3.4 Transport Sector

3.4.1 Preconditions for the sector

The subject of the transport sector is mainly an integrated development study for the transport sector covering the nation at large and also the big cities individually. In these studies, integrated future demand forecast will be calculated for traffic volume on roads, railways, aviation, shipping and inland waterways in the nation and for roads and railways in the big cities and the future traffic networks will be designed on that basis.

In general, the demand forecast is calculated by using the Four Step Method. First, demand for all transportation modes is estimated (Generation/ Attraction Model), and the distribution of starting/ ending points of all trips is estimated (Distribution Model), and the distribution is distributed amongst all transport sectors (Modal-Split Model), and the distributed traffic is assigned to the transport network (Traffic Assignment Model) and finally traffic volume in each section is forecasted. The demand forecast is set by future socio-economic conditions in the study area. In general, demand forecasts for three growth scenarios are made, and the medium growth scenario is selected for the forecast of demand. Therefore forecast demand has some flexibility.

The improvement of traffic conditions by mitigation of traffic congestion leads to better travel conditions, which will in turn lead to an increase in desire to use the roads for transport, which will generate an increase in traffic. The impacts from this generated traffic are difficult to be foreseen, and are under research step. So this issue is not included in this study.

For the road traffic, future networks will be established based on the input data for each road section. It is a prerequisite condition that traffic volume will be in line with future traffic demand. In the area (boundaries) established for demand forecast in implementation of the transport development plan or construction of public transport systems, it is a prerequisite condition that traffic movement in/out the boundaries by each mode are considered clearly in the distribution of demand forecasts.

In general, the integrated development master plan study for the transport sector proposes dozens of projects/ programs for all modes for 20-30 year terms. However, whether such projects/ programs are actually to be undertaken is indefinite.

As mentioned above, this study is implemented on the prerequisite conditions as follow:

1) Demand forecast is correct, and traffic volume will be as forecast.
2) The traffic volume in each section will be as forecast.

3) Mode change from road traffic to public traffic will occur as forecast.
4) The road and public traffic volumes can be clearly identified. (road traffic means traffic of vehicles, and public traffic means traffic of buses, railways, etc. Road and public traffic are estimated separately, because volume converted from road traffic to public traffic will be estimated.)
5) The boundary of each mode is clearly defined.
6) All proposed projects/ programs will be implemented on schedule.

3.4.2 Outline of quantification methods

The method for GHG quantification for the transport sector is to calculate the amounts of GHG emissions with/ without project cases first, and the GHG reduction volume is calculated by the difference between GHG emissions of two cases. In the basic concept, GHG reduction in volume is calculated by multiplication of "traffic volume (number of cars multiplied by kilometres)" and the emission factor for with/ without project cases.

The GHG emissions of road traffic are calculated by the multiplication of "traffic volume (number of cars multiplied by number of kilometres)" for the with/ without project cases and the "emission factors" based on average travel speed of each case. The emission factor is different for each travel speed. That the "travel average speed is constant in each section" is a prerequisite condition.

The emission factors are different for each energy source or vehicle type, etc. It is also different for new and used vehicles, so that data for the concerned country is necessary. In the case of developing countries, these data are not usually readily available. So it is necessary to obtain data by 1) implementation of chassis dynamometer tests, 2) data from other developing countries that have similar characteristics, or 3) analogy from data of new vehicles.

On the mode change from road to railway traffic, GHG emissions in the without case are calculated by multiplication of "traffic volume (Number of cars × kilometres)" and the "Emission factor" for road traffic. The with case is calculated from GHG emissions for road traffic after the mode change and GHG emissions of electricity consumption for the new railway operation. The reduction is calculated by the difference between the with/ without cases.

For shipping and inland waterways, GHG reduction is achieved by reduction of navigation distance and improvement of navigation efficiency. The GHG reduction is calculated by multiplication of "fuel consumption" of ship and the emission factor by fuel type for the with/ without project cases.

On the emissions from aviation, the environmental mitigation measures, such as improvement of aircraft or energy efficiency, reduction of navigation distance at takeoff or landing, etc, are implemented in developed countries. However, these measures are not yet included in JICA's master plan studies in developing countries. Since the emissions from aviation are still under discussion for CDM, the emissions from aviation are not analyzed in this study.

3.4.3 GHG emission reduction activities of JICA projects

Project examples listed in Table 3.4.1 consist of the projects that were recognized to be effective for mitigation of climate change in the research called "JICA's Assistance for Mitigation to Climate Change - The Co-Benefits Approach to Climate Change". And they also include the projects that JICA specified as the mitigation projects from JICA projects of year 2008.

Therefore, these project examples do not contain all of JICA projects. In other words, there are other JICA projects with other GHG reduction components shown in Table 3.4.1.

Table 3.4.1 Components of GHG Emission Reduction Activities

Project example	National integrated transport development									Urban integrated transport development						
	Road network development (national level)			Railway develop -ment	Airport develop -ment	Port (shipping/ inland waterway) development				Road network development (big city level)			Introduc-tion of public transport system		Implementa-tion of improvement plan on traffic management	
	Newly-build/ improvement of roads in the nation (including bypass/ bridge)	Newly-build/ improvement of expressway in the nation	newly-build bypass for reduction of congestion (with public transport promotion policy)	Newly-build/ improvement of railway	Newly-build/ improvement of airport	Contribution to reduction of road traffic travel distance and traffic congestion caused by improvement of port facilities	Mode change from truck transport to inland waterways	Efficiency of container transport by change from small boats to large vessels	Newly build/ improvement of inland waterway system (including shortcut canal)	Newly-build/ improvement of roads in big city (including bypass/ bridge)	Newly-build/ improvement of expressway in big city	Newly-build of bypass for reduction of traffic congestion (with public transport promotion policy)	Newly-build of public transport system (railway, subway, LRT, monorail), and improvement of transport capacity	Improvement of bus system (including low carbon type (CNG, hybrid bus)) and improvement of transport capacity	Improvement of crossing (two-level crossing/ signal system), introduction of ITS, bus lane/ priority system for public cars/ park-and-ride	Introduction of transport management (traffic demand control such as road pricing)
National transport development plan	○	○	○	○	○	○	○	○	○							
Railway development plan				○												
Logistics system development plan						○	○	○	○							
Railway development plan						○	○	○	○							
Urban transport development plan										○	○	○	○	○	○	○

3.4.4 Summary of GHG emission reduction scenarios and quantification methods by activity

In the transport sector, the activities regarding the transport development plan (at the national level and for big cities) are discussed as shown in the following figure. As shown in Table 3.4.1, road network development, railway development, airport development, and port development are typical components at the national level, these components, except for airport development, can reduce GHG and are quantifiable. Road network development, introduction of public transport systems, and implementation of an improvement plan for traffic management are typical components for the big cities.

These components can reduce GHG and are quantifiable. For components other than the road network development and railway development, detailed methods are described in the Quantification Sheets for the specific component, ex. "reduction of road travel distance and dissolution of traffic congestion by improvement of port facilities" in port development.

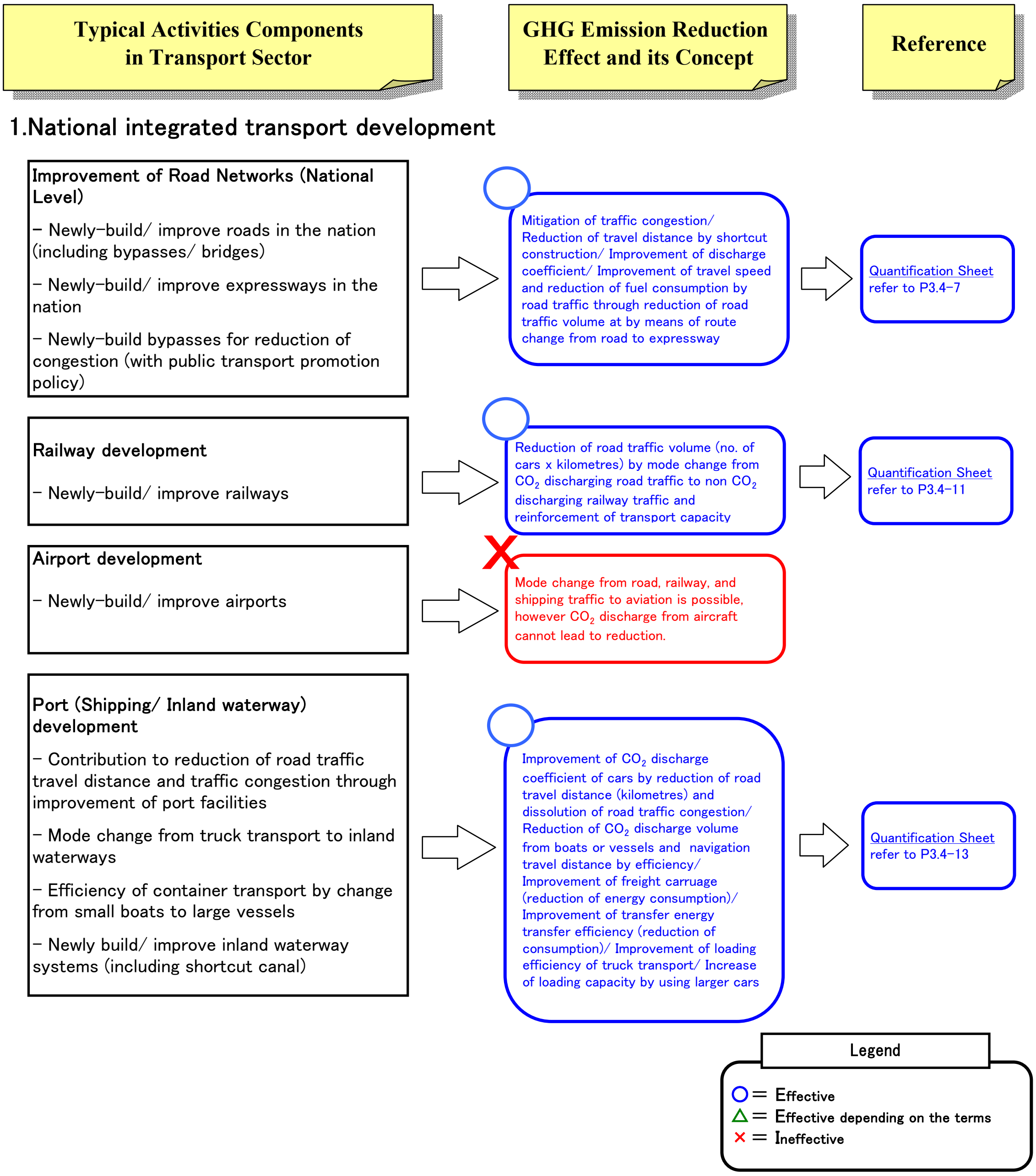


Figure 3.4.1 Quantification possibility of each component
(national integrated transport development)

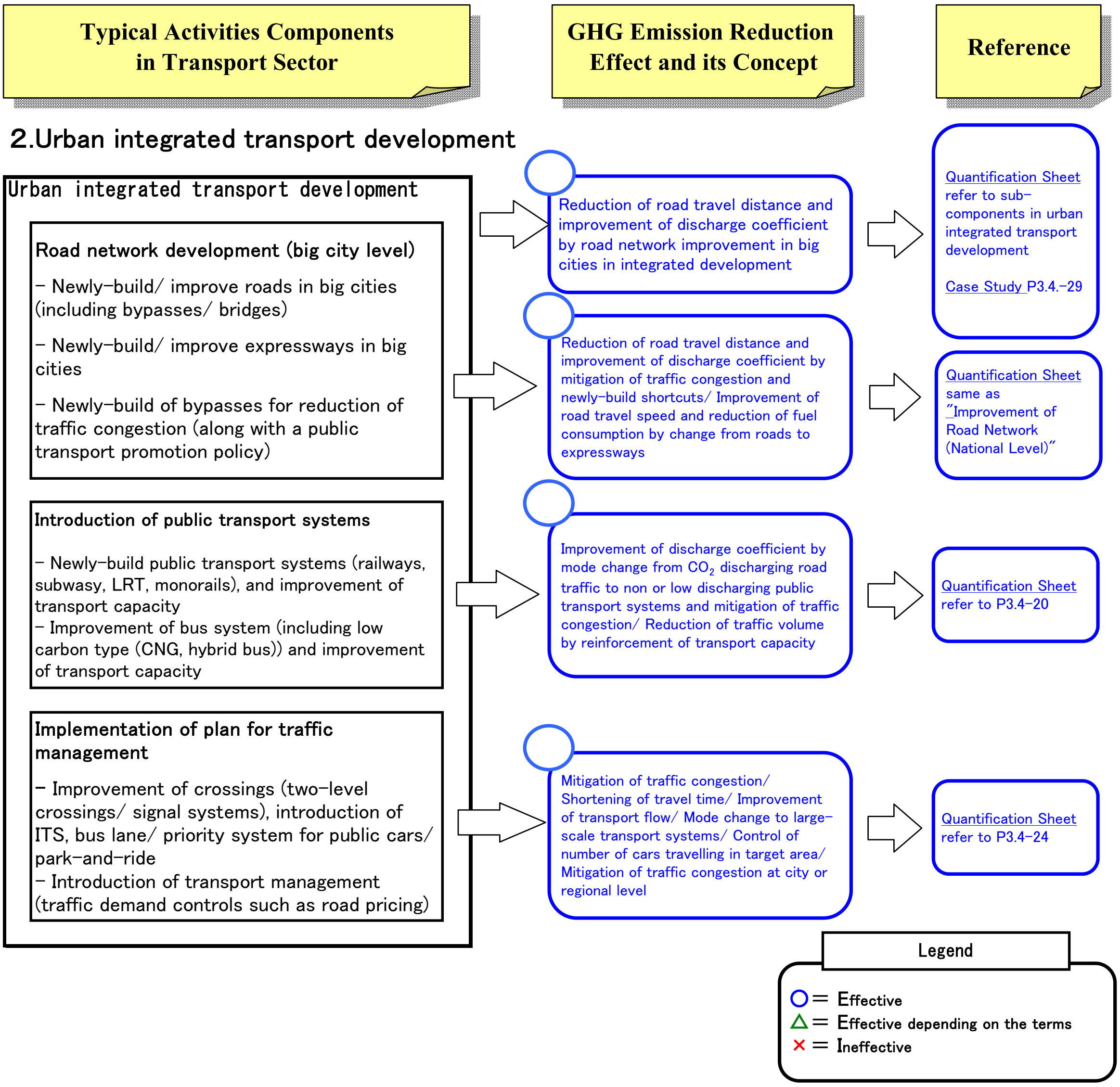
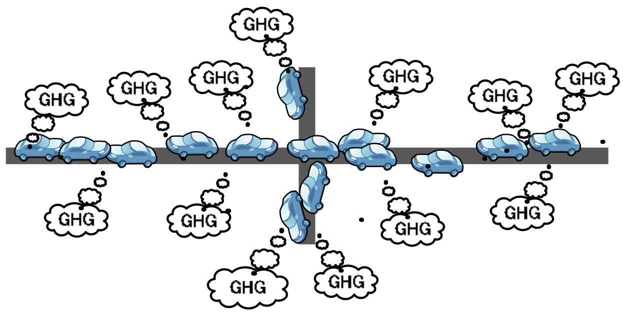
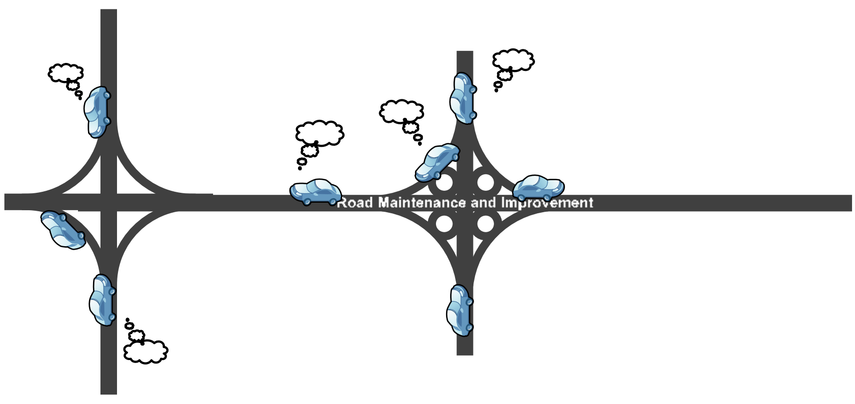


Figure 3.4.2 Quantification possibility of each component

(urban integrated transport development)

Quantification Sheet

Activity: Improvement of road networks

Sector	Transport
Sub-sector	Improvement of road networks
GHG emission reduction activity	Mitigation of traffic congestion/ Reduction of travel distance by shortcut construction/ Improvement of emission factor/ Improvement of travel speed and reduction of fuel consumption by road traffic through reduction of traffic volume on the roads because of route change from road to expressway
GHG emission reduction impact	1: Reduction effect is expected. 2: Reduction effect is expected with some conditions. 3: Reduction effect is not expected.
GHG emission reduction scenario (description of how GHG is reduced)	**<Without the activity>** Road network is not improved. GHG emission from vehicles occurs because road traffic volume increases.  **<With the activity>** Road network is improved corresponding to the demand. GHG from vehicles decreases because of dissolution of traffic congestion and/or shortening of travel distance. 

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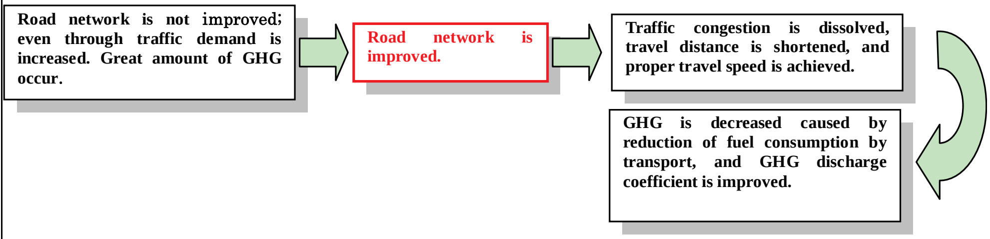
【Schematics of GHG emission reduction process】



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<td>Calculation of GHG emission reduction</td>
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For quantification of GHG from road transport, the following equation should be adopted. The equation is modified from Equation 3.2.1 (P3.12) and Equation 3.2.6 (P 3.26), from “2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy, Chapter 3 Mobile Combustion.”

Basic philosophy is that GHG emission amount is calculated by multiplication of “traffic volume (Number of cars × kilometres)” and the “Emission factor” for the with/ without project cases

（GHG quantification equation for road transport）

$E_{vehicle} = \sum[V_{i,j} \times D_{i,j} \times C_{i,j} \times NCV_j \times EF_j] = VD_{i,j} \times EF_{i,j}$

Where,

$E_{vehicle}$=CO_2 emission amount (kg CO_2)

$V_{i,j}$=Number of vehicles of vehicle type-i, fuel-j

$D_{i,j}$=Travel distance of vehicle type-i, fuel-j (km)

$C_{i,j}$=Average fuel consumption of vehicle type-i, fuel-j (Gg/km)

i=Vehicle type (Sedan, bus, etc.)

j=Fuel (petrol, diesel, etc.)

EF_j=Emission factor of fuel-j (kg CO_2/TJ)

NCV_j=Calorific value of fuel-j (TJ/Gg)

$VD_{i,j}$=Traffic volume of vehicle type-i, fuel-j (Number of cars × kilometres)

$EF_{i,j}$=Emission factor of vehicle type-i, fuel-j (kgCO_2/ Number of cars × kilometres)

[Equations]

<u>**Without the activity**</u>

GHG emission amount from road transport is calculated without improvement of road networks.

$BE_{vehicle}$ = Traffic volume without improvement of road networks (Number of cars × kilometres) × Emission factor of average travel speed without improvement of road networks (kgCO_2/ Number of cars × kilometres)

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	With the activity GHG emission from road transport is calculated with improvement of road networks. $PE_{vehicle}$ = Traffic volume with improvement of road networks (Number of cars × kilometres) × Emission factor of average travel speed with improvement of road networks ($kgCO_2$/ Number of cars × kilometres) **GHG emission reductions** GHG emission reductions (ER) with road network improvement is: $ER(kgCO_2) = BE_{vehicle} - PE_{vehicle}$
Required data and data source	In GHG quantification equation for road transport: $VD_{i,j}$=Traffic volume of vehicle type-i, fuel-j (Number of cars × kilometres)：data from transport master plan study $EF_{i,j}$=Emission factor of vehicle type-i, fuel-j ($kgCO_2$/ Number of cars × kilometres)： $= C_{i,j} \times NCV_j \times EF_j \times 44/12$ $C_{i,j}$：Average fuel consumption amount of vehicle type-i, fuel-j (Gg/km)： ① Measured test data of concerned country* ② In case the concerned country has not provided data, obtain data from the developed countries which produced the vehicles used in the concerned country, for example data on vehicle fuel efficiency by the Ministry of Land, Infrastructure and Transport, Japan, Mobile Model by EPA, USA, and COPERT by EEA should be collected. （refer to ***Annex 3***） NCV_j=Calorific value of fuel-j (TJ/Gg): refer to ***Annex 4*** EF_j=Emission factor of fuel-j ($kgCO_2$/TJ): refer to ***Annex 2*** **Note:** Vehicles are new and used. It is desirable to collect by measurement test data of average fuel consumption amount $C_{i,j}$ for each year and model in the concerned country.
Preconditions	Refer to items described in “3.4.1. Preconditions for Transport Sector” and “3.4.2. Outline of methodology for the transport sector”.
Special notes	Preconditions mentioned in “3.4.1 Preconditions for Transport Sector” involve various uncertain factors. The verification, as to whether the supposition is correct or not, is clear by monitoring which is implemented after operation of the projects. It is necessary to provide budget and time for monitoring. In this JICA master plan development study, the distribution of traffic volume for when road transport projects and public transport projects are implemented together. To evaluate individual GHG discharge reduction effects, traffic

	volume distribution should be calculated to evaluate both modes of transport separately in the master plan stage.

Quantification Sheet

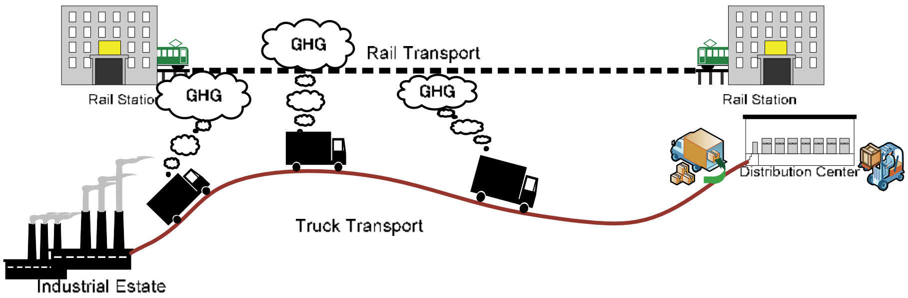
Activity: Railway development

Sector	Transport
Sub-sector	Railway development
GHG emission reduction activity	Reduction of road traffic volume (Number of cars × kilometres) by mode change from CO_2 emissions from road traffic to less carbon-intense railway transport and reinforcement of transport capacity
GHG emission reduction impact	1: Reduction effect is expected. 2: Reduction effect is expected with some conditions. 3: Reduction effect is not expected.

GHG emission reduction scenario (description of how GHG is reduced)

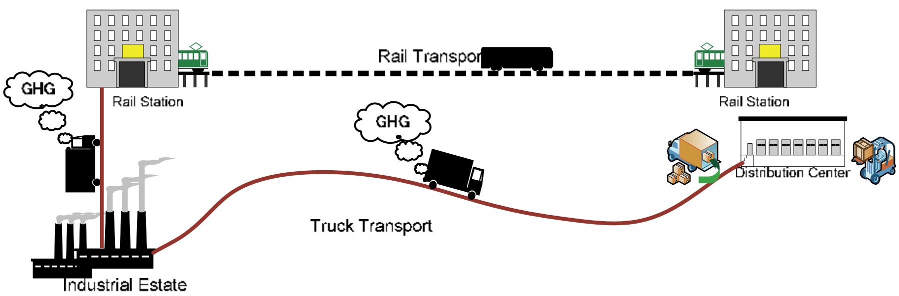
<Without the activity>

Railway system is not improved. GHG from vehicles occurs because road traffic volume increases.



<With the activity>

Railway system is improved to correspond with demand. GHG from vehicles decreases because of dissolution of traffic congestion.



【Schematics of GHG emission reduction process】

Railway system is not improved, even though traffic demand is increased. Great amount of GHG occur.

→ **Railway system is improved.**

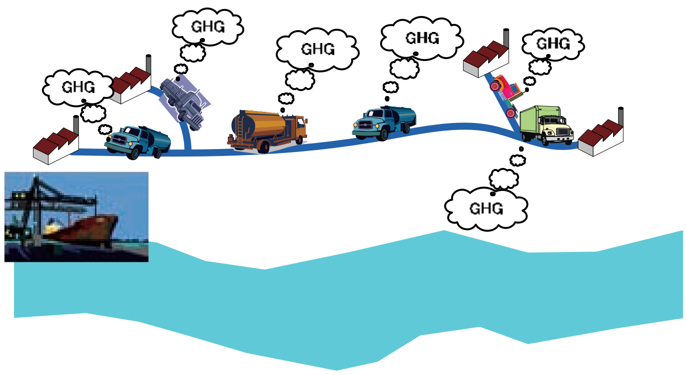
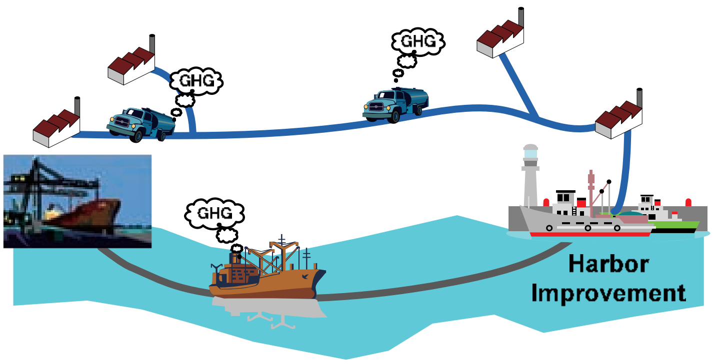
→ **Road traffic with discharge CO_2 is changed to railway system without discharge CO_2 GHG is decreased caused by reduction of fuel consumption by transport, and GHG discharge coefficient is improved.**

Note: Railway system discharge CO_2 from fuel consumption for electricity.

Calculation of GHG emission reduction	For quantification of GHG from road transport, the [**Quantification Sheet** Improvement of Road Networks] should be used. For quantification of fuel consumption amount for electricity, the CDM Methodology Tool (electricity consumption):"Tool to calculate baseline, project and/or leakage emissions from electricity consumption" should be used. **[Equations]** **<u>Without the activity</u>** GHG emissions from road transport are calculated without improvement of the railway system. $BE_{vehicle}$＝ Traffic volume without improvement of railway system (Number of cars × kilometre) × Emission factor of average travel speed without improvement of railway system ($kgCO_2$/ Number of cars × kilometres) **<u>With the activity</u>** GHG emissions from road transport are calculated with improvement of railway system. $PE_{vehicle}$＝Traffic volume with improvement of railway system (Number of cars × kilometres) × Emission factor of average travel speed with improvement of railway system ($kgCO_2$/ Number of cars × kilometres) GHG emissions from public transport are calculated with improvement of railway system. PE_{train}＝ Electricity consumption amount with improvement of railway system (kWh) ×Emission factor of electricity (($kgCO_2$/kWh) **<u>GHG emission reductions</u>** GHG emission reductions (ER) with railway system improvement is: $ER(kgCO_2) = BE_{vehicle} - (PE_{vehicle} + PE_{train})$
Required data and data source	For road transport, "Quantification Sheet Improvement of Road Network" should be used. Data for electricity consumption amount for railway operation should be collected from master plan study. Emission factor of electricity in concerned country should be calculated. Refer to ***Annex 1***.
Preconditions	Refer to items described in "3.4.1. Prerequisite Conditions for Transport Sector" and "3.4.2. Outline of methodology for the transport sector".
Special notes	Same as "Quantification Sheet Improvement of Road Network"

Quantification Sheet

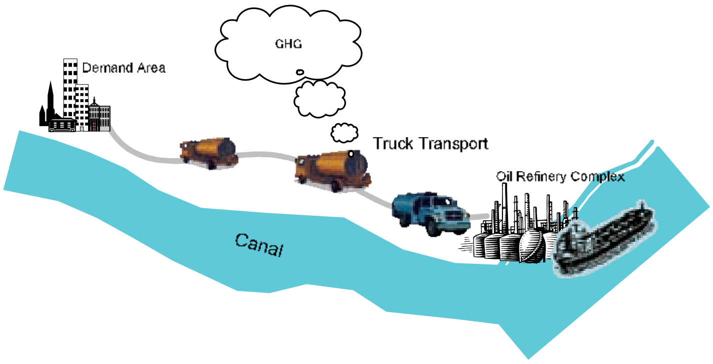
Activity: Port (shipping/ inland waterway) development

Sector	Transport
Sub-sector	Port (shipping/ inland waterway) development
GHG emission reduction activities	Improvement of CO_2 emission factor of cars by reduction of road travel distance (kilometres) and dissolution of road traffic congestion and Reduction of CO_2 emissions from boats or vessels and navigation travel distance by Improvement of freight transport efficiency (reduction of energy consumption)/ Improvement of transfer energy efficiency (reduction of consumption)/ Improvement of loading efficiency of truck transport/ Increase of load capacity by using larger cars
GHG emission reduction impact	1: Reduction effect is expected. 2: Reduction effect is expected with some conditions. 3: Reduction effect is not expected.
GHG emission reduction scenarios (description of how GHG is reduced)	**Reduction of road travel distance and dissolution of traffic congestion by improvement of port facilities** **<Without the Activity>** Port development is not improved. GHG from vehicles occurs because road traffic volume increases.  **<With the Activity>** Port development is improved by changes made to navigation transport. GHG from vehicles decreases because of dissolution of traffic congestion and/or shortening of travel distance. 

Change from truck transport to river boat transport

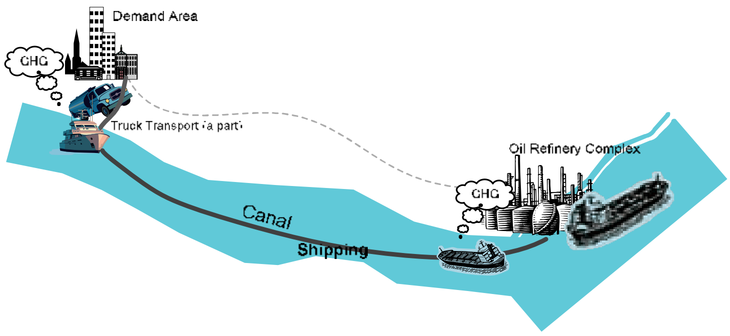
<Without the Activity>

Port development is not improved. GHG from vehicles occurs because road traffic volume increases.



<With the Activity>

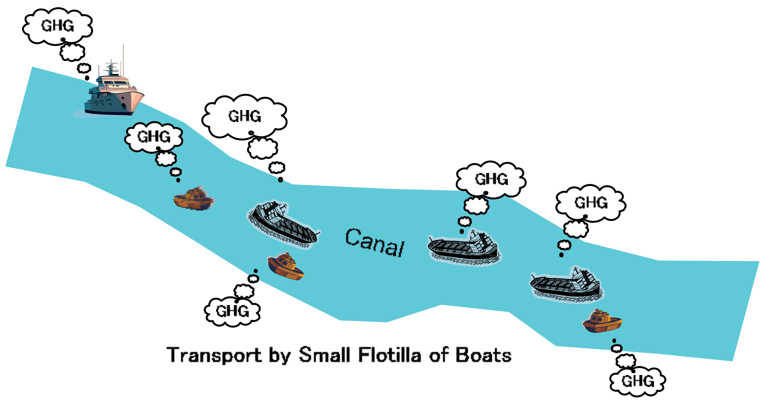
Port is improved to correspond with demand. GHG from vehicles decreases because of dissolution of traffic congestion and/or shortening of travel distance.



Efficiency of container transport by change from small boats to large vessels

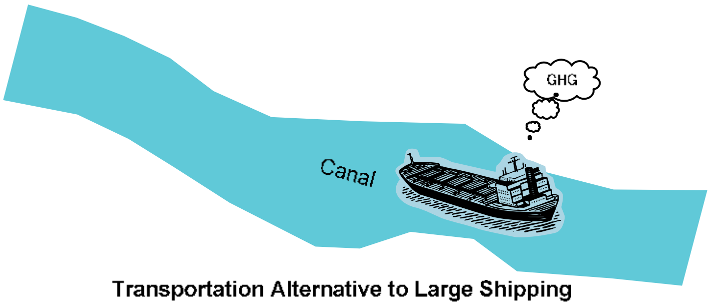
<Without the Activity>

Small boats transport increased loads, because port development is not improved. GHG is emitted from small boats.



<With the Activity>

Transport is implemented by larger vessels, because efficiency of container transport is implemented. GHG from boats/ vessels decreases

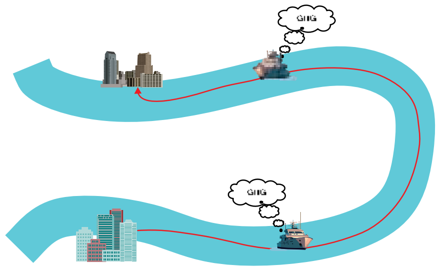


Transportation Alternative to Large Shipping

Newly build/ improve inland waterway systems (including shortcut canal)

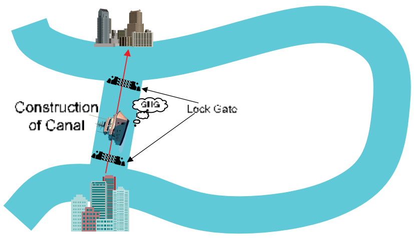
<Without the Activity>

In case of transport of logistics by inland waterways, GHG from boats/ vessels occurs because waterways are longer than necessary.

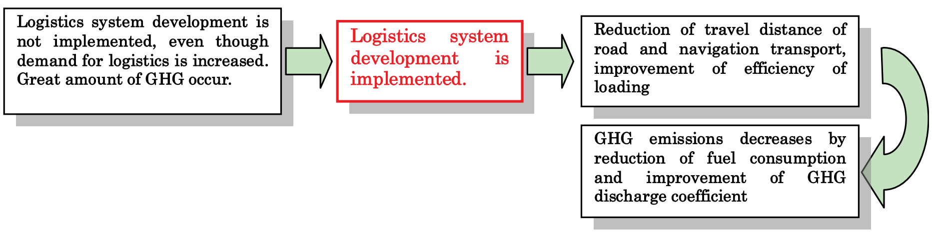


<With the Activity>

Travel distance is shortened by construction of shortcut canal for meandering waterways. GHG from boats/ vessels decreases



【Schematics of GHG emission reduction process】



Calculation of GHG emission reduction	For quantification of GHG from road transport, "Quantification Sheet Improvement of Road Network" should be used. For quantification of GHG from navigation transport, the following equation should be adopted. The equation is modified from Equation 3.5.1 (P 3.47), from "2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy, Chapter 3 Mobile Combustion." Basic principle is that GHG emission amount is calculated by multiplication of "energy consumption" and the "Emission factor" for the with/ without project cases （GHG quantification equation for navigation transport） $E_{ship} = \Sigma(FCa \times EFa)$ Where, E_{ship}=CO_2 emission amount ($kgCO_2$) FCa=Fuel consumption of fuel-a (TJ) EFa=Emission factor of fuel-a ($kgCO_2$/TJ) a=Fuel (petrol, diesel, etc.) **[Equations]** **Reduction of road travel distance and dissolution of traffic congestion by improvement of port facilities** **<u>Without the Activity</u>** GHG emissions from road transport and navigation is calculated without improvement of port facilities. $BE_{vehicle}$＝Traffic volume without improvement of port facilities (Number of cars × kilometres) × Emission factor of average travel speed without improvement of port facilities ($kgCO_2$/ Number of cars × kilometres) BE_{ship}＝Fuel consumption of navigation without improvement of port facilities (TJ) × Emission factor by fuel type without improvement of port facilities ($kgCO_2$/ TJ) **<u>With the Activity</u>** GHG emissions from road transport and navigation are calculated with improvement of port facilities. $PE_{vehicle}$＝Traffic volume with improvement of port facilities (Number of cars × kilometres) × Emission factor of average travel speed with improvement of port facilities ($kgCO_2$/ Number of cars × kilometres)

PE_{ship} = Fuel consumption of navigation with improvement of port facilities (TJ) × Emission factor by fuel type with improvement of port facilities ($kgCO_2$/ TJ)

GHG emission reductions

GHG emission reductions (ER) with port facility improvement is:

$ER(kgCO_2) = BE_{vehicle} + BE_{ship} – PE_{vehicle} – PE_{ship}$

Change from truck transport to river boat transport

Without the Activity

GHG emissions from truck transport are calculated.

BE_{truck} = Traffic volume of trucks (Number of trucks × kilometres) × Emission factor of average travel speed of trucks ($kgCO_2$/ Number of trucks × kilometres)

With the Activity

GHG emissions from truck transport and navigation is calculated, after change from truck transport to river boat transport.

PE_{truck} = Traffic volume of trucks after change from truck transport to river boat transport (Number of trucks × kilometres) × Emission factor of average travel speed of trucks after change from truck transport to river boat transport ($kgCO_2$/ Number of trucks × kilometres)

PE_{ship} = Fuel consumption of boats after change from truck transport to river boat transport (TJ) × Emission factor by fuel type after change from truck transport to river boat transport ($kgCO_2$/ TJ)

GHG emission reductions

GHG emission reductions (ER) by change from truck transport to river boat transport is:

$ER(kgCO_2) = BE_{truck} – PE_{truck} – PE_{ship}$

Efficiency of container transport by change from small boats to larger vessels

Without the Activity

GHG emissions from boats are calculated.

BE_{ship}= Fuel consumption of boats (TJ) × Emission factor by fuel type of boats ($kgCO_2$/ TJ)

	With the Activity GHG emissions from vessels are calculated. PE_{ship}= Fuel consumption of vessels (TJ) × Emission factor by fuel type of vessels ($kgCO_2$/ TJ) **GHG emission reductions** GHG emission reductions (ER) with Efficiency of container transport by change from small boats to large vessels is: $ER(kgCO_2) = BE_{ship} - PE_{ship}$ **Newly build/ improve inland waterway systems (including shortcut canal)** **Without the Activity** GHG emissions from navigation transport are calculated without newly built/ improved inland waterway systems (including shortcut canal). BE_{ship}=Fuel consumption of navigation without newly built/ improved inland waterway systems (TJ) × Emission factor by fuel type of navigation without newly built/ improved inland waterway systems ($kgCO_2$/ TJ) **With the Activity** GHG emissions from navigation are calculated with newly built/ improved inland waterway systems. PE_{ship}=Fuel consumption of navigation with newly built/ improved inland waterway systems (TJ) × Emission factor by fuel type with newly built/ improved inland waterway systems ($kgCO_2$/ TJ) **GHG emission reductions** GHG emission reductions (ER) with newly built/ improved inland waterway systems is: $ER(kgCO_2) = BE_{ship} - PE_{ship}$
Required data and data source	For road and navigation transport, "Quantification Sheet Improvement of Road Network" (P3.4-7) should be used. Fuel consumption of ships is calculated referring the following: TABLE 3.5.6（FUEL CONSUMPTION FACTORS, FULL POWER）in 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy, Chapter 3 Mobile Combustion. Transformation from ton to TJ: refer to ***Annex 4.*** Emission factor by navigation type (($kgCO_2$/TJ)：refer to ***Annex 2***.

Table 1 Fuel Consumption amount of Ships

Ship Type		**Average Consumption (tonne/day)**	**Consumption at full power(tonne/day) as a function of gross tonnage(GRT)**
Bulk Carriers	Solid Bulk	33.8	20.186 + 0.00049×GRT
	Liquid Bulk	41.8	14.685 + 0.00079×GRT
General Cargo		21.3	9.8197 + 0.00143×GRT
Container		65.9	8.0552 + 0.00235×GRT
Passenger/Ro-Ro/Cargo		32.3	12.834 + 0.00156×GRT
Passenger		70.2	16.904 + 0.00198×GRT
High Speed Ferry		80.4	39.483 + 0.00972×GRT
Inland Cargo		21.3	9.8197 + 0.00143×GRT
Sail Ships		3.4	0.4268 +0.00100×GRT
Tugs		14.4	5.6511 +0.01048×GRT
Fishing		5.5	1.9387 +0.00448×GRT
Other Ships		26.4	9.7126 +0.00091×GRT
All Ships		32.8	16.263 + 0. 001×GRT

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy

Preconditions	Refer to items described in “3.4.1. Prerequisite Conditions for Transport Sector” and “3.4.2. Outline of methodology for the transport sector”.
special notes	The development will be implemented in a relatively small area, so the monitoring for efficiency of the project is relatively easy.

Quantification Sheet

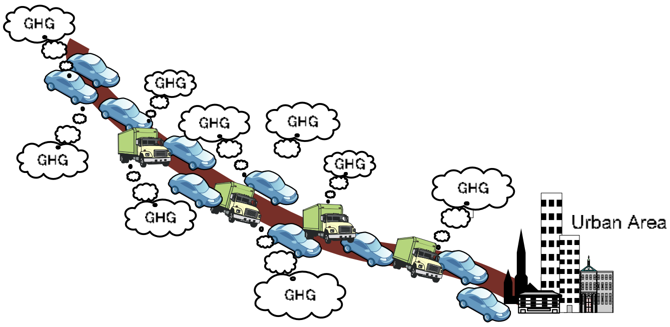
Activity: Introduction of public transport systems

Sector	Transport
Sub-sector	Introduction of public transport systems
GHG emission reduction activity	Improvement of emission factor by mode change from CO_2 discharging road traffic to non or low discharging public transport systems and mitigation of traffic congestion and/or Reduction of traffic volume by reinforcement of transport capacity
GHG emission reduction impact	1: Reduction effect is expected. 2: Reduction effect is expected with some conditions. 3: Reduction effect is not expected.
GHG emission reduction scenarios (description of how GHG is reduced)	(see below)

New construction of public transport systems (railways, subways, LRT, monorails), and improvement of transport capacity

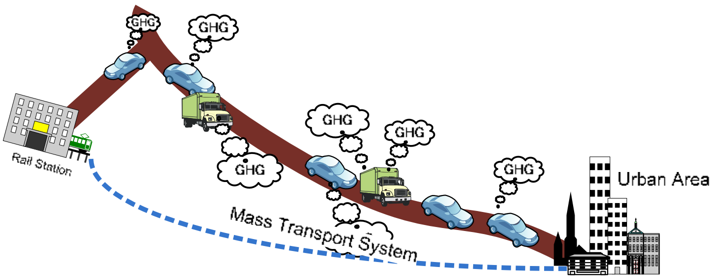
<Without the Activity>

Public transport system is not introduced. GHG from vehicles occurs because road traffic volume increases.



<With the Activity>

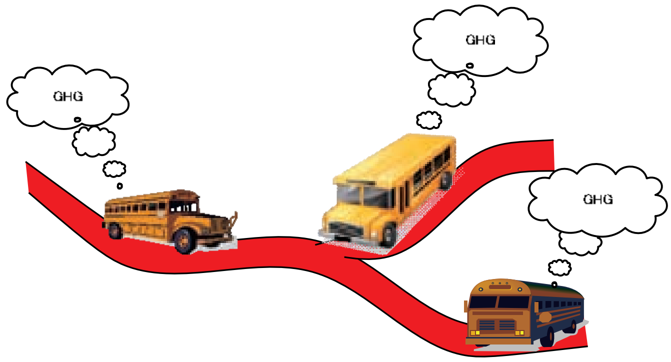
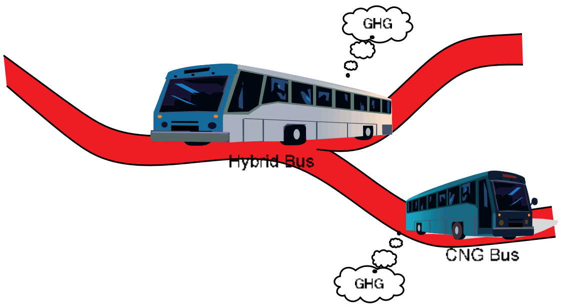
Public transport systems are introduced to correspond with demand. GHG from vehicles decreases because of dissolution of traffic congestion.



Improvement of bus systems (including low carbon type (CNG, hybrid buses)) and improvement of transport capacity

<Without the Activity>

Improvement of bus system (including low carbon type (CNG, hybrid bus)) and improvement of transport capacity is not implemented. GHG from vehicles occurs because road traffic volume in the city increases.

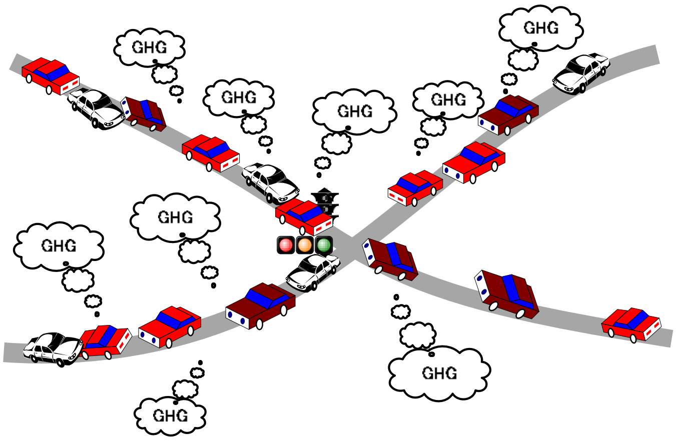
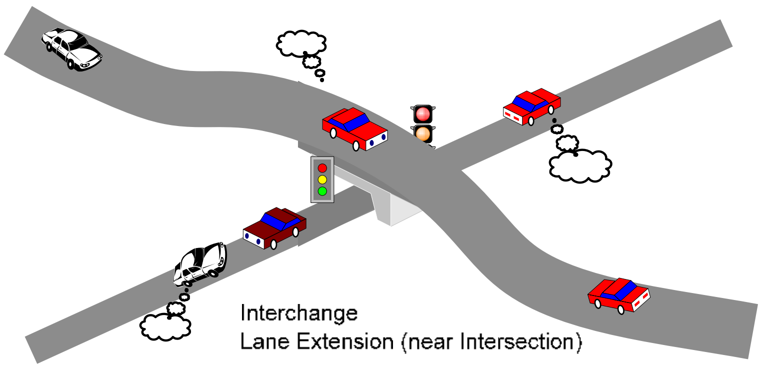
	 **<With the Activity>** Improvement of fuel consumption efficiency and transport capacity of buses is implemented. GHG from buses decreases.  **【Schematics of GHG emission reduction process】** Proper public transport system is not introduced, even though traffic demand is increased. Great amount of GHG occur. → Proper public transport system is introduced,. → GHG emissions decreases by reduction of fuel consumption and improvement of GHG discharge coefficient
Calculation of GHG emission reduction	For quantification of GHG from road transport, "Quantification Sheet Improvement of Road Network" should be used. For quantification of fuel consumption amount for electricity, Tool of CDM Methodology (electricity consumption):"Tool to calculate baseline, project and/or leakage emissions from electricity consumption" should be used. **[Equations]** **New construction of public transport system (railways, subways, LRT, monorails), and improvement of transport capacity** **<u>Without the Activity</u>** GHG emissions from road transport are calculated without introduction of public transport systems. $BE_{vehicle}$ = Traffic volume without improvement of public transport systems (Number of cars × kilometres) × Emission factor of average travel speed without improvement of public transport systems ($kgCO_2$/ Number of cars × kilometres)

	With the Activity GHG emissions from road transport are calculated after introduction of public transport systems $PE_{vehicle}$ = Traffic volume after introduction of public transport systems (Number of cars × kilometres) × Emission factor of average travel speed after introduction of public transport systems ($kgCO_2$/ Number of cars × kilometres) GHG emissions from public transport are calculated. PE_{PTS} = Electricity consumption amount by public transport systems (kWh) ×Emission factor of electricity (($kgCO_2$/kWh) **GHG emission reductions** GHG emission reductions (ER) with introduction of public transport systems is: $ER(kgCO_2) = BE_{vehicle} - (PE_{vehicle} + PE_{PTS})$ **Improvement of bus systems (including low carbon type (CNG, hybrid buses)) and improvement of transport capacity** **Without the Activity** GHG emissions from buses are calculated without improvement of bus systems (including low carbon type (CNG, hybrid buses)) or improvement of transport capacity. BE_{bus} = Traffic volume of buses without improvement of bus systems (including low carbon type (CNG, hybrid buses)) or improvement of transport capacity (Number of buses × kilometres) × Emission factor of average travel speed without improvement of bus systems (including low carbon type (CNG, hybrid buses)) and improvement of transport capacity ($kgCO_2$/ Number of buses × kilometres) **With the Activity** GHG emissions from buses are calculated with improvement of bus systems (including low carbon type (CNG, hybrid buses)) and improvement of transport capacity. PE_{bus} = Traffic volume with improvement of bus systems (including low carbon type (CNG, hybrid buses)) and improvement of transport capacity (Number of buses × kilometres) × Emission factor of average travel speed with improvement of bus systems ($kgCO_2$/ Number of buses × kilometres)

	GHG emission reductions GHG emission reductions (ER) with improvement of bus systems (including low carbon type (CNG, hybrid buses)) and improvement of transport capacity: $ER(kgCO_2) = BE_{bus} - PE_{bus}$
Required data and data source	For road transport, "Quantification Sheet Improvement of Road Network" should be used. Data for electricity consumption amount for railway operation should be collected from master plan study. Emission factor of electricity in concerned country should be calculated. Refer to ***Annex 1***.
Preconditions	Refer to items described in "3.4.1. Prerequisite Conditions for Transport Sector" and "3.4.2. Outline of methodology for the transport sector".
Special notes	For improvement of bus systems (including low carbon type (CNG, hybrid buses)) and improvement of transport capacity, quantification is relatively easy, because buses are travelling in relatively short lines or small area.

Quantification Sheet

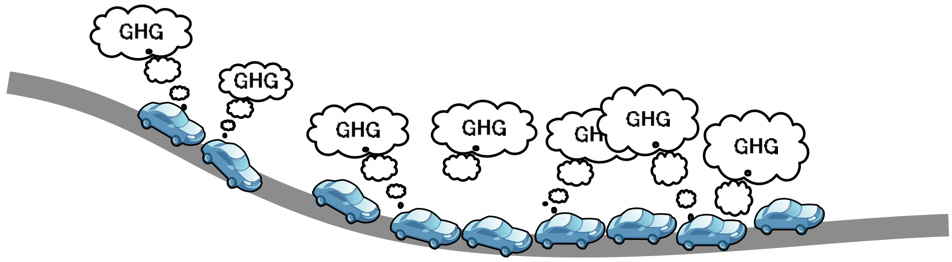
Activity: Implementation of improvement plan for traffic management

Sector	Transport
Sub-sector	Implementation of improvement plan for traffic management
GHG emission reduction activities	Mitigation of traffic congestion/ Shortening of travel time/ Improvement of transport flow/ Mode change to large-scale transport systems/ Control of Number of cars travelling in target area/ Mitigation of traffic congestion at city or regional level
GHG emission reduction impact	1: Reduction effect is expected. 2: Reduction effect is expected with some conditions. 3: Reduction effect is not expected.
GHG emission reduction scenarios (description of how GHG is reduced)	**Improvement of crossings (two-level crossings/ signal systems), introduction of ITS, bus lanes/ priority system for public cars/ park-and-ride** **<Without the Activity>** Improvement plan for traffic management is not implemented. GHG from vehicles occurs because road traffic volume in the city increases.  **<With the Activity> Note: case of crossing improvement** Improvement plan for traffic management is implemented to correspond with demand. GHG from vehicles decreases because of dissolution of traffic congestion by crossing improvement. 

Introduction of transport management (traffic demand controls such as road pricing)

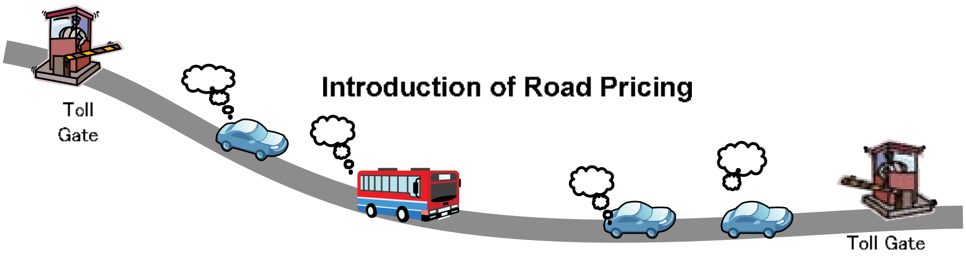
<Without the Activity>

Improvement plan for traffic management is not implemented. GHG from vehicles occurs because road traffic volume in the city increases.



<With the Activity>

Improvement plan for traffic management is implemented to correspond with demand. GHG from vehicles decreases because of dissolution of traffic congestion by introduction of traffic demand management.



【Schematics of GHG emission reduction process】

Calculation of GHG emission reduction

For quantification of GHG from road transport, "Quantification Sheet Improvement of Road Network" should be used.

[Equations]

Improvement of crossings (two-level crossings/ signal systems), introduction of ITS, bus lanes/ priority system for public cars/ park-and-ride

<u>Without the Activity</u>

GHG emissions from road transport are calculated without improvement of crossings, etc.

$BE_{vehicle}$ = Traffic volume without improvement of crossings, etc. (Number of cars × kilometres) × Emission factor of average travel speed without

	improvement of crossings, etc. ($kgCO_2$/ Number of cars × kilometres) **With the Activity** GHG emissions from road and public transport are calculated with improvement of crossings, etc. $PE_{vehicle}$ = Traffic volume with improvement of crossings, etc. (Number of cars × kilometres) × Emission factor of average travel speed with improvement of crossings, etc. ($kgCO_2$/ Number of cars × kilometres) **GHG emission reductions** GHG emission reductions (ER) with improvement of crossings, etc. is: $ER(kgCO_2) = BE_{vehicle} - PE_{vehicle}$ **Introduction of transport management (traffic demand controls such as road pricing)** **Without the Activity** GHG emission from road transport is calculated without introduction of traffic demand management. $BE_{vehicle}$ = Traffic volume without introduction of traffic demand management (Number of cars × kilometres) × Emission factor of average travel speed without introduction of traffic demand management ($kgCO_2$/ Number of cars × kilometres) **With the Activity** GHG emissions from road transport are calculated with introduction of traffic demand management. $PE_{vehicle}$ = Traffic volume with introduction of traffic demand management (Number of cars × kilometres) × Emission factor of average travel speed with introduction of traffic demand management ($kgCO_2$/ Number of cars × kilometres) **GHG emission reductions** GHG emission reductions (ER) after introduction of traffic demand management is: $ER(kgCO_2) = BE_{vehicle} - PE_{vehicle}$
Required data and data source	For road transport, "Quantification Sheet Improvement of Road Network" should be used.
Preconditions	Refer to items described in "3.4.1. Prerequisite Conditions for Transport Sector" and "3.4.2. Outline of methodology for the transport sector".

Special notes	Implementation of traffic management plan leads to effects indirectly. It should be noted that effects due to the traffic management plan have many unknown factors.

3.4.5 Case Study

No.	Project Title	Sector
8	Dar es Salaam Transport Policy and System Development Master Plan in Tanzania	Transport

Case study No.	8
Project title	Dar es Salaam Transport Policy and System Development Master Plan in Tanzania
Sector	Transport
Sub-sector	Integrated transport development in big cities
Project summary	**[Background]** The Poverty Reduction Strategy Paper (PRSP) for Tanzania indicated that economic growth and poverty reduction are key issues and concluded that one of the main conditions for high economic growth and realization of poverty reduction. It was also indicated that the improvement of transport infrastructure is important for economic growth through promotion of the private sector. Dar es Salaam City is the main city in Tanzania and has functioned as a centre of economy and industry. However, it has been hit by urbanization and increases of population intermittently after independence in 1967. Increase of population in recent years is remarkable. It was about 1.36 million in 1988, but it was reported as 2.5 million in the census in 2002. This increase ratio is over 8%. Due to the population growth, traffic volume has been increasing. The expansion of capacity of the transport infrastructure has been limited, so traffic congestion during rush hour, especially in the city centre and on the 4 main roads running radially is serious. The Japanese government supported provision of a master plan for road development in Dar es Salaam called the "Road Development Plan in Dar es Salaam" in 1995. After that, the Japanese government supported road improvement based on this development plan, such as grant cooperation (Road Network Development Plan in Metropolitan Areas) in 1991-95, Road Improvement Plan in Dar es Salaam in 1997-2000, Expansion Plan of Kirwa Road in 2006-2008, and certain results were obtained. However, the increase of vehicles and mini-buses and the expansion of urban area are expected to continue hereafter. So that new policies such as reinforcement of public transport and introduction of traffic demand management are required, **[Objectives]** The objectives of this study were to provide a master plan for urban transport in Dar es Salaam City, to implement a Pre-F/S for priority projects, and to provide capacity development programs for reinforcement of the implementing body and capacity building in urban transport in Dar es Salaam to utilize study results effectively.

	[Conditions before and after the Project] The project is on-going. It builds a foundation for new policy in areas such as reinforcement of public transport and introduction of traffic demand management, which will be realized in the future.
GHG emission reduction scenarios	**Without the Activity** : The existing urban transport system condition remains without improvement. **With the Activity** : Transport condition to correspond with demand is provided due to improvement of the urban transport systems.
Equations to calculate GHG emissions	For quantification of GHG from road transport, "Quantification Sheet Improvement of Road Network" should be used. 【Equation】 **Without the Activity** GHG emissions from road transport due to increase of travel distance, decrease of travel speed, and increase of traffic congestion, which occur without improvement of road network are calculated. $BE_{vehicle}$ = Traffic volume without improvement of urban transport systems (Number of cars × kilometres) × Emission factor of average travel speed without improvement of urban transport systems ($kgCO_2$/ Number of cars × kilometres) **With the Activity** GHG emissions from road transport are calculated with improvement of urban transport systems. $PE_{vehicle}$ = Traffic volume with improvement of urban transport systems (Number of cars × kilometres) × Emission factor of average travel speed with improvement of urban transport systems ($kgCO_2$/ Number of cars × kilometres) **GHG emission reductions** GHG emission reductions (ER) with railway system improvement is: $ER(kgCO_2) = BE_{vehicle} - PE_{vehicle}$
Applied data	For quantification of CO_2 reduction in "Dar es Salaam Transport Policy and System Development Master Plan in Tanzania", forecast conditions and demand forecast data was acquired. (These data used for this forecast were collected by an environmental specialist that worked for the study, not from the Final Report or Technical Report.

Table 1 Forecast Conditions in Target Year (2030)

	Travel Distance (PCU*km)	Travel Time (PCU*hr)	Capacity ×Length (PCU*km)	Road Length (km)	Ave. VCR	Ave. Travel Speed (km/h)
2030 Without Case	23,688,605	2,379,228	7,305,131	783	3.24	10
2030 With Case	22,012,455	871,949	24,741,882	1,215	0.89	25.2

* PCU: passenger car, VCR: volume capacity ratio

Table 2 Traffic Demand in Target Year (2030)

Target Year	2030
Passenger Car (PCU)	996,207
Truck (PCU)	135,464
Trailer (PCU)	59,225

Source: Hearing from environmental specialist in "Dar es Salaam Transport Policy and System Development Master Plan in Tanzania"

Calculation of GHG emissions

The CO_2 reduction amount was calculated (Table 3). From Table 3, 8,797t-CO_2/day in the without case in target year 2030 will decrease to 5,021tCO_2/day in the with case, so a reduction of 3,776tCO_2/day(43%) will be expected due to the Project.

Table 3 Quantification of CO_2 reduction in Target Year (2030)

	V=10 km/hr	Travel Distance ×vehicle (km×vehicle/ day)	Emission Factor (kgCO_2/km× vehicle) (*1)	Emission Loading CO_2 (tCO_2/day)
2030 Without	Passenger Car	19,816	372	7,372
	Truck	1,347	784	1,056
	Trailer	471	784	369
	sub- total	21,634		**8,797**
2030 With	V=25.2 km/hr	Travel Distance* vehicle	Emission Factor	Emission Loading CO_2 (t/day)
	Passenger Car	18,414	224	4,125
	Truck	1,252	530	664
	Trailer	438	530	232
	sub- total	20,104		**5,021**

(*1): Environmental Bureau, Tokyo Metropolitan Municipality, Study on Vehicular Emission for Future Traffic Demands in Metropolitan Area, 2000

Preconditions

Refer to items described in "3.4.1. Preconditions for Transport Sector" and "3.4.2. Outline of quantification methods".

Lessons learned from case study

The following data are necessary to perform a quantitative assessment

- Travel Distance × vehicle(km × vehicle) for without and with cases
- Emission factor(kgCO_2/km × vehicle) for without and with cases