can be carried out in these GHG intensive routes/ sections and based on the success of the climate change projects implemented in these routes/ sections; the projects can be replicated in other or lesser GHG intensive routes/sections.

In the Northern Corridor, the top 10 routes having maximum GHG emissions are Mombasa-Malaba, Mombasa-Nairobi, Mombasa-Busia, Nairobi-Busia, Busitema-Kampala, Luwero-Elegu, Luwero-Goli, Mbale-Goli, Mubende- Kasindi, and Mbale- Elegu. Out of 25 routes in Northern Corridor, these 10 routes constituted 86 % of estimated total GHG emissions of the corridor. Hence these routes are priority routes were climate change mitigation actions can be identified and implemented for reducing GHG emissions in the corridor.

The routes and sections have been divided country-wise for better comprehension and analysis, and details are figuratively represented below.

In Kenya, the top 3 GHG intensive routes are Mombasa-Malaba, Mombasa-Nairobi, and Mombasa-Busia. Meanwhile, in Uganda, the top 3 GHG intensive routes are Busitema-Kampala, Luwero-Elegu, and Luwero-Goli.

Figure 15: Total GHG emissions of Northern Corridor routes/ sections in Kenya - Section-wise

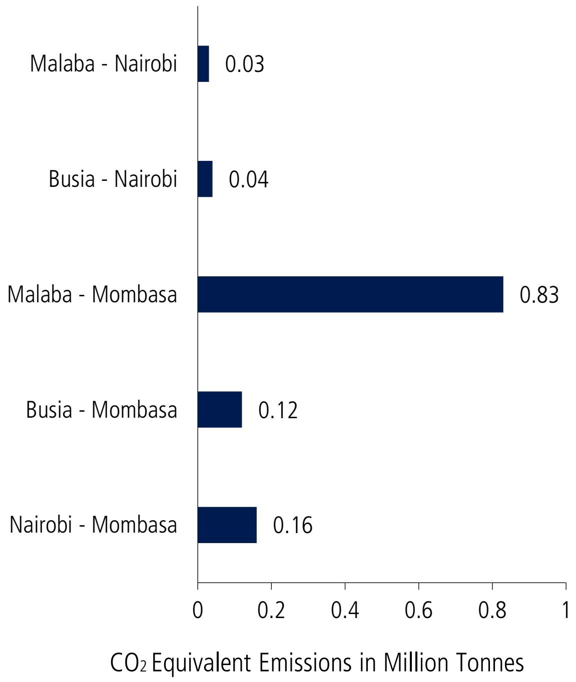


Figure 16: Total GHG emissions of Northern Corridor routes/ sections in Uganda (North) - section-wise

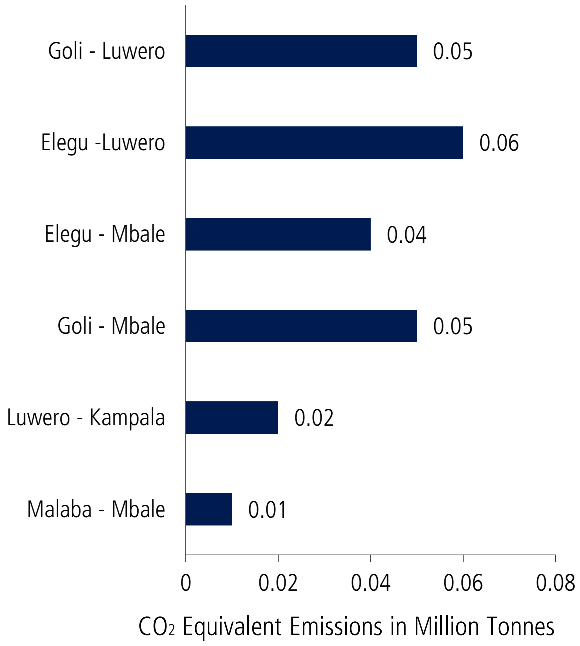


Figure 17: Total GHG emissions of Northern Corridor routes/ sections in Uganda (East, West, South) - Section-wise

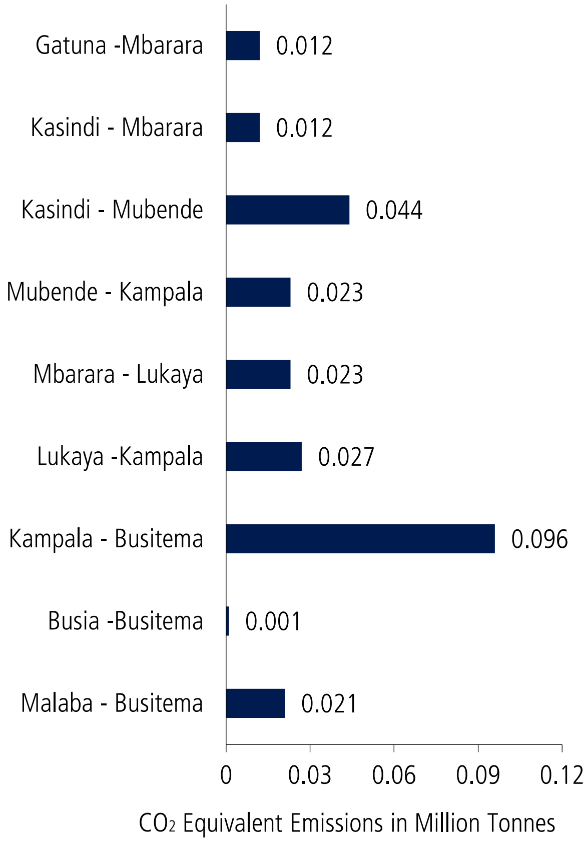
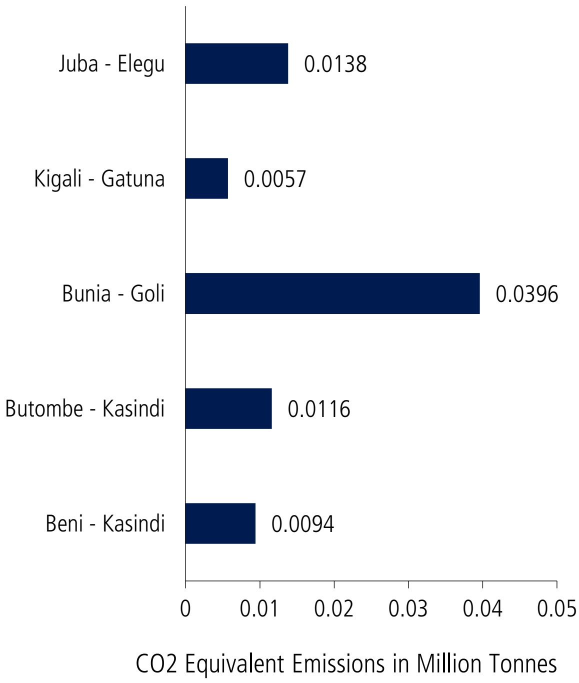


Figure 18: Total GHG emissions of Northern Corridor routes/ sections in Rwanda, DRC and South Sudan- Section-wise



In Central Corridor, the top 5 routes having maximum GHG emissions are: Morogoro – Isaka, Dar es Salaam – Morogoro, Isaka - Rusumo, Isaka – Mwanza, Isaka - Kabanga

Out of 11 routes in Central Corridor, these 5 routes constituted 94 % of estimated total GHG emissions of the corridor. Hence these routes are priority routes were climate change mitigation actions can be identified and implemented for reducing GHG emissions in Central Corridor.

The routes and sections have been divided country-wise for better comprehension and analysis, and details are figuratively represented below.

Figure 19: Total GHG emissions of Central Corridor routes/ sections in Tanzania - Section-wise

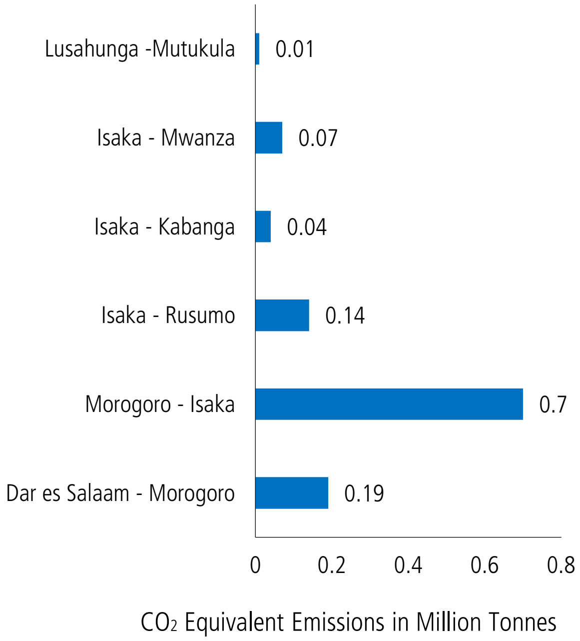
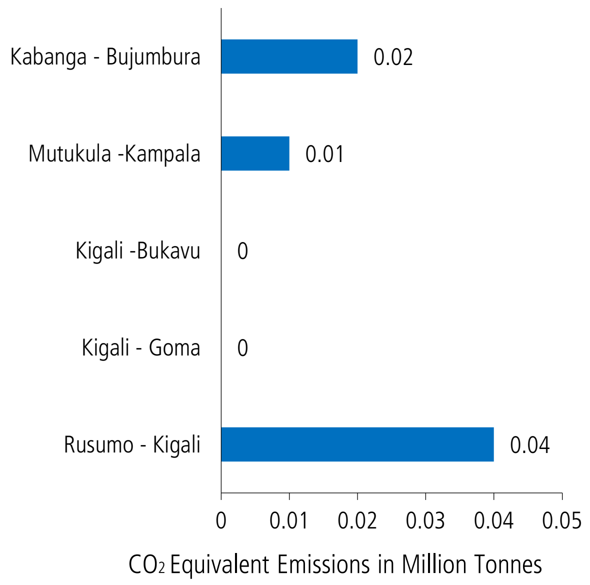


Figure 20: Total GHG emissions of Central Corridor routes/ sections in Rwanda, Burundi and Uganda - Section-wise

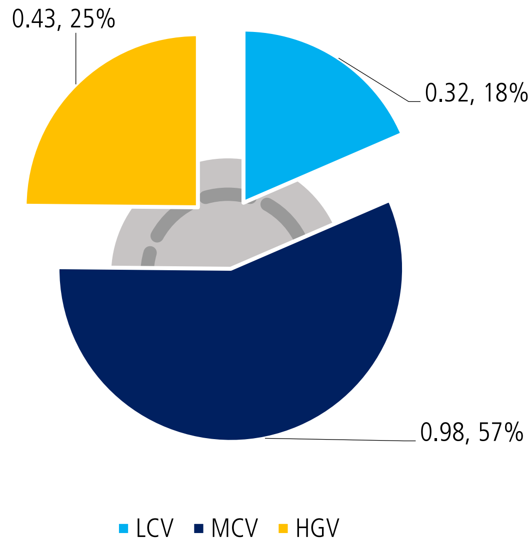


4. Estimated Total GHG Emissions of the Corridor - Breakup Vehicle Category wise (HGV, MCV, and LCV)

The estimated total GHG emissions of the corridors have been further analysed based on vehicle categories, i.e., Light Commercial Vehicles (LCV), Medium Commercial Vehicles (MCV) and Heavy Goods Vehicles (HGV). Based on the analysis from the survey data in Northern Corridor, LCV comprises of 26%, MCV comprises of 56% of the total freight traffic while HGV's comprised 18% of the total traffic plying in the corridor.

In the Northern Corridor out of total emissions, the LCV's contributed around 17% (0.32MMtCO$_2$e) of total emissions; HGV contributed 25% (0.41 MMtCO$_2$e) of total emissions and MCV contributed around 58% (1MMtCO$_2$e) of total emissions.

Figure 21: Estimated Total GHG Emissions of the Northern Corridor - Vehicle category wise



In the Central Corridor out of total emissions, the HGV's contributed around 100 % (1.23 MMtCO$_2$e) of total emissions as per the data shared by the corridor.

In Northern Corridor, vehicle fuel efficiency improvement related interventions like training of drivers, improvement in the aerodynamics of the vehicle can be focused more on MCVs and similarly such initiatives can be focused more on HGVs in Central Corridor.

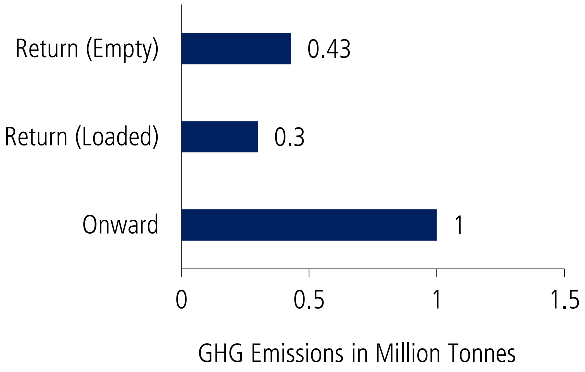
5. Estimated Total GHG emissions - Breakup-Onward & Return (Loaded & Empty) Journey

The GHG emissions for onward journey (port city to capital or major city) and return trip (capital or major city to port city) was analysed.

It has to be noted that in both the corridors, the export is only 14% of the total trade; hence a higher proportion of empty return trips is anticipated. Based on the survey conducted by the Northern Corridor, it was found that during the return journey, nearly 30% of trucks were loaded and 70% of the trucks were empty.

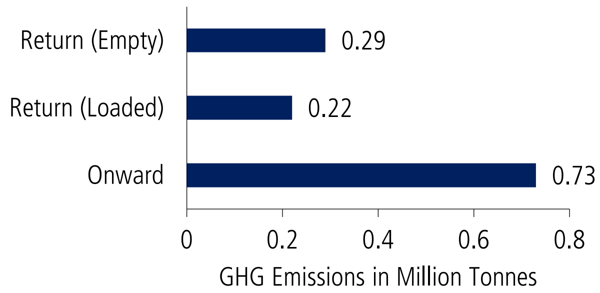
In the Northern Corridor, it was observed that the onward journey constituted 58% (1 MMtCO$_2$e) of estimated total GHG emissions and return journey constituted 42% (0.73 MMtCO$_2$e) of the estimated total GHG emissions. In the return journey, the empty trips contributed 59% (0.43 MMtCO$_2$e) of the estimated total GHG emissions of the return journey, and loaded trips contributed 41% (0.30 MMtCO$_2$e) of the total GHG emission of the return journey.

Figure 22: Total GHG emissions- Breakup - Onward & return (loaded & empty) journey- Northern Corridor



In the Central Corridor, it was observed that the onward journey constituted 59% (0.73 MMtCO_2e) of estimated total GHG emissions and return journey constituted 41% (0.51 MMtCO_2e) of the total GHG emissions. In the return journey, the empty trips contributed 57% (0.29 MMtCO_2e) of the estimated total GHG emissions of the return journey, and loaded trips contributed 43% (0.22 MMtCO_2e) of the total GHG emission of the return journey.

Figure 23: Estimated total GHG emissions – Breakup - Onward & return (loaded & empty) journey- Central Corridor



In both the corridors, it was observed that empty trips constituted a significant portion of the estimated total GHG emissions of the return journey. It has to be noted that in empty trips as well as in the loaded trips, GHG is emitted however in the empty trips, fuel is consumed, and subsequently, GHG is emitted without carrying out any useful work (no goods are transported). Hence empty trips not only cause climate issues but also affect or increase the logistics cost substantially. Therefore, corridors, along with truck operators, need to take initiatives like route optimisation, reverse logistics, truck aggregator model (similar to cab aggregator model of Uber) etc., to reduce empty return trips.

CHAPTER THREE: WAY FORWARD

3.1 Way Forward

GHG emissions from Northern Corridor sections/ routes in Kenya and Uganda constituted 95 % of total estimated GHG emissions of Northern Corridor. Similarly, the GHG emissions from Central Corridor sections/ routes in Tanzania and Rwanda comprised 98 % of total GHG emissions of Central Corridor.

Hence the climate change related policies and/ programs (like NDC, National Communications and Biannual Update Reports, National Climate Change Action plans etc.,) of these four countries (Kenya, Uganda, Tanzania, Rwanda) were reviewed comprehensively. Based on climate change reports of these countries, the total GHG emissions from freight transportation of each country were estimated based on certain assumptions and expert opinion. The below table provides a comparison between the total GHG emissions from freight transportation of the selected countries and GHG emissions from the corridor sections/ routes of the selected countries.

The above table indicates that GHG emissions from Northern/ Central Corridor of selected countries constitute a significant portion (48-97%) of total GHG emissions from freight transportation of the respective countries. Hence any reduction in GHG emissions in Northern / Central Corridor would lead to GHG emission reductions in the transport sector of the country and would positively contribute to meeting climate change targets of these countries.

Further analysis was carried out to understand the climate change mitigation targets or GHG emission reduction potential in the transport sector in these selected countries. The analysis was carried based on climate change targets or GHG emission reduction potential detailed out in various climate documents like NDC, Nation Climate Change Action plan etc. The below table provides the details of targets or GHG emission reduction potential in the transport sector of selected countries.

Table 17: GHG emissions from freight transportation of selected countries vs GHG emissions from sections/routes of Northern/ Central Corridor in these selected countries

Country	GHG emissions from routes /sections of Northern Corridor ($MMtCO_2e$)	GHG emissions from routes /sections of Central Corridor ($MMtCO_2e$)	GHG emissions from freight transportation of the country ($MMtCO_2e$)	GHG emission from Northern/ Central Corridor in selected countries as a percentage of total freight transport emission of respective countries ($MMtCO_2e$)
Kenya	1.24	-	2.56	48%
Uganda	0.48	0.01	0.51	97%
Tanzania	-	1.16	1.5	78 %
Rwanda	0.006	0.04	0.09	51%

Source: (Kenya's National Climate Change Action Plan- Mitigation Technical Analysis Report 2018*)(Uganda's First Biennial Update Report to the United Nations Framework Convention on Climate Change* 2019*)(Rwanda's Third National Communication under the United Nations Framework Convention on Climate Change* 2018*)*

Table 18: Country-specific climate change targets for the transport sector

Country	Climate change targets (GHG emission reduction targets as a percentage of BAU transport emissions)
Kenya	14%
Uganda	23%
Tanzania	10-20%
Rwanda	24%

It can be inferred from the above table that GHG emission reduction target in the transport sector of the selected countries ranged from 10-24 % (as compared to BAU GHG emission scenario).

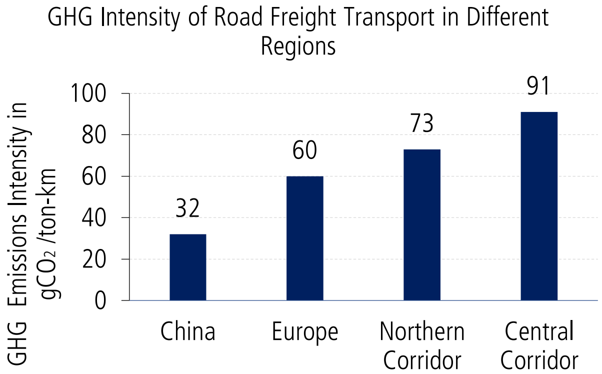
The above table indicates that the countries have GHG emission reduction targets for transport sector and the corridors can significantly help the countries to achieve these targets.

In order to assess the GHG emission reduction potential in the corridors, a comparative analysis (as depicted below) of GHG intensity of Northern and Central freight Corridor with the freight corridors in China and Europe was carried out.

Based on the analysis, the GHG intensity of Northern Corridor was 2.3 times more than the GHG intensity of freight corridors in China, and the GHG intensity of Northern Corridor was 1.22 times more than the GHG intensity of freight corridors in Europe.

Similarly, the GHG intensity of Central Corridor was 2.84 times more than the GHG intensity of freight corridors in China, and the GHG intensity of Central Corridor was 1.52 times more than the GHG intensity of freight corridors in Europe.

Figure 24: Comparative GHG intensity across corridors in the world



Source: (Lynn H Kaack 2018)

Moreover, if the GHG intensity of the Northern and Central Corridors are compared then GHG intensity of Central Corridor was 1.25 times more than GHG intensity of the Northern Corridor.

All the above analysis clearly shows that substantial GHG emission reduction potential exists in both the corridors.

The output from the GHG emission model not only provides critical information which can be used for GHG benchmarking but also helps in identifying GHG intensive segments or activities in the corridor. After identifying GHG intensive segments or activities, the corridors can develop climate goals and action plans to achieve the goals.

NCTTCA under Northern Corridor Green Freight Programme has already developed climate goals, and the details are provided below:

The Northern Corridor Green Freight Programme will help to reduce CO_2 emissions through NDCs committed by the member states of the Northern Corridor under the Paris Climate Agreement as well as through actions aimed at implementing the 2030 Agenda for Sustainable Development and related Sustainable Development Goals (SDGs).

The targets are aligned to the cycle of the Northern Corridor five-year rolling plan. In parallel and while implementing the Green Freight Programme, the NCTTCA will also carry out work to develop a sustainable freight transport strategy and related longer-term action plan for 2030 and beyond.

Below are set short term targets for the period 2016 baseline to 2021:

- Improved fuel economy litres per tonne-km for trucks by at least 5% by 2021.
- Reduction in Particulate Matter (PM), black carbon emissions and Oxides of Nitrogen (NO_X) grams per tonne-km by at least10% by 2021.
- Reduction of CO_2 emission intensity grams per tonne-km by 10% by 2021.
- Reduction of road accidents by 10% per million tonne-km.

In 2015, using the Northern Corridor GHG emission model, the baseline GHG intensity of Northern Corridor was estimated as 75 gCO_2/tonne-km based on which GHG intensity target was devised.

The GHG intensity of the Northern Corridor in 2018 was 73 gCO_2/ tonne-km. The GHG intensity of Northern Corridor has been reduced by 3 % compared to the baseline GHG intensity. There is a reduction in GHG intensity of the Northern Corridor, which is a positive development. The GHG intensity reduction is subtle lower than the targeted value of 4% by 2018, but overall, it seems that the Northern Corridor is in the right direction towards achieving the GHG intensity reduction target.

Considering the country level climate targets, GHG emission reduction potential and GHG intensity reduction trends, the following climate targets (GHG intensity reduction) targets are suggested for the corridors.

- Central Corridor: Reduction of CO_2 emission intensity grams per tonne-km by 20 % by 2030 considering CO_2 emission intensity in 2020 as baseline.
- Northern Corridor: Reduction of CO_2 emission intensity grams per tonne-km by 15 % by 2030 considering CO_2 emission intensity in 2021 as baseline.

The target year has been kept as 2030 considering the NDC target year of the countries.

In order to meet the proposed GHG intensity targets, the corridors can consider the following three broad climate mitigation interventions:

1. Climate mitigation interventions through implementing infrastructure projects

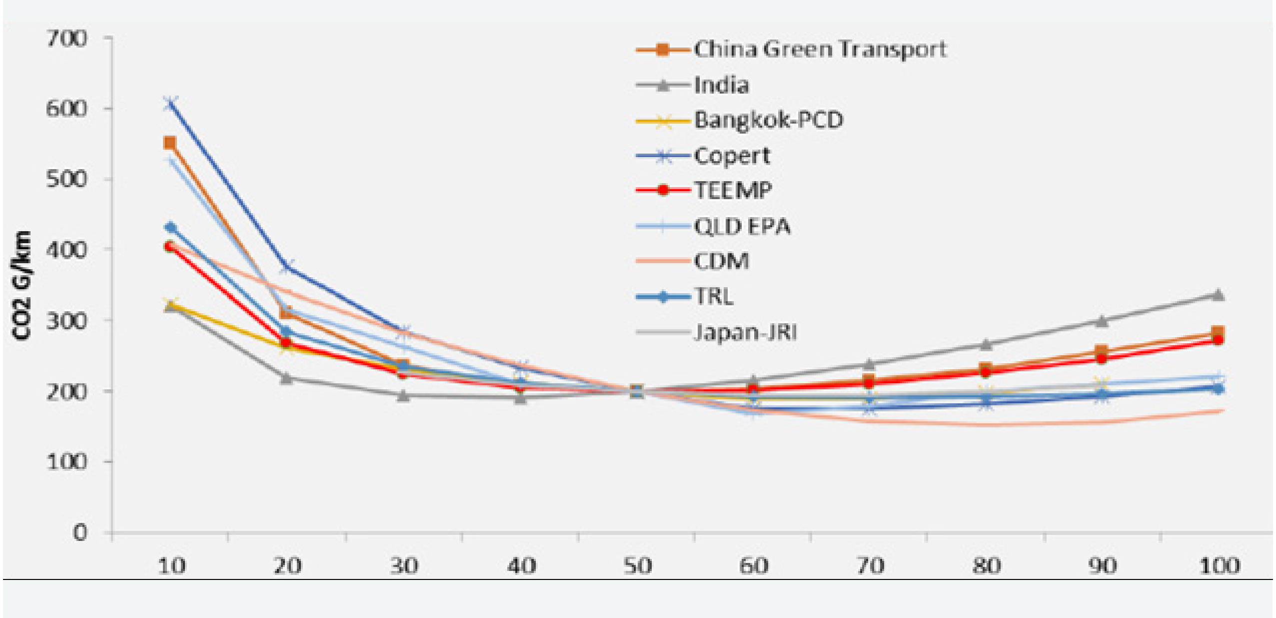
a. Modal shift

It has been observed in both corridors that a majority of the goods are transported through roadways. The intensity of GHG emission intensity is higher of roadways, as compared to railways and inland waterways. Substantial GHG emission reduction potential exists in modal shift (roadways to railways / inland waterways). Countries like Kenya, Rwanda have taken national-level climate targets for modal shift from roadways to railways for freight transportation.

b. Improving road conditions

GHG emissions of freight corridor are a function of fuel efficiency, distance travelled, and weight transported. The poor road condition impacts the speed of the vehicle, which increases fuel consumption and ultimately, increases GHG emission. The figure given below summarizes the relationship between the optimal speed and Carbon Dioxide emissions. It inferred that if the speed of the vehicle falls below 50 Km/

Figure 25: Impact of speed on a vehicle's CO_2 emissions (N. C. (NCTTCA) 2017)



hr, it significantly increases the GHG emissions.

Based on data/information from the corridor team, the road conditions of the Northern Corridor and Central Corridor has been tabulated below.

Table 19: Road condition of the Northern Corridor

Country	Excellent	Good	Fair	Poor	Total (KM)
Kenya	38%	37%	8%	17%	1,201
DRC	0%	31%	47%	21%	4,162
Burundi	0%	52%	27%	21%	516
Rwanda	46%	34%	20%	0%	977
South Sudan	0%	0%	5%	95%	3,351
Uganda	23%	19%	35%	23%	2,163

Source: 2018 Estimate (Northern Corridor Transport Observatory n.d.)

Table 20: Road condition of the Central Corridor

Good	Poor	Total (km)
75%	-	2234
-	24.85%	739

The above tables indicate that there is good scope for improvement of road conditions in both the corridors.

During this study, the top GHG intensive routes or sections were identified in both corridors. It is suggested that as a

Table 21: Recommended routes for improving roughness index in the Northern Corridor

Sl. No.	Routes/sections of Northern Corridor
1.	Mombasa-Malaba
2.	Mombasa-Nairobi
3.	Mombasa-Busia
4.	Nairobi-Busia
5.	Busitema-Kampala
6.	Luwero-Elegu
7.	Luwero-Goli
8.	Mbale-Goli
9.	Mubende- Kasindi
10.	Mbale- Elegu

Table 22: Recommended routes for improving roughness index in Central Corridor

Sl. No.	Routes/sections of Central Corridor
1.	Morogoro – Isaka
2.	Dar es Salaam – Morogoro
3.	Isaka - Rusumo
4.	Isaka – Mwanza
5.	Isaka - Kabanga

priority to carry out road condition improvement projects (improving roughness index) in these GHG intensive routes (details provided in below table). This would help in reducing GHG intensity in both the corridors.

2. Climate mitigation interventions through capacity building and institutional mechanisms

a. Capacity building of truck drivers on eco-driving practices

Efficient driving practices can reduce fuel consumption, significantly reducing vehicular emissions. NCTTCA and CCTTFA can run a capacity-building programme for the truck drivers on 5 fuel-efficient driving techniques.

- Gentle acceleration - The harder acceleration results in more fuel consumption
- Maintain a steady speed - over the journey, more variation in speed results into more fuel consumption
- Anticipate traffic
- Avoid high-speed driving
- Coast to decelerate

b. Reduction in empty return trips through smart practices like route optimisation, aggregator model.

In both the corridors, it was observed that empty trips constituted a significant portion of the estimated total GHG emissions of the return journey.

It has to be noted that in empty trips as well as in the loaded trips, GHG is emitted however in the empty trips, fuel is consumed, and subsequently, GHG is emitted without carrying out any useful work (no goods is transported) hence increasing the GHG intensity of the corridors. Hence empty trips not only cause climate issues but also affect or increase the logistics cost substantially.

Therefore, corridors along with truck operators need to take initiatives like route optimisation, reverse logistics, truck aggregator model (similar to cab aggregator model of Uber) etc., to reduce empty return trips

c. Green leadership programme for truck operators/ fleet owners

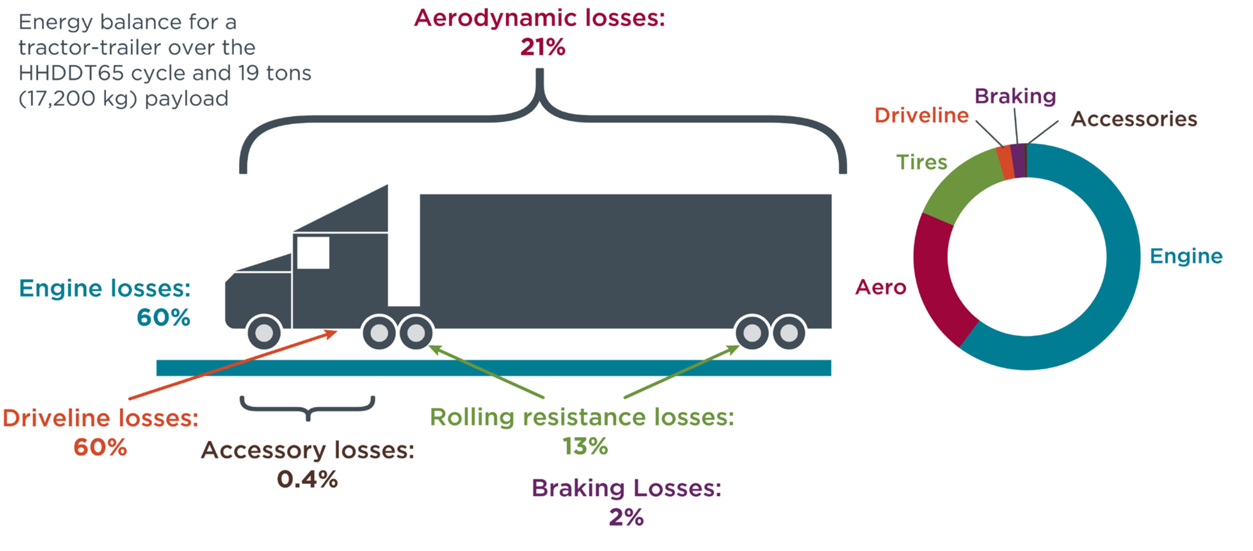
Green leadership programme may be developed for truck operators/ fleet owners, under this program the truck operators can take voluntary climate targets like improvement in fuel efficiency, reduction in pollutants among others, as defined in the program depending upon the type of truck, age and characteristics etc. The truck operators/fleet owners who achieve the climate targets can be incentivised by providing concessional toll rates, reduction in road tax, priority clearance in port or customs area etc. The programme will encourage truck operators and fleet owners to maintain the trucks regularly and periodically have pollution under control tests and subsequently help the corridors achieve the GHG intensity targets.

3. Vehicle efficiency improvement projects

As the freight transport accounts for majority of fuel use and emissions, it is recommended to assess the vehicle characteristics. Following figure 24 and 25 shows the breakdown of energy losses for a typical freight transport truck. After engine losses, majority of energy losses are due to aerodynamic drag. The aerodynamic drag is an opposing force that occurs due to air resistance that truck needs to overcome to move forward. The amount of work a truck must do to reduce drag creates a severe drain on fuel efficiency. Thus, corridors can collaborate with national automobile research institutes and truck manufacturers to standardize aerodynamic features of the trucks. The aerodynamic additions to the trucks, in totality, will reduce the strain on fuel efficiency and will reduce the GHG emissions.

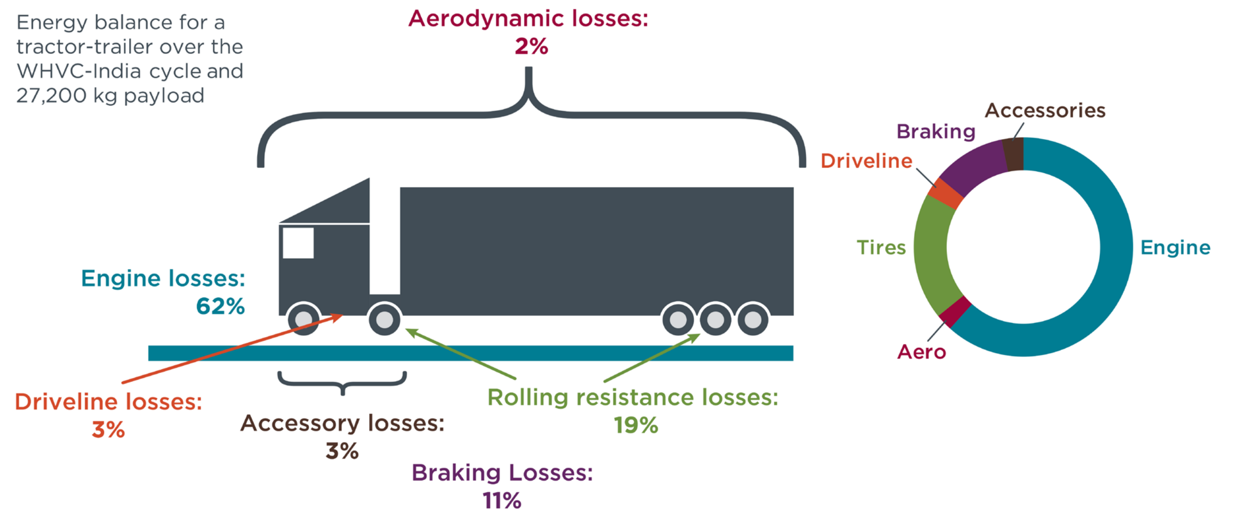
In the case of the Northern Corridor, vehicle fuel efficiency improvement related interventions can be focused more on MCVs and similarly, such initiatives can be focused more on HGVs in Central Corridor.

Figure 26: Energy balance for a U.S. tractor-trailer of 19 tonnes payload



Source: Delgado and Lutsey (2015)

Figure 27: Energy balance for an Indian tractor-trailer of 27.2 tonnes payload



Source: Delgado and Lutsey (2016)

ANNEXURE ONE: CONSULTATIONS AND MEMBER COUNTRY VISITS

The project started on 3rd September 2019 when the contract between TMEA and ClimateCare (on behalf of the consortium) was signed. The project kick-off meeting was held on 9th Sept 2019 at TMEA office, Nairobi and was attended by the consultants (Tom Owino and Joash Obare of ClimateCare, Joseph Prakash and Prabhakar Vanam of Meghraj Capital) and TMEA (Mikko Leppanen and Denis Maina). The meeting was also joined via video call by representatives from the NCTTCA (Gideon Chikamai) and CCTTFA (Melchior Barantandikiye, Ally Hamud Kakomile and Faraji Y. Kondo), who are critical users of the expected outputs of the work.

The inception phase then followed during which various literature reviews were conducted, and key stakeholders (TMEA, NCTTCA, CCTTFA and selected freight operators) were consulted as a means of levelling expectations and understanding the status quo.

Through the consultations during the inception phase, the consultant has developed a better and clearer understanding of the expectations of TMEA, NCTTCA and CCTTFA from the project, and to establish what previous works have been done on GHG emissions for the regional freight sector, what is in place, what data exists and what are the existing gaps. The consultants have built on the previously existing work, including the adoption of the corridor GHG emissions estimation model developed for the NCTTCA.

The process has been inclusive and consultative and has included visits to most of the corridors' member countries.

The following is a summary of what was agreed and the actions during the kick-off meeting.

Table 23: Summary of discussions during kick-off meeting

Sl. No.	Discussion area	Issue	Action	Coordination responsibility
1.	Collaboration	TOR needs to be enhanced further to reflect collaboration with Central Corridor in addition to Northern Corridor	• TOR document to be updated and shared.	TMEA (Denis)
			• Agreed upon updates on the TOR and any valuable insights obtained during project inception to be reflected in the inception report. • Northern and Central Corridor representatives to be adequately engaged during fieldwork to ensure continuous capacity building	Consultant (Tom)

2.	Planning	Need to engage further with corridor representative when they are in Nairobi (11th – 13th September)	• Liaise with ICT4Trade to accommodate sometime in the programme for a side-line meeting between corridor representatives, consultant and TMEA climate change to discuss and agree on among other things;
			  o Methodology and GHG emission tool;
			  o Revised work plan and corridor team's availability for field visit;
			  o Data requirements and data availability; and
			  o Baseline year for GHG Inventory.
			
			Preferred for the side-line meetings is Wednesday (11th September)
			
			The side-line meetings have paved the way for the data collection
				TMEA (Erick/ Lucy & Denis) and Consultant (Tom & Joseph)

			• Lead discussions for the side-line meetings • Share/define data requirements for the GHG Inventory	Consultant (Tom & Joseph)
			• Confirm availability for the side-line meetings • Confirm corridors availability for the field visits in line with the revised work plan • Assist in data collection efforts as per the defined data requirements.	Corridors (Gideon & Melchior)
3.	Billing	Guidance on the consortium's tax implication	• Seek clarification on tax exemption implication for the consultant consortium	TMEA(Denis)

Kick-off Meeting at TMEA

Before the side-line meeting of 11th September 2019, the data requirements for GHG emission model were shared with TMEA and corridor teams. During the meeting, the following was discussed after a presentation by the consultant:

Figure 28: Side-line meeting

1. Objectives of GHG accounting study
2. Critical considerations of GHG emission methodology
3. GHG inventory boundary – Temporal geographical, sectoral, GHG etc.,
4. GIZ-GHG Emission Methodology for Kenya's Transport Sector
5. UNFCCC-GHG Emission Methodology for Freight transport
6. Northern Corridor GHG emission model
7. Data requirements for GHG emission model
8. Tentative Work Plan

During the kick-off meeting, it was also understood that the Northern and Central corridor teams would be travelling to Nairobi on 11th September 2019 for an official meeting, so it was decided to have an initial face-to-face meeting with the corridor teams at the Nairobi meeting before proceeding for site visits as had been originally proposed.

Agenda:

- Introduction
- Key outcomes of the July workshop
- TOR
- Detailed revised work plan
- Timeline for the mission to Dar e Salaam and Mombasa and study Countries
- Special projects by TMEA, Kenya Port Authority (KPA).
- AOB

The following was agreed at the meeting following the consultations:

1. The geographical boundary of GHG inventory will be Northern and Central Corridors. The countries that will be covered in the study include Kenya, Tanzania, Uganda, Rwanda, Burundi, DRC and South Sudan. The consultations will not include visits to DRC and South Sudan.

2. The sartorial boundary of GHG inventory will be road freight sector and will cover all types of road freight (container trailers, bulk trailers, fuel tankers). Initially, it will cover three sizes of trucks Light Commercial Vehicle (LCV), Medium Commercial Vehicle (MCV) and Heavy Goods Vehicle (HGV).

3. The output of the GHG accounting study will reflect the estimated total GHG emissions in tonnes of carbon dioxide equivalents ($MMtCO_2e$). All GHGs that apply to freight transport will be considered; however, Carbon Dioxide (CO_2) will be the main GHG. Indirect greenhouse gases, including Non-Methane Volatile Organic Compounds (NMVOC), Carbon Monoxide (CO), Nitrogen Oxides (NO_X) and Sulphur Dioxide (SO_2) will also be considered as appropriate.

4. Since the Northern Corridor had a GHG emission model, it was suggested to carry out an in-depth study of the model to assess the suitability of using the model for both the Northern and Central Corridors, to identify gaps (if any) in the model and suggest improvement points.

5. It was also noted that the consultant should further reference other documents produced by the corridor secretariats such as the Northern Corridor Green Freight Programme developed with support from the United Nations Environment Programme (UNEP).

6. The site visits to the corridors would be conducted first before country visits and consultations. The respective corridor secretariats would facilitate and participate in the visits. For the country visits, the requests and the agenda would need to be communicated well in advance.

7. As per the initial plan, two weeks (from 11th September 2019 to 20th September 2019) was reserved for visits to the corridors and member countries, however, based on discussions and request from corridor teams the plan was revised. The visit to the Northern Corridor was confirmed for 19th to 20th September 2019.

Consultations and Member Country Visits

The table below is a summary of the consultations that were held during the assignment

Table 24: Summary of Consultations conducted during the assignment

Date	Stakeholder consulted	Forum of consultation
9th September 2019	TMEA, NCTTCA and CCTTFA	Kick-off meeting at TMEA offices and attended by corridor representatives via video call
11th September 2019	TMEA, NCTTCA and CCTTFA	Side-line Meeting at Park In, Nairobi attended by TMEA, NCTTCA and CCTTFA
16th September 2019	TMEA	Meeting at TMEA office
17th September 2019	GIZ TraCS Nairobi Team	Meeting at GIZ offices
19th to 20th September 2019	NCTTCA and TMEA	Visit the NCTTCA, Mombasa
7th October 2019	CCTTFA and TMEA	Visit the CCTTFA, Dar es Salaam
7th October 2019	CCTTFA and TMEA	Visit Super Star Forwarders Limited; Part of the Superdoll Group
20th October 2019	Ministry of Transport, Ministry of Environment and CCTTFA	Visit Dar es Salaam and Dodoma
23rd October 2019	Burundi Office for Protection of Environment, Ministry of Environment and Ministry of Transport and CCTTFA	Visit Bujumbura
19th November 2019	Ministry of Works and Transport, Ministry of Water and Environment and NCTTCA	Visit Kampala
21st November 2019	Ministry of Infrastructure, Ministry of Environment and NCTTCA	Visit Kigali

Meeting at TMEA office on 16th September 2019

The meeting was held to discuss the emissions of TMEA's key climate change- relevant projects and to update the visit plan. The consultant and TMEA attended the meeting.

The meeting noted that while the assignment had the following two objectives as stated in the ToRs, only the first one had been addressed in the proposal:

1. The Northern and Central Corridors in collection of data and calculating GHG estimates on freight transport (road) for the corridors
2. The identification and conceptualisation of TMEA's key climate change-relevant projects.

It was, therefore, necessary to address the second objective. The consultant noted that the work plan and the budget presented in the proposal, and the contract did not address any tasks to address the second objective. It was noted that while it was possible to include additional tasks in the work plan to address the second objective, this will have an impact on both the timelines and the project budget.

The list of TMEA projects was presented and reviewed during the meeting, and it was agreed that this issue would be further addressed in future. The consultant agreed to carry out objective 2 after signing the addendum to the existing TMEA contract.

Meeting at GIZ offices

GIZ under TraCS program has been closely working with the State Department of Transport under the Ministry of Transport, Infrastructure, Housing and Urban Development (MoTIHUD); Government of Kenya, on climate change related areas in the transport sector in Kenya and have published the followings reports, among others, which were found relevant and useful for the GHG accounting study:

1. INFRAS Transport Mitigation Options Kenya (2018); GIZ
2. Characteristics of the in-service vehicle fleet in Kenya (2018); GIZ
3. A Beginners Guide to Emissions Accounting in Transport (2018); GIZ
4. Updated transport data in Kenya, Ministry of Transport, Infrastructure, Housing and Urban Development (2019); Government of Kenya.

GIZ has developed GHG emission methodology for Kenya's transport sector using a bottom-up approach. The consultant met GIZ team on 17th September 2019 at their Nairobi office with the objective of understanding the GIZ GHG emission methodology in detail and the availability of local data like fuel consumption of trucks, the average age of the trucks and % of empty trips, among others. In the meeting, the GIZ team noted that during the GHG emissions study for the transport sector, they had interviewed more than 30,000 drivers (including freight) and had collected the following data sets:

1. Estimated fuel consumption of their vehicles
2. Odometer reading
3. Distance covered/travelled by trucks
4. Vehicle plate registration details
5. Vehicle fuel type
6. Vehicle category

With the above details, the GIZ team visited the National Transport and Safety Authority (NTSA) and collected more details of the vehicles whose drivers were interviewed. The following information was collected from NTSA:

1. Vehicle engine size
2. Year of vehicle manufacture and registration in Kenya
3. Fuel type
4. Vehicle category

The main aim of the GIZ study was to develop local emission factors for the transport sector. Although the GIZ study collected much information on fuel consumption, the GIZ team realised that the findings on fuel consumption were not reliable since they were not based on recorded data but estimates. Hence, GIZ team used fuel consumption and emission factor data published in the "Handbook Emission Factors for Road Transport (HBEFA 3.3)" and customised to local conditions.

GIZ suggested carrying out a small survey for collecting data on the fuel consumption of trucks and comparing with GIZ data on fuel consumption. If there is no significant variation, then GIZ data can be used in GHG emission model, in case of significant variation the survey data can be used after discussions with Transport Ministry officials.

GIZ team shared the following documents which can be useful for the GHG study:

1. JKUAT study report
2. Road transport GHG emission factors for Kenya: Pilot study for 2015 report

Visit to NCTTCA, Mombasa

The consultant visited the Northern Corridor office in Mombasa on 19th September 2019; the following were the objective of the visit:

1. To discuss and finalise the GHG emission model
2. To share and discuss the data requirements for GHG emission model
3. To understand the various data sets monitored and captured by the corridor observatory and to identify the relevant data which was used in GHG emission model
4. To discuss methods for collecting data which is not monitored and captured by the corridor observatory regularly
5. To collect reports /documents that is relevant to GHG accounting study.

The consultant discussed various GHG emission models (GIZ, UNFCCC, and Northern Corridor) and their advantages, gaps and challenges. The consultant informed the meeting that based on the analysis of the existing GHG emission models; the consultant had decided to adopt the Northern Corridor GHG emission model, which was found to be the most appropriate. The corridor team explained, in detail, the various data available at the secretariat ranging from the quality of road infrastructure, distances, transit time, volumes and capacity and transport rates, among others. The data requirements for the Northern Corridor GHG emission model ware discussed in detail and mapped with available data at the observatory/secretariat. The data needed for the Northern Corridor GHG emission model, which was not currently monitored and captured by the corridor observatory regularly was identified, and strategies on how to estimate were agreed. The corridor team also explained in detail the documents and reports available in the Corridor website. The Corridor team shared the following documents, which will be useful for the GHG emission model:

1. Northern Corridor Transport Observatory Report, June 2019
2. Northern Corridor Green Freight Programme
3. The Port of Mombasa- Emission inventory baseline report

The following were the outcomes of the meeting:

1. The Northern Corridor GHG Emission model considered all the required parameters and was more robust, comprehensive and was complying with international standards. Hence it was decided that the Northern Corridor GHG emission model will be used for the GHG accounting study. It was suggested that the Northern Corridor GHG emissions model estimations could be improved by enhancing the quality of data input. It was agreed that the consultant would further review

the GHG emission model to identify and propose further modifications (if any) for value addition.

2. Based on the availability of the data, it was suggested that the baseline year to be 2018. However, it was also agreed with the Northern Corridor to explore the opportunities for getting data from 2015 onwards till 2018.

3. It was also agreed that in the initial phase of GHG accounting, for sections of corridor border to border approach (for example Mombasa to Malaba) will be adopted and as the data availability and quality improve the sections (for example Mombasa to Nairobi, Nairobi to Nakuru, Nakuru to Malaba) can be broken down further for GHG accounting.

4. The Northern Corridor will assist in carrying out surveys of about 10 freight operators to collect data like actual fuel consumption, % of empty trips, among others while the consultant will share the survey questionnaire with the Northern Corridor for review and finalisation.

5. The actual fuel consumption of trucks obtained from the survey will be compared with those obtained through the GIZ study before deciding on the appropriate data set to use. It was also suggested that the data on transport rates along the corridor at various sections, the number of trips and transport cost structure in the region might provide insights on fuel consumption and this could be used to cross-check the fuel consumption data captured through the survey.

6. The data on the proportion of empty trips could be captured through survey and cross-checked with trade-related data (import and export data) of each country. The corridor observatory captures the trade-related data of each country. During the discussions, it was observed that for most of the regional countries, the imports are more than exports; hence it is anticipated that the proportion of empty trips will be more towards the port. However, this detail will be corroborated with actual data.

7. The consultant has prepared the data requirements for GHG emission model and the survey questionnaires to be shared with the corridors.

Visit to CCTTFA, Dar es Salaam

During the visit to the Central Corridor on 7th October 2019, most of the issues and the approaches to GHG emissions estimation and related data collection were agreed. The consultant presented the data to be collected, and the approaches agreed with the NCTTCA. The CCTTFA agreed with the approaches, and there were no areas of difference.

The CCTTFA explained in detail the locations of the weighbridges and how they could be used to collect or estimate various data. It was confirmed that data would be available for trucks from 3.5 tonnes and above, and that information on border post crossing (for destination estimation) would be available from the weighbridges and the revenue authorities. It was recommended that the consultant should visit and observe a weighbridge in operation.

It was noted that data on road conditions outside Tanzania would be challenging to obtain. However, the Central Corridor will be conducting a road condition survey in November 2019. The survey would provide useful data on road conditions.

For the estimation of the proportion of the empty trucks, data on imports and exports, which is available from the revenue authorities on an annual basis, would be compared.

The CCTTFA informed the consultant that the traffic growth in the Central Corridor was estimated at 16% per annum. An important point raised by the CCTTFA was the need for a well thought out communication strategy to support the advocacy of the GHG inventory and reduction along the corridor.

It was agreed that at the end of the process, a validation workshop would be held to review and validate the results.

Finally, it was agreed that the team of TMEA, CCTTFA and the consultant would visit Dodoma and Bujumbura (Ministries of Transport and Environment) from 21st to 23rd October 2019.

Visit to Super Star Forwarders Limited; Part of the Superdoll Group

On 7th October 2019, while visiting CCTTFA in Dar es Salaam, the consultant, TMEA and CCTTFA visited Super Star Forwarders Limited, a part of the Superdoll Group.

During the visit, the team was taken through the company's vehicle tracking system, with vehicle speeds (maximum 60 km/hr). The freight company explained that the average fuel consumption for the HGV trucks (about 30 tonnes) was around 2.7km per litre for the round trip (Dar es Salaam to Kampala), 4 km per litre, when empty, and 1.9 km per litre, when loaded.

Visit to the Ministry of Transport and Ministry of Environment in Tanzania

Summary of the country consultations of 21st October 2019 in Dodoma is provided below:

1. The Government of Burundi is in support of the project and were in principle in agreement with the GHG emission model, the methodology adopted, and data required for GHG emissions calculation
2. Tanzania would like a national workshop on the assignment in Tanzania, and they would prefer that the project also has a Tanzanian consultant in the consulting team. Without these two, they see significant challenges in data collection for the work we are doing.
3. It was pointed out that the required data could be available from the Land Transport Regulatory Authority (LATRA), Tanzania Port Authorities (TPA), National Institute of Transport (NIT) and Sokoine University (Testing/Research on Pollution and Emissions).
4. They also hoped that the output from the project would facilitate national inventory preparation for the transport sector in Tanzania.

Visit to the Ministry of Transport and Ministry of Environment in Burundi

Summary of the country consultations of 23rd October 2019 in Bujumbura is provided below:

1. The Government of Burundi is in support of the project and were in principle in agreement with the GHG emission model, the methodology adopted, and data required for GHG emissions calculation
2. Burundi emphasized the need for excellent and continuous communication to the regional governments about the project by the Central Corridor and by TMEA.
3. They are ready to provide any data requested for the project, but generally, the country lacks data on the transport sector.
4. There is a significant need for capacity building on GHG emissions in the transport sector, both at an institutional level and systems levels.
5. They would have preferred if the assignment covered the whole transport sector at the national level as well

Visit to Ministries of Transport and Environment in Rwanda and Uganda

The highlights from the discussions in Kigali, Rwanda and Kampala, Uganda regarding the proposed tool, methodology and data for measuring GHG emissions are:

Figure 29: Meeting with Ministry of Environment, Rwanda

1. The Ministries in charge of transport and environment both in Rwanda on 19th November 2019 and Uganda on 21st November 2019 were in principle in agreement with the tool, the methodology adopted and data required for GHG emissions calculation, however, it was suggested that there is need to ensure that the data collection and methodology is standardised and follows international best practices (UNFCCC/IPCC) requirements, furthermore, resonate with the existing data collection parameters agreed upon by the ministries and key emitting sectors.

2. There is a need to provide for how the corridor GHG inventory can inform country-specific GHG accounting and reporting in line with international accounting guidance standards and establish a basis for a continuous monitoring system. This is especially important for purposes of reporting to the UNFCCC by the individual countries.

3. As much as possible, the consultant should use local country or regional emission factors where data allows. This can also form part of the future improvement action areas.

Figure 30: Meeting with Ministry of Water and Environment, Uganda

Figure 31: Meeting with Ministry of works & Transport, Uganda

4. GHG inventory estimations results should be cross-checked with the fuel energy balances of the countries and the bi-annual update reports submitted to the UNFCCC.

5. Apart from the transport ministry, another key stakeholder for the assignment would be the ministry of energy.

6. It was observed that transparency in the results and report (clarity in sources, assumptions, etc.) is mandatory for the success of the assignment and stakeholder buy-in.

7. The consultant should explore to come up with a model which can be customised to apply to other modes of transport and other categories of road transport such as passenger vehicles and motorcycles that will enable transport sector-wide reporting on GHG emissions.

8. The consultant should improve on the map used and show all the major Corridor transit routes.

9. The consultant should check whether the default European emission factors used are applicable with the diesel vehicles used by African countries (e.g. Euro 4, 5, 6, etc.?).

10. The consultant should state the assumptions for every variable being used to estimate emissions using the tool.

11. The report by the consultant where possible should reflect gender inclusiveness in the assignment.

12. The Ministries responsible for energy should be included in the list of stakeholders targeted as data providers. Furthermore, be open to other data sources.

Figure 32: Meeting with Ministry of Infrastructure, Rwanda

Visit to CCTTFA, Dar es Salaam

The following key next steps were agreed upon:

- Finalisation of data collection by the observatories working closely with the relevant government agencies.
- GHG draft results and report by the consultant
- Validation workshop
- Capacity building
- Continuous monitoring by the observatories and relevant government agencies

ANNEXURE TWO: QUESTIONNAIRE

Survey Questionnaire – GHG Accounting

Name of the interviewer: ....

- Background information

Name of the company:	
Country:	
Name of the Interviewee:	
Title/position in the company:	
Contact No:	
Email Id:	

- Detailed questionnaire

1. Provide the following details about the type of vehicles in your transport company.

Light Commercial Vehicle (LCV)	[3-10 MT]
Medium Commercial Vehicle (MCV)	[10-25 MT]
Heavy Goods Vehicle (HGV)	[25 MT and above]
Others. Please Specify	________________________________

Type of vehicle	No. of vehicles owned/ leased	Model specification	Number of axles	Average age (in years)
LCV				
MCV				
HGV				
Others				

2. What is the typical route (origin and destination) taken by each vehicle category?

Type of vehicle	Origin of the journey	Destination of the journey
LCV		
MCV		
HGV		
Others		

3. What is the specific fuel consumption (km/litre) of each vehicle category?

Type of vehicle	Specific fuel consumption for loaded trip (km/litre)	Specific fuel consumption for empty trips (km/litre)
LCV		
MCV		
HGV		
Others		

4. What is the typical percentage of loading of the vehicles and what is the average speed of the vehicles?

Type of vehicle	Specific fuel consumption for loaded trip (km/litre)	Specific fuel consumption for empty trips (km/litre)
LCV		
MCV		
HGV		
Others		

____

(Signature of Interviewer)

Date:

ANNEXURE THREE: DATA REQUIREMENT QUESTIONNAIRE

Northern Corridor

Please provide data for border to border freight movement. Kindly feel free to edit (add/delete) the border to border routes tabulated below:

	LCV	MCV	HGV	Others	LCV	MCV	HGV	Others	Good	Fair	Bad
Section-Section Routes											
Mombasa-Nairobi											
Nairobi-Nakuru											
Nakuru-Malaba											
Nakuru-Kisumu											
Kisumu-Busia											
Border to Border Routes											
Mombasa- Busia											
Mombasa- Malaba											
Busia- Katuna											
Busia- Vura/Mahagi											
Busia- Mpondwe											
Malaba- Katuna Gatuna											
Malaba- Elegu Nimule											
Malaba- Mpondwe Kasindi											
Gatuna- Nemba Gasenyi											
Gatuna-Rubavu Goma											
Gatuna-Kanyaru Haut											

Kindly note the other parameters that will be utilised for GHG accounting project is provided below, the data for these parameters will be obtained through the survey:

Fuel Efficiency or Fuel Consumption data (km/litre)
Average Running Speed (kmph)

Central Corridor:

Please provide data for border to border freight movement. Kindly feel free to edit (add/delete) the border to border routes tabulated below:

	Annual Average Daily Traffic (Nos.)				Average Loading of Trucks (Tonnes)				Number of Lanes (Nos.)	Pavement conditions (in kms)			Length of the route (in kms)
	LCV	MCV	HGV	Others	LCV	MCV	HGV	Others		Good	Fair	Bad	
Routes													
Dar-es-Salaam-Morogoro													
Morogoro - Isaka													
Isaka - Rusumo/ Rusumo													
Isaka - Kabanga/ Kobero													
Isaka – Mwanza													
Lusahunga – Mutukula													
Mutukula – Kampala													
Kabanga - Bujumbura													
Rusumo - Kigali													
Kigali - Goma													
Kigali - Bukavu													

Kindly note the other parameters that will be utilised for GHG accounting project is provided below, the data for these parameters will be obtained through the survey:

Fuel Efficiency or Fuel Consumption data (km/litre)
Average Running Speed (kmph)

ANNEXURE FOUR: GHG EMISSION CALCULATION METHODOLOGY

GHG Emission Calculation Methodology

The detailed calculation methodology for calculating GHG emissions for freight transportation in the corridors are provided below:

Total GHG emissions:

The estimated total GHG emissions of freight transportation in the corridors are calculated as a sum of total CO_2 emissions, CO_2 equivalent of total CH_4 emissions and CO_2 equivalent of total N_2O emissions.

Total GHG emission (CO_2 equivalent) = **Total emission of CO_2** + **Total emission of CH_4 (CO_2 equivalent)** + **Total emission of N_2O(CO_2 equivalent)**

Source: (Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 25: Total GHG emission (in terms of Carbon Dioxide) computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total GHG emission in (CO_2 equivalent)	Total Greenhouse gas emission in terms of equivalent carbon dioxide emission	Million tonnes	Derived/ calculated	Total GHG emission is calculated from the summation of total emission of CO_2, total emission of CH_4 (CO_2 equivalent) and total emission of N_2O (CO_2 equivalent) of the corridor
2.	Total emission of CO_2	Total Carbon Dioxide (CO_2) emission of the corridor	Million tonnes	Derived/ calculated	The total emission of CO_2 is calculated by using total fuel consumed by the truck, density of fuel, net calorific value of the fuel and CO_2 emission factor of the fuel
3.	Total GHG emission of CH_4 (CO_2 equivalent)	Total Methane emission in terms of equivalent carbon dioxide emission.	Million tonnes	Derived/ calculated	The total emission of CH_4 (CO_2 equivalent) is calculated from total CH_4 emission of the corridor and global warming potential of CH_4
4.	Total GHG emission of N_2O (CO_2 equivalent)	Total Nitrous Oxide emission in terms of equivalent carbon dioxide emission	Million tonnes	Derived/ calculated	The total emission of N_2O (CO_2 equivalent) is calculated from total N_2O emission of the emission and global warming potential of N_2O

The GWP (details provided in section 2.1.1) of CH_4 and N_2O is used for calculating CO_2 equivalent of CH_4 and N_2O emissions, and calculation details are provided below.

Total CH_4 emissions

$$\text{Total emission of } CH_4 \ (CO_2 \text{ equivalent}) = \text{Total } CH_4 \text{ emission} \times GWPCH_4$$

Source: (Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 26: Total Methane emission (in terms of Carbon Dioxide) computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total emission of CH_4 (CO_2 equivalent)	Total Methane emission in terms of equivalent carbon dioxide emission	Million tonnes	Derived/ calculated	The total emission of CH_4 (CO_2 equivalent) is calculated from total CH_4 emission and global warming potential of CH_4
2.	Total CH_4 emission	Total Methane emission of a corridor	Million tonnes	Derived/ calculated	The total emission of CH_4 is calculated by using total fuel consumed, density of fuel, net calorific value of the fuel and CH_4 emission factor of the fuel
3.	$GWPCH_4$	Global warming potential of Methane (CH_4)	No units	IPCC Default Value	The global warming potential of CH_4 is sourced from IPCC Fifth Assessment Climate Change 2013-The Physical Science Basis, Chapter 8

Total N_2O emissions

$$\text{Total emission of } N_2O \ (CO_2 \text{ equivalent}) = \text{Total } N_2O \text{ emission} \times GW_{N_2O}$$

Source: (Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 27: Total nitrous oxide emission (in terms of Carbon Dioxide) computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total emission of N_2O (CO_2 equivalent)	Total Nitrous Oxide emission in terms of equivalent carbon dioxide emission	Million tonnes	Derived/ calculated	The total emission of N_2O (CO_2 equivalent) is calculated from total N_2O emission of the corridor and global warming potential of N_2O
2.	Total N_2O emission	Total Nitrous Oxide emission of a corridor	Million tonnes	Derived/ calculated	The total emission of N_2O is calculated by using total fuel consumed, density of fuel, net calorific value of the fuel and N_2O emission factor of the fuel
3.	GW_{N_2O}	Global Warming Potential of Nitrous Oxide (N_2O)	No units	IPCC default value	The Global Warming Potential of N_2O is sourced from IPCC Fifth Assessment Climate Change 2013-The Physical Science Basis, Chapter 8

For GHG emission calculation, the consultant has considered IPCC default values for fuel emission factor (CO_2, N_2O, CH_4) net calorific value and density. For the pollutant (CO, VOC, PM, NO_X) emission factor data has been taken from the European Monitoring and Evaluation Programme European Environment Agency (EMEP EEA). The detailed calculations for the same have been illustrated in the tables below. The energy content of the fuel is calculated from fuel consumption of the trucks (category wise), density of diesel and net calorific of diesel.

$$\text{Total } CO_2 \text{ emission} = FC_{LCV/MCV/HGV} \times D_{Diesel} \times NCV_{Diesel} \times EF_{CO_2}$$

Source: (Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 28: Total Carbon Dioxide emission computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total CO_2 emission	Total Carbon Dioxide (CO_2) emission of the corridor	Million tonnes	Derived/ calculated	The total emission of CO_2 is calculated by using total fuel consumed by the trucks, density of fuel, net calorific value of the fuel and CO_2 emission factor of the fuel
2.	$FC_{LCV/MCV/HGV}$	Total fuel consumption of LCV/MCV/HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck
3.	D_{Diesel}	Density of the diesel	Kg/l	HBEFA value	The density of the diesel is sourced from The Handbook Emission Factors for the Road Transport (HBEFA)
4.	NCV_{Diesel}	Net calorific value of diesel	TJ/Gg	IPCC default value	Net calorific value of Diesel is sourced from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2- chapter 1, (Page 1.18)
5.	EF_{CO_2}	CO_2 emission factor for diesel	$MtCO_2/TJ$	IPCC default value	CO_2 emission factor of the fuel is sourced from IPCC guidelines for National Greenhouse Gas Inventories, Volume 2- Energy, Chapter 3 Mobile Combustion (Page no 3.16)

The Total N_2O emissions are calculated from the energy content of the fuel (diesel) consumed in freight transportation and N_2O emission factor for diesel.

$$\text{Total } N_2O \text{ emission} = FC_{LCV/MCV/HGV} \times D_{Diesel} \times NCV_{Diesel} \times EF_{N_2O}$$

Source: (Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 29: Total Nitrous Oxide emissions computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total N_2O emission	Total Nitrous Oxide N_2O emission of the corridor	Million tonnes	Derived/ calculated	Total emission of N_2O is calculated by using total fuel consumed by the truck, density of fuel, net calorific value of the fuel and N_2O emission factor of the fuel
2.	$FC_{LCV/MCV/HGV}$	Total fuel consumption of LCV/MCV/HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck
3.	D_{Diesel}	Density of the diesel	Kg/l	HBEFA value	The density of the diesel is sourced from The Handbook Emission Factors for the Road Transport (HBEFA)
4.	NCV_{Diesel}	Net calorific value of diesel	TJ/Gg	IPCC default value	Net calorific value of diesel is sourced from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2- chapter 1, (Page 1.18)
5.	EF_{N_2O}	N_2O emission factor for diesel	Kg/TJ	IPCC default value	N_2O emission factor for diesel is sourced from IPCC guidelines for National Greenhouse Gas Inventories, Volume 2- Energy, Chapter 3 Mobile Combustion (Page no 3.21)

The total CH_4 emissions are calculated from the energy content of the fuel (diesel) consumed in freight transportation and CH_4 emission factor for diesel.

$$\text{Total } CH_4 \text{ emission} = FC_{LCV/MCV/HGV} \times D_{Diesel} \times NCV_{Diesel} \times EF_{CH_4}$$

Source: (Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 30: Total Methane emissions computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total CH_4 emission	Total Methane (CH_4) emission of the corridor	Million tonnes	Derived/ calculated	Total emission of CH_4 is calculated by using total fuel consumed by the truck, density of fuel, net calorific value of the fuel and CH_4 emission factor of the fuel
2.	$FC_{LCV/MCV/HGV}$	Total fuel consumption of LCV/MCV/HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck
3.	D_{Diesel}	Density of the diesel	Kg/l	HBEFA value	The density of the diesel is sourced from The Handbook Emission Factors for the Road Transport (HBEFA)

Sl. No.	Notation	Parameter	Unit	Source	Description
4.	NCV_{Diesel}	Net calorific value of diesel	TJ/Gg	IPCC default value	Net calorific value of diesel is sourced from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 2- chapter 1, (Page 1.18)
5.	EF_{CH_4}	CH_4 emission factor for diesel	Kg/TJ	IPCC default value	CH_4 emission factor for diesel is sourced from IPCC guidelines for National Greenhouse Gas Inventories, Volume 2- Energy, Chapter 3 Mobile Combustion (Page no 3.21)

Total Pollutants emissions:

The total CO emissions are calculated from the fuel consumption of the trucks (category wise), fuel density and CO emission factor for diesel.

$$\text{Total CO emission} = FC_{LCV/MCV/HGV} \times D_{Diesel} \times EF_{CO} \quad (1)$$

Source: (European Monitoring and Evaluation Programme European Environment Agency (EMEP/EEA) 2016)

Table 31: Total Carbon Monoxide computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total CO emission	Total Carbon Monoxide (CO) emission of the corridor	Million tonnes	Derived/ calculated	Total emission of CO is calculated using total fuel consumed by truck, density of fuel and CO emission factor
2.	$FC_{LCV/MCV/HGV}$	Total fuel consumption of LCV/MCV/ HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck
3.	D_{Diesel}	Density of the diesel	Kg/l	HBEFA value	The density of the diesel is sourced from The Handbook Emission Factors for the Road Transport (HBEFA)
4.	EF_{CO}	CO emission factor for diesel	Kg/TJ	IPCC default value	CO emission factor for diesel is sourced from EMEP EEA air pollutant emission inventory guidebook, 2016, Part B Sectoral guidance chapters, chapter 1 Energy

The total VOC emissions are calculated from the fuel consumption of the trucks (category wise), fuel density and VOC emission factor for diesel.

2 $$\text{Total VOC emission} = FC_{LCV/MCV/HGV} \times D_{Diesel} \times EF_{VOC}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006*)*

Table 32: Total Volatile Organic Compound computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total VOC emission	Total Volatile Organic Compounds (VOC) emission of the corridor	Million tonnes	Derived/ calculated	Total emission of VOC is calculated using total fuel consumed by truck, density of fuel and VOC emission factor
2.	$FC_{LCV/MCV/HGV}$	Total fuel consumption of LCV/MCV/ HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck
3.	D_{Diesel}	Density of the diesel	Kg/l	HBEFA value	The density of the diesel is sourced from The Handbook Emission Factors for the Road Transport (HBEFA)
4.	EF_{VOC}	VOC emission factor for diesel	Kg/TJ	IPCC default value	VOC emission factor for diesel is sourced from EMEP EEA air pollutant emission inventory guidebook, 2016, Part B Sectoral guidance chapters, chapter 1 Energy

The total NOx emissions are calculated from the fuel consumption of the trucks (category wise), fuel density and NOx emission factor for diesel.

3 $$\text{Total } NO_X \text{ emission} = FC_{LCV/MCV/HGV} \times D_{Diesel} \times EF_{NO_X}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 33: Total Nitrous Oxide Computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total NOx emission	Total Nitrogen Oxides (NO_x) emission of the corridor	Million tonnes	Derived/ calculated	Total emission of NOx is calculated using total fuel consumed by truck, density of fuel and NOx emission factor of the fuel
2.	$FC_{LCV/MCV/HGV}$	Total fuel consumption of LCV/MCV/ HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck
3.	D_{Diesel}	Density of the diesel	Kg/l	HBEFA value	The density of the diesel is sourced from The Handbook Emission Factors for the Road Transport (HBEFA)
4.	EF_{NO_x}	NO_x emission factor for diesel	Kg/TJ	IPCC default value	NOx emission factor for diesel is sourced from EMEP EEA air pollutant emission inventory guidebook, 2016, Part B Sectoral guidance chapters, chapter 1 Energy

The total PM emissions are calculated from the fuel consumption of the trucks (category wise), fuel density and PM emission factor for diesel.

$$\text{Total PM emission} = FC_{LCV/MCV/HGV} \times D_{Diesel} \times EF_{PM} \quad (4)$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 34: Total Particulate Matter emission computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total PM emission	Total Particulate Matter (PM) emission of the corridor	Million tonnes	Derived/ calculated	Total emission of PM is calculated using total fuel consumed by truck, density of fuel and NOx emission factor
2.	$FC_{LCV/MCV/HGV}$	Total fuel consumption of LCV/MCV/ HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck

Sl. No.	Notation	Parameter	Unit	Source	Description
3.	D_{Diesel}	Density of the diesel	Kg/l	HBEFA value	The Density of the diesel is sourced from The Handbook Emission Factors for the Road Transport (HBEFA)
4.	EF_{PM}	PM emission factor for diesel	Kg/TJ	IPCC default value	PM emission factor for diesel is sourced from EMEP EEA air pollutant emission inventory guidebook, 2016, Part B Sectoral guidance chapters, chapter 1 Energy

Fuel consumed (FC)

The fuel consumption of the trucks (category wise) is derived/ calculated from vehicle kilometre travelled and fuel efficiency of the trucks (category wise)

a

$$FC_{LCV/MCV/HGV} = \frac{\text{Vehicle kilometre travelled (VKT)}}{FE_{LCV/MCV/HGV}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 35: Fuel consumption computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Total $FC_{LCV/MCV/HGV}$ emission	Total fuel consumption of LCV/MCV/ HGV	Million litres	Derived/ calculated	Fuel consumed is calculated using vehicle kilometre travelled and fuel efficiency of truck
2.	Vehicle kilometre travelled (VKT)	Traffic flow	VKT	Derived/ calculated	The vehicle Kilometre travelled is calculated using average annual daily traffic and length of the corridor
3.	$FE_{LCV/MCV/HGV}$	Fuel efficiency	km/ l	Survey	The fuel efficiency of trucks is sourced from the survey conducted by the corridor

The vehicle kilometre travelled is derived/ calculated from annual average daily traffic of vehicle (category wise) and length of the corridor. Both these data are monitored by corridor observatory.

b

$$\text{Vehicle kilometre travelled (VKT)} = AADT_{LCV/MCV/HGV} \times \text{Length of the corridor} \times N_{LCV/MCV/HGV}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 36: Vehicle kilometre travelled computation

Sl. No.	Notation	Parameter	Unit	Source	Description
1.	Vehicle kilometre travelled (VKT)	Traffic flow	VKT	Derived/ calculated	The vehicle Kilometre travelled is calculated using average annual daily traffic and length of the corridor
2.	$AADT_{LCV/MCV/HGV}$	Average annual daily traffic	Nos.	Corridor observatory	The average annual daily traffic is sourced from the corridor observatory
3.	Length of the corridor	Length of corridor	km	Corridor observatory	The length of the corridor is sourced from the corridor observatory
4.	$N_{LCV/MCV/HGV}$	No. of days vehicle travelled	Nos.	Corridor observatory	No. of days in a year for which vehicles travelled

GHG Intensity Factors

The various GHG intensity factors area derived/ calculated from total CO_2, CH_4, N_2O and pollutant emission and payload distance. The GHG intensity factor is used for benchmarking, identifying GHG reduction potential, developing climate goals and action plan.

c

$$\text{Specific } CO_2 \text{ emission} = \frac{\text{Total } CO_2 \text{ emission}}{\text{Payload distance}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 37: Specific Carbon Dioxide emission of the corridor computation

Sl. No.	Parameter	Unit	Description
1.	Specific CO_2 emission	gCO_2/tonne-km	The specific CO_2 emission is calculated by total CO_2 emission of the corridor and payload distance
2.	Total CO_2 emission	Million tonnes	Total emission of CO_2 of the corridor is calculated by using total fuel consumed by the truck, density of fuel, net calorific value of the fuel and CO_2 emission factor of the fuel
3.	Payload distance	Tonne-km	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck

d

$$\text{Specific } N_2O \text{ emission} = \frac{\text{Total } N_2O \text{ emission}}{\text{Payload distance}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 38: Specific Nitrous Oxide emission of the corridor computation

Sl. No.	Parameter	Unit	Description
1.	Specific N_2O Emission	gN_2O /tonne-km	The specific N_2O emission is calculated by total N_2O emission of the corridor and payload distance
2.	Total N_2O Emission	Million tonnes	Total emission of N_2O of the corridor is calculated by using total fuel consumed, density of fuel, net calorific value of the fuel and N_2O emission factor of the fuel
3.	Payload distance	Tonne-km	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck

e

$$\text{Specific } CH_4 \text{ emission} = \frac{\text{Total } CH_4 \text{ emission}}{\text{Payload distance}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 39: Specific Methane emission of the corridor computation

Sl. No.	Parameter	Unit	Description
1.	Specific CH_4 emission	gCH_4 /tonne-km	The specific CH_4 emission is calculated by total CH_4 emission of the corridor and payload distance
2.	Total CH_4 emission	Million tonnes	Total emission of CH_4 of the corridors calculated by using total fuel consumed, density of fuel, net calorific value of the fuel and CH_4 emission factor of the fuel
3.	Payload distance	Tonne-km	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck

f

$$\text{Specific CO emission} = \frac{\text{Total CO emission}}{\text{Payload distance}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 40: Specific Carbon Monoxide emission of the corridor computation

Sl. No.	Parameter	Unit	Description
1.	Specific CO emission	gCO /Tonne-km	The specific CO emission is calculated by total CO emission of the corridor and payload distance
2.	Total CO emission	Million tonnes	Total emission of CO of the corridor is calculated using total fuel consumed by truck, density of fuel and CO emission factor of the fuel
3.	Payload distance	Tonne-km	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck

g

$$\text{Specific VOC emission} = \frac{\text{Total VOC emission}}{\text{Payload distance}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 41: Specific Volatile Organic Compound emission of the corridor computation

Sl. No.	Parameter	Unit	Description
1.	Specific VOC emission	gVOC /tonne-km	The Specific VOC emission is calculated by total VOC emission of the corridor and payload distance
2.	Total VOC emission	Million tonnes	Total emission of VOC of the corridor is calculated using total fuel consumed by truck, density of fuel and VOC emission factor of the fuel
3.	Payload distance	Tonne-km	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck

h

$$\text{Specific } NO_x \text{ emission} = \frac{\text{Total } NO_x \text{ emission}}{\text{Payload distance}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 42: Specific NOx emission of the corridor computation

Sl. No.	Parameter	Unit	Description
1.	Specific NO_X emission	gNO_X /tonne-km	The Specific NOx emission is calculated by total NOx emission of the corridor and payload distance
2.	Total NO_X emission	Million tonnes	Total emission of NOx of the corridor is calculated using total fuel consumed by truck, density of fuel and NOx emission factor of the fuel
3.	Payload distance	Tonne-km	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck

i

$$\text{Specific PM emission} = \frac{\text{Total PM emission}}{\text{Payload distance}}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 43: Specific Particulate Matter emission of the corridor computation

Sl. No.	Parameter	Unit	Description
1.	Specific PM emission	gPM /tonne-km	The specific PM emission is calculated by total pm emission of the corridor and payload distance
2.	Total PM emission	Million tonnes	Total emission of PM of the corridor is calculated using total fuel consumed by truck, density of fuel and NOx emission factor of the fuel
3.	Payload distance	Tonne-km	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck

Where,

$$\text{Payload distance (Tonne-km)} = \text{Vehicle kilometre travelled (VKT)} \times \text{Average weight of LCV/MCV/HGV}$$

Source:(Intergovernmental Panel on Climate Change (IPCC) 2006)

Table 44: Payload distance computation

Sl. No.	Parameter	Unit	Source	Description
1.	Payload distance	Tonne-km	Derived/ calculated	Payload distance is calculated using vehicle kilometre travelled (traffic flow) and the average weight of the truck
2.	Vehicle kilometre travelled (traffic flow)	VKT	From survey	The vehicle Kilometre travelled is calculated using average annual daily traffic, length of the corridor and no. of days for which vehicles travelled
3.	Average weight of LCV/MCV/HGV	tonnes	From survey	The actual weight of the trucks are sourced from a survey conducted by Corridor Transit and Transport Coordination Authority

ANNEXURE FIVE: QA/QC CHECKLIST

Quality Assurance and Control

The QA/QC procedures outlined in the UNFCCC GPG 2000 and IPCC GPG, 2000 has been followed. The QA/ QC plan was adhered to during the period of data collection and GHG inventory preparation.

Few examples of QA/ QC carried out are given below:

Fuel efficiency data obtained from transporters survey has been cross-checked with fuel efficiency figures of GIZ study and fuel efficiency figures of a study conducted by Jomo Kenyatta University of Agriculture and Technology (X. F. David Odeyo Abiero 2015)and it was found that the fuel efficiency data was comparable with both the studies. Hence this data was used for the GHG emission model.

The proportion of empty and loaded return journey by the trucks has been obtained through transporters survey has been cross-verified from trade (total import/export of member countries) related data of observatory and the survey data was found to be comparable. Hence this data was used for the GHG emission model.

The GHG emissions from corridor operations of countries like Kenya, Uganda, Tanzania, and Rwanda are the maximum among the other member countries. Hence the GHG emissions from corridor operations of these countries have been compared with their total countries transport or freight emissions and the GHG emission results obtained from the study are comparable to the country level figures.

Table 45: QA/QC checklist

General Inventory Level QC Procedure and Checklist			
QC Activity	Procedures	QC -Level 1	QC -Level 2
Check that assumptions and criteria for the selection of activity data, and emission factors are documented	- Cross-check descriptions of activity data and emission factors with information on source categories and ensure that these are properly recorded and archived.	√	√
Check for transcription errors in data input and reference	- Confirm that bibliographical data references are properly cited in the internal documentation. - Cross-check a sample of input data from each source category (either measurements or parameters used in calculations) for transcription errors.	√	√
Check that the emissions are calculated correctly	- Reproduce a representative sample of emissions calculations. - Selectively mimic complex model calculations with abbreviated calculations to judge relative accuracy.	√	√
Check that parameter and emission units are correctly recorded and that appropriate conversion factors are used.	- Check that the units are properly labelled in calculation sheets. - Check that the units are correctly carried through from beginning to end of calculations. - Check that conversion factors are correct. - Check that temporal and spatial adjustment factors are used correctly.	√	√
Check the integrity of database files	- Confirm that the appropriate data processing steps are correctly represented in the database. - Confirm that data relationships are correctly represented in the database. - Ensure that data fields are properly labelled and have the correct design specifications. - Ensure that adequate documentation of database and model structure and operation are archived.	√	√
Check for consistency in data between source categories	- Identify parameters (e.g. Activity data, constants) that are common to multiple source categories and confirm that there is consistency in the values used for these parameters in the emissions calculations.	√	√
Check that the movement of inventory data among processing steps is correct	- Check that emissions data are correctly aggregated from lower reporting levels to higher reporting levels when preparing summaries. - Check that emissions data are correctly transcribed between different intermediate products.	√	√

General Inventory Level QC Procedure and Checklist			
QC Activity	Procedures	QC -Level 1	QC -Level 2
Check that uncertainties in emissions and removals are estimated or calculated correctly.	- Check that qualifications of individuals providing expert judgement for uncertainty estimates are appropriate. - Check that qualifications, assumptions and expert judgements are recorded. Check that calculated uncertainties are complete and calculated correctly. - If necessary, duplicate error calculations or a small sample of the probability distributions used by Monte Carlo analyses.	√	√
Undertake a review of internal documentation	- Check that there is detailed internal documentation to support the estimates and enable duplication of the emission and uncertainty estimates. - Check that inventory data, supporting data, and inventory records are archived and stored to facilitate a detailed review. - Check integrity of any data archiving arrangements of outside organisations involved in inventory preparation.	√	√
Check methodological and data changes resulting in re-calculations	- Check for temporal consistency in time-series input data for each source category. - Check for consistency in the algorithm/method used for calculations throughout the time series.	√	√
Undertake completeness checks	- Confirm that estimates are reported for all source categories and for all years from the appropriate base year to the period of the current inventory. - Check that known data gaps that result in incomplete source category emissions estimates are documented	√	√
Compare estimates to other or previous estimates (as applicable)	For each source category, current inventory estimates should be compared to previous estimates. If there are significant changes or departures from expected trends, re-check estimates and explain any difference.	√	√

ANNEXURE SIX: UNCERTAINTY ANALYSIS

Uncertainties are generally associated with the activity data, emission factors being measured or extracted from the literature, and assumptions based on expert judgement.

All the data sources used and assumptions made for estimating GHG emissions has been referenced to ensure full transparency. The category of quality data and emission factor is assessed as high, medium or low, based on the degree to which data reflect the geographical location of the activity, the time or age of the activity and any technologies used, the assessment boundary and emission source, and whether data have been obtained from reliable and verifiable sources.

Table 46: Data quality analysis

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

This methodology uses a qualitative estimation of uncertainties by source category; however, the use of the error propagation equation and simple combination of uncertainties by source category to estimate overall uncertainty for one year and the uncertainty in the trend has not used but may be applied during regular monitoring of GHG emissions. However, the percentage of uncertainties associated with the activity data has been discussed with the GHG and sector experts who has done the estimation and is based on their expert judgement. The default or standard emission factors have been used for GHG emission; hence emission factor uncertainties are related to the standard deviation of the measured emission factors is not applicable.

ANNEXURE SEVEN: LITERATURE REVIEW

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TRANSPORT COORDINATION AUTHORITY

HOUSE 1196 LINKS ROAD NYALI

P.O BOX 34068-80118 MOMBASA, KENYA

+254 729 923574

+254 733 532485

ttca@ttcanc.org

www.ttcanc.org

CENTRAL CORRIDOR TRANSIT AND
TRANSPORT FACILITATION AGENCY

POSTA HOUSE GHANA AVENUE

P.O. BOX 2372 DAR ES SALAAM, TANZANIA

PHONE: +255 22 2127 149

MOBILE: +255 687 440 941

ttfa@centralcorridor-ttfa.org

www.centralcorridor-ttfa.org

@NorthernCoridor @ccttfaorg

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