Freight GHG Emissions and Cost Calculator

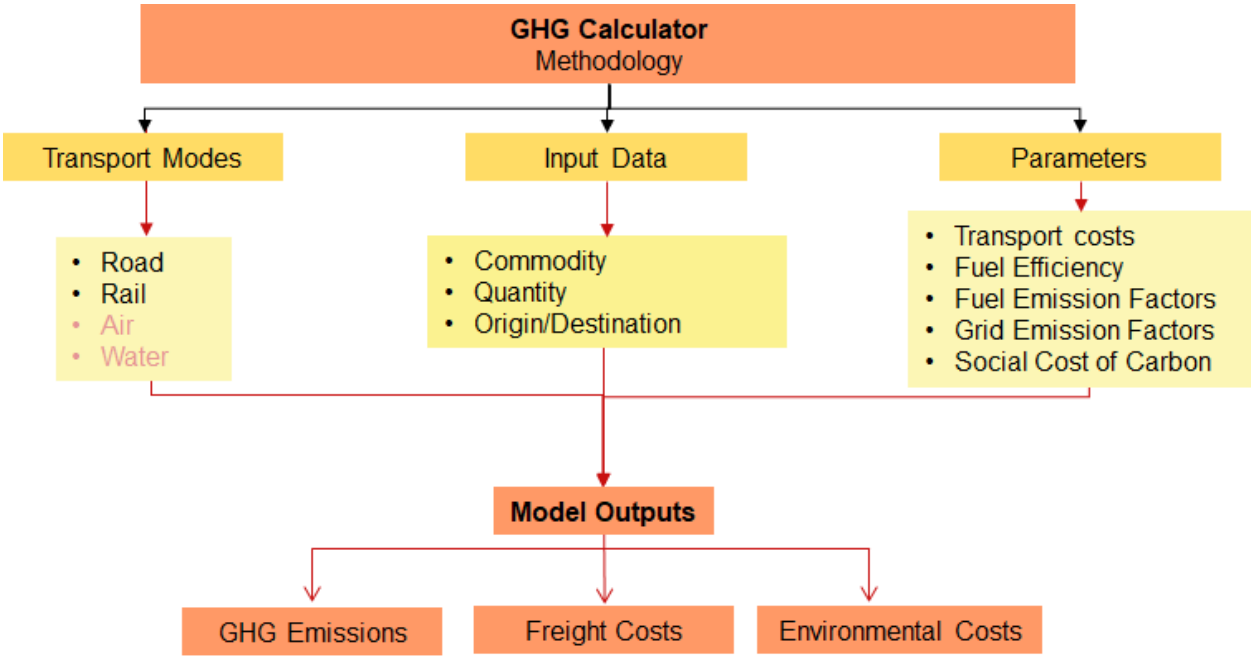
The 'Freight GHG Emissions and Cost Calculator' is an attempt to help users in estimating the emissions and costs on account of movement of freight through different transport modes in India. In its current form, the calculator allows comparison between movement by road and rail for different commodities, both GHG emissions and total cost of transportation, including the environmental cost. The tool is intended to help companies and individuals easily compare the tradeoffs involved with freight movement by different transport modes for pre-selected origin and destination points or manually entered distances.

Objective

To develop an India-specific calculator to estimate GHG emissions and total cost of freight from key modes of transport (road, rail, water and air)

Approach and Methodology

This calculator enables users to derive GHG emissions and freight costs by using the default options. However, the users are given an option to enter specific input values *manually* based on their experience so as to derive accurate GHG emissions and freight costs. The *input* and *output* parameters are discussed in detail in the following section. The general approach towards development of the GHG calculator is given below.



Note: Air and Water modes to be added in the second phase; Source: TERI

Input parameters

The calculator utilizes shipment, trip and cost inputs choices from the user for estimating the emissions and costs from freight movement (Figure 1). The data entered by the user is combined with fixed inputs such as emission factors to estimate GHG emissions, freight costs and environmental costs.

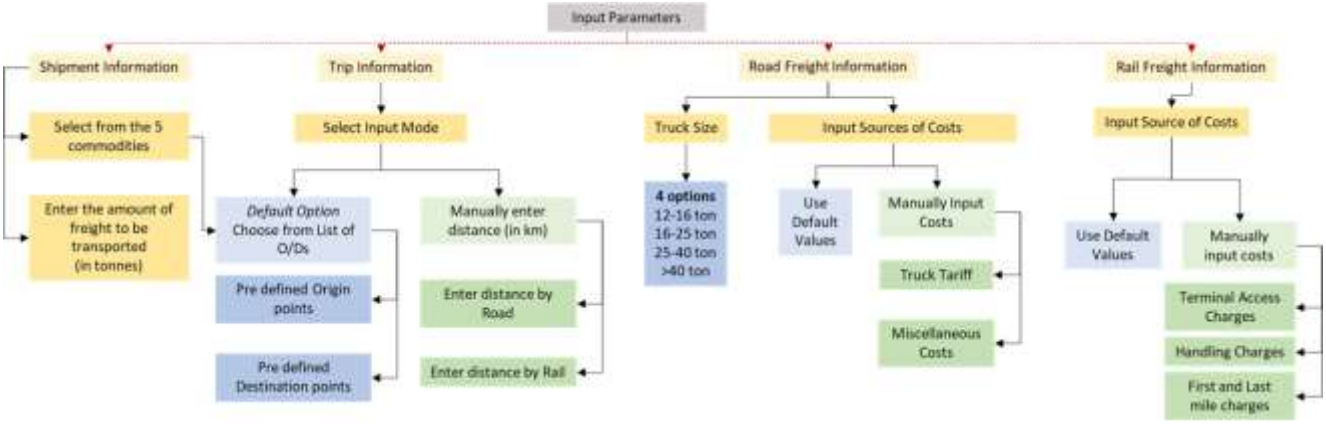


Figure 1: Input options for users in the calculator

Source: TERI

The basic principle involved in the calculation of emissions and costs are based on the weight of the shipment and the distance travelled (tonne-km). It is to be noted that the freight costs are dynamic in nature and would require regular updates.

Outputs

- ***GHG emissions:*** Mode-wise estimate of the total greenhouse gas emissions associated with the selected freight movement.

- ***Freight costs:*** Mode-wise estimate of the total costs associated with selected freight movement.

- ***Environmental costs:*** Mode-wise estimate of the monetary cost to society from the GHG emissions, estimated based on the social cost of carbon for India[1].

Estimations for Road Freight

Emissions from road freight are estimated based on the below principle:

$$\boldsymbol{Emission\ from road = Transport\ distance\ by\ road * quantity\ of\ freight\ transported * vehicle\ emissions\ per\ net\ tonne\ km}$$

[1] Social cost of carbon is defined as the quantifiable costs and benefits of emitting one additional tonne of CO_2, in *monetary terms*. The costs have been calculated for different countries, including India, by the Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. As per the study, the social cost of carbon for India is estimated to be US$86 per tonne of CO_2 as per the publication by Ricke et al.[4].

The emission per-tonne km is estimated based on the fuel efficiency of different trucks and the emission factor for diesel. The emissions are estimated for different truck sizes in order to reflect the difference in fuel efficiency for different truck sizes.

Table 1: Details of HDVs considered in the calculator

Truck Size	Average Payload (tons)	Mileage (km/lt)[1]	Diesel consumption (lt/tkm)	Emission Factor ($KgCO_2$/tkm)
12-16 ton	10	5.10	0.019	0.05
16-25 ton	14	4.63	0.015	0.04
25-40 ton	25	3.03	0.014	0.04
>40 ton	27	2.35	0.016	0.04

Source: Compiled by TERI

Similar to emissions, freight costs from road transport are also estimated based on the tonne km travelled. Truck rental rates in India are dynamic and heterogenous in nature. It varies with commodities, routes or ODs, regions, nature of relation between consigner/consignee and the trucking company, delivery time, etc. Since specific estimates would not be accurate, representative estimates of rates per tonne km were obtained from a National Freight Index[2], which was last updated in February 2020. While these rates may be slightly outdated, they are obtained based on sampling of about 950 lanes which represent close to 70% of India's road freight traffic, and was deemed to be the most appropriate way of capturing a nationally representative rate. However, these representative unit costs may not represent exact location and situation specific estimates. Hence, the user is provided the option to directly input costs, if available, in Rs per tonne-kms.

Estimations for Rail Freight

Emissions from rail freight are also based on tonne-kms covered:

$$\boldsymbol{Emission\ \ from\, rail = Transport\ distance\ by\, rail * quantity\ of\ freight\ transported * vehicle\ emissions\ per\ net\ tonne\ km}$$

The emission factors from rail were estimated to account for the proportion of rail freight that is carried by diesel and electric traction in India. Fuel use from the Indian Railways Annual Statistical Publication (2018-19) was use to estimate the emissions from diesel and electric respectively. The estimated emissions were converted to tonne-kms based on the tonne-kms of freight moved by diesel and electric traction to obtain an overall emission factor for freight movement by railways. For electric traction the grid emission factor, obtained from Central Electricity Authority, were applied. This method is similar to the method followed by India GHG program publications[3].

Costs from rail freight were broken up into different components to incorporate the additional multi-modal aspects associated with movement by rail. The components are described below:

Table 2: Cost components associated with rail transportation

Cost component	Description	Data source	Comments
Rail Tariff	The per ton rate charged by Indian Railways for moving freight. The rates differ by commodity type and are telescopic, so rate is lower as	FOIS	Directly applied based on the distance and weight being carried

	the distance increases		
Terminal charges	Access charges for using terminals	Indian Railways	Not applied on commodities, assumed to originate from private sidings. Exempt for automobiles Can be directly entered by user as well
First and last mile charges	Cost of transport goods to and from the rail terminal to origin and destination points	Based on stakeholder interactions	Not applied on commodities assumed to originate from private sidings. Exempt for automobiles Can be directly entered by user as well
Handling charges	Cost of loading and unloading goods at terminals	Based on stakeholder interactions	Can be directly entered by user as well

Source: TERI

Limitations

While developing the calculator, several unavoidable limitations were encountered. These have been listed below:

- In this phase only road and rail have been considered, while water and air will be included in the next phase
- Limited number of commodities and origin-destination points have been considered in this calculator, which will be expanded to include pan-India operation
- The cost estimates for road freight are based on representative unit costs for freight movement in India and may not to be an exact location specific estimate. The user is provided the option to directly input costs if available
- Truck rental rates in India are dynamic and heterogeneous in nature. It varies with commodities, routes or ODs, regions, nature of relation between consigner/consignee and the trucking company, delivery time, etc. The calculator uses the National Freight Index, which was last updated in February 2020
- The handling charges and first and last mile costs for rail are taken based on representative estimates and may not represent location-specific charges. The user is provided with the option to directly input costs if available
- To arrive at emissions from the railways, emission factor of diesel and electricity have been taken based on the proportion of goods moved by diesel traction and electric tractions as per Indian Railways' Annual Statistical Summary.

References

[1] Based on Phase 1 fuel efficiency norms for HDVs (Bureau of Energy Efficiency)

[2] https://nationalfreightindex.co.in/

[3] https://indiaghgp.org/

[4] Ricke, K., Drouet, L., Caldeira, K. and Tavoni, M., 2018. Country-level social cost of carbon. *Nature Climate Change*, *8*(10), pp.895-900.

Disclaimer

The calculator gives indicative mode-wise comparisons related to GHG emissions and total cost of freight, and should not to be used in making business decisions.

ANNEXURE

Table 3 Methodology and Formula Details

Inputs	Parameters	Factors Considered	Source	Results (Formula used)
Distance	Rail	-	FOIS – Freight Calculator	Shortest distance in km
	Road	-	Google Maps	Shortest distance in km
Commodity	Origin - Destination Points	Based on Maximum Movement between OD	-	-
Ton km	Rail	1. Distance 2. Quantity (Ton)	-	TKM by Rail = Distance by rail x Quantity (in tonnes)
	Road		-	TKM by Road = Distance by road x Quantity (in tonnes)
Emission Factors	Rail	1. Fuel consumption – Diesel (CO_2 emission factor) and Electric (grid emission factor) 2. Tonnage km	• GHG Programme India for Rail • Indian Railways – Annual Statistical Statement Report	Rail Emissions in tCO_2 = Emission Factor x TKM by Rail
	Road	1. Truck Size 2. Fuel consumption ($KgCO_2/km$)	• GHG Programme India for Road • TERI Analysis	Road Emissions in tCO_2 = Emission Factor (based on truck size) x TKM by Road
Freight Cost	Rail	1. Commodity wise rate per ton 2. Quantity (ton) 3. Distance travelled by rail	FOIS – Commodity wise Freight rate	• Rail Tariff = Rate per ton depending on the distance travelled x Quantity (in tonnes) • Total Cost = Rail tariff + Development Charges + GST + Terminal charges + First and Last mile charges + Handling Charges
	Road	1. Truck size 2. Rate per ton km 3. Distance travelled by road	National Freight Index *(represents close to 70% of India's road freight traffic.)*	• Truck Tariff = Rate per ton km x TKM by road • Total Cost = Truck Tariff + Miscellaneous Charges
Environmental Cost	Rail	Social Cost of carbon	Country-level Social Cost of Carbon, Nature Climate Change, Vol 8, October 2018, 895–900	• SCC for rail = Emission by rail (tCO_2) x $US86 per tCO_2
	Road			• SCC for road = Emission by road (tCO_2) x $US86 per tCO_2

Source: TERI