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Climate Finance Impact Tool for Mitigation

JICA Climate-FIT (Mitigation)

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List of Abbreviations

ADB	Asian Development Bank
ALOS	Advanced Land Observing Satellite
AR-CDM	Afforestation/Reforestation Clean Development Mechanism
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BM	Build Margin
BRT	Bus Rapid Transit
CDM	Clean Development Mechanism
CM	Combined Margin
COP	Conference of the Parties
COD	Chemical Oxygen Demand
CSP	Concentrated Solar Thermal Power
E10	Fuel containing 10% Ethanol
GEF	Global Environment Facility
GHG	Greenhouse Gas
GREEN	Global Action for Reconciling Economic Growth and Environmental Preservation (JBIC)
Green-e	Green-e
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPCC GPG	IPCC Good Practice Guidance
IPCC GPG for LULUCF	IPCC Good Practice Guidance for Land Use, Land Use Change, and Forestry
IPCC-GNGGI	IPCC Guidelines for National Greenhouse Gas Inventories
JBIC	Japan Bank for International Cooperation
J-MRV	Measurement, Reporting and Verification of GHG Emission Reductions in JBIC's GREEN
J-VER	Japan Verified Emission Reduction
LANDSAT	LANDSAT
LCA	Life Cycle Assessment
LFG	Landfill Gas
LRT	Light Rail Transit
MRT	Mass Rapid Transit
MRV	Measurement, Reporting and Verification
MSW	Municipal Solid Waste
OM	Operational Margin
QuickBird	QuickBird
RDF	Refuse. Derived. Fuel
REDD	Reducing Emissions from Deforestation and Forest Degradation
SBSTA	Subsidiary Body for Scientific and Technological Advice
SPOT	Satellite Pour l'Observation de la Terre
UNFCCC	United Nations Framework Convention on Climate Change
US-EPA	US Environmental Protection Agency
VCS	Verified Carbon Standard
VER	Verified Emission Reduction

Chapter 1 Outline of the Survey

1.1 Background and Objective

The 16th Conference of the Parties (COP16) of the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Cancun Agreements. The agreements clearly state the commitment by developed countries to provide financial support to developing countries in the field of climate change, which include i) collective commitment approaching USD 30 billion for three years from 2010 to 2012 (as Fast-start finance) and ii) joint mobilization of USD 100 billion per year by 2020 (as Long-term finance). The direction of future framework on climate change after 2013 is still under discussion. It is considered that Official Development Assistance (ODA) will continue to be actively utilized as part of the support for the developing countries in the field of climate change. The Cancun Agreements request implementation of measurement, reporting and verification (MRV) regarding quantitative evaluations of greenhouse gas（GHG）emission reduction (sequestration) through supported mitigation actions.

Taking into account the above situations, JICA is faced with the task to consider MRV regarding GHG emission reduction (sequestration) during the planning stages of country assistance strategies and individual projects to ensure its implementation. This survey presents a reference document providing estimation methodologies of quantitative evaluations of GHG emission reduction (sequestration), in order to facilitate consideration of MRV during the planning stages of country assistance strategies and individual projects. This survey is not intended to provide methodologies for estimating emission reduction credits, such as those generated by the Clean Development Mechanism (CDM). The purpose of this survey is to calculate the impacts of projects assisted by JICA. Therefore, this survey does not take into account additionality considerations required by the CDM.

This report contains survey on mitigation measures as part of the “Study on Mainstreaming Climate Change Considerations into JICA Operation”. The reports for survey on adaptation measures and national and regional climate impacts are prepared separately.

1.2 Selection of Target Sub-sectors and Review of Existing Methodologies

After reviewing past JICA ODA loan projects and the trend of other donors’ assistance, 25 sub-sectors were chosen as potential areas of future JICA ODA loan assistance. In order to establish the estimation methodologies for quantitative evaluation of GHG emission reduction (sequestration), the survey reviewed existing methodologies and tools including those used by other donors and by credit generating mechanisms like the CDM.

1.3 Basic Concept and Guidelines for the Quantitative Evaluation of GHG Emission Reduction (Sequestration)

For the selected 6 sectors and 25 sub-sectors, methodology sheets summarizing GHG emission reduction methodologies were prepared. The five items included in the methodology sheets are: i) typical project outline, ii) applicability, iii) methodology on emission reduction, iv) data required for estimation and monitoring, and v) others. In developing countries, it can be easily anticipated that there exists great limitation in data availability. In order to overcome this limitation, the presented methodology allows flexibility by indicating several options when possible, along with the order of priority. Furthermore, excel sheets with embedded estimation formula were prepared to enable estimating actual GHG emission reductions (calculation sheets).

1.4 Framework of the Report

Chapter 1 Outline of the Survey

Chapter 3 Basic Concept and Guidelines for the Quantitative Evaluation of GHG Emission Reduction (Sequestration)

- ■ Basic Concept
  - ①Quantitative Evaluation
  - ②Basic Concept
- ■ Outline of Methodology sheet and Calculation sheet
  - ①Aim and Application
  - ②Outline of Methodology sheet
  - ③Outline of Calculation sheet

Chapter 2 Selection of Target Subsectors and Review of Existing Methodologies

- ■ Selection of Target Subsectors
  - ①Past JICA ODA loan projects (Classification of yen loan projects from 1995 to 2010)
  - ②Trend of Other Donors
- ■ Methodologies of Other Certification Organizations, etc.
  - ①Reviewed Methodologies
  - ②Existing Methodologies for Targeted Sub-sectors

Chapter 4 Methodology Sheets and Calculation Sheets

Identification of mitigation projects

Outline of methodology and calculation sheets for each subsector

Methodology Sheet
1. Typical project outline
2. Applicability
3. Methodology on emission reduction
   (1) Baseline Emission
   (2) Project Emission
4. Data required for estimation and monitoring
   <Timing of calculation>
   <Data acquisition methods>
   <Priority among options>
5. Others
   (1) Project boundary
   (2) Leakage
   (3)Reviewed Methodologies and Major Differences

Calculation sheets
(1) Input Sheet
(2) Result sheet

Target sub-sectors

Forest and natural resources conservation
1. Afforestation 2. Forest conservation

Traffic and Transportation
3. Freight/Passenger Transportation Improvement
4. MRT 5. Monorail, LRT 6.Bus

Energy Conservation (Industry)
7. Energy Efficiency Improvement
8. Electricity and heat supply
9. Fuel switching

Energy
10. Energy plant with fuel switching
11. Thermal power with electricity and heat supply
12. Thermal power with fuel switching
13. Thermal power with higher efficiency
14. Power transmission with improved efficiency
15. Power distribution with improved efficiency
16. Rural electrification

Renewable energy
17. Hydro power 18. Wind power
19. Photovoltaic power /solar heat 20. Geothermal power
21. Biomass

Sewerage, Urban sanitation
22. Landfill disposal of waste
23. Intermediate treatment of waste
24. Wastewater treatment 25. Sewerage

Chapter 2 Selection of Target Sub-sectors and Review of Existing Methodologies

2.1 Selection of Target Sub-sectors

In this section, target sub-sectors are selected for discussion in Chapters 3 and 4. The following items are considered for selection of the sub-sectors.

・Past JICA ODA loan projects

・Potential for formulating future mitigation projects

The process of selection is as follows:

1. Establish sector and sub-sector categories that cover all yen loan projects from 1995 to 2010

2. Classify all yen loan projects into mitigation sub-sectors and non-mitigation sub-sectors

3. Compare yen loan projects with mitigation projects by other donors and check whether mitigation sub-sectors supported by other donors are included

4. Consider future high-potential sectors and sub-sectors for mitigation measures based on the second and third steps.

5. Select target sub-sectors.

Figure 2.1.1 Process of Selecting Sub-sectors

2.1.1 Identification of Sectors and Sub-sectors Based on Past JICA ODA Loan Projects

First, in order to classify and identify sectors and sub-sectors based on past JICA ODA loan projects[1], projects classified in mitigation sub-sectors are extracted from all projects committed from 1995 to 2010 (1,139 projects). The mitigation and non-mitigation sub-sectors and the number of projects classified in each group are shown in Table 2.1.1.

There are 503 projects classified into 6 mitigation sectors (forestry/natural environment, disaster prevention, traffic and transportation, mining and industry, energy, and public utility) and 29 mitigation sub-sectors. On the other hand, there are 793 projects classified into 14 non-mitigation sectors (including miscellaneous sector) and 52 non-mitigation sub-sectors. Projects classified into more than one sub-sector are counted in their respective sub-sectors, resulting in a total of 1,296 counted projects.

[1] http://www2.jica.go.jp/ja/yen_loan/index.php

Table 2.1.1 Projects in Mitigation Sub-sectors among Japan's Yen Loan Projects

(Target: Committed Projects from 1995 to 2010)/1

Mitigation Sub-sectors

Sector	Sub-sector		projects
3 Forestry/natural resources conservation	01	Forestry	37
	02	Forest conservation , Slope conservation/Soil conservation	15
	03	Mangrove conservation	0
	05	Ecosystem (biodiversity)	5
4 Disaster management	07	Forest disaster prevention	0
	08	Landslide disaster management	0
6 Transportation	04	Railway	
	001	Freight (a new railway double track	21
	002	Passenger (a new railway、a double track railway, or a quadruple track railway)	9
	003	MRT (City and suburb rapid railway: Subway, Elevated railway)	46
	004	Monorail, LRT	2
	005	Improvement of rails, High standardization , Rehabilitation of railway	10
	006	Rehabilitation of train cars and railway facilities	8
9 Mining and manufacturing industries	01	Industry	4
	02	Factory, Plant	16
	03	Mining industry	3
11 Energy	01	Energy conservation	2
	02	Intensive heat-supply system with fuel switching	26
	03	Thermal power plants with electricity and heat supply	4
	04	Thermal power plants with fuel switching	12
	05	Thermal power plants with higher energy efficiency	39
	06	Transmission and distribution	64
	07	Hydro power plants (except for small hydropower and pumped and storage hydropower)	42
	08	Renewable energy	12
	09	Rural electrification	17
	10	Energy facilities (construction of new natural gas pipelines)	2
13 Public utilities	02	Urban health (waste disposal)	16
	03	Sewerage	56
	03	Wastewater treatment	35
		Total	503

Non-mitigation Sub-sectors

Sector	Sub-sector		projects
1 Water resources	01	Proper management of water resources	2
	02	Water resources development, facility upgrade	14
	03	Utilization of water resources	2
	04	Water and sanitary reform	0
2 Agriculture, Food /2	01	Irrigation, drainage	56
	02	Cultivation management (Assistance of agricultural management), enhancement of irrigation association	13
	03	Crop development	3
	04	Information system	0
	05	Livestock	1
	06	Fisheries	4
	07	Agro- economy	1
	08	Sustainable agriculture	2
	09	Development/improvement of farmland	1
	10	Agricultural process	1
3 Forestry/natural resource conservation	04	Coastal/lakefront protection/restoration	3
4 Disaster management	01	Coastal protection	3
	02	River prevention (flood control)	35
	03	Disaster-relief	1
	04	Information system	1
	05	Development of human resources, Environmental control ability	4
	06	Urban disaster prevention	0
	09	Land-use management	0
5 Urban-regional development	01	Rural development	38
	02	Urban community improvement	2
6 Transportation	01	Road, bridge	164
	02	Airport	35
	03	Port	36
	05	Marine transportation	7
	06	TDM and other soft measures	1
	07	Logistic facilities	1
	08	ICT	0
7 Health	01	Adaptation capacity development	0
	02	Adaptations for high risk area	0
	03	Heat prevention	0
	04	Malaria control	0
	05	Waterborne (infectious) disease control	1
	06	Medical care	15
8 Architect	01	Architect	31
10 Government administration	01	Finance, monetary	25
	02	Environmental-related issues	21
	03	Survey/cartography	1
	04	General government	5
	05	Assistance in policy-making system	57
	06	Assistance for rehabilitation and reconstruction	0
12 Human resources	01	Education	42
	02	Healthcare education	13
13 Public Utility	01	Water Supply	96
14 Commerce	01	Tourism	7
15 Communications and broadcasting	01	Telecommunications	17
	02	Broadcasting	11
99 Others	01	Instauration	1
	02	Poverty program	19
		Total	793

/1 1,139 projects are extracted from JICA's database of Japan's ODA loan projects from 1995 to 2010, and classified into sectors.

/2 As for agricultural and food sectors, countermeasures and utilization for ''methane emissions from paddy fields'', ''domestic animals' waste'', ''loss of soil organic material due to surface soil runoff '', ''nitrous oxide originated from fertilizers'', and ''methane emissions from paddy fields'' are expected as promising projects in the future.

2.1.2 Trend of Projects by Other Donors

The trend of mitigation projects implemented by other donors is as follows:

(1) World Bank (WB)

Projects whose major theme is climate change are extracted from WB database[2] and classified into project fields. Project fields are divided into major sectors and sectors. The WB database system allows projects to be classified into more than one major sector and/or sector as shown in Figure 2.1.2. The figure summarizes the result for 193 projects classified into major sectors and sectors. Among the major sectors, energy has 124 projects, which is overwhelmingly greater than that of other major sectors. Sectors with a larger number of projects include, power generation, renewable energy, agriculture, forestry, and public utility (sewerage, etc.).

(2) Global Environment Facility (GEF)

From GEF's database[3], 645 projects whose focal area is climate change and implemented after year 2000 are extracted. 385 projects are classified as mitigation projects. These projects are further classified into project fields and implementing international organizations (Figure 2.1.3). 298 of the total 385 projects are energy projects.

(3) Asian Development Bank (ADB)

From ADB's database[4], 38 loan projects related to mitigation measures are extracted. ADB's project classification system allows selection of multiple sectors and sub-sectors for one project (Figure 2.1.4). It is noted that there are more mitigation projects in the energy sector than other sectors.

[2] http://www.worldbank.org/
[3] http://www.gefonline.org/
[4] http://www.adb.org/Climate-Change/projects.asp#promoting

Table 2.1.2 Sector Classification of World Bank Mitigation Projects

Major Sector	Sector		count					
			only	1st	2nd	3rd	4th	Total
Agriculture, Fishing, and Forestry	AB	Agricultural extension and research	1	1	3	0	0	5
	AJ	Animal production	0	1	0	0	0	1
	AH	Crops	2	0	0	0	0	2
	AI	Irrigation and drainage	2	4	0	0	0	6
	AT	Forestry	12	2	10	0	0	24
	AZ	General agriculture, fishing and forestry	19	3	9	4	0	35
Public Administration, Law and Justice	BC	Central government administration	7	3	5	0	0	15
	BE	Compulsory pension and unemployment insurance	0	0	0	0	0	0
	BG	Law and justice	0	0	0	0	0	0
	BH	Sub-national government administration	6	3	0	0	0	9
	BK	Compulsory health finance	0	0	0	0	0	0
	BZ	General public administration	2	3	5	0	0	10
	BL	Public administration - Agriculture, fishing and forestry	0	0	0	0	0	0
	BM	Public administration - Information and communications	0	0	0	0	0	0
	BN	Public administration - Education	0	0	0	0	0	0
	BO	Public administration - Finance	0	0	0	0	0	0
	BQ	Public administration - Health	0	0	0	0	0	0
	BS	Public administration - Other social services	0	0	0	0	0	0
	BT	Public administration - Industry and trade	0	0	0	0	0	0
	BU	Public administration - Energy and mining	0	0	3	0	0	3
	BV	Public administration - Transportation	0	1	0	0	0	1
	BW	Public administration - Water, sanitation and flood protection	0	1	1	0	0	2
Information and Communications	CA	Information technology	0	0	0	0	0	0
	CB	Media	0	0	0	0	0	0
	CT	Telecommunications	0	0	0	0	0	0
	CZ	General information and communications	0	0	0	0	0	0
Education	EL	Adult literacy/non-formal education	0	0	0	0	0	0
	EC	Pre-primary education	0	0	0	0	0	0
	EP	Primary education	0	1	0	0	0	1
	ES	Secondary education	0	0	0	0	0	0
	ET	Tertiary education	0	0	0	0	0	0
	EV	Vocational training	0	0	0	0	0	0
	EZ	General education	0	0	0	0	0	0
Finance	FA	Banking	0	0	0	0	0	0
	FB	Non-compulsory health finance	0	0	0	0	0	0
	FC	Housing finance and real estate markets	0	0	0	0	0	0
	FD	Non-compulsory pensions, insurance, and contractual savings	0	2	0	0	0	2
	FE	Micro- and SME finance	0	0	0	0	0	0
	FG	Payment systems, securities clearance, and settlement	0	0	0	0	0	0
	FK	Capital markets	0	0	0	0	0	0
	FZ	General finance	0	0	0	0	0	0
Health and Other Social Services	JA	Health	0	0	0	1	0	1
	JB	Other social services	0	0	2	2	0	4
Industry and Trade	YA	Agricultural marketing and trade	0	0	0	0	0	0
	YB	Agro-industry	0	0	1	0	0	1
	YC	Housing construction	0	0	0	0	0	0
	YD	Petrochemicals and fertilizers	0	1	0	0	0	1
	YW	Other industry	2	0	4	3	0	9
	YY	Other domestic and international trade	0	0	0	0	0	0
	YZ	General industry and trade	0	0	0	8	0	8
Energy and Mining	LA	District heating and energy efficiency services	12	7	0	0	0	19
	LB	Mining and other extractive	1	5	0	0	0	6
	LC	Oil and gas	2	0	0	0	0	2
	LD	Power	29	6	0	0	0	35
	LE	Renewable energy	23	16	0	0	0	39
	LZ	General energy	6	17	0	0	0	23
Transportation	TA	Roads and highways	1	0	0	0	0	1
	TV	Aviation	0	0	0	0	0	0
	TP	Ports, waterways and shipping	0	0	0	0	0	0
	TW	Railways	2	0	0	0	0	2
	TZ	General transportation	3	0	5	4	1	13
Water, Sanitation, and Flood Protection	WD	Flood protection	3	0	5	3	0	11
	WA	Sanitation	0	0	0	0	0	0
	WS	Sewerage	1	0	0	0	0	1
	WB	Solid waste management	8	0	1	0	2	11
	WC	Water supply	0	0	2	1	0	3
	WZ	General water, sanitation and flood protection	8	0	13	5	1	27

Project Total	193

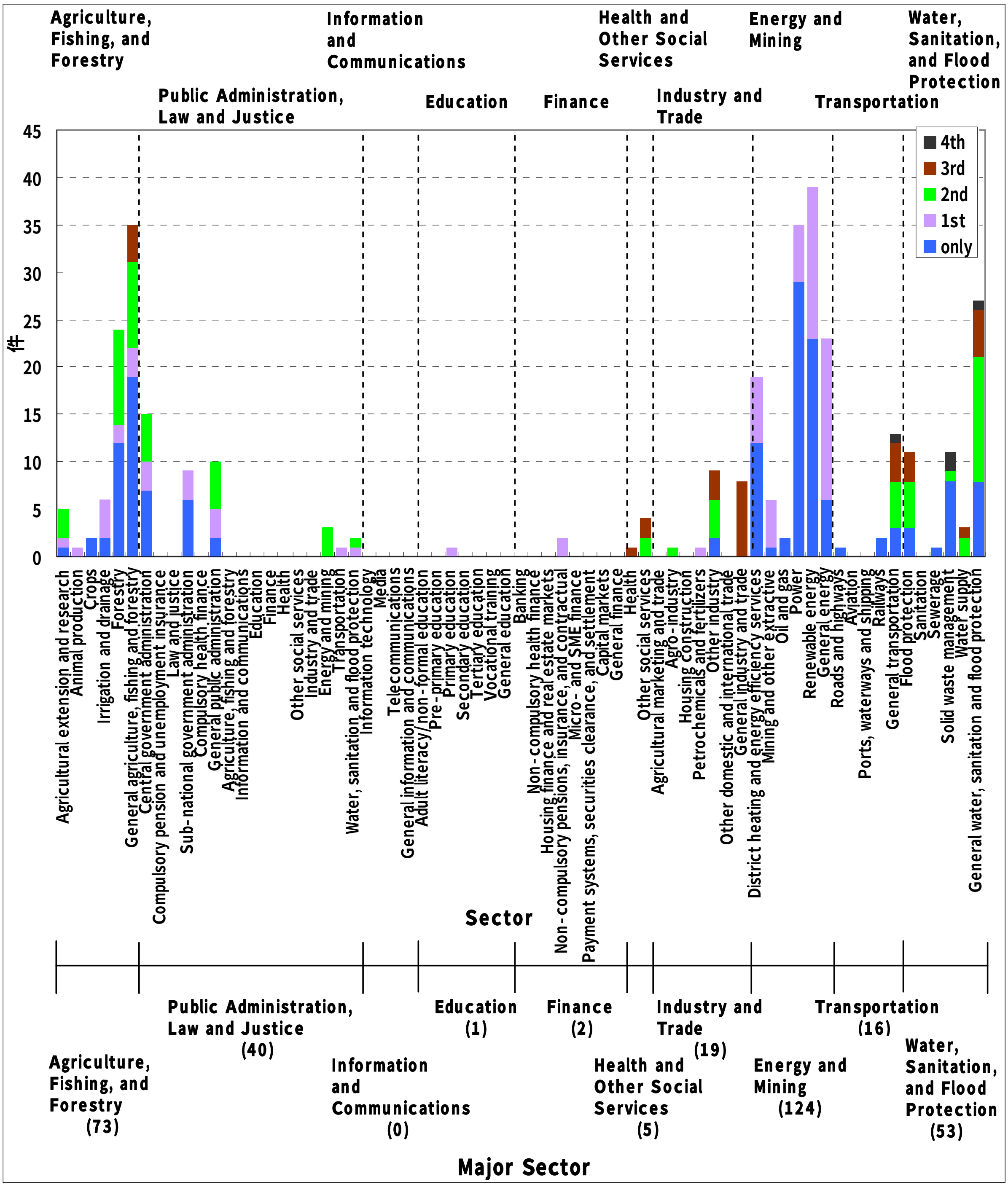
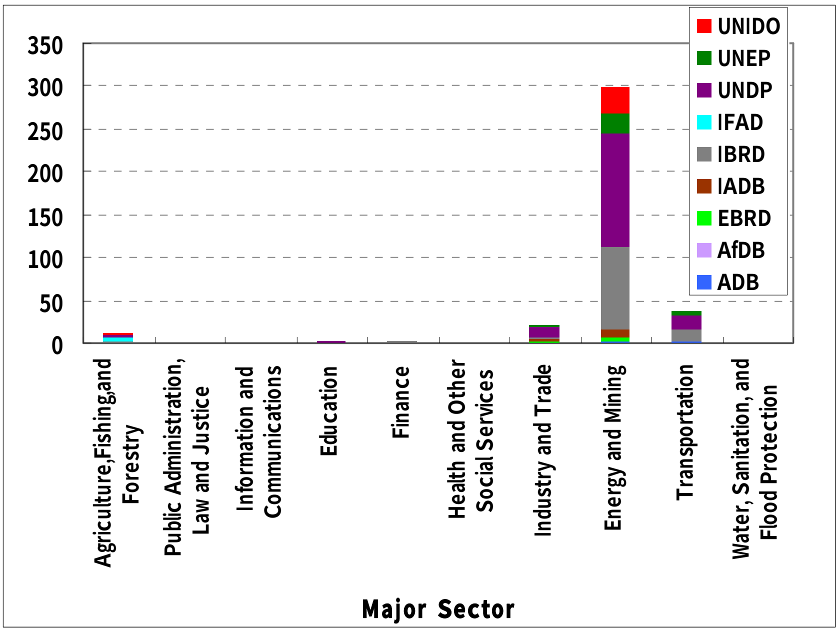


Figure 2.1.2 Summary of Sector Classification of World Bank Mitigation Projects



ADB	Asian Development Bank
AfDB	African Development Bank
EBRD	European Bank for Reconstruction and Development
IADB	Inter-American Development Bank
IBRD	International Bank for Reconstruction and Development
IFAD	International Fund for Agricultural Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization

Figure 2.1.3 Sector Classification of GEF Registered Mitigation Projects Implemented by Various International Organizations

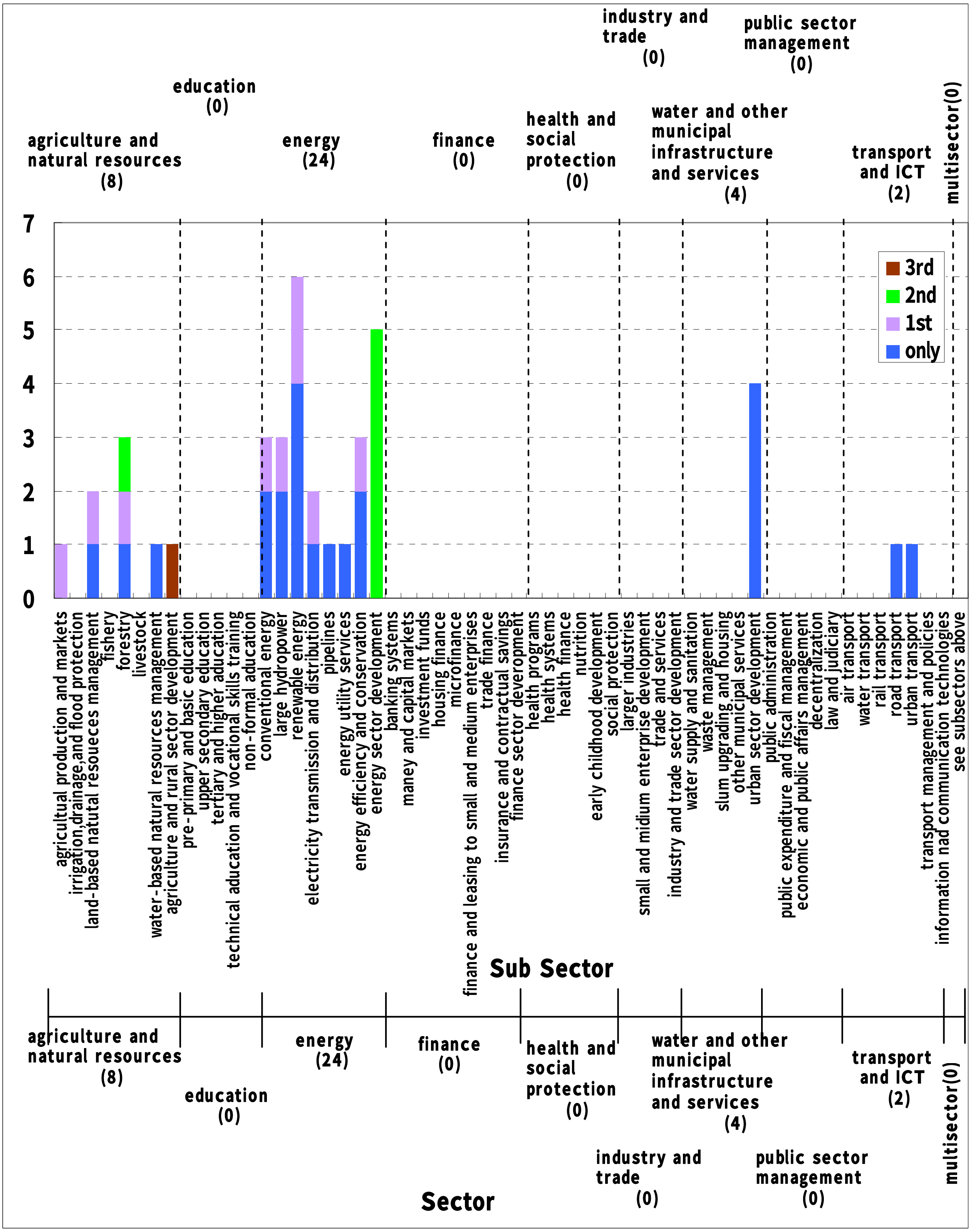


Figure 2.1.4 Summary of Sector Classification of ADB Mitigation Projects

(4) Selection of Target Sub-sectors

Based on the above investigation, the potential of mitigation actions in each sub-sector are re-classified. As a result, the following 6 sectors and 25 sub-sectors shown in Table 2.1.3 are selected.

Table 2.1.3 Sub-sectors for Mitigation Measures

Sector	Sub-sector	Examples of mitigation measures
Forest/natural resource conservation	1.Afforestation	Afforestation , reforestation
	2.Forest conservation	Forest conservation
Transportation	3.Passenger/Freight transportation improvement	Passenger (a new railway、a double track railway, or a quadruple track railway)
		Freight (a new railway , double track railway)
		Improvement of rails, High standardization
	4.MRT(Mass Rapid Transit)	City and suburb rapid railway (Subway, Elevated railway)
	5.Monorail, LRT	Monorail and Light Rail Transits
	6.Bus (BRT,Trunk bus)	BRT , Trunk bus
Energy conservation (Industry)	7.Energy efficiency improvement in industrial facilities	Introduction of high efficiency facilities and technology
	8.Electricity and heat supply in industrial facilities	Effective utilization of waste heat and waste gas
	9.Fuel switching in industry facilities	Fuel switching from coal or petroleum to natural gas
Energy	10.Energy plant construction with fuel switching	Natural gas pipeline
		Natural gas supply system
		Intensive heat-supply facilities
	11.Thermal power with electricity and heat supply	Cogeneration(waste heat and waste gas use)
	12.Thermal power with fuel switching	Natural gas plants
		Natural gas pipeline
		Fuel switching from coal or petroleum to natural gas for existing thermal power plants
	13.Thermal power with high efficiency	Combined-cycle electric generation
		High efficient coal thermal power plants
		Thermal power plants improvement
	14.Power transmission with improved efficiency	Decreasing of electrical loss due to improved power transmission systems
	15.Power distribution with improved efficiency	Decreasing of electrical loss due to improved power distribution systems
	16.Rural electrification	Rural electrification project by renewable energy use
Renewable energy	17.Hydro power	Small hydro power , river-runoff hydro power Reservoir hydro power (except for pumped and storage hydro power)
	18.Wind power	Wind power plants
	19.Photovoltaic power/Solar heat	Solar power plants
	20.Geothermal	Geothermal plants
	21.Biomass	Biomass power generation and heat-supply
Sewerage, Urban sanitation	22.Landfill disposal of waste	Landfill LFG power generation
	23.Intermediate treatment of waste	Waste power plants , waste composition
	24.Wastewater treatment	Methane emission reduction by improving wastewater treatment
	25.Sewerage	Biomass generation and composting sewage sludge

2.2 Methodologies of Other Certification Organizations, etc.

Existing methodologies and tools are reviewed in order to clarify the basic concept and guidelines to be provided under this survey.

2.2.1 Reviewed Methodologies

This survey mainly reviews CDM methodologies. Other methodologies, including domestic and international Voluntary Emissions Trading methodologies, GHG emission reduction calculation manual or tool used by international organization for assistance to developing countries, and VER certification organization methodologies are also considered.

Table 2.2.1 below shows the surveyed methodologies and their outlines.

Table 2.2.1 Target and Outline of Existing GHG Estimation Methodologies (1)

Survey Targets		Overview
CDM Methodology	Approved methodologies, Approved consolidated methodologies, Small-scale CDM methodology, Afforestation/reforestation CDM methodology Approved consolidated afforestation/reforestation CDM methodology, Small-scale approved consolidated afforestation/reforestation CDM methodology	International standard method for project-based GHG emission reductions as a method to quantify. Covering all sectors, there are 179 methodologies applied to more than 2,400 projects, as of April 28, 2011. [1]
Domestic Voluntary Emissions Trading methodologies	J-VER（offset-credit system: Ministry of the Environment, Japan）	This is the methodology for calculation and certification of project-based voluntary GHG emission reduction (sequestration). [2] Energy:24 , Forestry:3 , Waste:1
	Domestic Credit System (Domestic emission certification system) （Ministry of the Environment、Ministry of the Environment、Ministry of Agriculture, Forestry and Fisheries, Japan）	This is the methodology for authentication and GHG estimation done by small businesses[3] Energy, Waste, etc.:34
	J-MRV（Japan Finance Corporation、Japan Bank For International Cooperation）	This is JBIC's tool for MRV for environmental protection activities (GREEN: Global action for Reconciling Economic growth and ENvironmental preservation)[4] Energy Sector: 4, as of February 28, 2011.
Manual or tool to estimate GHG emission reduction by international organization(Developing country support)	WB（The World Bank/Carbon Finance Unit)	The handbook has been published. CDM projects are in accordance with the CDM methodology while other projects conform to the GEF manual.[5]
	IFC（International Finance corporation)	IFC offers project-GHG calculation sheet for sectors such as forestry, water supply and sewerage and drainage, urban sanitation, others） [6]
	OECD Organization for Economic Co-operation and Development)	Published a power sector manual for calculating GHG. [7]
	ADB(Asian Development Bank)	Released a transportation and energy sector manual on basic concept for GHG estimation.[8]

Table 2.2.1 Target and Outline of Existing GHG Estimation Methodologies (2)

Survey Targets		Overview
Manual or tool to estimate GHG emission reduction by international organization(Developing country support)	UNEP (United Nations Environment Program)	Released energy, transportation and industrial processes GHG calculation sheets.[9]
	GEF(Global Environment Facility)	In the published manual, CDM-like approach is used to quantify GHG.[10]
	GHG protocol (the Greenhouse Gas Protocol Initiative)	Released energy consumption, transportation and industrial processes GHG calculation sheets.[11]
	USAID（United States Agency for International Development）	Released forestry and transportation sectors GHG calculation sheets (outline).[12]
	CIDA（Canadian International Development Agency）	GHG calculations are conducted under a fund targeting climate change operations. Details of the program are unknown.
	GTZ(Deutsche Gesellschaft fur Technische Zusammenarbeit) (*Now GIZ：The Deutsche Gesellschaft für Internationale Zusammenarbeit)	GHG calculator is released in the waste sector.[13]
	KFW（Kreditanstalt für Wiederaufbau）	Released tool for GHG calculation for landfill.[14]
	PROPARCO (single pour Promotion et Participation pour la Coopération économique)	Estimates GHG of the project they assist. Information on the program is unknown.[15]
Methodology of VER Certification agency	Gold Standard	In addition to the verification and certification of CDM projects, the following criteria is used to determine the quality of CDM /JI projects:[16] i) Project Eligibility, ii) Additionality and baseline iii) Contribution to sustainable development
	VER+	Certification audit is basically being done using the same methodology as with CDM and JI projects.[17]
	CCB Standards(The Climate, Community and Biodiversity Project Design Standards)	Assessment of biodiversity, climate change mitigation effects and impact to the local community. [18]
	Green-e	Green Power Certification Program (Green-e) is aimed at consumer protection when power credits are sold, verifying whether the goods satisfy environmental standards.[19]
	VOS(Voluntary Offset Standard)	Certification system equivalent to the standard of the Kyoto credits. Target countries are mainly countries that did not ratify the Kyoto Protocol, and in particular, the U.S. and Australia (Australia ratified the Protocol). [20]
	CCX(Chicago Climate Exchange)	System has its own validation criteria. Provides manuals for calculation of GHG in multiple sectors.[21]
	CCAR(California Climate Action Registry)	The methodology of California NPO. Provides manuals for calculation of GHG in multiple sectors.[22]
	Plan Vivo	Grass root criteria that offer high standard for environmental protection and local benefits. The methodology is an expensive option compared to those used in the global carbon market. [23]

Table 2.2.1 Target and Outline of Existing GHG Estimation Methodologies (3)

Survey Targets		Overview
Methodology of VER Certification agency	Social Carbon	The feature of the methodology is to evaluate and verify the long-term impact assessment of sustainable development.[24]
	NCOS(National Carbon Offset Standard)	Efforts by the Australian Government started in July 2010, replacing Greenhouse Friendly™. The targets are Australian companies.[25]

1 http://www.kyomecha.org/cdm.html#method
2 http://www.4cj.org/jver/system_doc/methodology.html
3 http://jcdm.jp/process/methodology.html
4 http://www.jbic.go.jp/ja/about/environment/j-mrv/pdf/jmrv-guideline.pdf
5 http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTCARBONFINANCE/0,,contentMDK:22366206~pagePK:64168445~piPK:64168309~theSitePK:4125853,00.html
6 http://www.ifc.org/ifcext/climatebusiness.nsf/Content/GHGaccou
7 http://www.oecd.org/dataoecd/45/43/1943333.pdf
8 http://www.adb.org/documents/papers/adb-working-paper-series/ADB-WP09-Transport-CO2-Emissions.pdf
9 http://www.unemg.org/MeetingsDocuments/IssueManagementGroups/SustainabilityManagement/UnitedNationsGreenhouseGasCalculator/tabid/3975/Default.aspx
10 http://www.thegef.org/gef/node/313
11 http://www.ghgprotocol.org/calculation-tools
12 http://www.usaid.gov/our_work/environment/climate/docs/forest_carbon_calculator_jan10.pdf
13 http://www.gtz.de/en/themen/umwelt-infrastruktur/abfall/30026.htm
14 http://www.kfw-entwicklungsbank.de/EN_Home/Sectors/Waste_management/Solid_Waste_Management_Greenhouse_Gas_Calculator/index.jsp
15 http://www.proparco.fr/jahia/webdav/site/afd/shared/PUBLICATIONS/INSTITUTIONNEL/plaquettes-presentation/AFD-Brochure-english-2008.pdf
16 http://www.cdmgoldstandard.org/Current-GS-Rules.102.0.html
17 http://www.netinform.de/KE/Beratung/Service_Ver.aspx
18 http://www.climate-standards.org/standards/pdf/second_edition/CCB_Standards_2nd_Edition_JAPANESE.pdf
19 http://www.green-e.org/getcert_ghg_products.shtml
20 http://www.carboninvestors.org/ECISVoluntaryOffsetStandardFINALJune.pdf
21 https://registry.chicagoclimatex.com/public/projectsReport.jsp
22 http://www.climateregistry.org/
23 http://planvivo.org.34spreview.com/documents/standards.pdf
24 http://www.socialcarbon.org/
25 http://www.climatechange.gov.au/en/government/initiatives/national-carbon-offset-standard.aspx

2.2.2 Existing Methodologies for Targeted Sub-sectors

The existing methodologies and tools are classified into each of the mitigation sub-sectors chosen in the earlier section "Selection of Targeted Sub-sectors" and served as basic data for discussion of this survey. Some of the applied methodologies in past projects were introduced. (All existing methodologies and tools are shown in Table2.2.2, including those in sectors with a relatively small number of or no past applications.)

(1) Forest and Natural Resources Conservation Sector

Some of the methodologies of CDM and J-VER are applied in the forestry sector. CDM is only applicable for afforestation and reforestation in the first commitment period (2008～2012), excluding forest management (REDD) or farmland management. Application of CDM to afforestation projects is limited. AR-AM003 has the most applied numbers, with only 4 approved projects. On the other hand, there is progress in application of Japan's J-VER methodologies to domestic forest management projects. There are two methodologies on increase of CO_2 sequestration through forest management activities, with 51 applications for one of the methodologies (Thinning Promotion R001).

The 'forest conservation' explained here means the "Reduced Emission from Deforestation and Forest Degradation (REDD)". The VCS guideline is referred to because the United Nations has not approved any of the REDD methodologies at the timing of the survey.

Table 2.2.2 Existing Methodologies in Forest and Natural Resources Conservation Sector

Sub-sector	CDM			J-VER			VCS			ODA Loan Projects	
	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Classification	Project
Afforestation	AR-AM0003	Afforestation and reforestation of degraded land through tree planting, assisted natural regeneration and control of animal grazing	4	—			—			Forestation	37
	AR-AM0002	Restoration of degraded lands through afforestation/reforestation	1								
	AR-AM0001	Reforestation of degraded land	2								
	AR-ACM0001	Afforestation and reforestation of degraded land	2								
	AR-AM0004	Reforestation or afforestation of land currently under agricultural use	1								
	AR-AM0005	Afforestation and reforestation project activities implemented for industrial and/or commercial uses	1								
	AR-AM0010	Afforestation and reforestation project activities implemented on unmanaged grassland in reserve/protected areas	1								
Forest conservation	—			R001	Increase in CO_2 sequestration through forest management activity (Thinning Promotion Project)	51	VM0003	Methodology for Improved Forest Management through Extension of Rotation Age, v1.0	Unknown	Forest Conservation, Slope Conservation/ Soil Conservation, Mangrove Conservation, Ecosystem （Biodiversity） conservation, Restoration, Forest disaster prevention	31
							VM0004	Methodology for Conservation Projects that Avoid Planned Land Use Conversion in Peat Swamp Forests, v1.0			
							VM0005	Methodology for Conversion of Low-productive Forest to High-productive Forest			
							VM0006	Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and Degradation			

Sub-sector	CDM			J-VER			VCS			ODA Loan Projects	
	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Classification	Project
				R002	Increase in CO_2 sequestration through forest management activity (Thinning Promotion Project)	9	VM0007	REDD Methodology Modules (REDD-MF)			
							VM0009	Methodology for Avoiding Mosaic Deforestation of Tropical Forests			
							VM0010	Methodology for Improved Forest Management: Conversion from Logged to Protected Forest			
							VM0003	Methodology for Improved Forest Management through Extension of Rotation Age, v1.0			

Note：Application number is indicated in the approved real ones. In (   ) indicate the number of cases pending projects.（as of March 31, 2011）

(2) Traffic and Transportation Sector

Some methodologies are currently available for CDM and J-VER in traffic and transportation sector. However, only CDM methodologies have been applied to actual project activities. There are only 6 projects because of the geographically large project boundary and difficulties in estimating/verification/monitoring of GHG emission reductions effect. As shown in Table 2.2.3, there are 5 modal shift projects applied, including 2 for bus rapid transit or BRT projects, 1 for railway, 1 for rolling stock cars for subways, 1 for cable cars, and 1 for bio-diesel production projects.

Table2.2.3 Existing Methodologies in Traffic and Transportation Sector

Sub-sector	CDM			ODA Loan Projects	
	Method No.	Title	Project	Classification	Project
Freight/Passenger Transportation Improvement	AM0090	Modal shift in transportation of cargo from road transportation to water or rail transportation	0	Freight (a new railway , double track railway) Passenger (a new railway、a double track railway, or a quadruple track railway) Improvement of railway facilities, High standardization , Rehabilitation of railway bridges	48
	AMS-III.C.	Emission reductions by electric and hybrid vehicles	1		
MRT (Mass Rapid Transit)	ACM0016	Baseline and monitoring methodology for Mass Rapid Transit Projects	0	MRT (City and suburb rapid railway：Subway, Elevated railway)	46
	AMS-III.U.	Cable Cars for Mass Rapid Transit System (MRTS)	1		
Monorail, LRT	ACM0016	Baseline and monitoring methodology for Mass Rapid Transit Projects	0	Monorail, LRT	2
	AMS-III.U.	Cable Cars for Mass Rapid Transit System (MRTS)	1		
Bus(BRT , Trunk bus)	ACM0016	Baseline and monitoring methodology for Mass Rapid Transit Projects	0		
	AM0031	Cable Cars for Mass Rapid Transit System (MRTS)	2		0

(3) Energy Conservation (Industry) Sector

Energy conservation (Industry) sector has methodologies and actual application examples in the CDM, J-VER, Domestic Credit System and J-MRV. Domestic Credit System 001 is ranked highest at 248 applications in the sub-sector of energy efficiency improvement for industrial facilities. Also, the small-scale approved methodologies, AMS-II.D, ranked highest at 42 among other methodologies for the CDM. These are projects that include upgrading of boilers in industrial facilities.

The CDM-approved consolidated methodology, ACM0012, ranked highest at 22 in cogeneration (supply of electricity and heat) for industrial facilities. There are many scenarios in approved consolidated methodologies; however, cogeneration (supply of electricity and heat) by effective utilization of waste energy (waste gas, waste heat, waste pressure) is the target.

Small-scale CDM methodology AMS-III.B and consolidated methodology ACM0003, both with 13 applications each, rank the highest among the methodologies in the sub-sector of fossil fuel switching measure for industrial facilities. These involve fuel switching to low-carbon fuel, from fossil fuel to natural gas, etc..

Table 2.2.4 Existing Methodologies in Energy Conservation (Industry) Sector (1)

	CDM			J-VER			Domestic Credit System			J-MRV			ODA Loan Projects	
	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Classification	Project
Energy Efficiency Improvement	AMS-II.D.	Energy efficiency and fuel switching measures for industrial facilities	42	E011	Upgrade･fuel switch of boiler equipment	Update of boiler.	001	Upgrading of boiler.	248	J-MRV002	Methodology for Energy conservation project	Unknown	Energy conservation	2
	AMS-II.C.	Demand-side energy efficiency activities for specific technologies Baseline Methodology for steam optimization systems	11				004	Upgrading of air-conditioning equipment.	109	—				
							001-A	Installing a new boiler.	33					
	AM0018	Energy efficiency measures through centralization of utility provisions of an industrial facility	10				002	Upgrading of heat source equipment by introducing a heat pump.	28					
	AMS-II.H.	Methodology for improved electrical energy efficiency of an existing submerged electric arc furnace used for the production of SiMn	1				002-A	Upgrading of heat source equipment by introducing a heat pump. (Heat-collecting type)	8					
							002-B	Installing a new heat source equipment by introducing a heat pump	3					
	AM0038	Energy efficiency and fuel switching measures for industrial facilities; Demand-side energy efficiency activities for specific technologies	1				003	Upgrading of industrial furnace	14					
							005	Intermittent operational control, Inverter control, or Install of regulating equipments for pumps and fans	43					
	AM0059	Baseline methodology for steam optimization systems	1				010	Upgrading of transformer	5					
							022	Upgrading of refrigeration equipment	2					

	CDM			J-VER			Domestic Credit System			J-MRV			ODA Loan Projects	
	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Classification	Project
Electricity and heat supply	ACM0012	Consolidated baseline methodology for GHG emission reductions for waste gas or waste heat or waste pressure based energy system	22(1)	E006	Recovery and utilization of waste heat	2	014	Introduction of a small steam generator by utilizing excess steam	5	J-MRV003	Recovery and utilization of waste energy project	Unknown	Industry	15
	AMS-III.Q.	Waste gas based energy systems	11(1)	—			009	Energy utilization of hot spring heat and waste heat	2				Factory, plant Mining industry	
	AM0024	Methodology for greenhouse gas reductions through waste heat recovery and utilization for power generation at cement plants	9				013	Switching to thermal applications from the external high-efficiency heating equipment	1					
	AMS-III.P.	Recovery and utilization of waste gas in refinery facilities	4											

Table 2.2.5 Existing Methodologies in Energy Conservation (Industry) Sector (2)

	CDM			J-VER			Domestic Credit System			J-MRV			ODA Loan Projects	
	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Classification	Project
Fuel switching	AMS-III.B.	Supply side energy efficiency improvements – generation	13(1)	E001	Switch from fossil fuel to unused woody biomass for boiler fuel	8	012	Switch from coke to biocoke in melting furnace	1	—			Factory, plant Mining industry	8
	AMS-II.D.	Methodology for conversion from single cycle to combined cycle power generation	42	E002	Switch from fossil fuel to unused wood pellets for boiler fuel	5	—							
	ACM0003	Consolidated baseline and monitoring methodology for new grid connected fossil fuel fired power plants using a less GHG intensive technology	13(1)	—										
	ACM0009	Supply side energy efficiency improvements – transmission and distribution	5											
	AM0036	Methodology for installation of energy efficient transformers in a power distribution grid	3											
	AMS-II.G.	Supply side energy efficiency improvements – transmission and distribution	1											

Note：Application number is indicated in the approved real ones. Values in ( ) indicate the number of cases of pending projects.（as of March 31, 2011）

(4) Energy Sector

The energy sector has methodologies and actual application examples in the CDM and VCS. Projects under CDM-approved methodology AM0029 ranked highest at 31 in the sub-sector of plant supplying energy maintenance with fuel switching, targeting projects that supply natural gas originated electricity to a grid.

Projects under CDM-approved consolidated methodology ACM0012 ranked second at 22 in the sub-sector of fossil fuel fired power plants for supplying electricity. Projects under CDM small-scale methodology MS-III.B ranked third at 13 in the sub-sector of fossil fuel-fired power plants for fuel switching.

10 projects have applied CDM small-scale methodology AMS-II.B in the sub-sector of fossil fuel-fired power plants for efficiency improvement, targeting projects that replace plants such as boilers in fossil fuel-fired power plants.

Table 2.2.6 Existing Methodologies in the Energy Sector

Sub-sector	CDM			ODA Loan Projects	
	Method No.	Title	Project	Classification	Project
Energy plant with fuel switching	AM0029	Baseline Methodology for Grid-Connected Electricity Generation Plants using Natural Gas	31	Intensive heat-supply system with fuel switching Energy facilities(Establishment of natural gas pipeline)	28
	AM0014	Natural gas-based package cogeneration	5		
	AM0058	Introduction of a new primary district heating system	0(1)		
Thermal power with electricity and heat supply	ACM0012	Consolidated baseline methodology for GHG emission reductions for waste gas or waste heat or waste pressure based energy system	22(1)	Thermal power with electricity and heat supply	4
	AM0055	Baseline and Monitoring Methodology for the recovery and utilization of waste gas in refinery facilities	1		
Thermal power with fuel switching	AMS-III.B.	Switching fossil fuels	13(1)	Intensive heat-supply system with fuel switching	12
	ACM0011	Consolidated baseline methodology for fuel switching from coal and/or petroleum fuels to natural gas in existing power plants for electricity generation	1		
Thermal power with higher efficiency	AMS-II.B.	Supply side energy efficiency improvements – generation	10	Thermal power with high efficiency	39
	ACM0007	Methodology for conversion from single cycle to combined cycle power generation	4		
	ACM0013	Consolidated baseline and monitoring methodology for new grid-connected fossil fuel-fired power plants using a less GHG-intensive technology	3		
Power transmission with improved efficiency	AMS-II.A.	Supply side energy efficiency improvements – transmission and distribution	0	Transmission and distribution	53
	AM0067	Methodology for installation of energy efficient transformers in a power distribution grid	0		
Power distribution with improved efficiency	AMS-II.A.	Supply side energy efficiency improvements – transmission and distribution	0	Transmission and distribution	11
	AM0067	Methodology for installation of energy efficient transformers in a power distribution grid	0		
Rural electrification	AMS-I.F.	Renewable electricity generation for captive use and mini-grid	0	Renewable energy Rural electrification	31

Note：Application number is indicated in the approved real ones. Values in ( ) indicate the number of cases of pending projects.（as of March 31, 2011）

(5) Renewable Energy Sector

The renewable energy sector has some methodologies available with the CDM, J-VER, and Domestic Credit System. However, only the CDM and Domestic Credit System exhibit actual application examples. Most CDM methodologies fall into two sub-sectors. One group is categorized into hydro, wind, photovoltaic and geothermal. The other is biomass.

Projects under approved consolidated methodology ACM0002 ranked highest at 900, while projects under small-scale approved methodology AMS-I.C ranked second at 846 in the sub-sector group of hydro, wind, photovoltaic and geothermal. These are all projects for grid-connected electricity generation from renewable sources. The above 2 methodologies account for about half of the current CDM approved projects.

Bio-diesel production and use for transportation applications are referred separately in the fuel switching methodologies. In this chapter, approved consolidated methodology for electricity generation with biomass residues under ACM0006 is regarded as the highest ranking methodology with 93 application cases.

Table 2.2.7 Existing Methodologies in Renewable Energy Sector

<table>
<tr><th rowspan="2">Sub-sector</th><th colspan="3">CDM</th><th colspan="3">Domestic Credit System</th><th colspan="2">Yen Loan Aid Projects</th></tr>
<tr><th>Method No.</th><th>Title</th><th>Project</th><th>Method No.</th><th>Title</th><th>Project</th><th>Classification</th><th>Project</th></tr>
<tr><td rowspan="4">Hydro power, Wind power, Photovoltaic power /solar heat, Geothermal power</td><td>ACM0002</td><td>Consolidated baseline methodology for grid-connected electricity generation from renewable sources</td><td>900(29)</td><td rowspan="4">008</td><td rowspan="4">Methodology for grid-connected electricity generation from photovoltaic power system</td><td rowspan="4">21</td><td rowspan="4">Hydro power plants（except for small hydropower and pumped and storage hydropower）

Renewable energy</td><td rowspan="4">54</td></tr>
<tr><td>AMS-I.D.</td><td>Grid-connected renewable electricity generation</td><td>846(21)</td></tr>
<tr><td>AMS-I.C.</td><td>Thermal energy production with or without electricity</td><td>114(4)</td></tr>
<tr><td>AM0026</td><td>Methodology for zero emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid</td><td>4</td></tr>
<tr><td>Biomass</td><td>ACM0006</td><td>Consolidated methodology for electricity and heat generation from biomass residues</td><td>93(1)</td><td colspan="3">－</td><td>Renewable energy</td><td>0</td></tr>
</table>

Note：Application number is indicated in the approved real ones. Values in ( ) indicate the number of cases of pending projects.（as of March 31, 2011）

(6) Sewerage and Urban Sanitation Sector

Sewerage and urban sanitation sector have methodologies, but only the CDM has actual application examples. In the sub-sector of waste management, projects under approved consolidated methodology ACM0001 ranked highest at 129. These include the methodologies for landfill gas capture projects.

In the 2 sub-sectors of treatment of wastewater and sewerage, 93 projects have applied small-scale approved methodology, targeting projects for methane recovery in wastewater treatment.

Table 2.2.8 Existing Methodologies in Sewerage and Urban Sanitation Sector

Sub-sector	CDM			Yen Loan Aid Projects	
	Method No.	Title	Project	Classification	Project
Landfill disposal of waste	ACM0001	Consolidated baseline and monitoring methodology for landfill gas project activities	129	Urban sanitation (waste disposal)	7
	AMS-III.E.	Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment	27		
	AMS-III.G.	Landfill methane recovery	13		
	AM0083	Avoidance of landfill gas emissions by in-situ aeration of landfills	1		
	AM0025	Avoided emissions from organic waste through alternative waste treatment processes	17		
Intermediate treatment of waste	AMS-III.F.	Avoidance of methane emissions through composting	36	Urban sanitation (waste disposal)	9
	AM0039	Methane emissions reduction from organic waste water and bioorganic solid waste using co-composting	2		
Wastewater treatment	AMS-III.H.	Methane recovery in wastewater treatment	93(5)	Drainage	35
	AMS-III.I.	Avoidance of methane production in wastewater treatment through replacement of anaerobic lagoons by aerobic systems	7		
	AMS-III.Y.	Methane avoidance through separation of solids from wastewater or manure treatment systems	1		
Sewerage	AMS-III.H.	Methane recovery in wastewater treatment	93(5)	Sewerage	56
	AMS-III.I.	Avoidance of methane production in wastewater treatment through replacement of anaerobic lagoons by aerobic systems	7		
	AMS-III.Y.	Methane avoidance through separation of solids from wastewater or manure treatment systems	1		
	ACM0014	Mitigation of greenhouse gas emissions from treatment of industrial wastewater	2		

Note：Application number is indicated in the approved real ones. Values in ( ) indicate the number of cases of pending projects.（as of March 31, 2011）

Reference-1 Comparison of Methodologies (1)

Sector	Sub-Sector	CDM			J-VER			VCS			Domestic Credit System			J-MRV			Yen loan aid projects	
		Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Classification	Project
Forest and natural resources conservation	Afforestation	AR-AM0003	Afforestation and reforestation of degraded land through tree planting, assisted natural regeneration and control of animal grazing	4													Afforestation	37
		AR-AM0002	Restoration of degraded lands through	1														
		AR-AM0001	Reforestation of degraded land	2														
		AR-ACM0001	Afforestation and reforestation of degraded land	2														
		AR-AM0004	Reforestation or afforestation of land currently under agricultural use	1														
		AR-AM0005	Afforestation and reforestation project activities implemented for industrial and/or commercial uses	1														
		AR-AM0010	Afforestation and reforestation project activities implemented on unmanaged grassland in reserve/protected areas	1														
	Forest conservation				R001	Increase in CO2 sequestration through forest management activity (Thinning Promotion Project)	51	VM0003	Methodology for Improved Forest Management through Extension of Rotation Age, v1.0	Unknown							・Forest conservation , Slope conservation/Soil conservation ・Mangrove conservation ・Ecosystem (biodiversity) integrity/restoration ・Forest disaster prevention	20
					R002	Increase in CO2 sequestration through forest management activity (Thinning Promotion Project)	9	VM0004	Methodology for Conservation Projects that Avoid Planned Land Use Conversion in Peat Swamp Forests, v1.0	Unknown								
								VM0005	Methodology for Conversion of Low-productive Forest to High-productive Forest	Unknown								
								VM0006	Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and Degradation	Unknown								
								VM0007	REDD Methodology Modules (REDD-MF)	Unknown								
								VM0009	Methodology for Avoided Mosaic Deforestation of Tropical Forests	Unknown								
								VM0010	Methodology for Improved Forest Management: Conversion from Logged to Protected Forest	Unknown								
								VM0003	Methodology for Improved Forest Management through Extension of Rotation Age, v1.0	Unknown								
Traffic and Transportation	Freight/Passenger Transportation Improvement	AM0090	Modal shift in transportation of cargo from road transportation to water or rail transportation	0	E023	Eco-drive with mounted digital tachographs	0										・Freight (a new railway double track railway) ・Passenger (a new railway、a double track railway, or a quadruple track railway) ・Improvement of rails, High standardization , Rehabilitation of railway bridges ・Rehabilitation of train cars and railway facilities	48
		AMS-III.C.	Emission reductions by electric and hybrid vehicles	1														
	MRT	AMS-III.U.	Cable Cars for Mass Rapid Transit System (MRTS)	1													MRT (City and suburb rapid railway：Subway, Elevated railway)	46
		ACM0016	Baseline Methodology for Mass Rapid Transit Projects	0														
	Mono-rail,LRT	AMS-III.U.	Cable Cars for Mass Rapid Transit System (MRTS)	1													Monorail, LRT	2
		ACM0016	Baseline Methodology for Mass Rapid Transit Projects	0														
	Bus	ACM0016	Baseline Methodology for Mass Rapid Transit Projects	0													BRT,Trunk Bus	0
		AM0031	Baseline Methodology for Bus Rapid Transit Projects	2														
Energy Conservation (Industry)	Energy Efficiency Improvement	AMS-II.D.	Energy efficiency and fuel switching measures for industrial facilities	42	E011	Upgrade・fuel switch of boiler equipment	5				001	Upgrading of boiler.	248	J-MRV002	Methodology for Energy conservation project	Unknown	Energy Conservation	2
		AMS-II.C.	Demand-side energy efficiency activities for specific technologies	11							004	Upgrading of air-conditioning equipment.	109					
		AM0018	Baseline methodology for steam optimization systems	10							001-A	Installing a new boiler.	33					
		AMS-II.H.	Energy efficiency measures through centralization of utility provisions of an industrial facility	1							002	Upgrading of heat source equipment by introducing a heat	28					
		AM0038	Methodology for improved electrical energy efficiency of an existing submerged electric arc furnace used for the production of SiMn	1							002-A	Upgrading of heat source equipment by introducing a heat pump.	8					
		AM0059	Reduction in GHGs emission from primary aluminium smelters	1							002-B	Installing a new heat source equipment by introducing a heat pump	3					
											003	Upgrading of industrial furnace	14					
											005	Intermittent operational control, Inverter control, or Install of regulating equipments for pumps and fans	43					
											010	Upgrading of transformer	5					
											022	Upgrading of refrigeration equipment	2					
	Electricity and heat supply	ACM0012	Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects	22(1)	E006	Recovery and utilization of waste heat	2				014	Introduction of a small steam generator by utilizing excess steam	5	J-MRV003	Recovery and utilization of waste energy project	Unknown	・Factory、Plant ・Mining	15
		AMS-III.Q.	Waste energy recovery (gas/heat/pressure) projects	11(1)							009	Energy utilization of hot spring heat and waste heat	2					
		AM0024	Baseline methodology for greenhouse gas reductions through waste heat recovery and utilization for power generation at cement plants	9							013	Switching to thermal applications from the external high-efficiency heating equipment	1					
		AMS-III.P.	Recovery and utilization of waste gas in refinery facilities	4														
	Fuel switching	AMS-III.B.	Switching fossil fuels	13(1)	E001	Switch from fossil fuel to unused woody biomass for boiler fuel	8				012	Switch from coke to biocoke in melting furnace	1				・Factory、Plant ・Mining	8
		AMS-II.D.	Energy efficiency and fuel switching measures for industrial facilities	42	E002	Switch from fossil fuel to unused wood pellets for boiler fuel	5											
		ACM0003	Emissions reduction through partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels in cement or quicklime manufacture	13(1)														
		ACM0009	Consolidated baseline and monitoring methodology for fuel switching from coal or petroleum fuel to natural gas	5														
		AM0036	Fuel switch from fossil fuels to biomass residues in heat generation equipment	3														
		AMS-II.G.	Energy efficiency measures in thermal applications of non-renewable biomass	1														

Reference-2 Comparison of Methodologies (2)

Sector	Sub-Sector	CDM			J-VER			VCS			Domestic Credit System			J-MRV			Yen loan aid projects	
		Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Method No.	Title	Project	Classification	Project
Energy	Energy plant with fuel switching	AM0029	Baseline Methodology for Grid Connected Electricity Generation Plants using Natural Gas	31													・Intensive heat-supply system with fuel switching ・Energy Facilities (Construction of Natural gas ipelines)	28
		AM0014	Natural gas-based package cogeneration	5														
		AM0058	Introduction of a new primary district heating system	0(1)														
	Thermal power electricity	ACM0012	Consolidated baseline methodology for GHG emission reductions from waste energy recovery projects	22(1)													Thermal power plants with electricity and heat supply	4
		AM0055	Recovery and utilization of waste gas in refinery	1														
	Thermal power with fuel switching	AMS-III.B.	Switching fossil fuels	13(1)													Thermal power plants with fuel switching	12
		ACM0011	Consolidated baseline methodology for fuel switching from coal and/or petroleum fuels to natural gas in existing power plants for electricity generation	1														
	Thermal power with higher efficiency	AMS-II.B.	Supply side energy efficiency improvements – generation	10										J-MRV004	Methodology for fossil fuel fired power plants using a less GHG intensive technology	Unknown	Thermal power plants with higher energy efficiency	39
		ACM0007	Conversion from single cycle to combined cycle power generation	4														
		ACM0013	Consolidated baseline and monitoring methodology for new grid connected fossil fuel fired power plants using a less GHG intensive technology	3														
	Power transmission with improved efficiency	AMS-II.A.	Supply side energy efficiency improvements – transmission and distribution	0													Electricity Transmission	53
		AM0067	Methodology for installation of energy efficient transformers in a power distribution grid	0														
	Power distribution with improved efficiency	AMS-II.A.	Supply side energy efficiency improvements – transmission and distribution	0													Electrical Distribution	11
		AM0067	Methodology for installation of energy efficient transformers in a power distribution grid	0														
	Rural electrificatio	AMS-I.F.	Renewable electricity generation for captive use and mini-grid	0													Renewable energy Rural electrification	31
Renewable energy	Hydro power, Wind Power, Photovoltaic power / solar heat, Geothermal	ACM0002	Consolidated baseline methodology for grid-connected electricity generation from renewable sources	900(29)							008	Methodology for grid-connected electricity generation from photovoltaic power system	21				Hydro power plants (except for small hydropower and pumped and storage hydropower) Renewable energy	54
		AMS-I.D.	Grid connected renewable electricity generation	846(21)														
		AMS-I.C.	Thermal energy production with or without electricity	114(4)														
		AM0026	Methodology for zero-emissions grid-connected electricity generation from renewable sources in Chile or in countries with merit order based dispatch grid	4														
	Biomass	ACM0006	Consolidated methodology for electricity and heat generation from biomass	93(1)										J-MRV0001	Methodology for electricity and heat generation from biomass residues	Unknown	Renewable energy	0
Sewerage, Urban sanitation	Landfill disposal of waste	ACM0001	Consolidated baseline and monitoring methodology for landfill gas project activities	129													Urban Sanitation (Disposal of waste)	7
		AMS-III.E.	Avoidance of methane production from decay of biomass through controlled combustion, gasification or	27														
		AMS-III.G.	Landfill methane recovery	13														
		AM0083	Avoidance of landfill gas emissions by in-situ aeration of landfills	1														
		AM0025	Avoided emissions from organic waste through alternative waste treatment processes	17														
	Intermediate treatment of waste	AMS-III.F.	Avoidance of methane emissions through composting	36													Urban Sanitation (Disposal of waste)	9
		AM0039	Methane emissions reduction from organic waste water and bioorganic solid waste using co-composting	2														
	Wastewater treatment	AMS-III.H.	Methane recovery in wastewater treatment	93(5)													Wastewater	35
		AMS-III.I.	Avoidance of methane production in wastewater treatment through replacement of anaerobic systems by aerobic systems	7														
		AMS-III.Y.	Methane avoidance through separation of solids from wastewater or manure treatment systems	1														
	Sewerage	AMS-III.H.	Methane recovery in wastewater treatment	93(5)													Sewerage	56
		AMS-III.I.	Avoidance of methane production in wastewater treatment through replacement of anaerobic systems by aerobic systems	7														
		AMS-III.Y.	Methane avoidance through separation of solids from wastewater or manure treatment systems	1														
		ACM0014	Natural gas-based package cogeneration	2														

Note:Application number is indicated in the approved real ones. Values in ( ) indicate the number of cases of pending projects. (March 31, 2011)

Reference-3 Methodologies of International Organization (1)

Established agency / Institution	WB (The Worlds Bank/Carbon Finance Unit)	IFC (International Finance corporation)	OECD (Organization for Economic Co-operation and Development)	ADB (Asian Development Bank)	UNEP (United Nations Environment Programme)	GEF (Global Environment facility)	GHG protocol (The Greenhouse Gas Protocol Initiative)	USAID (United States Agency for International Development)	CIDA (Canadian International Development Agency)
Multi／Bilateral	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Bi	Bi
Outline	The handbook has been published. CDM projects are in accordance with the CDM methodology while other projects conform to the GEF manual.	IFC offers project-GHG calculation sheet for sectors such as forestry, water supply and sewerage and drainage, urban sanitation, others)	Published a power sector manual for calculating GHG.	Released a transportation and energy sector manual on basic concept for GHG estimation.	Released energy, transportation and industrial processes GHG calculation sheets.	In the published manual, CDM-like approach is used to quantify GHG.	Released energy consumption, transportation and industrial processes GHG calculation sheets.	Released forestry and transportation sectors GHG calculation sheets (outline).	Canada Climate Change Development Fund estimates GHG, but the details including an estimation program are unknown.
Sector: Forest and natural resources conservation	・Forestry	・Forestry ・Land use	○Provide estimation methodology for GHG emission reductions in Agriculture sector ・EX-ACT, EX-ante					○Carbon estimation tool FOREST CARBON CALCULATOR	
Sector: Traffic and Transportation	・Transport (modal shift) ・Infrastructures (Construction of Port、Bridge, etc.)			○Transport and Carbon Dioxide Emissions: Forecasts, Options Analysis, and Evaluation		Others：MANUAL FOR CALCULATING GREENHOUSE GAS BENEFITS FOR GLOBAL ENVIRONMENT FACILITY TRANSPORTATION PROJECTS	○GHG estimation sheet for traffic and transportation ・WRI_Transport_Tool		
Sector: Energy Conservation (Industry)	・Cement ・Fertilizer	・Cement ・Metal ・Chemistry ・Glasses ・Lime production ・Oil、Mining				・Energy conservation in general	○GHG estimation sheet for industry ・GHG emissions from the production of aluminum ・CO2 emissions from the production of lime ・CO2 emissions from the production of iron and steel ・CO2 emissions from the production of cement (US EPA) ・CO2 emissions from the production of ammonia		
Sector: Energy	・Fuel switch from fossil fuel ・Cogeneration ・Updating of refinery ・Updating of electricity transmission ・Updating of electric power substation ・Construction of natural gas pipeline		○PRACTICAL BASELINE RECOMMENDATIONS FOR GREENHOUSE GAS MITIGATION PROJECTS IN THE ELECTRIC POWER SECTOR	○EVALUATION KNOWLEDGE BRIEF ON GREENHOUSE GAS IMPLICATIONS OF ADB'S ENERGY SECTOR OPERATIONS		・Higher efficiency of energy			
Sector: Renewable energy	・・Fuel switch from fossil fuel					・Renewable energy in general			
Sector: Sewerage, Urban sanitation	・Landfill ・wetland reclamation ・Reservoir Others：Evaluation tool for GHG emissions reduction in the field of waste ・Simplified Toolkit for Manure Management Processes ・Simplified toolkit for wastewater treatment projects Simplified toolkit for solid waste management projects ・Simplified toolkit for landfill gas capture projects	・Waste disposal ・Waste water treatment							
Sector: all	○Greenhouse Gas Assessment Handbook(1998)	○GHG estimation sheet IFC Carbon Emissions Estimation Tool (CEET) ・Fuel consumption ・Electricity consumption ・Refrigerator, Air conditioner	○GHG MitiGation actions: MRV issues and options		○GHG estimation sheet ・Spreadsheet for calculating greenhouse gas (GHG) emissions based on the UNEP GHG Calculator ・United Nations Greenhouse Gas Calculator	○Manual for Calculating GHG Benefits of GEF Projects: Energy Efficiency and Renewable Energy Projects Others：GHG estimation tool for GEF project GHG Benefits of GEF Projects: Carbon Dioxide Calculator	○GHG estimation tool for fixed sources ・Stationary_combustion_tool ○GHG estimation tool using electrical consumption ・GHG emissions from purchased electricity ○HFC、PFC emissions tool ・hfc-pfc		
Source	http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTCARBONFINANCE/0,,contentMDK:22366206~pagePK:64168445~piPK:64168309~theSitePK:4125853,00.html	http://www.ifc.org/ifcext/climatebusiness.nsf/Content/GHGaccou	http://www.oecd.org/dataoecd/45/43/1943333.pdf	http://www.adb.org/documents/papers/adb-working-paper-series/ADB-WP09-Transport-CO2-Emissions.pdf	http://www.unemg.org/MeetingsDocuments/IssueManagementGroups/SustainabilityManagement/UnitedNationsGreenhouseGasCalculator/tabid/3975/Default.aspx	http://www.thegef.org/gef/node/313	http://www.ghgprotocol.org/calculation-tools	http://www.usaid.gov/our_work/environment/climate/docs/forest_carbon_calculator_jan10.pdf	
			http://www.oecd.org/dataoecd/26/44/42474623.pdf	http://www.adb.org/Documents/Evaluation/Knowledge-Briefs/REG/EKB-REG-2009-38.pdf	http://www.energyefficiencyasia.org/docs/SimplifiedGHGCalculator.xls	http://www.thegef.org/gef/GEF_C39_Inf.16_Manual_Greenhouse_Gas_Benefits	http://www.ghgprotocol.org/calculation-tools/all-tools		

Reference-4 Methodologies of International Organization (2)

Established agency / Institution	GTZ (Deutsche Gesellschaft fur Technische Zusammenarbeit)	KFW (Kreditanstalt für Wiederaufbau)	PROPARCO (sigle pour Promotion et Participation pour la Coopération économique)	U.S. Department of Commerce	US Environmental Protection Agency	U.S. Department of Transportation	Defra：Department for Environment, Food and Rural Affairs	Co-Benefit Manual of Quantitative evaluation (Ministry of Environment,JAPAN)
Multi／Bilateral	Bi	Bi	Bi	－	－	－	－	BI
Outline	GHG calculations are conducted under a fund targeting climate change operations. Details of the program are unknown.	Released tool for GHG calculation for landfill.	Estimates GHG of the project they assist. Information on the program is unknown.	GHG calculation tool for Landuse,Traffic Sector has been released.	GHG calculation tool for Traffic Sector and Climate Change has been released.	GHG Model for Traffic Sector has been released.	GHG calculation Guidelinel for Traffic and Energy Sector has been released.	The conditions required to organize a quantitative assessment of global warming co-benefits.
Sector: Forest and natural resources conservation								
Sector: Traffic and Transportation				Calculation sheets for Simulation of Traffic Network ・VMT Spreadsheet ・Trip Generation with 4Ds Spreadsheet ・TDF Model ・Enhanced TDF Model GHG Calculation software ・URBEMIS Software ・ICLEI CACP Software ・Place3s Software ・INDEX Software	Optimization Model for Reducing Emissions of Greenhouse Gases from Automobiles (OMEGA)	GHG Calculation Model for traffic Sector ・MOBILE6 ・NONROAD ・NMIM ・COMMUTER ・SIT ・SIPT ・CLIP etc. 17Models.	○Guidance on measuring and reporting Greenhouse Gas (GHG) emissions from freight transport operations	・Air quality improvement (Calculation formula by mobile sources)
Sector: Energy Conservation (Industry)								
Sector: Energy							・2010 Guidelines to Defra / DECC's GHG Conversion Factors for Company Reporting	
Sector: Renewable energy								
Sector: Sewerage, Urban sanitation	○GHG estimation tool for waste management GHG calculator for waste management	SWM Greenhouse Gas Calculator (the solid waste and wastewater management sector)			・Waste Reduction Model (WARM) ・Recycled Content (ReCon) Tool			・Water Pollution Control (GHG emission reduction from Wastewater treatment system ：small scale CDM AMSIII-I) ・Air quality improvement (Calculation formula by fixed sources) ・Waste Management (Landfill methane recovery tool)
Sector: all			Calculation of GHG emission program for each project ・Bilan Carbone					
Source	http://www.gtz.de/en/themen/umwelt-infrastruktur/abfall/30026.htm	http://www.kfw-entwicklungsbank.de/EN_Home/Sectors/Waste_management/Solid_Waste_Management_Greenhouse_Gas_Calculator/index.jsp	http://www.proparco.fr/jahia/webdav/site/afd/shared/PUBLICATIONS/INSTITUTIONNEL/plaquettes-presentation/AFD-Brochure-english-2008.pdf	http://www.commerce.wa.gov/DesktopModules/CTEDPublications/CTEDPublicationsView.aspx?tabID=0&ItemID=7797&MId=944&wversion=Staging	http://www.epa.gov/otaq/climate/models.htm	http://climate.dot.gov/methodologies/analysis-resources.html	http://www.defra.gov.uk/environment/business/reporting/pdf/ghg-freight-guide.pdf	http://www.env.go.jp/press/file_view.php?serial=13728&hou_id=11242
				http://www.newpartners.org/2010/docs/presentations/thursday/np10_samdahl.pdf	http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_home.html		http://www.defra.gov.uk/environment/business/reporting/pdf/100805-guidelines-ghg-conversion-factors.pdf	

VMT:Vehicle-Miles Traveled
TDF：Travel Demand Forecasting

Reference-5 Methodologies of VER Certification Organization

VER Certification agency		Gold Standard	VER+	CCB Standards (The Climate, Community and Biodiversity Project Design Standards)	Green-e	VOS (Voluntary Offset Standard)	CCX (Chicago Climate Exchange)	CCAR (California Climate Action Registry)	Plan Viivo	Social Carbon	NCOS (National Carbon Offset Standard)
Established Institutions		WWF (World Wide Fund for Nature) 、SSN (SouthSouthNorth) 、Helio International etc.	TÜV SÜD Group、3C Group	CCBA (Company、NGO etc.)	CRS (Center for Resource Solution、NPOs in US)	International Carbon Investors and Services (INCIS) 、Morgan Stanley ※ INCIS was established by financial institutions for the development of emissions trading markets GHG.	CCX(Private Sector)	California	ECCM(Edinburgh Centre for Carbon Management)、BR&D (BioClimate Research & Development)	NGO of Brazil：Ecologica Institute (IE)	Australian Government
Multi／Bilateral		-	-	-	-	-	-	-	-	-	-
Outline		In addition to the verification and certification of CDM projects, the following criteria is used to determine the quality of CDM /JI projects: i) Project Eligibility, ii) Additionality and baseline iii) Contribution to sustainable development	Certification audit is basically being done using the same methodology as with CDM and JI projects.	Assessment of biodiversity, climate change mitigation effects and impact to the local community.	Green Power Certification Program (Green-e) is aimed at consumer protection when electric credits are sold, verifiying whether the goods satisfy environmental standards.	Certification system equivalent to the standard of the Kyoto credits. Target countries are mainly countries that did not ratify the Kyoto Protocol, and in particular, the U.S. and Australia (Australia ratified the Protocol).	System has its own validation criteria. Provides manuals for calculation of GHG in multiple sectors.	The methodology of California NPO. Provides manuals for calculation of GHG in multiple sectors.	Grass root criteria that offer high standard for environmental protection and local benefits. The methodology is an expensive option compared to those used in the global carbon market.	The feature of the methodology is to evaluate and verify the long-term impact assessment of sustainable development.	Efforts by the Australian Government started in July 2010, replacing Greenhouse Friendly™. The targets are Australian companies.
Sectors	Forest and natural resources conservation		*Afforestation	*Forest Conservation、Forest Management *Afforestation *Nature Restoration			*Forest Conservation、Forest Management *Afforestation	*Forest Conservation、Forest Management *Afforestation	*Forest Conservation、Forest Management *Afforestation *Agroforestry	*Afforestation/reafforestation	*Forest management (forests established before 1990) *Revegetation (establishment of woody biomass that does not meet forest criteria)
Sectors	Traffic and Transportation	*Energy efficiency Target:Industry・Residential ・Transportation・Public・Agricultural ・Business Sector	Suppression of methane emission in Area circulation								
Sectors	Energy Conservation (Industry)	*Energy efficiency Target:Industry・Residential ・Transportation・Public・Agricultural ・Business Sector									
Sectors	Energy	*Energy efficiency Target:Industry・Residential ・Transportation・Public・Agricultural ・Business Sector	*Energy efficiency				*Energy efficiency *Fuel Switching			*Water power	
Sectors	Renewable energy	*Renewable Energy photovoltaic/Solar Heat(Electricity/Heat) ,Biomass/Biogas /Liquid biofuels,Wind power,Geothermal power,Water power	*Renewable Energy Biomass,Water power,Wind power etc.		*Renewable Energy photovoltaic,Wind power,Geothermal power,,Small Water power,Biomass,Bio Diesel,Hydrogen battery		*Renewable Energy Wind power,Biomass,Biogas, etc.				
Sectors	Sewerage, Urban sanitation		*Landfill methane recovery				*Landfill methane recovery *Proper disposal of ozone-depleting substances *Effective use of methane in the organic waste treatment	*Landfill methane utilization *Composting of organic refuse *Decomposition of organic refuse (proper disposal) *Proper disposal of ozone-depleting substances		*Landfill	
	all										
Source		http://www.cdmgoldstandard.org/Current-GS-Rules.102.0.html	http://www.netinform.de/KE/Beratung/Service_Ver.aspx	http://www.climate-standards.org/standards/pdf/second_edition/CCB_Standards_2nd_Edition_JAPANESE.pdf	http://www.green-e.org/getcert_ghg_products.shtml	http://www.carboninvestors.org/ECISVoluntaryOffsetStandardFINALJune.pdf	https://registry.chicagoclimatex.com/public/projectsReport.jsp	http://www.climateregistry.org/	http://planvivo.org.34spreview.com/documents/standards.pdf	http://www.socialcarbon.org/	http://www.climatechange.gov.au/en/government/initiatives/national-carbon-offset-standard.aspx
		http://www.wwf.or.jp/activities/climate/cat1297/cat1299/index.html	http://www.netinform.de/KE/Wegweiser/Ebene1_Projekte2.aspx?Ebene1_ID=49&mode=4	http://www.climate-standards.org/projects/index.html			http://www.chicagoclimatex.com/docs/offsets/CCX_Rulebook_Chapter09_OffsetsAndEarlyActionCredits.pdf			http://www.socialcarbon.org/uploadDocs/Documents/SOCIALCARBON_STANDARD_v.4.1.pdf	
		http://goldstandard.apx.com/resources/AccessReports.asp									

Chapter 3 Basic Concept and Guidelines for the Quantitative Evaluation of GHG Emission Reduction (Sequestration)

3.1 Basic Concept

3.1.1 Quantitative Evaluation

Mitigation measures against global warming are intended to stop the progress of global warming by reducing (or sequestrating) GHG emissions and stabilize the concentrations of GHG in the atmosphere. The mitigation measures need time to show their effects but are the fundamental solutions. Actual mitigation measures such as effective use of energy and energy conservation, carbon dioxide capture and storage, and increasing carbon sinks are being implemented.

Quantification of GHG emission reduction (sequestration) aims to calculate the impact of mitigation through individual measures.

3.1.2 Basic Concept of Estimation

(1) Traffic and Transportation, Energy Conservation, Energy, Renewable Energy, Sewerage and Urban Sanitation Sectors

The effects of GHG emission reductions through a mitigation measure (ER_y) can be estimated as the difference between the GHG emissions without the mitigation measure (baseline emissions: BE_y) and those with the mitigation measure（project emission: PE_y). For example, the mitigation measure involving implementation of mass rapid transportation (MRT) is as follows:

$$ER_y = BE_y - PE_y$$

Basically, the baseline emission is the GHG emission in case present conditions would continue without project implementation (other concepts can be adopted depending on individual circumstances in each project). To compare between ‘with’ and ‘without’ mitigation measure, GHG is estimated based on the assumption that the level of activities is equivalent to the ‘with’ mitigation measure case (such as the amount of electricity used or the volume of production).

On the other hand, the project emission is determined as the GHG emission by implementing the project. Generally, the volume of project emission is smaller than that of the baseline emission. Also, the project emission of a renewal energy project activity becomes zero.

For financial intermediary loans (two-step loans) which provide assistance to numerous small-scale or medium-scale projects through intermediate financial organizations, etc., a simplified methodology based on the methodologies presented in this report can be applied to estimate the effects of GHG emission reductions, considering the availability of the required data and work volume.

BE_y : Baseline Emission (Without project) PE_y : Project Emission (With Project)

Ex. MRT Project

(2) Forestry and Natural Resources Conservation Sectors

Because trees grow by sequestrating carbon dioxide from the air through photosynthesis and capturing of carbon, a forested site can be considered as a sink of carbon dioxide (or carbon). According to IPCC guidelines, net anthropogenic GHG removals by sinks ($ER_{AR,y}$) can be estimated by extracting the increase (or the decrease) without the forestry (baseline absorptions: $\Delta C_{BSL,y}$). Meanwhile, GHG emissions at the initial stage of the forestry project (project emissions: $GHG_{PRJ,y}$) can be estimated from the increase of carbon dioxide sink after the forestry project progresses over a certain period (or the decrease by thinning and harvesting) (project absorptions: $\Delta C_{PRJ,y}$).

The details are also shown in the explanatory sheets for forestry and natural resources conservation sub-sectors in Chapter 4.

$$ER_{AR,y} = \Delta C_{PRJ,y} - \Delta C_{BSL,y} - GHG_{PRJ,y}$$

3.2 Framework of Methodology Sheet and Calculation Sheet (Excel)

3.2.1 Aim and Application of Methodology Sheet and Calculation Sheet (Excel)

Methodology sheets are prepared to simply estimate the quantitative effects of the GHG emission reduction at the pre-project and post-project stages on the individual project. Workflow and utilization of the methodology sheet and calculation sheets are shown in the figure below.

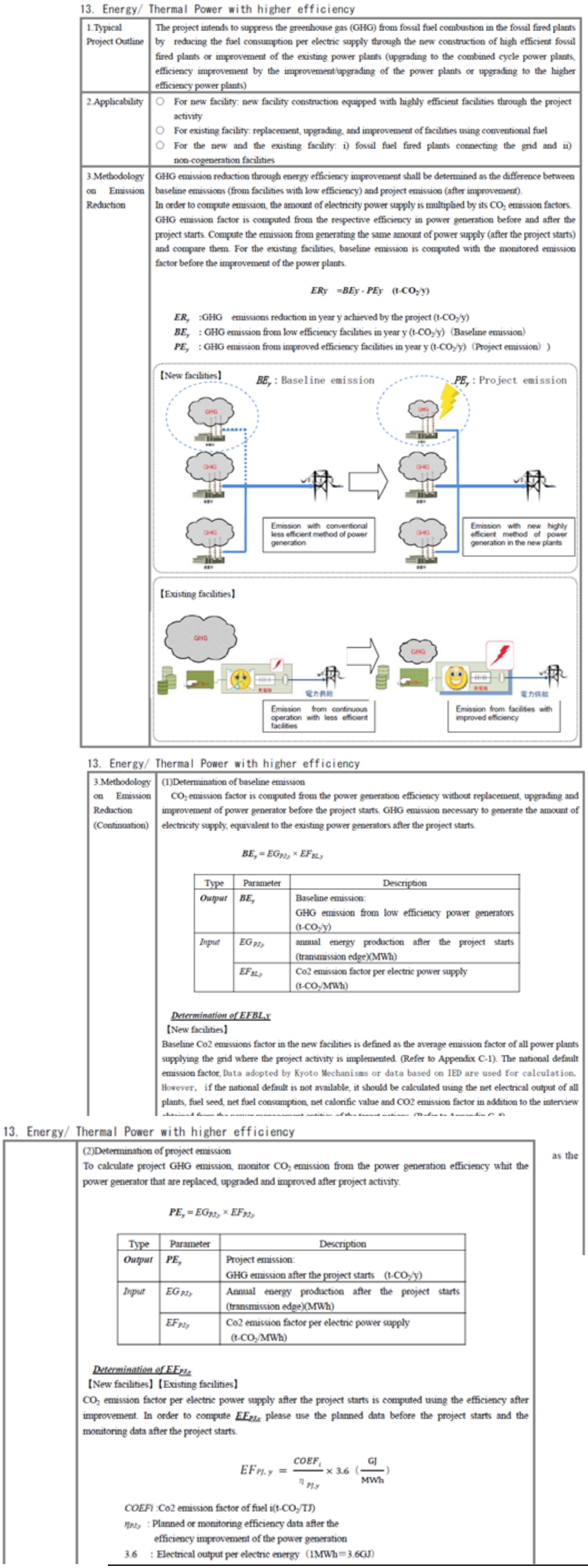
STEP-1	Confirmation of the target project and the guidelines for related sector/sub-sector
Consider which sector or sub-sector is suitable for the purpose of the target project. Refer to Table2.1.3 and select the sector/sub-sector.	

STEP-2	Confirmation of the estimation methodology
Refer to ‘‘Methodology Sheet’’ prepared for each sub-sector selected in Step-1. This step includes review of the applicability of typical project outline and methodology in the sub-sector, before confirmation of the estimation methodologies, required data for calculating and monitoring of GHG emission reductions.	

STEP-3	Implementation of the estimation
Based on the methodology confirmed in Step 2, fill in project specific value/coefficient published value applicable in the country, etc. in the “Calculation Sheet”.	

3.2.2 Outline of Methodology Sheet

Outline of the methodology sheet is described as follows:



13. Energy/ Thermal Power with higher efficiency

1.Typical Project Outline	The project intends to suppress the greenhouse gas (GHG) from fossil fuel combustion in the fossil fired plants by reducing the fuel consumption per electric supply through the new construction of high efficient fossil fired plants or improvement of the existing power plants (upgrading to the combined cycle power plants, efficiency improvement by the improvement/upgrading of the power plants or upgrading to the higher efficiency power plants)
2.Applicability	○ For new facility: new facility construction equipped with highly efficient facilities through the project activity ○ For existing facility: replacement, upgrading, and improvement of facilities using conventional fuel ○ For the new and the existing facility: i) fossil fuel fired plants connecting the grid and ii) non-cogeneration facilities
3.Methodology on Emission Reduction	GHG emission reduction through energy efficiency improvement shall be determined as the difference between baseline emissions (from facilities with low efficiency) and project emission (after improvement). In order to compute emission, the amount of electricity power supply is multiplied by its CO_2 emission factors. GHG emission factor is computed from the respective efficiency in power generation before and after the project starts. Compute the emission from generating the same amount of power supply (after the project starts) and compare them. For the existing facilities, baseline emission is computed with the monitored emission factor before the improvement of the power plants. $ER_y = BE_y - PE_y$ (t-CO_2/y) ER_y : GHG emissions reduction in year y achieved by the project (t-CO_2/y) BE_y : GHG emission from low efficiency facilities in year y (t-CO_2/y) (Baseline emission) PE_y : GHG emission from improved efficiency facilities in year y (t-CO_2/y) (Project emission)

13. Energy/ Thermal Power with higher efficiency

3.Methodology on Emission Reduction (Continuation)

(1)Determination of baseline emission

CO_2 emission factor is computed from the power generation efficiency without replacement, upgrading and improvement of power generator before the project starts. GHG emission necessary to generate the amount of electricity supply, equivalent to the existing power generators after the project starts.

$$BE_y = EG_{PJ,y} \times EF_{BL,y}$$

Type	Parameter	Description
Output	BE_y	Baseline emission: GHG emission from low efficiency power generators (t-CO_2/y)
Input	$EG_{PJ,y}$	annual energy production after the project starts (transmission edge)(MWh)
	$EF_{BL,y}$	Co2 emission factor per electric power supply (t-CO_2/MWh)

Determination of EFBL,y

【New facilities】

Baseline Co2 emissions factor in the new facilities is defined as the average emission factor of all power plants supplying the grid where the project activity is implemented. (Refer to Appendix C-1). The national default emission factor, Data adopted by Kyoto Mechanisms or data based on IED are used for calculation. However, if the national default is not available, it should be calculated using the net electrical output of all plants, fuel seed, net fuel consumption, net calorific value and CO2 emission factor in addition to the interview ...

13. Energy/ Thermal Power with higher efficiency

(2)Determination of project emission

To calculate project GHG emission, monitor CO_2 emission from the power generation efficiency whit the power generator that are replaced, upgraded and improved after project activity.

$$PE_y = EG_{PJ,y} \times EF_{PJ,y}$$

Type	Parameter	Description
Output	PE_y	Project emission: GHG emission after the project starts (t-CO_2/y)
Input	$EG_{PJ,y}$	Annual energy production after the project starts (transmission edge)(MWh)
	$EF_{PJ,y}$	Co2 emission factor per electric power supply (t-CO_2/MWh)

Determination of $EF_{PJ,y}$

【New facilities】【Existing facilities】

CO_2 emission factor per electric power supply after the project starts is computed using the efficiency after improvement. In order to compute $EF_{PJ,y}$ please use the planned data before the project starts and the monitoring data after the project starts.

$$EF_{PJ,y} = \frac{COEF_i}{\eta_{PJ,y}} \times 3.6 \left(\frac{GJ}{MWh}\right)$$

$COEF_i$:Co2 emission factor of fuel i(t-CO_2/TJ)

$\eta_{PJ,y}$: Planned or monitoring efficiency data after the efficiency improvement of the power generation

3.6 : Electrical output per electric energy (1MWh=3.6GJ)

1. Typical project outline
Outline of the typical mitigation project for the sub-sector

2. Applicability
Applicability of the methodology of GHG reduction calculation shown in this sheet

3. Methodology on emission reduction
Description of the basic concept and formula of the estimation method

Image figure of baseline emission and project emission of typical mitigation project for the sub-sector

(1) Baseline Emission
Baseline emission is the emission calculated based on the assumption that the current condition continues in the absence of the mitigation measure. (However, a different assumption can be made according to individual circumstances in each project.) To compare between 'with' and 'without' mitigation measure, GHG is estimated based on the assumption that the level of activities is equivalent to the 'with' mitigation measure case (such as the amount of electricity used or the volume of production)
Here, basic calculation formula and explanation on the required parameters or figures, including the sub-formula for calculating the required parameters or figures, are described.

(2) Project Emission
Project emission is the emission calculated based on the result of the mitigation measure.
Here, basic calculation formula and explanation on the required parameters or figures, including the sub-formula for calculating the parameters or figures, are described.

13. Energy / Thermal Power with Higher Efficiency

4. Data Required for Estimation and Monitoring

【New Facilities】

Data Type		Description of Data	Data Acquisition Methods			
			Baseline Emissions		Project Emissions	
			Before the Project Starts	After Project Completion	Before the Project Starts	After Project Completion
Quantity of power supply (After : $EG_{PJ,y}$)		Quantity of power supply of the fossil fuel fired plants by the project activity(MWh/y)	Planned data	Measured data	Planned data	Measured data
Efficiency of power generation (Before : $\eta_{BL,y}$) (After : $\eta_{PJ,y}$)		Efficiency of power generation in the fossil fuel-fired plants	Measured data of one or two old and typical power plants existing in the grid.		Planned data	Measured data
CO_2 emission factor	CO_2 emission factor of each fuel type($COEF_i$)	CO_2 emissions factor of each fuel type (t-CO_2/TJ)	Data availability is validated in the following order because it is preferable to calculate using data and information unique to the project: i) Unique data obtained from interview with power management entity ii) National default iii) IPCC Guideline default data(Annex C-3)			

【Existing Facilities】

Data Type	Description of Data	Data Acquisition Methods			
		Baseline Emissions		Project Emissions	
		Before the Project Starts	After Project Completion	Before the Project Starts	After Project Completion
Quantity of power supply (After : $EG_{PJ,y}$)	Quantity of power supply of the fossil fuel fired plants by the project activity(MWh/y)	Planned data	Measured data	Planned data	Measured data
Efficiency of power generation (Before : $\eta_{BL,y}$)	Efficiency of power generation in the	Measured data Before the Project Starts		Planned data	Measured data

4. Data required for estimation and monitoring
Description of the data to be collected

<Timing of calculation>
Before the project starts: During preparatory survey
After project completion: During monitoring after project completion.

<Data acquisition methods>
Planned data: Planned data during the preparatory survey before the project starts
Actual data: Data measured (monitored) at power plants and factories after project completion

<Data type>
Description of the terms in formula.

<Priority among options>
If there are options, such as publicly available country specific value and default values issued by international organizations, the sheet presents options plus priority, based on the recognition that calculation based on project / country specific data is more desirable. If other appropriate data can be collected, users can apply a more suitable data for calculation.

13. Energy/ Thermal Power with higher efficiency

5.Others

(1)Project boundary

The physical boundary for measuring GHG emissions includes power facilities where project activity is implemented.

(2)Leakage

Project activity could lead to the following leakages:

Plant replacement: the indirect emissions potentially lead to leakage due to activities such as product manufacturing or materials transport. This respective emission is temporary and negligible considering the project scale. Therfore it can be ignored.

(3)Reference methodology and differences

1)AM0061(ver02):Methodology for rehabilitation and/or energy efficiency improvement in existing power plants.

【Differences】

- Though the rference methodology excludes new facilities as element, new facilities are used in this formula.
- Power plants which run over 10 years and the last 5 year data is available is used in the reference methodology. This formula excludes these conditions.
- Different calculation method is used for baseline emission when it exceeds the average electric power supply or not. It is determined using the efficiency in power supply with the specific formula. However, it is determined simply using the net power supply or the amount of power supply of the representative year in this formula.
- The reference methodology excludes the leakage potential unless there are great influences. This formula also excludes the leakage in the same manner.

2)AM0062(ver1.1): Energy efficiency improvements of a power plant through retrofitting turbines

【Differences】

- Though the rference methodology excludes new facilities as element, new facilities are used in this formula.
- The reference methodology is applied to the steam turbine and gas turbine. The amount of steam supply and the amount of power supply of the steam turbine should be able to be measured in the turbine improved under the project activities. This formula excludes these conditions.
- The reference methodology excludes the leakage potential unless there are great influences. This formula also excludes the leakage in the same manner.

3)ACM0013(ver02): Consolidated baseline and monitoring methodology for new grid connected fossil fuel fired power plants using a less GHG intensive technology

【Differences】

- Though the rference methodology excludes new facilities as element, new facilities are used in this formula.
- Regarding the baseline fuel based on the reference methodology, applicability of the formula is for fossil fuel used in the absence of the project, which is more than 50% of the net electricity power supply in the last three years. This formula excludes these conditions. This formula excludes these conditions.

4)AMS-II.B(ver09):Supply side energy efficiency improvements – generation

【Differences】

- The reference methodology is applied to reduction of the electric power at 60GWh or less or fuel consumption reduction from thermal application through improvement of existing facilities, however, the formula here has no restrictions with quantity of electricity nor excludes heat supply.
- The reference methodology applies to the cogeneration facilities however, in this formula cogeneration

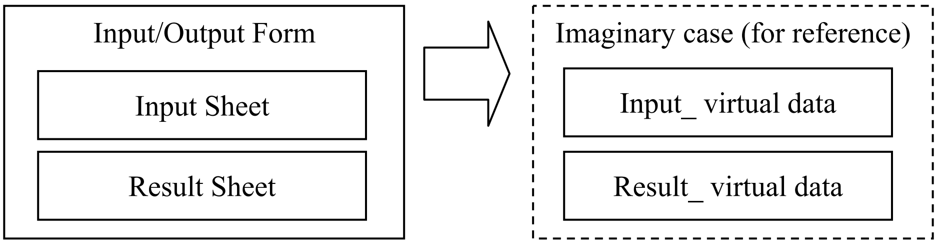
5. Others
(1) Project boundary
Basically, the project boundary is the project area itself. However, if special considerations are necessary for the sub-sector, it is described in this column.

(2) Leakage
Leakage means the possibility of GHG emission outside the boundary due to the project activities. Expected leakage and how leakage is dealt with is described for each sub-sector.

(3) Reviewed Methodologies and Major Differences
Brief description of major differences between reviewed methodologies and the methodology presented in this sheet is shown

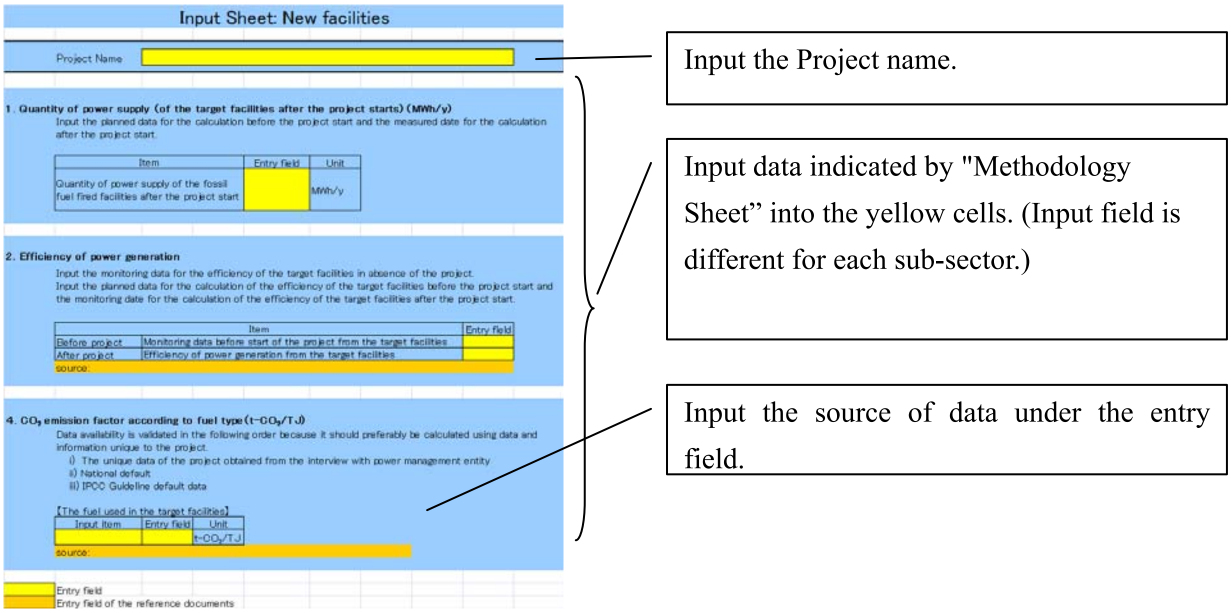
3.2.3 Outline of Calculation Sheet (Excel)

Calculation sheet is composed of two sheets: "Input Sheet" and "Result Sheet.". For each sub-sector, an imaginary case using virtual data is attached to help users understand how the sheets can be utilized.



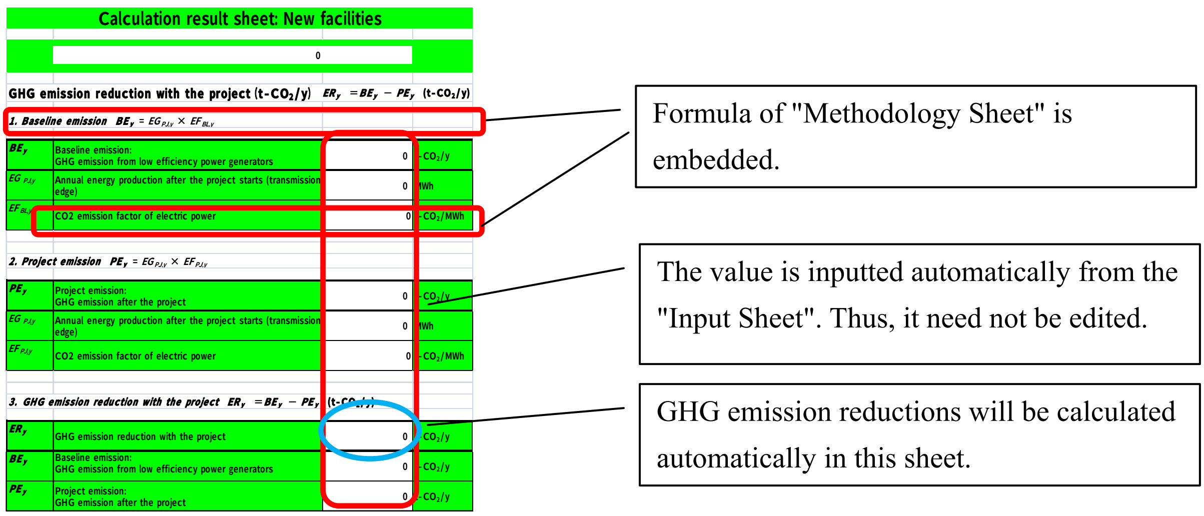
(1) Input Sheet

The contents of the " Data required for monitoring and estimation " indicated in the "Methodology Sheet " serve as inputs to the "Input Sheet".



(2) Result Sheet

The calculation results are shown in the "Result Sheet".



Chapter 4 Methodology Sheets and Calculation Sheets

This chapter shows how to formulate the mitigation measures.

In Figure 4.1, a workflow shows how to identify a mitigation project, and how corresponding information should be provided to the partner nation at the preparatory survey.

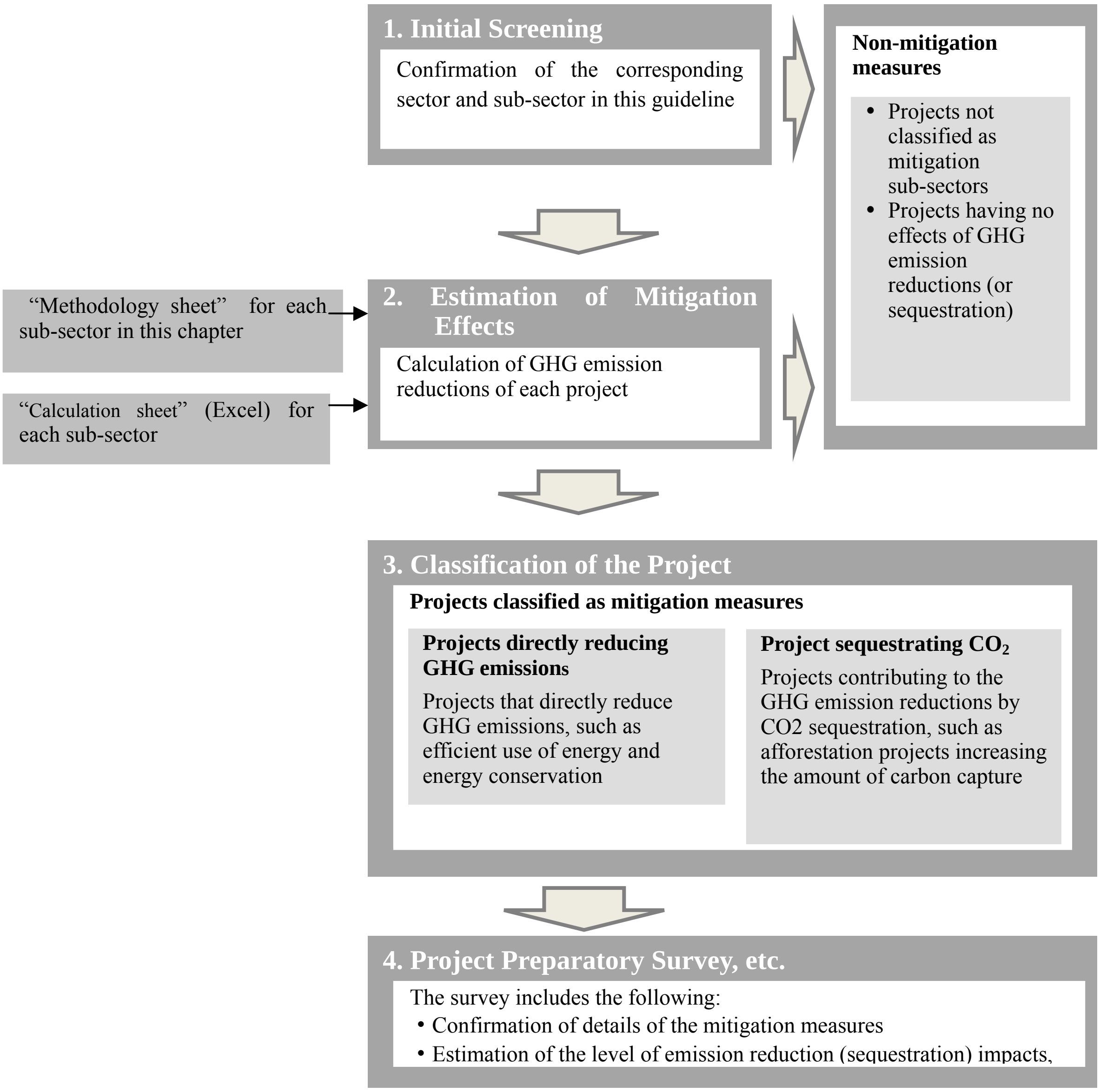


Figure 4.1 Process for Formulating Mitigation Projects

4.1 Typical Project Outlines in Targeted Sub-sectors

A typical project is outlined before preparing a guideline for each sub-sector, based on past JICA ODA loan project information. The outlines of the typical projects are shown in Table 4.1.1.

Table 4.1.1 Outlines of Supposed Projects for Target Sub-sector(1)

Sub-sector		Typical Project Outline
1. Afforestation		The project intends to expand CO_2 sink through afforestation in non-forest lands including degraded, pasture or agricultural lands. For reducing emissions from deforestation and forest degradation (REDD), refer to "2. Forest Conservation".
2. Forest conservation		The project intends to reduce GHG emission through prevention of deforestation such as unregulated logging in developing countries (REDD). Refer to "1. Afforestation" for CO2 sinks increase through afforestation.
3. Passenger /Freight transportation improvement	3.1 Railway ,passengers	The project intends to reduce GHG emissions by realizing "modal shift" from existing passenger transport systems (i.e., conventional buses, passenger cars, taxies and bikes) to passenger railway systems such as a new railway, a double track railway, or a quadruple track railway. In addition, "electrification" of passenger railway systems will reduce GHG emissions.
	3.2 Railway , freight	The project intends to reduce GHG emissions by realizing "modal shift" from existing freight transport systems (i.e., conventional trucks and trailers) to freight railway systems such as a new railway, a double track railway. In addition, "electrification" of freight railway systems will reduce GHG emissions.
4.MRT(Mass Rapid Transit)		The project intends to reduce GHG emissions by realizing "modal shift" from existing transport systems (i.e., buses, private cars, taxies and bikes) to a Mass Rapid Transit (MRT) system.
5.Monorail, LRT		The project intends to reduce GHG emissions by realizing "modal shift" from existing transport systems (i.e., buses, private cars, taxies and bikes) to a light or medium transport system such as monorail and LRT (Light Rail Transit).
6.Bus（BRT, Trunk bus）		The project intends to reduce GHG emissions by realizing "modal shift" from existing transport systems (i.e., buses, private cars, taxies and bikes) to Bus Rapid Transit (BRT) or trunk bus systems.
7.Energy efficiency improvement		The project intends to inhibit greenhouse gas (GHG) emissions by reducing fuel consumption in industrial facilities through energy efficiency improvements such as efficient motors adoption.
8. Electricity and heat supply		The project intends to directly suppress electricity/fuel consumption and reduce GHG emissions in industrial facilities, such as steel plants and cement plants, through recovery and utilization from waste energy (waste heat, waste gas pressure).
9.Fuel switching		The project intends to inhibit GHG emissions through switching from high carbon content heavy oil fuel in order to lower carbon content fuel in new and existing industrial facilities.
10.Energy plant with fuel switching		The project intends to inhibit GHG emissions by switching from high carbon content heavy oil fuel in order to lower carbon content fuel of new and existing intensive heat-supply facilities.
11.Thermal power with electricity and heat supply		The project intends to directly reduce GHG emissions and suppress fuel consumption for electricity generation through recovery and utilization (new construction of combined cycle power plants etc.) from waste energy (waste heat, waste) at fossil fuel fired power plants.

Table 4.1.1 Outlines of Supposed Projects for Target Sub-sector(2)

Sub-sector		Typical Project Outline
12.Thermal power with fuel switching		The project intends to inhibit GHG emissions by switching from high carbon content heavy oil fuel to lower carbon content fuel at new and existing intensive heat supply facilities.
13.Thermal power with higher efficiency		The project intends to suppress the greenhouse gas (GHG) from fossil fuel combustion in the fossil fired plants by reducing the fuel consumption per electric supply through the new construction of high efficient fossil fired plants or improvement of the existing power plants (upgrading to the combined cycle power plants, efficiency improvement by the improvement/upgrading of the power plants or upgrading to the higher efficiency power plants)
14.Power transmission with improved efficiency		The project intends to directly suppress GHG emissions associated with transmission loss, through reducing power loss in the transmission grid or through maintenance of high voltage substation at new and existing facilities for electric energy transmission-transformation.
15.Power distribution with improved efficiency		The project intends to directly suppress GHG emissions associated with distribution loss, through reducing power loss in the distribution grid or efficiency improvements of distribution equipment at new and existing facilities for electric energy distribution.
16.Rural electrification		The project intends to directly reduce greenhouse gas (GHG) emissions by generating power from renewable energy sources, which generate limited amounts of GHG. This is realized through the implementation of renewable energy utilization project in the area where there is no connection to the main electricity transmission grid, or diesel power generation or kerosene lamp is not applied.
17.Hydro power		The project intends to directly contribute to GHG emission reduction through hydropower plants construction aiming to generate renewable energy, which does not emit GHG at flaring, with the use of natural resources such as hydro power.
18.Wind power		The project intends to directly contribute to GHG emission reduction through the use of wind power plants in generating power. Thus, no GHG is generated with the use of natural resources such as wind power.
19.Photovoltaic power /Solar heat	19.1 Photovoltaic power	The project intends to directly contribute to GHG emission reduction through generation of power from photovoltaic power plants. Thus there is reduction in GHG emission with the use of non-fossil fuel source such as photovoltaic power.
	19.2 Solar heat	The project intends to directly reduce GHG emissions by generating power from solar power plants, which generate limited amounts of GHG. The requirement for flaring of GHGs to reduce emissions, with the use of natural resources such as concentrated solar power, is eliminated.
20.Geothermal power		The project intends to directly reduce GHG emissions by generating power from geothermal power plants, which generate limited amounts of GHG. The requirement for flaring of GHGs to reduce emissions with the use of natural resources such as geothermal power is eliminated.
21.Biomass		The project indents to directly reduce GHG emissions through electricity generation or heat generation from biomass residues instead of fossil fuel fired at power plants or factories which leads to reduce consumption of electricity or fossil fuel.

Table 4.1.1 Outlines of Supposed Projects for Target Sub-sector(3)

Sub-sector	Typical Project Outline
22.Landfill disposal of waste	The project intends to reduce GHG emission through recovery and utilization of landfill gas (LFG) generated from landfill after the completion of reclamation and from active landfill.
23.Intermediate treatment of waste	The project intends to reduce the GHG emissions without disposing in landfill but by waste treatment such as composting or anaerobic digestion etc.
24.Wastewater treatment	The project intends to reduce the GHG emissions by suppressing CH4 from the sewage sludge decay through composting the sewage sludge.
25.Sewerage	The project intends to reduce GHG emission through improving the living condition and reducing CH_4 from sewer water with wastewater treatment from the houses or factories.

4.2 Methodology Sheets and Calculation Sheets (Excel) for Each Sub-sector

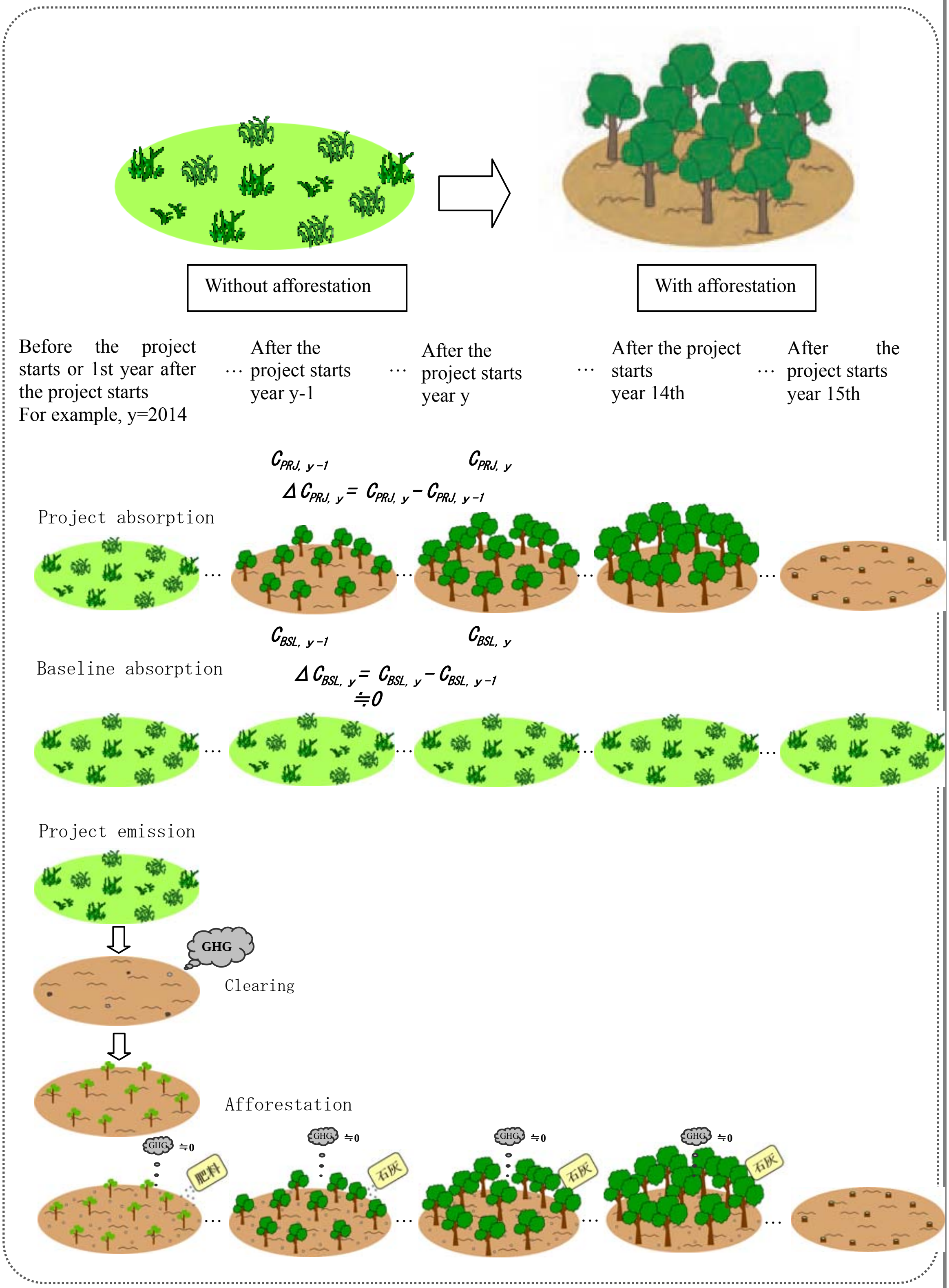
Methodology sheets are shown below and calculation sheets are attached in Appendix "Calculation Sheet".

Forest and Natural Resources Conservation Sector

Sub-sector：

1. **Afforestation**
2. **Forest Conservation**

1. Typical Project Outline	The project intends to increase CO_2 sink through afforestation of non-forest lands including degraded, pasture or agricultural lands. For reducing emissions from deforestation and forest degradation (REDD), refer to "2. Forest Preservation".
2. Applicability	○This project is not applicable to the lands defined as forests in the target country. ○AR-CDM defines afforestation lands as non-forests for the past 50 years and reforestation lands as non-forests since 1990, respectively. Formulas presented below are to estimate the amount of GHG emission reduction as the outcome resulted from afforestation regardless of time constraints. ○The forests should be sustainably managed after afforestation with appropriate management tasks including thinning in place.
3. Methodology of GHG reduction calculation	Since trees absorb and fix carbons in atmosphere for growth in photosynthesis, they are regarded as the carbon dioxide (or carbon) reservoirs. Thus, the net anthropogenic GHG absorption through afforestation is calculated as the difference between increase in carbon dioxide sink in forested lands (or reduction due to thinning and harvesting) (project absorption) and assumed increase (or decrease) in carbon dioxide sinks without afforestation project (baseline absorption) plus GHG emission associated with the afforestation project (project emission) in a certain period after the project. $$ER_{AR,y} = \Delta C_{PRJ,y} - \Delta C_{BSL,y} - GHG_{PRJ,y}$$ $ER_{AR,y}$: Net anthropogenic GHG absorption with afforestation project in Year y (t-CO_2/y) $\Delta C_{PRJ,y}$: Annual GHG absorption with afforestation project in year y (t-CO_2/y)(Project absorption) $\Delta C_{BSL,y}$: Annual GHG absorption without afforestation project in year y (t-CO_2/y)(Baseline absorption) $GHG_{PRJ,y}$: GHG emission associated with afforestation project in Year y (t-CO_2/y)(Project emission) where $$\Delta C_{PRJ,y} = \frac{C_{PRJ,y} - C_{PRJ,y-t}}{t}$$ $$\Delta C_{BSL,y} = \frac{C_{BSL,y} - C_{BSL,y-t}}{t}$$ $C_{PRJ,y}$: CO_2 absorbed by planted trees until year y (CO_2 sink of forested lands in year y)(t-CO_2/y) $C_{PRJ,y-1}$: CO_2 absorbed by planted trees until year y-t (CO_2 sink of forested lands in year y-t)(t-CO_2/y) $C_{BSL,y}$: GHG absorbed by non-woody plants without afforestation project until year y (CO_2 stock in year y)(t-CO_2/y) $C_{BSL,y-1}$: GHG absorbed by non-woody plants without afforestation project until year y-t (CO_2 stock in year y-t)(t-CO_2/y) The difference of CO_2 sink in the forested lands can be obtained as the difference between year y and the year earlier (y-1) as well as between year y and year y-t (i.e., t=3 or 5 years). Per year GHG absorption can be calculated by dividing the calculated GHG absorption by t years. To simplify and generalize descriptions here, t is assumed as 1 year. Then, the cumulative net anthropogenic GHG absorption stored after the project implementation until year y can be expressed in the following formula. $$cumER_{AR} = \sum_{y}^{Y} ER_{AR,y}$$ The figure below illustrates the above-mentioned concept (formula).



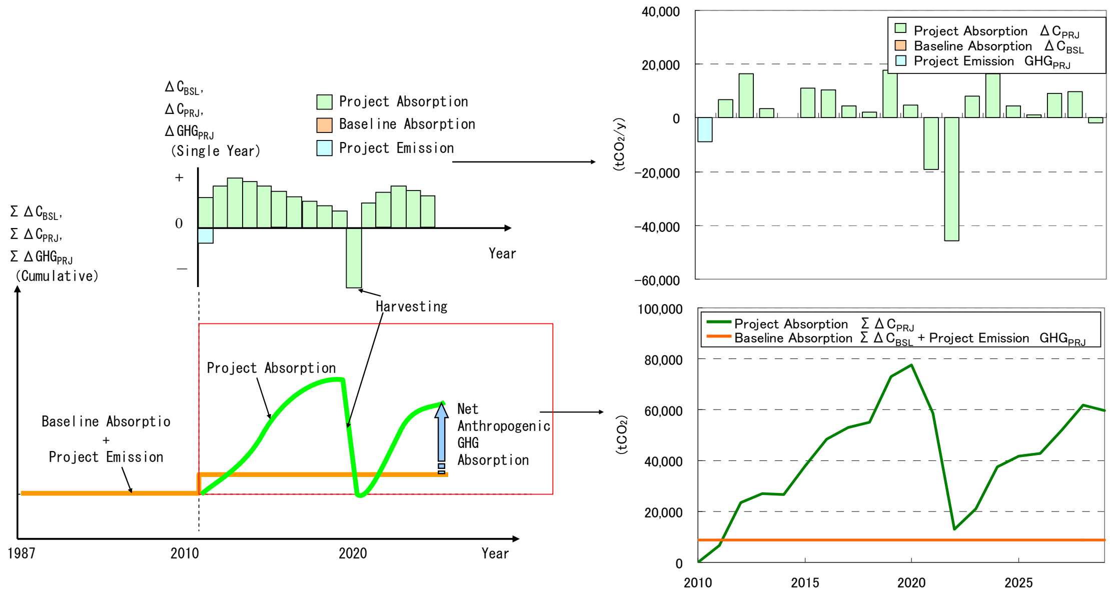
As shown in the figure above, each of project absorption (t-CO_2/y), baseline absorption (t-CO_2/y), and project emission (t-CO_2/y) changes along the time scale.

・ Project absorption is obtained as the difference of carbon dioxide stocks in the forested land between year y and the year earlier (y-1).

・ Baseline absorption is obtained as the difference of carbon dioxide stocks in the project area before year y and the year earlier (y-1) assumed without afforestation project. If the vegetation originally grown in the land is reproduced in the same cycle over years, $\Delta C_{BSL,y} = 0$ is derived as the baseline absorption as $B_{y,i}$=$B_{y-1,i}$=constant, thus $C_{BSL,y}$=$C_{BSL,y-1}$=constant.

・ Project emission includes dinitrogen monoxide (N_2O) emission due to fertilization (nitrogen fertilizer, caustic lime) and GHG emission due to clearing grasses, crops and trees originally grown on the project area. The former is usually negligibly small, thus treated as zero here. The latter is limited only to the initial stage to prepare for afforestation, however, it is not always negligible.

The figures below show changes and cumulatives (carbon dioxide stocks in the forested land, t-CO_2) of project absorption (t-CO_2/y), baseline absorption (t-CO_2/y), and project emission (t-CO_2/y) along the time scale in a typical afforestation project. In this afforestation project, seedlings were planted in 2010 and trees are harvested in 2020. Subsequently planting and harvesting will be repeated in the cycle of 10 years. The figure on the left shows the overall view, while the figures on the right are enlarged versions.



In 2010, project emission should be considered for clearance of the afforestation land. From 2012 to 2020, project absorption is expected along with tree growth, however, as trees are harvested in 2020, project absorption turned to negative. Baseline absorption remains at zero throughout the project period.

On the other hand, the cumulative shown on the left bottom shows constant increase of carbon dioxide stocks absorbed by original vegetation from 1987 to 2009. After 2010 until 2020, cumulative project absorption continues to increase along with tree growth in a sigmoid curve. Once trees are harvested in 2020, the cumulative absorption reduces to the baseline level. Cumulative baseline absorption and project emission level off from 2010 when project emission occurred. The difference between cumulative project absorption and cumulative project emission represents cumulative net anthropogenic GHG absorption or the carbon dioxide stocks in the forested land until the specific year.

(1) Boundary and land use of afforestation land

Afforestation in lands with low CO_2 stocks (degraded/ pasture land) may effectively increase CO_2 absorption. In this regard, the boundary and historical land use need to be accurately understood using the following means.

・ Arial photos or satellite images that show historical land use in the target area.

・ Documents that provide land use information, i.e., land use map, vegetation map or land cover map

In developing countries where the afforestation land usually extends in a wider area (or scattered in a wider extent) and land cover and/or land use are not well-documented, satellite images from LANDSAT, ASTER, SPOT, ALOS, or QuickBird will provide useful data.

3. Methodology of GHG reduction calculation (cont'd)

(2) Calculation of project absorption

Annual project absorption after project implementation can be obtained as the difference of carbon dioxide stocks in the afforested area between Year y and the year earlier (y-1). Carbon dioxide stocks can be obtained by multiplying the forested tree biomass (dry matter) by the forested acreage and CO_2 conversion factor for carbon.

$$\Delta C_{PRJ,y} = C_{PRJ,y} - C_{PRJ,y-1}$$

$$C_{PRJ,y} = \sum_i (N_{y,i} \times A_{PRJ,i} \times 44/12)$$

$$C_{PRJ,y-1} = \sum_i (N_{y-1,i} \times A_{PRJ,i} \times 44/12)$$

Type	Term	Description
Output	$\Delta C_{PRJ,y}$	Project absorption: Annual GHG absorption by planted trees in Year y after project implementation (t-CO_2/y)
Input	$N_{y,i}$	Carbon stocks in strata in Year y after project implementation (t-C ha)
	$A_{PRJ,i}$	F r sted acreage of stratum I (ha)
	44/12	CO_2 conversion factor for carbon

Note: Strata represent forest growth attributes such as species, density, forested year, degree (grade of land fertility) in the forested land. All attribute data are required per stratum. Since there is no standardized stratification, strata can be specifically defined in each project. In the land with uniform degree, the required stratum may be species only even in a wide area. More numbers of strata are required in lands with diverse species and degrees. The past projects registered in CDM typically defined 2 -16 strata. Stratification can be simplified, for example, trees can be roughly classified into 3 strata based on growth rate where diverse species are found. Annex table A-7 shows the sample stratification.

Determination of $N_{y,i}$

Carbon stocks acquired through afforestation are calculated for aboveground and belowground, respectively.

$$N_{y,i} = (N_{A,y,i} + N_{B,y,i})$$

$N_{A,y,i}$: carbon stock in aboveground (t-C/ha)

$N_{B,y,i}$: carbon stock in belowground (t-C/ha)

Aboveground and belowground carbon stocks are calculated by multiplying aboveground biomass (dry matter stem, branches, and leaves) and belowground biomass (dry matter roots), respectively, by tree carbon fraction.

$$N_{A,y,i} = T_{A,y,i} \times CF_i$$

$$N_{B,y,i} = T_{B,y,i} \times CF_i$$

$T_{A,y,i}$: Aboveground biomass (t-dm/ha: ton dry matter/ha)

$T_{B,y,i}$: Belowground biomass (t-dm/ha)

CF_i : Carbon fraction

Aboveground biomass is calculated by multiplying the tree volume by the biomass expansion factor and bulk density.

$$T_{A,y,i} = SV_{y,i} \times BEF_i \times WD_i$$

$SV_{y,i}$: Tree volume (m^3/ha)
BEF_i : Biomass expansion factor (-)
WD_i : Bulk density (t-dm/m^3)

- Tree volume ($SV_{y,i}$) means the stem volume. Based on "the yield table" listing the average tree volumes in relation to species and tree ages, develop "the yield projection table" for the project. The yield table shows the course of tree growth under the standard management for a specific region/ species/ degree. Use the country-specific table if available.
- If the yield table is not available, measure the breast-height diameter and tree height to calculate tree volumes in the tree volume equation.
- Biomass expansion factor (BEF_i) is the factor to expand the tree volume to the whole tree including branches, leaves and roots. One should apply factors specific to species and ages. Preferably the country-specific factor should be applied, however, values in Table 3A. 1. 10 (Annex Table A-1) in IPCC Good Practice Guidance (GPG) for Land Use, Land Use Change, and Forestry (LULUCF) are also applicable where no specific factor is available in the country.
- Bulk density is the coefficient to convert volume into weight. Various coefficients are available specific to species. Preferably the country-specific coefficient should be applied, however, values in Table 3A. 1. 9 (Annex Table A-2) are also applicable where no specific coefficient is available in the country).
- Carbon fraction (CF_i) is the carbon ratio to the whole tree weight. Preferably the country-specific ratio should be applied, however, values in Table 4.3 (Annex Table A-3) in IPCC Guidelines for National Greenhouse Gas Inventories (GNGGI), Volume4. Agriculture, Forestry, and Other Land Use are also applicable where no specific rate is available in the country.
- Aboveground biomass can be obtained based on the tree volume (indirect approach) as well as the allometry formula (direct approach). If these approaches are not applicable, values in Table 3A. 1.6 in IPCC GPG for LULUCF (Annex Table A-4) is also applicable.

Belowground biomass can be obtained in the following formula.

$$T_{B,y,i} = R_i \times T_{A,y,i}$$

R_i : Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground) (-)

- The ratio of belowground biomass to aboveground biomass is specific to species. Preferably, the country-specific values should be applied, however, values in Table 3A.1.8 of IPCC GPG for LULUCF (Annex Table A-5) are also applicable where no specific value is available.

(3) Baseline absorption calculation

Baseline absorption would be zero under the assumption that the vegetation grows in the same cycle over years without afforestation project.

Baseline absorption can be obtained as the difference of carbon dioxide stocks in vegetation originally grown on the afforestation land between year y when afforestation is implemented and the year earlier (y-1). Carbon dioxide stocks are calculated by multiplying biomass such as grasses (dry matter) by the acreage and CO_2 conversion factor for carbon.

$$\Delta C_{BSL,y} = C_{BSL,y} - C_{BSL,y-1}$$

$$C_{BSL,y} = \sum_j (B_{y,j} \times A_{BSL,j} \times 44/12)$$
$$C_{BSL,y-1} = \sum_j (B_{y-1,j} \times A_{BSL,j} \times 44/12)$$

Type	Term	Description
Output	$\Delta C_{BSL,y}$	Baseline absorption CO_2 absorption by original vegetation in Year y without afforestation project (t-CO_2/y)
Input	$B_{y,j}$	Carbon stock in stratum j in year y (t-C/ha)
	$A_{BSL,j}$	Acreage of stratum j (ha)
	$44/12$	CO_2 conversion factor for carbon

Determination of $B_{y,j}$

Carbon stocks in vegetation without afforestation project are calculated for aboveground and belowground, respectively.

$$B_{y,i} = (B_{A,y,j} + B_{B,y,j})$$

$B_{A,y,j}$: Aboveground carbon stocks (in grasses, crops)(t-C/ha)
$B_{B,y,j}$: Belowground carbon stocks (in grasses, crops)(t-C/ha)

Aboveground and belowground carbon stocks are calculated by multiplying aboveground biomass (dry matter stem, branches, and leaves) and belowground biomass (dry matter roots), respectively, by carbon fraction for vegetation.

$$B_{A,y,j} = M_{A,y,j} \times 0.5$$
$$B_{B,y,j} = M_{B,y,j} \times 0.5$$

$M_{A,y,j}$: Aboveground biomass (t-dry matter/ha)
$M_{B,y,j}$: Belowground biomass (t-dry matter/ha)
0.5 : Carbon fraction for vegetation

Belowground biomass is calculated in the following formula.

$$M_{B,y,i} = R_j \times M_{A,y,i}$$

R_j : Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground) (-)

Baseline absorption $\Delta C_{BSL,y}=0$

In the land without afforestation project, under the assumption that the vegetation grows in the same cycle over years, baseline absorption would be $\Delta C_{BSL,y} = 0$ as $B_{y,i}$=$B_{y-1,i}$=constant, thus $C_{BSL,y}$=$C_{BSL,y-1}$=constant.

(4)Project emission calculation

Project emission may include emission of dinitrogen monoxide (N_2O) associated with fertilization and GHG emission associated with clearing grasses and crops to prepare for afforestation.

$$GHG_{PRJ,y} = N2O_y + C_{RMV,y}$$

Type	Term	Description
Output	$GHG_{PRJ,y}$	Project emission CO_2 emission after project implementation (t-CO_2/y)
Input	N_2O_y	N_2O emission associated with fertilization (t-CO_2e/ha)
	$C_{RMV,y}$	Carbon stocks in vegetation to be cleared for afforestation (t-C/ha)

Emission of dinitrogen monooxide associated with fertilization

This emission is usually negligibly small compared to CO_2 absorption after project implementation, thus disregarded. CO2 emission resulted from fertilizing are listed in Annex Table A-6 in CDM registered projects for your reference.

Therefore,

$$N2O_y = 0$$

GHG emission associated with clearing vegetation originally grown on the afforestation land

This GHG emission corresponds to carbon stocks in vegetation originally grown on the afforestation land. It can be calculated by multiplying biomass (dry matter) such as grasses before the project by the acreage and CO2 conversion factor for carbon. Note that this emission is calculated for the year of clearance for afforestation only.

$$C_{RMV,y} = \sum_j (O_{py,j} \times A_{orj,j} \times 44/12)$$

$O_{py,j}$: Carbon stocks in stratum j in the year of clearance for afforestation (t-C/ha)
$A_{orj,j}$: Acreage of stratum j (ha)
$44/12$: CO_2 conversion factor for carbon

Determination of $O_{y,j}$

Carbon stocks in vegetation cleared in the afforestation land are calculated for aboveground and belowground, respectively.

$$O_{y,j} = (R_{A,y,j} + R_{B,y,j})$$

$R_{A,py,j}$: Aboveground carbon stocks in the year of clearance (year py)(t-C/ha)
$R_{B,py,j}$: Belowground carbon stocks in the year of clearance (year py)(t-C/ha)

Aboveground and belowground carbon stocks are calculated by multiplying aboveground biomass (dry matter stem and leaves) and belowground biomass (dry matter roots), respectively, by carbon fraction for vegetation.

$$R_{A,py,i} = V_{A,py,i} \times 0.5$$
$$R_{B,py,i} = V_{B,py,i} \times 0.5$$

$V_{A,py,i}$: Aboveground biomass in the year of clearance (year py)(t-C/ha)
$V_{B,py,i}$: Belowground biomass in the year of clearance (year py)(t-C/ha)
0.5 : Carbon fraction to vegetation biomass

・ Preferably, the country-specific aboveground biomass should be used; however, values in Table 3A.1.8 of IPCC GPG for LULUCF (Annex Table A-5) are also applicable where the specific value is not available.

Belowground biomass is calculated in the following formula.

$$V_{B,y,i} = R_j \times V_{A,y,i}$$

R_j : Ratio of belowground biomass to aboveground biomass (ratio of belowground vs. aboveground) (-)

Preferably, the country-specific ratio of belowground biomass to aboveground biomass (R) should be used; however, values in Table 6.1 of PCC-GNGGI are also applicable where specific values are not available.

Vegetation in scope of biomass calculation

Among vegetation in pasture or agricultural lands, perennial plants are included in carbon stock calculation. Perennial plants prefer to grow in pasture lands. In addition, shrubs grown on pasture lands are also in scope of calculation. Among crops on agricultural lands, perennial orchards and horticultural trees such as gum trees and date palms are also in scope of calculation. Annual crops (vegetables, corns and cottons) are grown and harvested in a year, thus contribution to carbon stocks would be almost zero.

CO_2 stock calculation per land use

Biomass in pasture and agricultural lands is preferably calculated for aboveground and belowground, respectively. However, biomass per land use issued in the target country can be used to estimate CO_2 stocks per hectare. The tables below show some samples.

< Biomass and CO_2 stocks per land use>

Land use category			Biomass (t-dm ha)	Carbon fraction (t-C/t-dm)	Conversion factor from carbon to carbon dioxide	CO_2 stock (t-CO_2/ha)
Before conversion	Agricultural land	Paddy	0.00	0.5	44/12	0.00
		Upland	0.00			0.00
		Orchard	30.63			56.16
	Pasture		13.50			24.75
	Wetland, developed land, others		0.00			0.00

Extracted from “Report of Greenhouse Gas Inventory of Japan”

Land use category	Biomass (t-dm ha)	Carbon fraction (t-C/t-dm)	Conversion factor from carbon to carbon dioxide	CO_2 stock (t-CO_2/ha)
1. Glass land	11	0.5	44/12	20
2. Glass land with shrubs	16			29
3. Annual crops/fa low land (slas and burn)	0			0
4. Perennial crops	24			44

PDD:CARBON SEQUESTRATION THROUGH REFORESTATION IN THE BOLIVIAN TROPICS BY SMALLHOLDERS OF “The Federación de Comunidades Agropecuarias de Rurrenabaque (FECAR)” extracted from Version 2.03 4th of December 2008 Page28

04.Data for estimation and monitoring

Data Type	Description of Data	Data Acquisition method			
		Baseline Absorption		Project Absorption	
		Before project	After project	Before Project	After Project
Acreage (A_i)	Forested acreage after project (ha)	(Not required; out of the scope of calculation)		Planned value	Measured value
Aboveground biomass (T_{yi})	Biomass of planted trees (t-C/ha)	(Not required; out of the scope of calculation)		Planned value	Measued value
Tree volume (Sv_i)	Tree volume after project (t-dm/ha)	(Not required; out of the scope of calculation)		Planned value	Measured value
Biomass expansion factor (BEF_i)	Biomass expansion factor of planted trees	(Not required; out of the scope of calculation)		Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability. i Interview to competent authorities for data specifically used in this project ii Values announced in the target country iii Values based on data provided by IPCC or others (See Annex Table A-1)	
Bulk density (WDi)	Bulk density of planted trees (t-dm/m^3)	(Not required; out of the scope of calculation)		Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability. i Interview to competent authorities for data specifically used in this project ii Values announced in the target country iii Values based on data provided by IPCC or others (See Annex Table A-2)	
Carbon fraction (CF_i)	Carbon ratio to the total tree weight (-)	(Not required; out of the scope of calculation)		Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability. i Interview to competent authorities for data specifically used in this project ii Values announced in the target country iii Values based on data provided by IPCC or others (See Annex Table A-3) iv 0.5 (Note that 0.5 is applied regardless of species in J-VER R003)	

Data type	Description of Data	Data Acquisition Method			
		Baseline Absorption		Project Absorption	
		Before Project	After Project	Before Project	After Project
Ratio of aboveground and belowground biomass (*Ri*)	Ratio of belowground biomass (dry matter roots) to aboveground biomass (dry matter stem, branches and leaves) (-)	(Not required; out of the scope of calculation)		Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability. i Interview to competent authorities for data specifically used in this project ii Values announced in the target country iii Values based on data provided by IPCC or others (See Annex Table A-5)	
Biomass of cleared vegetation (M_{yi})	Dry matter stems, branches, leaves and roots of vegetation grown originally on the project area (t-dm/ha)	Not required: baseline absorption is assumed as 0		(Not required; out of the scope of calculation)	

Data Type	Description of Data	Data Acquisition Method	
		Project Emission	
		Before Project	After Project
Original acreage (A_j)	Acreage of vegetation coverage originally grown on the project area (ha)	Measured value	(Not required; out of the scope of calculation)
Original aboveground biomass (M_{yi})	Aboveground biomass of vegetation originally grown on the project area (t-C/ha)	Preferably, the country-specific data and information should be used for calculation of aboveground biomass. Follow the steps below to check data availability. i Interview to competent authorities for data specifically used in this project ii Values announced in the target country iii Values based on data provided by IPCC or others (See Annex Table A-4)	(Not required; out of the scope of calculation)
Original ratio of underground biomass to aboveground biomass (*R*)	Ratio of underground biomass to aboveground biomass (-)	Preferably, the country-specific data and information should be used for calculation. Follow the steps below to check data availability. i Interview to competent authorities for data specifically used in this project ii Values announced in the target country iii Values based on data provided by IPCC or others (See Annex Table A-5)	(Not required; out of the scope of calculation)

5. Others	(1) Project boundary Afforestation lands in the project area are in the scope of GHG estimation. (2) Leakage If residents and/ or farming activities (cultivation, animal husbandry) need to be migrated in the course of project implementation, loss of carbon stocks (leakage) might be a concern in relation to deforestation out of the project boundary. Although pasture and agricultural lands are in scope of afforestation in this estimation formula, migration of many farmers and farming activities out of the project boundary is not assumed in the course of the project implementation. Therefore, leakage is deemed as zero. However, migration of residents and farming activities (cultivation, animal husbandry) needs to be counted as a concern, leakage should be calculated in consideration of cultivated acreage and number of livestock migrated out of the project boundary. For example, in CDM methodology (AR-AMS001), 15% of anthropogenic GHG reduction is calculated as leakage for cases where 10-50% of cultivated lands are migrated out of the project boundary (50% or more cultivated land migration may not regard as feasible as a project). (3) Monitoring JICA ODA loan projects usually require post-project evaluation only once after project completion. Baseline absorption (BC_y) monitoring is not required in afforestation projects. Other items (project absorption and project emission) need monitoring at the timing when the afforestation outcomes can be confirmed for the purpose of post-project estimation. Challenges inherent to afforestation projects include difficulties to know the timing to implement post-project evaluation as well as the wide extent of the project area. To cope with such challenges, satellite images may provide useful means. The use of QuickBird in resolution of 1.0 m enabled to identify individual trees planted in a past afforestation project. For the long-term monitoring for 10-30 years throughout the forest growth period, set up the permanent sampling plots and temporary sampling plots (for soil plots) to monitor states after afforestation (2-3 years) and for several times after 5, 10 and following years. A permanent sampling plot is the site to monitor carbon pool changes throughout the project period. Such plots should be maintained at the same level as the other plots within the project boundary and never be destroyed during the monitoring period. A soil plot is the site to measure soil organic carbons. (4) Reference methods and the differences 1) AR-AM0001：Reforestation of degraded land 【Difference】 ・ The target area should be stratified based on the site category map/ chart, latest land use/ cover map or satellite images, soil map, vegetation map, topographical map and additional studies. It is required to define baseline scenarios by stratum; however, this requirement is integrated and simplified under this estimation formula, classifying the area up to 5 to 7 strata for species and the characteristic of the certain afforestation project. 2) AR-AM0007：Afforestation and Reforestation of Land Currently Under Agricultural or Pastoral Use 【Difference】 ・ Baseline carbon pool changes should be defined based on the land use scenarios, however, this is not applied in this estimation formula. ・ Baseline absorption is estimated for littered or dead trees based on carbon stocks, however, it is not considered in this estimation formula. ・ Leakage associated with migration of residents and agricultural activities (cultivation, animal husbandry) is considered in relation to the project implementation, however, leakage is deemed as zero in this estimation formula. 3) J-VER003：Increase of CO2 absorption through afforestation activities 【Difference】 ・ The following conditions are required to meet, however, they are not considered in this estimation formula. a) The project area does not fall in the forest prescribed in Article 5 or Article 7-2 of Forest Act as of March 31, 2008, and does not satisfy the following forest definitions.

◆ Japan's forest definitions

Definition	Threshold
Minimum forest area	0.3ha
Minimum canopy coverage	30%
Minimum tree height	5m
Minimum forest width	20m

b) The project is implemented for afforestation.

c) The project area is well-planned to be included within the forest planning area. Alternatively, the project area has been designated as the forest planning area at the inception of this project.

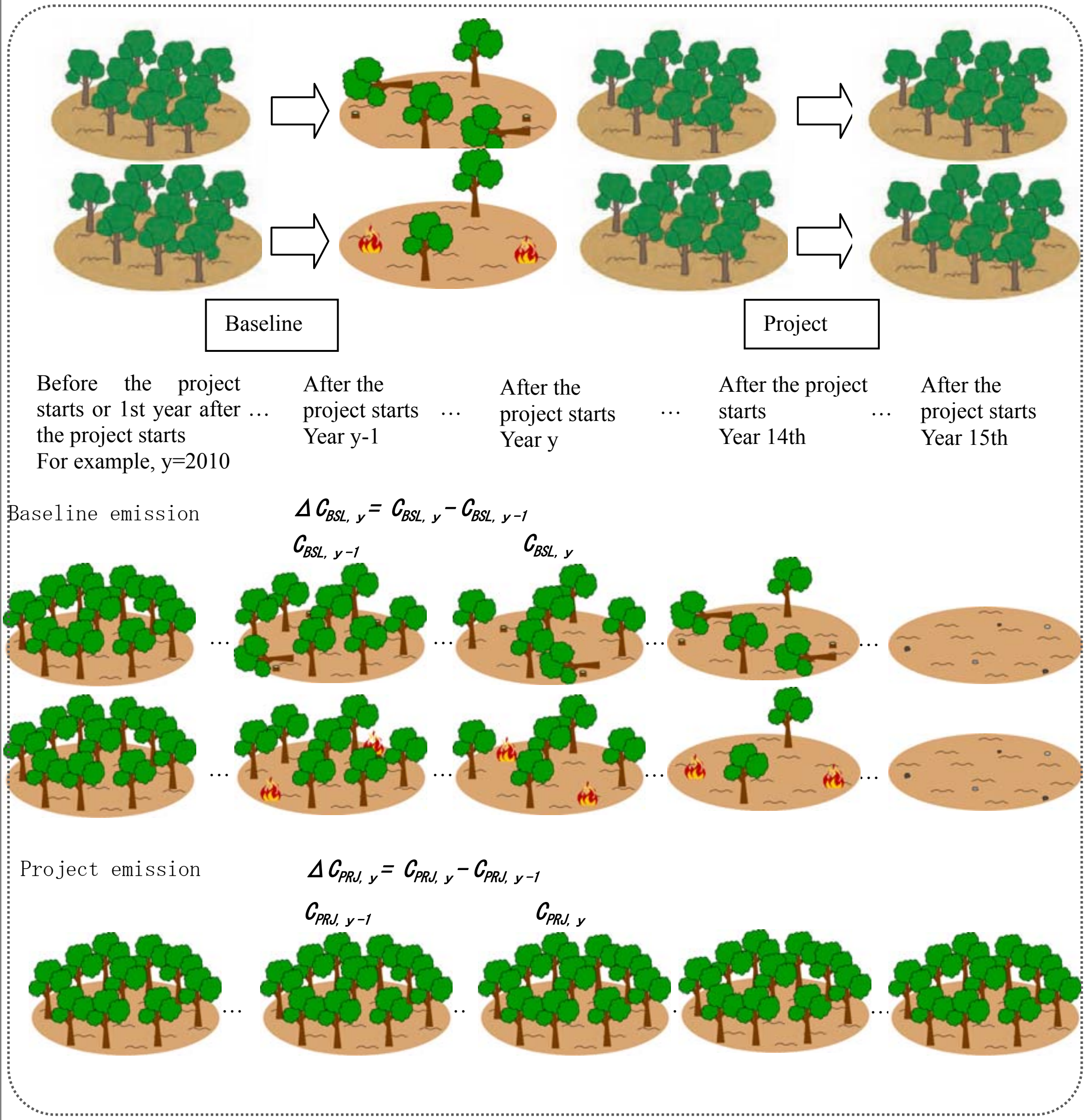
d) Follow the monitoring guideline (for forestry management projects) under offset credit (J-VER) scheme in monitoring.

4) The Carbon Assessment Tool for Afforestation Reforestation（CAT-AR）

【Difference】

・ Kyoto Protocol defines three approaches for carbon dioxide absorption by forests, namely "afforestation", "reforestation", and "forestry management". CAT-AR is the tool developed for "afforestation" and "reforestation" compatible to AR-CDM, however, this estimation formula is not AR-CDM compatible.

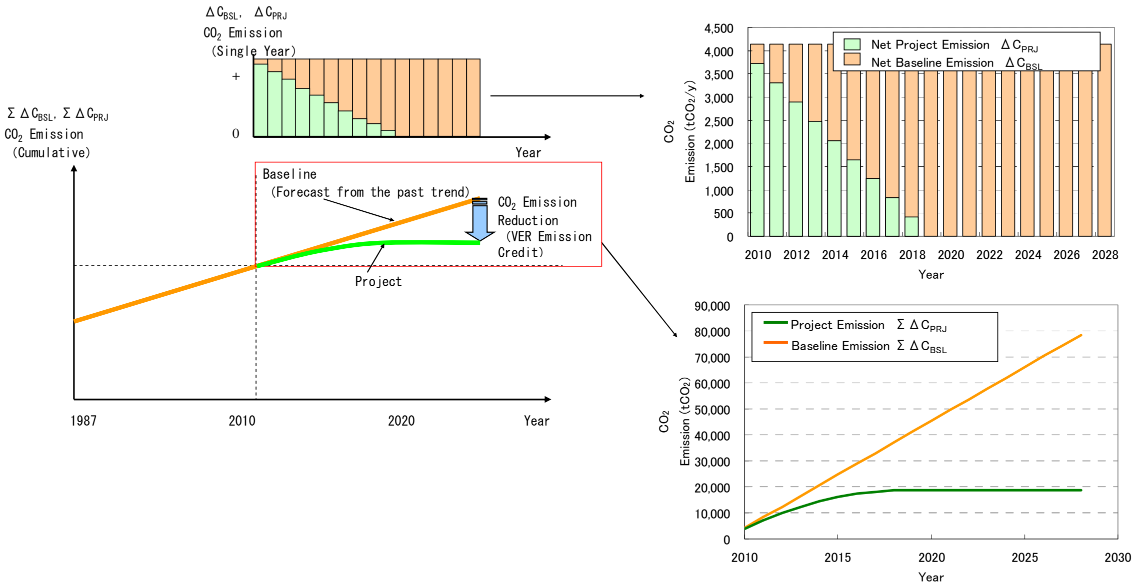
1. Typical project outline	This project intends to reduce GHG emission through prevention of deforestation due to unregulated logging in developing countries (REDD). Refer to 1. Afforestation for GHG sinks increase through afforestation.
2. Applicability	○This project is applicable to sustainably managed forests.
3. Methodology of GHG reduction calculation	This project aims at reducing GHG emission (REDD) by preventing forests from converting into farmlands through clearing and swiddening. As trees absorb and fix carbon dioxide for growth in photosynthesis, forests are regarded as carbon dioxide (or carbon) stocks. The net anthropogenic GHG emission reduction through afforestation is calculated as the difference between carbon dioxide stock reduction without project in a certain period (baseline emission) and carbon dioxide stock reduction after project implementation (project emission). $$ER_{REDD,y} = \Delta C_{BSL,y} - \Delta C_{PRJ,y}$$ $ER_{REDD\ y}$: Net anthropogenic GHG reduction through REDD in year y (t-CO_2/y) $\Delta C_{BSL,\ y}$: Annual GHG emission without REDD in year y (t-CO_2/y)(baseline emission) $\Delta C_{PRJ,\ y}$: Annual GHG emission with REDD in year y (t-CO_2/y)(project emission) where $$\Delta C_{BSL,y} = \frac{C_{BSL,y} - C_{BSL,y-t}}{t}$$ $$\Delta C_{PRJ,y} = \frac{C_{PRJ,y} - C_{PRJ,y-t}}{t}$$ $C_{BSL,\ y}$: CO_2 stocks in forest without REDD in year y (t-CO_2/y) $C_{BSL,\ y-1}$: CO_2 stocks in forest without REDD in year y-t (t-CO_2/y) $C_{PRJ,\ y}$: CO_2 stocks in forest after REDD implementation in year y (t-CO_2/y) $C_{PRJ,\ y-1}$: CO_2 stocks in forest after REDD implementation in year y-t (t-CO_2/y) The difference of CO_2 stock in REDD project area can be obtained for a year or as the change between year y and year y-t (i.e., t=3 or 5 years). Per year GHG absorption is calculated by dividing the difference by t years. To simplify and generalize descriptions here, t is assumed as 1 year. Thus, the cumulative of net anthropogenic GHG emission from project implementation to year Y is calculated in the following formula. $$cumER_{REDD} = \sum_{y}^{Y} ER_{REDD,y}$$ The figure below illustrates the above-mentioned concept (formula).



The figure above illustrates changes of baseline emission (t-CO_2/y) and project emission (t-CO_2/y) over years.

- Baseline emission is obtained as the expected difference in carbon dioxide stocks between year y and the year earlier (y-1) without REDD project.
- Project emission with REDD project is obtained as the difference in forest carbon dioxide stocks between the year y and the year earlier (y-1).

Graphs in the next page show changes in baseline emission (t-CO_2/y) and project emission (t-CO_2/y), and cumulative (t-CO_2) over years for a typical REDD project. This project started in 2010. The figure on the left shows the overall view and the figures on the right are enlarged ones.



As certain forest acreage is assumed as reduced year-by-year, baseline emission (t-CO_2/y) is constant throughout the project period. This REDD project assumes to prevent 10% of forest acreage reduction in each year in a phased manner, thus project emission (t-CO2/y) in 2010 would be 90% of baseline emission (t-CO_2/y). Likewise, project emission would be 80% and 70% in 2011 and 2012, respectively, achieving 0 in 2019.

The cumulative of baseline emission shown on the left bottom is calculated under the assumption that certain forest acreage is reduced each year from 1987 to 2009, thus carbon dioxide emission would be cumulated linearly. On the other hand, cumulative project emission gradually decreases from the cumulative baseline emission after REDD project implementation in 2010. In 2019 and the following years, project emission remains constant as the deforestation is fully controlled. The difference between the cumulative baseline emission and the cumulative project emission is the cumulative net anthropogenic GHG reduction or the carbon dioxide amount reduced in REDD project by the target year.

3. Methodology of GHG reduction calculation (cont'd)

(1) Current and future land use in REDD project area

It is crucial to understand historical land use statuses in REDD projects as CO_2 emission is reduced by preventing forests with higher CO_2 stock capacity from being converted into lands with less stock capacity (for example, land use conversion from forest to pasture, or to farmland). In developing countries where a REDD project tends to cover a wider extent land cover or land use is not well-documented, satellite images from LANDSAT, ASTER, SPOT, ALOS or QuickBird will provide useful data.

To project future deforestation, firstly confirm the presence of reference scenarios based on international agreement in the target country (use such scenarios if available). If there are no available scenarios, simply assume that forest acreage is reduced at the same rate as in the past (linearly). The rate of deforestation may be different in each section even within the project area; the rate should be calculated per section.

(2) Baseline emission calculation

Baseline emission is obtained as the difference in expected carbon dioxide stocks in forests without REDD project between year y and the year earlier (y-1). Carbon dioxide stocks is calculated by multiplying tree biomass (dry matter) by the acreage projected in (1) with consideration of deforestation and CO_2 conversion factor.

$$\Delta C_{BSL,y} = C_{BSL,y} - C_{BSL,y-1}$$

$$C_{BSL,y} = \sum_{i} (BT_{y,k} \times A_{BSL,k} \times 44 / 12)$$

$$C_{BSL,y-1} = \sum_{i} (BT_{y-1,k} \times A_{BSL,k} \times 44 / 12)$$

Type	Term	Description
Output	$\Delta C_{BSL,y}$	Baseline emission: Annual CO_2 emission in year y without REDD project (t-CO2/y)
Input	$BT_{y,k}$	Carbon stock in stratum k in year y without REDD project (t-C/h)
	$A_{BSL,k}$	Forest acreage of stratum k (ha)
	44/1	CO_2 conversion factor for carbon

Note: Strata represent attributes relating to forest growth such as species, density, forested year, and degree (grade of soil fertility). All attribute data are required per stratum for estimation. There is no standardized stratification. Strata can be set specifically for a project. In lands with uniform degree, the required stratum may be species even in a wide forest area. More numbers of strata may be needed for diverse species and degrees. In projects registered in CDM so far, 2 – 16 strata are usually set. Stratification can be simplified, for example, by classifying species into three categories based on growth rate if many species are found in the area. Annex Table A-7 shows the sample stratification.

Determination of $BT_{y,k}$

Carbon stocks acquired through forestation can be calculated for aboveground and belowground, respectively.

$$BT_{y,k} = (BT_{A,y,k} + BT_{B,y,k})$$

$BT_{A,y,k}$: Aboveground carbon stock (t-C/ha)

$BT_{B,y,k}$: Belowground carbon stock (t-C/ha)

Aboveground and below ground carbon stocks are calculated by multiplying aboveground biomass (stem, branches and leave dry matter) and belowground biomass (root dry matter), respectively, by tree carbon fraction.

$$BT_{A,y,k} = TU_{A,y,k} \times CF_k$$
$$BT_{B,y,k} = TU_{B,y,k} \times CF_k$$

$TU_{A,y,k}$: Aboveground biomass (t-C/ha)

$TU_{B,y,k}$: Belowground biomass (t-C/ha)

CF_k : tree carbon fraction

Aboveground biomass is calculated in the formula below, by multiplying tree volume by biomass expansion factor and bulk density.

$$TU_{A,y,k} = SV_{y,k} \times BEF_k \times WD_k$$

$SV_{y,k}$: Tree volume (m^3/ha)

BEF_k : Biomass expansion factor (-)

WD_k : Bulk density (t-dm/m^3)

- Tree volume ($SV_{y,i}$) means the stem volume. Based on “the yield table” listing the average tree volumes in relation to species and tree ages, develop “the yield projection table” for the project. The yield table shows the course of tree growth under the standard management for a specific region/ species/ degree. Use the country-specific table if available.
- If the yield table is not available, measure the breast-height diameter and tree height to calculate tree volumes in the tree volume formula.
- Biomass expansion factor (BEF_i) is the factor to expand the tree volume to the whole tree including branches, leaves and roots. One should apply factors specific to species and ages. Preferably the country-specific factor should be applied, however, values in Table 3A. 1. 10 (Annex Table A-1) in IPCC Good Practice Guidance (GPG)

for Land Use, Land Use Change, and Forestry (LULUCF) are also applicable where no specific factor is available in the country.

- Bulk density (WD_k) is the coefficient to convert volume into weight. Various coefficients are available specific to species. Preferably the country-specific coefficient should be applied, however, values in Table 3A. 1. 9 (Annex Table A-2) are also applicable where no specific coefficient is available in the country.
- Carbon fraction (CF_i) is the carbon ratio to the whole tree weight. Preferably the country-specific ratio should be applied, however, values in Table 4.3 (Annex Table A-3) in IPCC Guidelines for National Greenhouse Gas Inventories (GNGGI), Volume4. Agriculture, Forestry, and Other Land Use are also applicable where no specific rate is available in the country.
- Aboveground biomass can be obtained based on the tree volume (indirect approach) as well as the allometry formula (direct approach). If these approaches are not applicable, values in Table 3A. 1.6 in IPCC GPG for LULUCF (Annex Table A-4) is also applicable.

Belowground biomass is calculated in the formula below.

$$T_{B,y,k} = R_k \times T_{A,y,k}$$

R_k : Ratio of underground biomass to aboveground biomass (ratio of belowground vs. aboveground) (-)

- The ratio of underground biomass to aboveground biomass is specific to species. Preferably, the country-specific value should be used; however, values in Table 3A.1.8 of IPCC GPG for LULUCF (Annex Table A-5) are also available where no specific values are available.

(3) Project emission calculation

Project emission after REDD project implementation can be obtained as the difference of carbon dioxide stocks in forests between Year y and the year earlier (y-1). Carbon dioxide stock is calculated by multiplying dry matter biomass by forest acreage and CO_2 conversion factor for carbon.

$$\Delta C_{PRJ,y} = C_{PRJ,y} - C_{PRJ,y-1}$$

$$C_{PRJ,y} = \sum_k (NT_{y,k} \times A_{PRJ,k} \times 44/12)$$

$$C_{PRJ,y-1} = \sum_k (NT_{y-1,k} \times A_{PRJ,k} \times 44/12)$$

Type	Term	Description
Output	$\Delta C_{PRJ,y}$	Project emission: Annual CO_2 emission in year y with REDD (t-CO_2/y)
Input	$NT_{y,k}$	Carbon stock in stratum j in year y with REDD (t-C/ha)
	$A_{PRJ,k}$	Acreage of stratum i (ha)
	44/12	CO_2 conversion factor for carbon

Carbon stocks are calculated for aboveground and belowground, respectively.

$$NT_{y,k} = (NT_{A,y,k} + NT_{B,y,k})$$

$NT_{A,y,k}$: Aboveground carbon stock (t-C/ha)

$NT_{B,y,k}$: Belowground carbon stock (t-C/ha)

	Aboveground and belowground carbon stocks are calculated by multiplying aboveground biomass (dry matter stem, branches, and leaves) and belowground biomass (dry matter roots) by carbon fraction of tree. $$NT_{A,y,k} = TT_{A,y,k} \times CF_k$$ $$TT_{B,y,k} = TT_{B,y,k} \times CF_k$$ $TT_{A,y,k}$: Aboveground biomass (t-C/ha) $TT_{B,y,k}$: Belowground biomass (t-C/ha) CF_k : Carbon fraction of tree Aboveground biomass is calculated in the formula below, by multiplying tree volume by biomass expansion factor and bulk density. $$TT_{A,y,k} = SV_{y,k} \times BEF_k \times WD_k$$ $SV_{y,k}$: Tree volume (m^3/ha) BEF_k : Biomass expansion factor (-) WD_k : Bulk density (t-dm/m^3) Belowground biomass is calculated in the formula below. $$T_{B,y,k} = R_k \times T_{A,y,k}$$ R_k : Ratio of underground biomass to aboveground biomass (ratio of belowground vs. aboveground) (-) ・ The ratio of underground biomass to aboveground biomass is specific to species. Preferably, the country-specific value should be used; however, values in Table 3A.1.8 of IPCC GPG for LULUCF (Annex Table A-5) can be also applicable where specific values are not available.

4. Data for estimation and monitoring

<table>
<tr><th rowspan="3">Data type</th><th rowspan="3">Description of Data</th><th colspan="4">Data acquisition method</th></tr>
<tr><th colspan="2">Baseline emission</th><th colspan="2">Project emission</th></tr>
<tr><th>Before project</th><th>After project</th><th>Before project</th><th>After project</th></tr>
<tr><td>Acreage (A_i)</td><td>Forested acreage after project implementation (ha)</td><td>Projected value</td><td>(Not required: not in scope of calculation)</td><td>Planned value</td><td>Measured value</td></tr>
<tr><td>Aboveground biomass (T_{yi})</td><td>Aboveground biomass of planted trees (t-C/ha)</td><td>Planned value</td><td>(Not required: not in scope of calculation)</td><td>Planned value</td><td>Measured value</td></tr>
<tr><td>Tree volume (Sv_i)</td><td>Tree volume of planted trees (t-dm/ha)</td><td>Planned value</td><td>(Not required: not in scope of calculation)</td><td>Planned value</td><td>Measured value</td></tr>
<tr><td>Biomass expansion factor (BEF_i)</td><td>Biomass expansion factor of planted trees</td><td colspan="4">Preferably, the country-specific data and information should be used for calculation.
Follow the steps below to check data availability.
i Interview to competent authorities for data specifically used in this project
ii Values announced in the target country
iii Values based on data provided by IPCC or others
(See Annex Table A-1)</td></tr>
<tr><td>Bulk density (WDi)</td><td>Bulk density of planted trees (t-dm/m^3)</td><td colspan="4">Preferably, the country-specific data and information should be used for calculation.
Follow the steps below to check data availability.
i Interview to competent authorities for data specifically used in this project
ii Values announced in the target country
iii Values based on data provided by IPCC or others
(See Annex Table A-2)</td></tr>
<tr><td>Carbon fraction (CF_i)</td><td>Carbon ratio to the whole tree weight (-)</td><td colspan="4">Preferably, the country-specific data and information should be used for calculation.
Follow the steps below to check data availability.
iv Interview to competent authorities for data specifically used in this project
v Values announced in the target country
vi Values based on data provided by IPCC or others
(See Annex Table A-3)
vii 0.5 (Note that 0.5 is applied in J-VER R003 regardless of species)</td></tr>
<tr><td>Ratio of belowground biomass to aboveground biomass (Ri)</td><td>Ratio of belowground biomass (dry matter roots) to aboveground biomass (drymatter stem, branches and leaves)(-)</td><td colspan="4">Preferably, the country-specific data and information should be used for calculation.
Follow the steps below to check data availability.
i Interview to competent authorities for data specifically used in this project
ii Values announced in the target country
Values based on data provided by IPCC or others
(See Annex Table A-5)</td></tr>
</table>

5. Others	(1) Project boundary Forestation lands in the project area are in the scope of GHG estimation. (2) Leakage If residents and/ or farming activities (cultivation, animal husbandry) need to be migrated in the course of project implementation, loss of carbon stocks (leakage) might be a concern in relation to deforestation out of the project boundary. Although pasture and agricultural lands are in scope of forestation in this estimation formula, migration of many farmers and farming activities out of the project boundary is not assumed in the course of the project implementation. Therefore, leakage is deemed as zero. However, migration of residents and farming activities (cultivation, animal husbandry) needs to be counted as a concern, leakage should be calculated in consideration of cultivated acreage and number of livestock migrated out of the project boundary. For example, in CDM methodology (AR-AMS001), 15% of anthropogenic GHG reduction is calculated as leakage for cases where 10-50% of cultivated lands are migrated out of the project boundary (50% or more cultivated land migration may not regard as feasible as a project). (3) Monitoring JICA ODA loan projects usually require post-project evaluation only once after project completion. Baseline absorption (BC_y) monitoring is not required in afforestation projects. Other items (project absorption and project emission) need monitoring at the timing when the afforestation outcomes can be confirmed for the purpose of post-project estimation. Challenges inherent to afforestation projects include difficulties to know the timing to implement post-project evaluation as well as the wide extent of the project area. To cope with such challenges, satellite images may provide useful means. The use of QuickBird in resolution of 1.0 m enabled to identify individual trees planted in a past afforestation project. For the long-term monitoring for 10-30 years throughout the forest growth period, set up the permanent sampling plots and temporary sampling plots (for soil plots) to monitor states after afforestation (2-3 years) and for several times after 5, 10 and following years. A permanent sampling plot is the site to monitor carbon pool changes throughout the project period. Such plots should be maintained at the same level as the other plots within the project boundary and never be destroyed during the monitoring period. A soil plot is the site to measure soil organic carbons. (4) Differences between REDD＋ and REDD Reduce Emission from Deforestation and forest Degradation (REDD) is a mechanism to reduce GHG emission through mitigation of deforestation and forest degradation in developing countries. Currently discussion centers on legally binding force of this mechanism under the future climate change framework. Under REDD mechanism, a mitigation measure for deforestation and degradation taken in developing countries is deemed as GHG removal that might be emitted without measures. Such efforts are conferred with credit and compensation. REDD+ (REDD plus) adds active carbon stock increase efforts through afforestation and forest management (mitigating degradation under appropriate forest management). (5) Reference methods and the differences 1) World Bank BioCarbonFund "Methodology for Estimating Reductions of GHG Emissions from Mosaic Deformation" 【Difference】 ・ Although REDD comprehensive methodology consists of 5 modules (Carbon Pool, Baseline, Leakage, Emission, Monitoring, Miscellaneous), this estimation formula focuses on the basic only. 2)The Carbon Assessment Tool for Sustainable Forest Management (CAT-SFM) 【Difference】 ・ This is the tool developed for "Forestry Management" of AR-CDM, however, this estimation formula is not for AR-CDM. ・ The specifications include calculation of emission, absorption, credit and parameters comprehensively; however, this estimation formula focuses on the basic.

Annex Table A-1 Default values of biomass expansion factors（BEF）

TABLE 3A.1.10
DEFAULT VALUES OF BIOMASS EXPANSION FACTORS (BEFS)
(BEF_2 to be used in connection with growing stock biomass data in Equation 3.2.3; and BEF_1 to be used in connection with increment data in Equation 3.2.5)

Climatic zone	Forest type	Minimum dbh (cm)	BEF_2 (overbark) to be used in connection to growing stock biomass data (Equation 3.2.3)	BEF_1 (overbark) to be used in connection to increment data (Equation 3.2.5)
Boreal	Conifers	0-8.0	1.35 (1.15-3.8)	1.15 (1-1.3)
	Broadleaf	0-8.0	1.3 (1.15-4.2)	1.1 (1-1.3)
Temperate	Conifers: Spruce-fir	0-12.5	1.3 (1.15-4.2)	1.15 (1-1.3)
	Pines	0-12.5	1.3 (1.15-3.4)	1.05 (1-1.2)
	Broadleaf	0-12.5	1.4 (1.15-3.2)	1.2 (1.1-1.3)
Tropical	Pines	10.0	1.3 (1.2-4.0)	1.2 (1.1-1.3)
	Broadleaf	10.0	3.4 (2.0-9.0)	1.5 (1.3-1.7)

Note: BEF_2s given here represent averages for average growing stock or age, the upper limit of the range represents young forests or forests with low growing stock; lower limits of the range approximate mature forests or those with high growing stock. The values apply to growing stock biomass (dry weight) including bark and for given minimum diameter at breast height; Minimum top diameters and treatment of branches is unspecified. Result is above-ground tree biomass.

Sources: Isaev *et al.*, 1993; Brown, 1997; Brown and Schroeder, 1999; Schoene, 1999; ECE/FAO TBFRA, 2000; Lowe *et al.*, 2000; please also refer to FRA Working Paper 68 and 69 for average values for developing countries (http://www.fao.org/forestry/index.jsp)

Source：IPCC Good Practice Guidance for Land Use, Land Use Change, and Forestry (LULUCF) Table3A.1.10, 2003[1]

[1] IPCCC: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf

Annex Table A-2 Basic wood densities of stemwood WD (1) (t-dry matter/m^3)

TABLE 3A.1.9-1
BASIC WOOD DENSITIES OF STEMWOOD (tonnes dry matter/m^3 fresh volume)
FOR BOREAL AND TEMPERATE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

Species or genus	Basic wood density m_0/V_{wet}	Source
Abies	0.40	1
Acer	0.52	1
Alnus	0.45	1
Betula	0.51	1
Carpinus betulus	0.63	3
Castanea sativa	0.48	3
Fagus sylvatica	0.58	1
Fraxinus	0.57	1
Juglans	0.53	3
Larix decidua	0.46	1
Larix kaempferi	0.49	3
Picea abies	0.40	1
Picea sitchensis	0.40	2
Pinus pinaster	0.44	5
Pinus strobus	0.32	1
Pinus sylvestris	0.42	1
Populus	0.35	1
Prunus	0.49	1
Pseudotsuga menziesii	0.45	1
Quercus	0.58	1
Salix	0.45	1
Thuja plicata	0.31	4
Tilia	0.43	1
Tsuga	0.42	4

Source:

1. Dietz, P. 1975: Dichte und Rindengehalt von Industrieholz. Holz Roh- Werkstoff 33: 135-141
2. Knigge, W.; Schulz, H. 1966: Grundriss der Forstbenutzung. Verlag Paul Parey, Hamburg, Berlin
3. EN 350-2 (1994): Durability of wood and wood products - Natural durability of solid wood - Part 2: Guide to the natural durability and treatability of selected wood species of importance in Europe
4. Forest Products Laboratory: Handbook of wood and wood-based materials. Hemisphere Publishing Corporation, New York, London
5. Rijsdijk, J.F.; Laming, P.B. 1994: Physical and related properties of 145 timbers. Kluwer Academic Publishers, Dordrecht, Boston, London
6. Kollmann, F.F.P.; Coté, W.A. 1968: Principles of wood science and technology. Springer Verlag, Berlin, New York

Source : IPCC Good Practice Guidance for LULUCF , Table3A.1.9, 2003[2]

[2] IPCCC: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf

Annex Table A-2 Basic wood densities of stemwood WD (2) (t-dry matter/m^3)

TABLE 3A.1.9-2

BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES

(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Acacia leucophloea	0.76	Albizia spp.	0.52	Afzelia spp.	0.67
Adina cordifolia	0.58, 0.59+	Alcornea spp.	0.34	Aidia ochroleuca	0.78*
Aegle marmelo	0.75	Alexa grandiflora	0.6	Albizia spp.	0.52
Agathis spp.	0.44	Alnus ferruginea	0.38	Allanblackia floribunda	0.63*
Aglaia llanosiana	0.89	Anacardium excelsum	0.41	Allophyllus africanus f. acuminatus	0.45
Alangium longiflorum	0.65	Anadenanthera macrocarpa	0.86	Alstonia congensis	0.33
Albizzia amara	0.70*	Andira retusa	0.67	Amphimas pterocarpoides	0.63*
Albizzia falcataria	0.25	Aniba riparia lduckei	0.62	Anisophyllea obtusifolia	0.63*
Aleurites trisperma	0.43	Antiaris africana	0.38	Annonidium mannii	0.29*
Alnus japonica	0.43	Apeiba echinata	0.36	Anopyxis klaineana	0.74*
Alphitonia zizyphoides	0.5	Artocarpus comunis	0.7	Anthocleista keniensis	0.50*
Alphonsea arborea	0.69	Aspidosperma spp. (araracanga group)	0.75	Anthonotha macrophylla	0.78*
Alseodaphne longipes	0.49	Astronium lecointei	0.73	Anthostemma aubryanum	0.32*
Alstonia spp.	0.37	Bagassa guianensis	0.68,0.69+	Antiaris spp.	0.38
Amoora spp.	0.6	Banara guianensis	0.61	Antrocaryon klaineanum	0.50*
Anisophyllea zeylanica	0.46*	Basiloxylon excelsum	0.58	Aucoumea klaineana	0.37
Anisoptera spp,	0.54	Beilschmiedia sp.	0.61	Autranella congolensis	0.78
Anogeissus latifolia	0.78, 0.79+	Berthollettia excelsa	0.59, 0.63+	Baillonella toxisperma	0.71
Anthocephalus chinensis	0.36,0.33+	Bixa arborea	0.32	Balanites aegyptiaca	0.63*
Antidesma pleuricum	0.59	Bombacopsis sepium	0.39	Baphia kirkii	0.93*
Aphanamiris perrottetiana	0.52	Borojoa patinoi	0.52	Beilschmiedia louisii	0.70*
Araucaria bidwillii	0.43	Bowdichia spp.	0.74	Beilschmiedia nitida	0.50*
Artocarpus spp.	0.58	Brosimum spp. (alicastrum group)	0.64, 0.66+	Berlinia spp.	0.58
Azadirachta spp.	0.52	Brosimum utile	0.41, 0.46+	Blighia welwitschii	0.74*
Balanocarpus spp.	0.76	Brysenia adenophylla	0.54	Bombax spp.	0.4
Barringtonia edulis *	0.48	Buchenauia capitata	0.61, 0.63+	Brachystegia spp.	0.52
Bauhinia spp.	0.67	Bucida buceras	0.93	Bridelia micrantha	0.47*
Beilschmiedia tawa	0.58	Bulnesia arborea	1	Calpocalyx klainei	0.63*
Berrya cordifolia	0.78*	Bursera simaruba	0.29, 0.34+	Canarium schweinfurthii	0.40*
Bischofia javanica	0.54,0.58,0.62+	Byrsonima coriacea	0.64	Canthium rubrocostratum	0.63*
Bleasdalea vitiensis	0.43	Cabralea cangerana	0.55	Carapa procera	0.59
Bombax ceiba	0.33	Caesalpinia spp.	1.05	Casearia battiscombei	0.5
Bombycidendron vidalianum	0.53	Calophyllum sp.	0.65	Cassipourea euryoides	0.70*
Boswellia serrata	0.5	Campnosperma panamensis	0.33,0.50+	Cassipourea malosana	0.59*
Bridelia squamosa	0.5	Carapa sp.	0.47	Ceiba pentandra	0.26
Buchanania latifolia	0.45	Caryocar spp.	0.69, 0.72+	Celtis spp.	0.59
Bursera serrata	0.59	Casearia sp.	0.62	Chlorophora excelsa	0.55
Butea monosperma	0.48	Cassia moschata	0.71	Chrysophyllum albidum	0.56*
Calophyllum spp.	0.53	Casuarina equisetifolia	0.81	Cleistanthus mildbraedii	0.87*
Calycarpa arborea	0.53	Catostemma spp.	0.55	Cleistopholis patens	0.36*
Cananga odorata	0.29	Cecropia spp.	0.36	Coelocaryon preussii	0.56"
Canarium spp.	0.44	Cedrela spp.	0.40, 0.46+	Cola sp.	0.70"
Canthium monstrosum	0.42	Cedrelinga catenaeformis	0.41, 0.53+	Combretodendron macrocarpum	0.7
Carallia calycina	0.66*	Ceiba pentandra	0.23,0.24,0.25, 0.29+	Conopharyngia holstii	0.50*

+ The wood densities specified pertain to more than one bibliographic source.

* Wood density value is derived from the regression equation in Reyes *et al.* (1992).

Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

Annex Table A-2 Basic wood densities of stemwood WD (3) (t-dry matter/m^3)

TABLE 3A.1.9-2 (CONTINUED)
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Cassia javanica	0.69	Centrolobium spp.	0.65	Copaifera religiosa .	0.50"
Castanopsis philippensis	0.51	Cespedesia macrophylla	0.63	Cordia millenii	0.34
Casuarina equisetifolia	0.83	Chaetocarpus schomburgkianus	0.8	Cordia platythyrsa	0.36"
Casuarina nodiflora	0.85	Chlorophora tinctoria	0.71,0.75+	Corynanthe pachyceras	0.63"
Cedrela odorata	0.38	Clarisia racemosa	0.53,0.57+	Coda edulis	0.78*
Cedrela spp.	0.42	Clusia rosea	0.67	Croton megalocarpus	0.57
Cedrela toona	0.43	Cochlospermum orinocensis	0.26	Cryptosepalum staudtii	0.70*
Ceiba pentandra	0.23	Copaifera spp.	0.46, 0.55+	Ctenolophon englerianus	0.78*
Celtis luzonica	0.49	Cordia spp. (gerascanthus group)	0.74	Cylicodiscus gabonensis	0.8
Chisocheton pentandrus	0.52	Cordia spp. (alliodora group)	0.48	Cynometra alexandri	0.74
Chloroxylon swietenia	0.76, 0.79, 0.80+	Couepia sp.	0.7	Dacryodes spp.	0.61
Chukrassia tabularis	0.57	Couma macrocarpa	0.50,0.53+	Daniellia ogea	0.40*
Citrus grandis	0.59	Couratari spp.	0.5	Desbordesia pierreana	0.87"
Cleidion speciflorum	0.5	Croton xanthochloros	0.48	Detarium senegalensis	0.63*
Cleistanthus collinus	0.88	Cupressus lusitanica	0.43, 0.44+	Dialium excelsum	0.78*
Cleistocalyx spp.	0.76	Cyrilla racemiflora	0.53	Didelotia africana	0.78"
Cochlospermum gossypium+religiosum	0.27	Dactyodes colombiana	0.51	Didelotia letouzeyi	0.5
Cocos nucifera	0.5	Dacryodes excelsa	0.52, 0.53+	Diospyros spp.	0.82
Colona serratifolia	0.33	Dalbergia retusa.	0.89	Discoglypremna caloneura	0.32*
Combretodendron quadrialatum	0.57	Dalbergia stevensonii	0.82	Distemonanthus benthamianus	0.58
Cordia spp.	0.53	Declinanona calycina	0.47	Drypetes sp.	0.63*
Cotylelobium spp.	0.69	Dialium guianensis	0.87	Ehretia acuminata	0.51*
Crataeva religiosa	0.53*	Dialyanthera spp.	0.36, 0.48+	Enantia chlorantha	0.42"
Cratoxylon arborescens	0.4	Dicorynia paraensis	0.6	Endodesmia calophylloides	0.66"
Cryptocarya spp.	0.59	Didymopanax sp.	0.74	Entandrophragma utile	0.53
Cubilia cubili	0.49	Dimorphandra mora	0.99*	Eribroma oblongum	0.60*
Cullenia excelsa	0.53	Diplotropis purpurea	0.76, 0.77, 0.78+	Eriocoelum microspermum	0.50"
Cynometra spp.	0.8	Dipterix odorata	0.81,0.86,0.89+	Erismadelphus ensul	0.56*
Dacrycarpus imbricatus	0.45, 0.47+	Drypetes variabilis	0.69	Erythrina vogelii	0.25"
Dacrydium spp.	0.46	Dussia lehmannii	0.59	Erythrophleum ivorense	0.72
Dacryodes spp.	0.61	Ecclinusa guianensis	0.63	Erythroxylum mannii	0.5
Dalbergia paniculata	0.64	Endlicheria cocvirey	0.39	Fagara macrophylla	0.69
Decussocarpus vitiensis	0.37	Enterolobium schomburgkii	0.82	Ficus iteophylla	0.40"
Degeneria vitiensis	0.35	Eperua spp.	0.78	Funtumia latifolia	0.45*
Dehaasia triandra	0.64	Eriotheca sp.	0.4	Gambeya spp.	0.56*
Dialium spp.	0.8	Erisma uncinatum	0.42, 0.48+	Garcinia punctata	0.78"
Dillenia spp.	0.59	Erythrina sp.	0.23	Gilletiodendron mildbraedii	0.87"
Diospyros spp.	0.7	Eschweilera spp.	0.71,0.79,0.95+	Gossweilerodendron balsamiferum	0.4
Diplodiscus paniculatus	0.63	Eucalyptus robusta	0.51	Guarea thompsonii	0.55"
Dipterocarpus caudatus	0.61	Eugenia stahlii	0.73	Guibourtia spp.	0.72
Dipterocarpus eurynchus	0.56	Euxylophora paraensis	0.68,0.70+	Hannoa klaineana	0.28"
Dipterocarpus gracilis	0.61	Fagara spp.	0.69	Harungana madagascariensis	0.45"
Dipterocarpus grandiflorus	0.62	Ficus sp.	0.32	Hexalobus crispiflorus	0.48"
Dipterocarpus kerrii	0.56	Genipa spp.	0.75	Holoptelea grandis	0.59"

\+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

Annex Table A-2 Basic wood densities of stemwood WD (4) (t-dry matter/m^3)

TABLE 3A.1.9-2 (CONTINUED)

BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES

(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Dipterocarpus kunstlerii	0.57	Goupia glabra	0.67, 0.72+	Homalium spp.	0.7
Dipterocarpus spp.	0.61	Guarea chalde	0.52	Hylodendron gabonense.	0.78"
Dipterocarpus warburgii	0.52	Guarea spp.	0.52	Hymenostegia pellegrini	0.78"
Dracontomelon spp.	0.5	Guatteria spp.	0.36	Irvingia grandifolia	0.78"
Dryobalanops spp.	0.61	Guazuma ulmifolia	0.52, 0.50+	Julbernardia globiflora	0.78
Dtypetes bordenii	0.75	Guettarda scabra	0.65	Khaya ivorensis	0.44
Durio spp.	0.53	Guilliema gasipac	0.95, 1.25+	Klainedoxa gabonensis	0.87
Dyera costulata	0.36	Gwtavia sp.	0.56	Lannea welwitschii	0.45"'
Dysoxylum quercifolium	0.49	Helicostylis tomentosa	0.68, 0.72+	Lecomtedoxa klainenna	0.78"
Elaeocarpus serratus	0.40*	Hernandia Sonora	0.29	Letestua durissima	0.87"
Emblica officinalis	0.8	Hevea brasiliense	0.49	Lophira alata	0.87"
Endiandra laxiflora	0.54	Himatanthus articulata	0.40,0.54+	Lovoa trichilioides	0.45"
Endospermum spp.	0.38	Hirtella davisii	0.74	Macaranga kilimandscharica	0.40*
Enterolobium cyclocarpum	0.35	Humiria balsamifera	0.66,0.67+	Maesopsis eminii	0.41
Epicharis cumingiana	0.73	Humiriastrum procera	0.7	Malacantha sp. aff. alnifolia	0.45"
Erythrina subumbrans	0.24	Hura crepitans	0.36, 0.37, 0.38+	Mammea africana	0.62
Erythrophloeum densiflorum	0.65	Hyeronima alchorneoides	0.60,0.64+	Manilkara lacera	0.78"
Eucalyptus citriodora	0.64	Hyeronima laxiflora	0.59	Markhamia platycalyx	0.45*
Eucalyptus deglupta	0.34	Hymenaea davisii	0.67	Memecylon capitellatum	0.77"
Eugenia spp.	0.65	Hymenolobium sp.	0.64	Microberlinia brazzavillensis	0.7
Fagraea spp.	0.73	Inga sp.	0.49,0.52,0.58, 0.64+	Microcos coriaceus	0.42"
Ficus benjamina	0.65	Iryanthera spp.	0.46	Milletia spp.	0.72
Ficus spp.	0.39	Jacaranda sp.	0.55	Mitragyna stipulosa	0.47
Ganua obovatifolia	0.59	Joannesia heveoides	0.39	Monopetalanthus pellegrinii	0.47"
Garcinia myrtifolia	0.65	Lachmellea speciosa	0.73	Musanga cecropioides	0.23
Garcinia spp.	0.75	Laetia procera	0.68	Nauclea diderrichii	0.63
Gardenia turgida	0.64	Lecythis spp.	0.77	Neopoutonia macrocalyx	0.32"
Garuga pinnata	0.51	Licania spp.	0.78	Nesogordonia papaverifera	0.65
Gluta spp.	0.63	Licaria spp.	0.82	Ochtocosmus africanus	0.78'
Gmelina arborea	0.41,0.45+	Lindackeria sp.	0.41	Odyendea spp.	0.32
Gmelina vitiensis	0.54	Linociera domingensis	0.81	Oldfieldia africana	0.78*
Gonocaryum calleryanum	0.64	Lonchocarpus spp.	0.69	Ongokea gore	0.72
Gonystylus punctatus	0.57	Loxopterygium sagotii	0.56	Oxystigma oxyphyllum	0.53
Grewia tiliaefolia	0.68	Lucuma spp.	0.79	Pachyelasma tessmannii	0.70"
Hardwickia binata	0.73	Luehea spp.	0.5	Pachypodanthium staudtii	0.58"
Harpullia arborea	0.62	Lueheopsis duckeana	0.64	Paraberlinia bifoliolata	0.56"
Heritiera spp.	0.56	Mabea piriri	0.59	Parinari glabra	0.87"
Hevea brasiliensis	0.53	Machaerium spp.	0.7	Parkia bicolor	0.36"
Hibiscus tiliaceus	0.57	Macoubea guianensis	0.40*	Pausinystalia brachythyrsa	0.56"
Homalanthus populneus	0.38	Magnolia spp.	0.52	Pausinystalia cf. talbotii	0.56"
Homalium spp.	0.76	Maguira sclerophylla	0.57	Pentaclethra macrophylla	0.78"
Hopea acuminata	0.62	Mammea americana	0.62	Pentadesma butyracea	0.78"
Hopea spp.	0.64	Mangifera indica	0.55	Phyllanthus discoideus	0.76"
Intsia palembanica	0.68	Manilkara sp.	0.89	Pierreodendron africanum	0.70;"
Kayea garciae	0.53	Marila sp.	0.63	Piptadeniastrum africanum	0.56

+ The wood densities specified pertain to more than one bibliographic source.

* Wood density value is derived from the regression equation in Reyes *et al.* (1992).

Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

Annex Table A-2 Basic wood densities of stemwood WD (5) (t-dry matter/m^3)

TABLE 3A.1.9-2 (CONTINUED)

BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES

(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Kingiodendron alternifolium	0.48	Manmaroxylon racemosum	0.78*	Plagiostyles africana	0.70"
Kleinhovia hospita	0.36	Matayba domingensis	0.7	Poga oleosa	0.36
Knema spp.	0.53	Matisia hirta	0.61	Polyalthia suaveolens	0.66"
Koompassia excelsa	0.63	Maytenus spp.	0.71	Premna angolensis	0.63"
Koordersiodendron pinnatum	0.65, 0.69+	Mezilaurus lindaviana	0.68	Pteleopsis hylodendron	0.63*
Kydia calycina	0.72	Michropholis spp.	0.61	Pterocarpus soyauxii	0.61
Lagerstroemia spp.	0.55	Minquartia guianensis	0.76,0.79+	Pterygota spp.	0.52
Lannea grandis	0.5	Mora sp.	0.71	Pycnanthus angolensis	0.4
Leucaena leucocephala	0.64	Mouriria sideroxylon	0.88	Randia cladantha	0.78*
Litchi chinensis ssp. philippinensis	0.88	Myrciaria floribunda	0.73	Rauwolfia macrophylla	0.47*
Lithocarpus soleriana	0.63	Myristica spp.	0.46	Ricinodendron heudelotii	0.2
Litsea spp.	0.4	Myroxylon balsamum	0.74, 0.76, 0.78+	Saccoglottis gabonensis	0.74"
Lophopetalum spp.	0.46	Nectandra spp.	0.52	Santiria trimera	0.53*
Macaranga denticulata	0.53	O c o t e a spp.	0.51	Sapium ellipticum	0.50*
Madhuca oblongifolia	0.53	Onychopetalum amazonicum	0.64	Schrebera arborea	0.63*
Mallotus philippensis	0.64	Ormosia spp.	0.59	Sclorodophloeus zenkeri	0.68*
Mangifera spp.	0.52	Ouratea sp.	0.66	Scottellia coriacea	0.56
Maniltoa minor	0.76	Pachira acuatica	0.43	Scyphocephalium ochocoa	0.48
Mastixia philippinensis	0.47	Paratecoma peroba	0.6	Scytopetalum tieghemii	0.56"
Melanorrhea spp.	0.63	Parinari spp.	0.68	Sindoropsis letestui	0.56*
Melia dubia	0.4	Parkia spp.	0.39	Staudtia stipitata	0.75
Melicope triphylla	0.37	Peltogyne spp.	0.79	Stemonocoleus micranthus	0.56"
Meliosma macrophylla	0.27	Pentaclethra macroloba	0.65,0.68+	Sterculia rhinopetala	0.64
Melochia umbellata	0.25	Peru glabrata	0.65	Strephonema pseudocola	0.56*
Me&a ferrea	0.83,0.85+	Peru schomburgkiana	0.59	Strombosiopsis tetrandra	0.63"
Metrosideros collina	0.70,0.76+	Persea spp.	0.40, 0.47,0.52+	Swartzia fistuloides	0.82
Michelia spp.	0.43	Petitia domingensis	0.66	Symphonia globulifera	0.58"
Microcos stylocarpa	0.4	Pinus caribaea	0.51	Syzygium cordatum	0.59*
Micromelum compressum	0.64	Pinus oocarpa	0.55	Terminalia superba	0.45
Milliusa velutina	0.63	Pinus patula	0.45	Tessmania africana	0.85"
Mimusops elengi	0.72*	Piptadenia sp.	0.58	Testulea gabonensis	0.6
Mitragyna parviflora	0.56	Piranhea longepedunculata	0.9	Tetraberlinia tubmaniana	0.60"
Myristica spp.	0.53	Piratinera guianensis	0.96	Tetrapleura tetraptera	0.50"
Neesia spp.	0.53	Pithecellobium guachapele (syn. Pseudosamea)	0.56	Tieghemella heckelii	0.55"
Neonauclea bernardoi	0.62	Platonia insignis	0.70'	Trema sp.	0.40*
Neotrewia cumingii	0.55	Platymiscium spp.	0.71, 0.84+	Trichilia prieureana	0.63"
Ochna foxworthyi	0.86	Podocarpus spp.	0.46	Trichoscypha arborea	0.59"
Ochroma pyramidale	0.3	Pourouma aff. melinonii	0.32	Triplochiton scleroxylon.	0.32
Octomeles sumatrana	0.27, 0.32+	Pouteria spp.	0.64, 0.67+	Uapaca spp.	0.6
Oroxylon indicum	0.32	Prioria copaifera	0.40,0.41+	Vepris undulata	0.70"
Ougenia dalbergiodes	0.7	Protium spp.	0.53,0.64+	Vitex doniana	0.4
Palaquium spp.	0.55	Pseudolmedia laevigata	0.64	Xylopia staudtii	0.36*
Pangium edule	0.5	Pterocarpus spp.	0.44		
Parashorea malaanonan	0.51	Pterogyne nitens	0.66		
Parashorea stellata	0.59	Qualea albiflora	0.5		
Paratrophis glabra	0.77	Qualea cf. lancifolia	0.58		
Parinari spp.	0.68	Qualea dinizii	0.58		

+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

Annex Table A-2 Basic wood densities of stemwood WD (6) (t-dry matter/m^3)

TABLE 3A.1.9-2 (CONTINUED)
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Parkia roxburghii	0.34	Qualea spp.	0.55		
Payena spp.	0.55	Quararibaea guianensis	0.54		
Peltophorum pterocarpum	0.62	Quercus alata	0.71		
Pentace spp.	0.56	Quercus costaricensis	0.61		
Phaeanthus ebracteolatus	0.56	Quercus eugeniaefolia	0.67		
Phyllocladus hypophyllus	0.53	Quercus spp.	0.7		
Pinus caribaea	0.48	Raputia sp.	0.55		
Pinus insularis	0.47,0.48+	Rheedia spp.	0.72		
Pinus merkusii	0.54	Rollinia spp.	0.36		
Pisonia umbellifera	0.21	Saccoglottis cydonioides	0.72		
Pittosporum pentandrum	0.51	Sapium ssp.	0.47,0.72+		
Planchonia spp.	0.59	Schinopsis spp.	1		
Podocarpus spp.	0.43	Sclerobium spp.	0.47		
Polyalthia flava	0.51	Sickingia spp.	0.52		
Polyscias nodosa	0.38	Simaba multiflora	0.51		
Pometia spp.	0.54	Simarouba amara	0.32, 0.34,0.38+		
Pouteria villamilii	0.47	Sloanea guianensis	0.79		
Premna tomentosa	0.96	Spondias mombin	0.30, 0.40,0.41+		
Pterocarpus marsupium	0.67	Sterculia spp.	0.55		
Pterocymbium tinctorium	0.28	Stylogyne spp.	0.69		
Pyge'um vulgare	0.57	Swartzia spp.	0.95		
Quercus spp.	0.7	Swietenia macrophylla	0.42,0.45,0.46, 0.54+		
Radermachera pinnata	0.51	Symphonia globulifera	0.68		
Salmalia malabarica	0.32,0.33+	Tabebuia spp. (lapacho group)	0.91		
Samanea saman	0.45, 0.46+	Tabebuia spp. (roble)	0.52		
Sandoricum vidalii	0.43	Tabebuia spp. (white cedar)	0.57		
Sapindus saponaria	0.58	Tabebuia stenocalyx	0.55,0.57+		
Sapium luzontcum	0.4	Tachigalia myrmecophylla	0.56		
Schleichera oleosa	0.96	Talisia sp.	0.84		
Schrebera swietenoides	0.82	Tapirira guianensis	0.47*		
Semicarpus anacardium	0.64	Terminalia sp.	0.50, 0.51, 0.58+		
Serialbizia acle	0.57	Tetragastris altisima	0.61		
Serianthes melanesica	0.48	Toluifera balsamum	0.74		
Sesbania grandiflora	0.4	Torrubia sp.	0.52		
Shorea assamica forma philippinensis	0.41	Toulicia pulvinata	0.63		
Shorea astylosa	0.73	Tovomita guianensis	0.6		
Shorea ciliata	0.75	Trattinickia sp.	0.38		
Shorea contorta	0.44	Trichilia propingua	0.58		
Shorea gisok	0.76	Trichosperma mexicanum	0.41		
Shorea guiso	0.68	Triplaris spp.	0.56		
Shorea hopeifolia	0.44	Trophis sp.	0.54		
Shorea malibato	0.78	Vatairea spp.	0.6		
Shorea negrosensis	0.44	Virola spp.	0.40, 0.44, 0.48+		
Shorea palosapis	0.39	Vismia spp.	0.41		
Shorea plagata	0.7	Vitex spp.	0.52,0.56, 0.57+		

\+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

Annex Table A-2 Basic wood densities of stemwood WD (7) (t-dry matter/m^3)

TABLE 3A.1.9-2 (CONTINUED)
BASIC WOOD DENSITIES (D) OF STEMWOOD (tonnes dry matter/m^3 fresh volume) FOR TROPICAL TREE SPECIES
(To be used for D in Equations 3.2.3., 3.2.5, 3.2.7, 3.2.8)

TROPICAL ASIA	D	TROPICAL AMERICA	D	TROPICAL AFRICA	D
Shorea polita	0.47	Vitex stahelii	0.6		
Shorea polysperma	0.47	Vochysia spp.	0.40,0.47, 0.79+		
Shorea robusta	0.72	Vouacapoua americana	0.79		
Shorea spp. balau group	0.7	Warszewicsia coccinea	0.56		
Shorea spp. dark red meranti	0.55	Xanthoxylum martinicensis	0.46		
Shorea spp. light red meranti	0.4	Xanthoxylum spp.	0.44		
Shorea spp. white meranti	0.48	Xylopia frutescens	0.64"		
Shorea spp. yellow meranti	0.46				
Shorea virescens	0.42				
Sloanea javanica	0.53				
Soymida febrifuga	0.97				
Spathodea campanulata	0.25				
Stemonurus luzoniensis	0.37				
Sterculia vitiensis	0.31				
Stereospermum suaveolens	0.62				
Strombosia philippinensis	0.71				
Strychnos potatorum	0.88				
Swietenia macrophylla	0.49,0.53+				
Swintonia foxworthyi	0.62				
Swintonia spp.	0.61				
Syeopsis dunni	0.63				
Syzygium spp.	0.69, 0.76+				
Tamarindus indica	0.75				
Tectona grandis	0.50,0.55+				
Teijsmanniodendron ahernianum	0.9				
Terminalia citrina	0.71				
Terminalia copelandii	0.46				
Terminalia foetidissima	0.55				
Terminalia microcarpa	0.53				
Terminalia nitens	0.58				
Terminalia pterocarpa	0.48				
Terminalia tomentosa	0.73,0.76, 0.77+				
Ternstroemia megacarpa	0.53				
Tetrameles nudiflora	0.3				
Tetramerista glabra	0.61				
Thespesia populnea	0.52				
Toona calantas	0.29				
Trema orientalis	0.31				

+ The wood densities specified pertain to more than one bibliographic source.
* Wood density value is derived from the regression equation in Reyes *et al.* (1992).
Source: Reyes, Gisel; Brown, Sandra; Chapman, Jonathan; Lugo, Ariel E. 1992. Wood densities of tropical tree species. Gen. Tech. Rep. SO-88 New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 15pp.

Annex Table A-3 Carbon fraction of aboveground forest biomass（CF）

TABLE 4.3
CARBON FRACTION OF ABOVEGROUND FOREST BIOMASS

Domain	Part of tree	Carbon fraction, (CF) [tonne C (tonne d.m.)$^{-1}$]	References
Default value	All	0.47	McGroddy *et al.*, 2004
Tropical and Subtropical	All	0.47 (0.44 - 0.49)	Andreae and Merlet, 2001; Chambers *et al.*, 2001; McGroddy *et al.*, 2004; Lasco and Pulhin, 2003
	wood	0.49	Feldpausch *et al.*, 2004
	wood, tree d < 10 cm	0.46	Hughes *et al.*, 2000
	wood, tree d ≥ 10 cm	0.49	Hughes *et al.*, 2000
	foliage	0.47	Feldpausch *et al.*, 2004
	foliage, tree d < 10 cm	0.43	Hughes *et al.*, 2000
	foliage, tree d ≥ 10 cm	0.46	Hughes *et al.*, 2000
Temperate and Boreal	All	0.47 (0.47 - 0.49)	Andreae and Merlet, 2001; Gayoso *et al.*, 2002; Matthews, 1993; McGroddy *et al.*, 2004
	broad-leaved	0.48 (0.46 - 0.50)	Lamlom and Savidge, 2003
	conifers	0.51 (0.47 - 0.55)	Lamlom and Savidge, 2003

Source : IPCC Guidelines for National Greenhouse Gas Inventories (GNGGI), Volume4. Agriculture, Forestry, and Other Land Use, Table 4.3, 2006[3]

3 IPCCC:http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

Annex Table A-4 Annual average aboveground biomass increment in plantations by broad category

(t/ha)

	Age Class	Wet	Moist with Short Dry Season	Moist with Long Dry Season	Dry	Montane Moist	Montane Dry
		R >2000	2000>R>1000		R<1000	R>1000	R<1000
Africa							
Eucalyptus spp	≤20 years	-	20.0	12.6	5.1 (3.0-7.0)	-	-
	>20 years	-	25.0	-	8.0 (4.9-13.6)	-	-
Pinus sp	≤20 years	18.0	12.0	8.0	3.3 (0.5-6.0)	-	-
	>20 years		15.0	11.0	2.5	-	-
others	≤20 years	6.5 (5.0-8.0)	9.0 (3.0-15.0)	10.0 (4.0-16.0)	15.0	11.0	-
	>20 years	-	-	-	11.0	-	-
Asia							
Eucalyptus spp	All	5.0 (3.6-8.0)	8.0	15.0 (5.0-25.0)	-	3.1	-
other species	-	5.2 (2.4-8.0)	7.8 (2.0-13.5)	7.1 (1.6-12.6)	6.45 (1.2-11.7)	5.0 (1.3-10.0)	-
America	-	-	-	-	-	-	-
Pinus	-	18.0	14.5 (5.0 – 19.0)	7.0 (4.0 - 10.3)	5.0	14.0	-
Eucalyptus	-	21.0 (6.4 - 38.4)	16.0 (6.4 - 32.0)	16.0 (6.4 - 32.0)	16.0	13.0 (8.5 - 17.5)	-
Tectona	-	15.0	8.0 (3.8 - 11.5)	8.0 (3.8 - 11.5)	-	2.2	-
other broadleaved	-	17.0 (5.0 - 35.0)	18.0 (8.0 – 40.0)	10.5 (3.2 - 11.8)	-	4.0	-

Note 1 : R= annual rainfall in mm/yr

Note 2 : Data are given as mean value and as the range of possible values.

Note 3 : Some Boreal data were calculated from original values in Zakharov *et al.* (1962), Zagreev *et al.* (1993), Isaev *et al.* (1993) using 0.23 as belowground/aboveground biomass ratio and assuming a linear increase in annual increment from 0 to 20 years.

Note 4 : For plantations in temperate and boreal zones, it is good practice to use stemwood volume increment data (I_v in Equation 3.2.5) instead of above ground biomass increment as given in above table.

Source：IPCC Good Practice Guidance for LULUCF Annex 3A.1, Table 3A.1.6[4]

[4] IPCCC: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf

Annex Table A-5 Average belowground to aboveground biomass ratio (Root-Shoot ratio, R) in natural regeneration by broad category（R）

	Vegetation type	Aboveground biomass (t/ha)	Mean	SD	lower range	upper range	References
Tropical/sub-tropical forest	Secondary tropical/sub-tropical forest	<125	0.42	0.22	0.14	0.83	5, 7, 13, 25, 28, 31, 48, 71
	Primary tropical/sub-tropical moist forest	NS	0.24	0.03	0.22	0.33	33, 57, 63, 67, 69
	Tropical/sub-tropical dry forest	NS	0.27	0.01	0.27	0.28	65
Conifer forest/ plantation	Conifer forest/plantation	<50	0.46	0.21	0.21	1.06	2, 8, 43, 44, 54, 61, 75
	Conifer forest/plantation	50-150	0.32	0.08	0.24	0.50	6, 36, 54, 55, 58, 61
	Conifer forest/plantation	>150	0.23	0.09	0.12	0.49	1, 6, 20, 40, 53, 61, 67, 77, 79
Temperate broadleaf forest/ plantation	Oak forest	>70	0.35	0.25	0.20	1.16	15, 60, 64, 67
	Eucalypt plantation	<50	0.45	0.15	0.29	0.81	9, 51, 59
	Eucalypt plantation	50-150	0.35	0.23	0.15	0.81	4, 9, 59, 66, 76
	Eucalypt forest/plantation	>150	0.20	0.08	0.10	0.33	4, 9, 16, 66
	Other broadleaf forest	<75	0.43	0.24	0.12	0.93	30, 45, 46, 62
	Other broadleaf forest	75-150	0.26	0.10	0.13	0.52	30, 36, 45, 46, 62, 77, 78, 81
	Other broadleaf forest	>150	0.24	0.05	0.17	0.30	3, 26, 30, 37, 67, 78, 81
Grassland	Steppe/tundra/prairie grassland	NS	3.95	2.97	1.92	10.51	50, 56, 70, 72
	Temperate/sub-tropical/ tropical grassland	NS	1.58	1.02	0.59	3.11	22, 23, 32, 52
	Semi-arid grassland	NS	2.80	1.33	1.43	4.92	17-19, 34
Other	Woodland/savanna	NS	0.48	0.19	0.26	1.01	10-12, 21, 27, 49, 65, 73, 74
	Shrubland	NS	2.83	2.04	0.34	6.49	14, 29, 35, 38, 41, 42, 47, 67
	Tidal marsh	NS	1.04	0.21	0.74	1.23	24, 39, 68, 80
NS = Not specified							

Source：IPCC Good Practice Guidance for LULUCF Annex 3A.1, Table 3A.1.8[5]

[5] IPCCC: http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Anx_3A_1_Data_Tables.pdf

Annex Table A-6 CO_2 emissions from fertilizer, leakages and effects of GHG emissions reduction[6]

Project	Host Parties	fertilizer (tonnes of CO2 e)	Estimation of baseline net GHG removals by sinks (tonnes of CO2 e)	Estimation of actual net GHG removals by sinks (tonnes of CO2 e)	Estimation of leakage (tonnes of CO2 e) [A]	Estimation of net anthropogenic GHG removals by sinks (tonnes of CO2 e) [B]	Ratio of leakage [A]/[B]
CARBON SEQUESTRATION THROUGH REFORESTATION IN THE BOLIVIAN TROPICS BY SMALLHOLDERS OF "The Federación de Comunidades Agropecuarias de Rurrenabaque (FECAR)"	Bolivia	zero	0	11,529	24,124	91,165	26%
Reforestation of croplands and grasslands in low income communities of Paraguarí Department, Paraguay	Paraguy	3	8,737	58,188	18,983	30,468	62%
Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin	China	zero	531	794,225	19,852	773,842	3%
The International Small Group and Tree Planting Program (TIST), Tamil Nadu, India	India	zero	0	107,810	0	107,810	0%
Moldova Soil Conservation Project	Moldova	zero	109,962	3,702,513	7,705	3,584,846	0%
Southern Nicaragua CDM Reforestation Project	Nicaragua	zero	0	237,448	0	237,448	0%
Uganda Nile Basin Reforestation Project No 3	Uganda	zero	0	111,798	0	111,798	0%
Reforestation, sustainable production and carbon sequestration project in José Ignacio Távara´s dry forest, Piura, Peru	Peru	zero	171,545	1,145,332	0	973,788	0%
Reforestation on Degraded Lands in Northwest Guangxi	China		15,394	1,761,552	0	1,746,158	0%
Reforestation of grazing Lands in Santo Domingo, Argentina	Argentina	zero	21,366	1,342,140	0	1,320,775	0%
Assisted Natural Regeneration of Degraded Lands in Albania	Albania	zero	6,250	465,537	0	459,287	0%
„Posco Uruguay" afforestation on degraded extensive grazing land	Uruguay	zero	0	659	0	659	0%
Forestry Project for the Basin of the Chinchiná River, an Environmental and Productive Alternative for the City and the Region .	Columbia	zero	0	755,678	0	755,678	0%
Ibi Batéké degraded savannah afforestation project for fuelwood production (Democratic Republic of Congo)	Congo	zero	0	1,635,338	0	1,635,338	0%
AES Tietê Afforestation/Reforestation Project in the State of São Paulo, Brazil	Brasil	—	59,257	4,788,332	0	4,729,074	0%
Humbo Ethiopia Assisted Natural Regeneration Project	Ethiopia	zero	0	880,296	0	880,296	0%
Cao Phong Reforestation Project	Vietnam	22	0	53,735	11,090	42,645	26%
India: Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds	India	zero	0	828,016	0	828,016	0%
Improving Rural Livelihoods Through Carbon Sequestration By Adopting Environment Friendly Technology based Agroforestry Practices	India	—	0	146,888	0	146,888	0%
Reforestation as Renewable Source of Wood Supplies for Industrial Use in Brazil	Brasil	—	751,894	30,409,091	15,522	2,273,493	1%
Argos CO2 Offset Project, through reforestation activities for commercial use.	Columbia	—	133,021	1,079,384	23,100	923,263	3%
Small Scale Cooperative Afforestation CDM Pilot Project Activity on Private Lands Affected by Shifting Sand Dunes in Sirsa, Haryana.	India	zero	43	29,785	0	231,920	0%
Nerquihue Small-Scale CDM Afforestation Project using Mycorrhizal Inoculation in Chile	Chile	zero	0	185,836	0	185,836	0%
Forestry Project in Strategic Ecological Areas of the Colombian Caribbean Savannas	Columbia	zero	279	1,999,849	0	1,999,571	0%

[6] UNFCCC CDM http://cdm.unfccc.int/Projects/projsearch.html

Forest and Natural Resources Conservation/ Annex Table

Annex Table A-7 Examples of stratum（CDM Project）[7]

Country : Paraguay
Project participants : Japan International Research Center for Agricultural Sciences
Instituto Forestal Nacional (Public entity)
Title : Reforestation of croplands and grasslands in low income communities of Paraguari Department, Paraguay
CDM registered 2009

Stratum	Tree species	Tree spacing(m)	Plant age	Forested area (ha)
S1	Eucalyptus grandis	3.0×2.5	2007	30.05
S2	Eucalyptus grandis	3.0×2.5	2008	31.17
S3	Eucalyptus camaldulensis	3.0×2.5	2007	16.36
S4	Eucalyptus camaldulensis	3.0×2.5	2008	64.48
S5	Grevillea robusta	3.0×2.5	2007	5.59
S6	Grevillea robusta	3.0×2.5	2008	15.16
S7	Grevillea robusta	5.0×4.0	2007	14.05
S8	Grevillea robusta	5.0×4.0	2008	38.30
Total				215.16

Country : Chile
Project participants : Mikro-Tek Inc. , Natsource Europe Limited
Title : Nerquihue Small-Scale CDM Afforestation Project using Mycorrhizal Inoculation in Chile
CDM registered 2009

Stratum	Tree species	Tree spacing(m)	Plant age	Forested area (ha)
S1	Eucalyptus grandis	3.0×2.5	2007	30.05
S2	Eucalyptus grandis	3.0×2.5	2008	31.17
Total				215.16

Country : India
Project participants : Haryana CDM Variksh Kisan Samiti, Ellenabad, Sirsa
Title : Small Scale Cooperative Afforestation CDM Pilot Project Activity on Private Lands Affected by Shifting Sand Dunes in Sirsa, Haryana.
CDM registered 2008

Stratum	Tree species	Tree spacing(m)	Plant age	Forested area (ha)
S1	*Eucalyptus hybrid*		2007	26.30
S2	*Ailanthus excelsa*		2007	57.86
S3	*Acacia tortilis*		2007	61.65
S4	*Dalbergia sissoo*		2007	53.65
S5	*Acacia nilotica*		2007	60.75
S6	*Prosopis cineraria*		2007	74.20
S7	*Zizyphus mauritiana*		2007	35.46
Total				369.87

[7] UNFCCC: http://cdm.unfccc.int/Projects/projsearch.html

Country : Vietnam
Project participants : Forest Development Fund
Title : Cao Phong Reforestation Project
CDM registered 2009

Stratum	Tree species	Tree spacing(m)	Plant age	Forested area (ha)
S1	*A.mangium*	2.5×2.5	2008	166.65
S2	*A.mangium*	2.5×2.5	2009	166.65
S3	*A.auriculiformis*	2.0×2.0	2009	31.96
Total				365.26

Country : India
Project participants : ITC Limited, Paperboards and Specialty Papers Division (PSPD), Unit: Bhadrachalam
Title : Reforestation of severely degraded landmass in Khammam District of Andhra Pradesh, India under ITC Social Forestry Project
CDM registered 2007

Stratum	Tree species	Tree spacing(m)	Plant age	Forested area (ha)
S1	*Eucalyptus tereticornis Smith and Eucalyptus camaldulensis Dhen 1 year old tree*	–	2001	979.79
S2	*Eucalyptus tereticornis Smith and Eucalyptus camaldulensis Dhen 2 yeasr old tree*	–	2002	556.65
S3	*Eucalyptus tereticornis Smith and Eucalyptus camaldulensis Dhen 3 yeasr old tree*	–	2003	971.33
S4	*Eucalyptus tereticornis Smith and Eucalyptus camaldulensis Dhen 4 yeasr old tree*	–	2004	562.42
Total				3070.19

Country : Bolivia
Project participants : FECAR (community organization), (Private entity)
Foundation Centro Tecnico Forestal (CETEFOR) (Private entity)
Asociación Accidental Cetefor-Sicirec (Private entity)
Vlaams Gewest (Public entry)
Title : CARBON SEQUESTRATION THROUGH REFORESTATION IN THE BOLIVIAN TROPICS BY SMALLHOLDERS OF "The Federación de Comunidades Agropecuarias de Rurrenabaque (FECAR)" Version 2.03
CDM registered 2009

Stratum	Tree species	Tree spacing(m)	Plant age	Forested area (ha)
S1	*Fast growing/ plantation*	—	—	—
S2	*Fast growing/Agroforestry System*	—	—	—
S3	*Fast growing/ Silvipastoral System*	—	—	—
S4	*Midium growing/ plantation*	—	—	—
S5	*Midiumgrowing/AgroforestrySystem*	—	—	—
S6	*Midium growing/ Silvipastoral System*	—	—	—
S7	*Slow growing/ plantation*	—	—	—
S8	*Slow growing/Agroforestry System*	—	—	—
S9	*Slow growing/ Silvipastoral System*	—	—	—
Total				317ha

Country : Uganda
Project participants : National Forest Authority (NFA)
International Bank for Reconstruction and Development as trustee of the BioCarbon Fund
Title : Uganda Nile Basin Reforestation Project No 3
CDM registered 2009

Stratum	Tree species	Tree spacing(m)	Plant age	Forested area (ha)
S1	*Pine /Maesopsis (&Prunus)*	—	—	—
S2	*Pine /Maesopsis (&Prunus)*	—	—	—
S3	*Pine /Maesopsis (&Prunus)*	—	—	—
S4	*Pine /Maesopsis (&Prunus)*	—	—	—
S5	*Pine /Maesopsis (&Prunus)*	—	—	—
Total				2014ha

Traffic and Transportation Sector

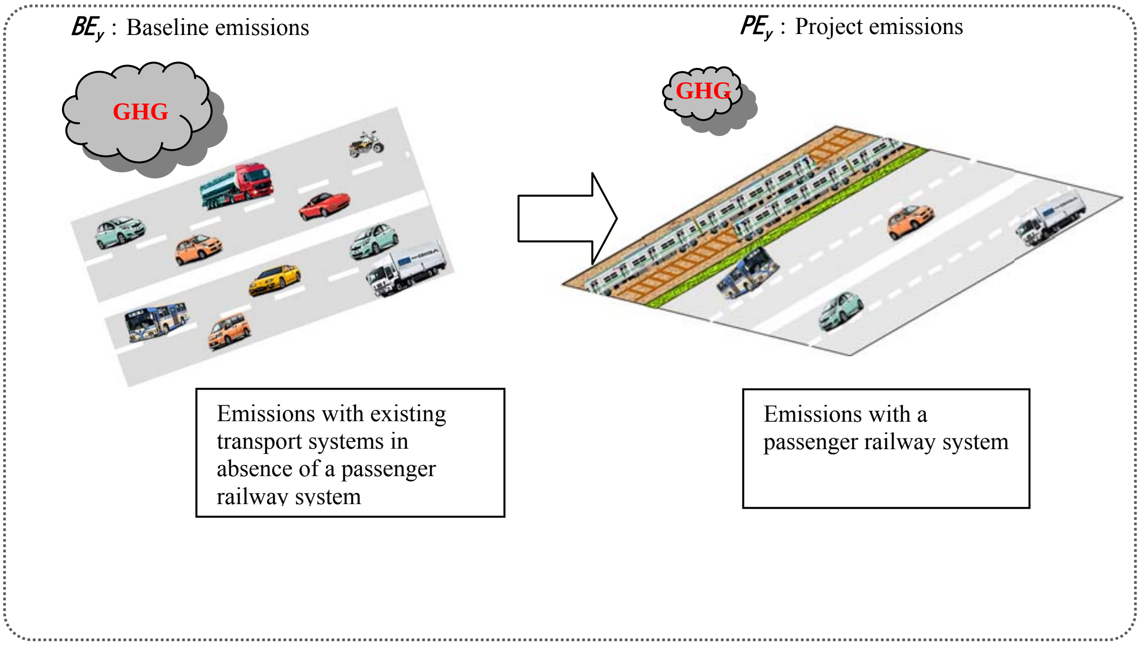
Sub-sector：

3. **Freight/Passenger Transportation Improvement**
4. **MRT**
5. **Monorail, LRT**
6. **Bus (BRT, Trunk bus)**

<table>
<tr>
<td>1.Typical Project Outline</td>
<td>The project intends to reduce GHG emissions by realizing “modal shift” from existing passenger transport systems (i.e., conventional buses, passenger cars, taxies and bikes) to passenger railway systems such as a new railway, a double track railway, or a quadruple track railway. In addition, “electrification” of passenger railway systems will reduce GHG emissions.</td>
</tr>
<tr>
<td>2.Applicability</td>
<td>○ After the project completes, the passenger rail system will have its own rail-based infrastructure and it will provide rapid transportation for a large number of passengers.
○The current baseline transport system should be road based (i.e., buses, private cars, taxies and bicycles). Hence, the current transport system does not involve ships or civil aviation.
○Railway electrification projects are also targeted. In such cases, the current baseline transportation systems are non-electrified railways.
○The motive power of passenger railways should be electricity or of internal-combustion (engine).</td>
</tr>
<tr>
<td>3. Methodology on Emission Reduction</td>
<td>GHG emissions reduction due to passenger railway projects is calculated as the difference between the GHG emissions with the existing transport systems (baseline) and those after the success of the modal shift to a passenger railway system (project emission). In addition, GHG emissions reduction due to railway electrification is calculated as the difference between the GHG emissions with the existing non-electrified railway (baseline) and those with the electrified railway (Project).

$$ER_y = BE_y - PE_y \quad (t\text{-}CO_2/y)$$

ER_y : GHG emissions reduction due to project activity in year y ($t\text{-}CO_2/y$)
BE_y : GHG emissions with existing transport systems in year y ($t\text{-}CO_2/y$) (Baseline emissions)
PE_y : GHG emissions after the success of modal shift to the passenger railway from the existing transport systems in year y ($t\text{-}CO_2/y$) (Project emissions)


</td>
</tr>
</table>

3. Methodology on Emission Reductions (Continuation)	(1) Baseline Emissions Estimation 1) Road-based Transportation Systems In case the existing transport systems would share a similar number of passengers transported by the projected railway, the baseline emissions for various types of vehicles are estimated by multiplying the shared number of passengers with the respective CO_2 emission factors per passenger before the project starts. $$BE_y = \sum_i \left(EF_{P,i,y} \times P_{PJ,i,j} \right)$$

Type	Items	Description
Output	***BE_y***	Baseline emissions： GHG emissions in the absence of the passenger railway project (gr-CO_2/y)
Input	$EF_{P,i,y}$	CO_2 emission factor per passenger for vehicle category i (gr-CO_2/passenger)
	$P_{PJ,i,y}$	Annual number of passengers transported by vehicle category i after the project has completed

Determination of $EF_{P,i,y}$

Involving parameters such as CO_2 emission factor per kilometer, average trip distance, and average occupation rate of vehicle before the project starts, the CO_2 emission factor per passenger for each vehicle category is estimated using the following formula:

$$EF_{P,i,y} = \frac{EF_{KM,i} \times TD_i}{OC_i}$$

$EF_{KM,i}$ ：CO_2 emission factor per km for vehicle category i before the project starts（gr-CO_2/km）
TD_i ：Average daily trip distance driven by vehicle category i (km/vehicle)
OC_i ：Average daily occupancy rate for vehicle category i (person/vehicle)

$EF_{KM,i}$ is calculated using the following formula:

$$EF_{KM,i} = \sum_x \left[\frac{(1-\alpha_{x,i})}{SEC_{x,i}} \times EF_{CO2,x} \times \left(\frac{N_{x,i}}{N_i} \right) \right]$$

$SEC_{x,i}$ ：Specific fuel consumption per vehicle category i (km/L)
$EF_{CO2,x}$ ：CO_2 emission factor of fuel category x (gr-CO_2/L)
$N_{x,i}$ ：Number of vehicle category i using fuel category x (vehicle)
N_i ：Number of vehicle category i (vehicle)
$\alpha_{x,i}$ ：Mixing rate of biofuel (e.g., = 0.1 for biodiesel 10% mixing fuel)

2) Non-electrified railways

Baseline emissions are calculated by multiplying the total annual fuel consumption of non-electrified passenger trains (diesel trains or internal-combustion locomotives) with the CO_2 emission factor of fuel.

$$BE_y = TC_{dt\,y} \times EF_{CO_2,x}$$

Type	Item	Description
Output	***BE_y***	Baseline emissions： GHG emissions of non-electrified trains (t-CO_2/y)
Input	$TC_{dt,y}$	Total annual fuel consumption of non-electrified trains (diesel trains or internal-combustion locomotives) after the project has completed (L/y)
	$EF_{CO2,x}$	CO_2 emission factor of fuel category x (gr-CO_2/L)

<u>Determination of $EF_{P,i,y}$</u>

The total annual fuel consumption of the non-electrified passenger trains is estimated considering their specific fuel consumption multiplied by their total annual trip distance. By involving a mixing rate of biofuel in fuel consumption, the formula is as follows:

$$TC_{dt,y} = \frac{(1-\alpha_{x,bs})DD_y}{SEC_{x,dt}}$$

$SEC_{x,dt}$: Specific fuel consumtion (km/L)

DD_y : Total annual trip distance of passenger trains (train km/y)

$\alpha_{x,bs}$: Mixing ratio of biofuel

(2) Project Emissions Estimation

1) Electric-powered Freight Trains

Project emissions are calculated by multiplying the total annual electricity consumption of passenger trains (electric train/electric locomotive) after project completion (planned value) with the CO_2 emission factor of electricity.

$$PE_y = TC_y \times EF_{CO2,x}$$

Type	Item	Description
Output	***PE_y***	Project emissions： GHG emissions of passenger trains (electric train/electric locomotive) after project completion (t-CO_2/y)
Input	TC_y	Total annual electricity consumption of passenger trains after project completion (kWh/y)
	$EF_{CO2,x}$	CO_2 emission factor of electricity (gr-CO_2/kWh)

<u>Determination of TC_y</u>

The total electricity consumption of pasenger trains is estimated considering their electricity consumption rate multiplied by the total annual trip distance as follows:

$$TC_{et\,y} = DD_y \cdot SEC_{et,y}$$

$SEC_{et,y}$: Electricity consumption rate (kWh/km)

DD_y : Total annual trip distance driven by passenger trains (train km/y)

2) Engine-powered Passenger Trains (Internal Combustion).

Project emissions are calculated by multiplying the total annual fuel consumption of passenger trains (diesel trains or internal-combustion locomotives) after project completion (planned value) with the CO_2 emission factor of fuel.

$$PE_y = TC_y \times EF_{CO_2,x}$$

Type	Item	Description
Output	PE_y	Project emissions: GHG emissions of passenger trains (diesel train /internal-combustion locomotive) after project completion ($t\text{-}CO_2/y$)
Input	TC_y	Total annual fuel consumption of passenger trains after project completion (L/y)
	$EF_{CO2,x}$	CO_2 emission factor of fuel category x ($gr\text{-}CO_2/L$)

Determination of TC_y

The total fuel consumption of pasenger trains is estimated considering their fuel consumption rate multiplied by their total annual trip distance.By involving a mixing rate of biofuel in the fuel consumption, the formula is as follows:

$$TC_{dt,y} = \frac{(1-\alpha_{x,bs})DD_y}{SEC_{x,dt,y}}$$

$SEC_{x,dt,y}$: Specific fuel consumtion (km/L)

DD_y : Total annual trip distance of passenger trains (train km/y)

$\alpha_{x,dt}$: Mixing ratio of biofuel

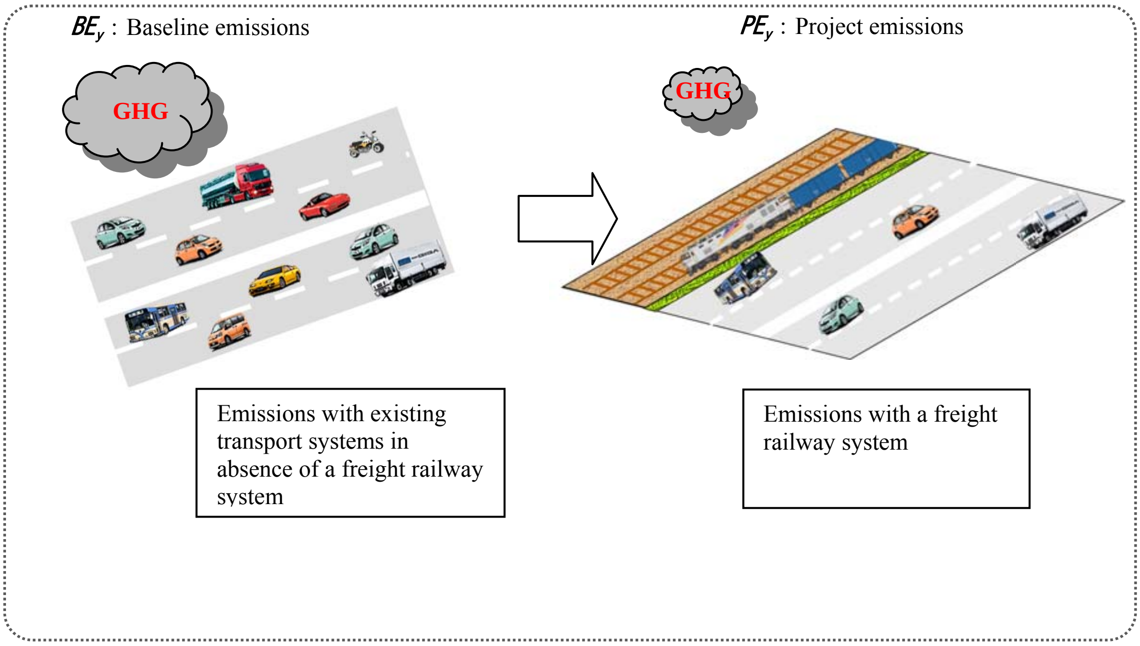
4. Data Required for Estimation and Monitoring

Data Type		Description of Data	Data Acquisition Methods			
			Baseline Emissions		Project Emissions	
			Before the Project Starts	After Project Completion	Before the Project Starts	After Project Completion
Passengers of existing transport systems (After : $P_{PJ,i,y}$)		Passengers of existing transport systems that would be shared in the absence of the passenger train project. The total number of passengers of existing transport systems is equal to the passengers of passenger trains	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Total annual trip distance driven by unelectrified passenger trains (After:DD_y)		Total annual trip distance driven by unelectified passenger trains	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Specific fuel consumption of unelectirfied passenger trains in fuel type x, vehicle category i, ($SEC_{x,dt}$)		Fuel consumption rate per liter (km/L)	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Total annual trip distance driven by passenger trains(After:DD_y)		Total annual trip distance driven by passenger trains after projct completion	(Not necessary because data are not involved in the calculation)		Planned values	Measured values
Electricity consumption rate of passenger trains ($SEC_{x,bs,s}$)		Electricity consumption rate of passenger trains	(Not necessary because data are not involved in calculation)		Planned values	Measured values
CO_2 emissions factor	Total number of existing vehicles in fuel type x, and vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category and a fuel type	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Total number of existing vehicles in vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average trip distance driven by existing vehicles in vehicle category i,(OD_i)	Trip distance for each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average occupation rate of existing vehicles in vehicle	Occupation rate of each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	

<table>
<tr><th colspan="2" rowspan="3">Data Types</th><th rowspan="3">Description of Data</th><th colspan="4">Data Acquisition Methods</th></tr>
<tr><th colspan="2">Baseline Emissions</th><th colspan="2">Project Emissions</th></tr>
<tr><th>Before the Project Starts</th><th>After Project Completion</th><th>Before the Project starts</th><th>After Project Completion</th></tr>
<tr><td rowspan="3">CO_2 emissions factor</td><td>Specific fuel consumption of existing vehicles in fuel type x, vehicle category i, ($SEC_{x,i}$)</td><td>Fuel consumption rate per liter (km/L)</td><td colspan="2">It is best desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews with transport management authorities
ii) Published values in the country where the project exists
iii) Values based on IPCC database</td><td colspan="2">(Not necessary because data are not involved in the calculation)</td></tr>
<tr><td>CO_2 emission factor of fuel（$EFCO_{2,x}$）</td><td>CO_2 emission factor of fuel per liter, such as gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. with the transport management authorities
ii) Published values in the country where the project exists
iii) Values based on IPCC database</td></tr>
<tr><td>Mixing ratio of biofuel</td><td>Mixing ratio of biofuel in gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. for the transport management authorities
ii) Published values in the country where the project exists</td></tr>
</table>

5. Others	(1) Project boundary The project delineation for GHG estimations is defined by the outreach of the passenger train project. (2) Leakage Considering the life cycle assessment (LCA) related to the passenger train project, the production and freight of raw materials needed for passenger trains and the energy consumed during construction and manufacturing of raw materials are expected as leakages of GHG emissions. However, these are significantly small as compared with the GHG emissions reduction caused by the project. Hence, these are not counted as leakages in this estimation methodology. Looking at five CDM registered projects, only the Bagota Bus Rapid Transit (BRT) Project took account of leakage, while the other projects counted leakage as zero. For reference, the estimated leakages of the Bogota BRT Project are shown in the appended Table B-3 attached herewith. The total volume of leakages is 0.8% as compared with that of the GHG emissions reduction due to the BRT project. (3) Relevant methodologies and their differences with this estimation methodology ACM0090：Modal Shift in Transportation of Cargo from Road Transportation to Water or Rail Transportation 【Differences】 ・A cargo (freight) railway project can be the target for GHG emissions estimation; however, this estimation methodology targets passenger train projects. ・At least 50% of investments for water or railway transport systems should be used for the cargo transportation systems including construction of facilities (i.e., railway stations) or purchase of equipments. ・The cargo is transported from the same origin (point A) to the same destination (point B); however, this condition is not considered in this estimation methodology. ACM0016：Baseline Methodology for Mass Rapid Transit Projects 【Differences】 ・All mass rapid transit (MRT) systems including not only rail-based systems such as subways and light rail transit (LRT) but also bus systems such as BRT; however, only passenger train systems are considered in this estimation methodology. ・CH_4, N_2O other than CO_2 can be counted as GHG emissions; however, only CO_2 emission is counted in this estimation methodology. ・The effects of GHG emission reduction by the improvement of technology can be counted; however, these are not counted in this estimation methodology. ・The effects of GHG emission reduction due to the improvement of technology can be counted; however, these are not counted in this estimation methodology. In particular, a technology improvement factor is assumed 0.99/year (or 1%/year) and the GHG emissions are expected to reduce by 1% per year with the technology improvement. In 10th year, 0.99 to the 9th power equals 0.91, and so the baseline emissions from the existing transport systems becomes 0.91 times due to their technological improvement. Simply assuming annual GHG emissions is constant over 10 years, the difference between with and without the technology improvement factors is around 4%. Thus, the baseline GHG emissions over 10 years would reduce by 4% due to technology improvement, and so the effects of GHG emission reduction lessen by 4%, meaning it is on the safety side. In developing countries, however, it is reasonable to consider that old vehicles will be continuously used rather than acquiring brand-new vehicles. Because of this, the technological improvement factors are not considered in this estimation methodology. ・Once the MRT system has been newly introduced, passengers must utilize the MRT stations that were not available before the project has started in order to reach their destinations. This results in producing additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・The reduction of traffic congestions after the project has started may reduce GHG emissions since vehicle operation will speed due to reduced traffic congestion. On the other hand, it may induce an increase in GHG emissions because of the increasing traffic caused by transport systems other than passenger trains. These are involved in AM0016 but not considered in this estimation methodology.

	・ CO_2 emission factors for passenger cars and taxies are a function of speed; however, these are not considered as a function of speed (constant for average speed) in this estimation methodology. ・ The changes in load factors of conventional buses and taxies after the MRT project has started are involved in its GHG emissions estimation; however, these factors are not considered in this estimation methodology. ・ The motive power of transport systems may be either through an internal combustion (engine) or electricity; however, only an internal combustion is considered in this estimation methodology. AMS-III-U：Cable Cars for Mass Rapid Transit Projects 【Differences】 ・ Cable car projects can be the target for GHG emissions estimation; however, the passenger railway project is the target in this estimation methodology. ・ CH_4 and N_20 can be counted as GHG emissions other then CO_2; however, only CO_2 emissions are counted in this estimation methodology. ・ The effects of GHG emissions reduction due to technology improvements can be counted; however, these are not counted in this estimation methodology. ・ Once the cable car system has been introduced, passengers must utilize the cable car stations which were not available before the project started in order to reach their destinations. This results in additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・ Cable cars are powered by electricity; however, both electricity and engine (internal combustion) is considered in this estimation methodology.

1. Typical Project Outline	The project intends to reduce GHG emissions by realizing "modal shift" from existing freight transport systems (i.e., conventional trucks and trailers) to freight railway systems such as a new railway, a double track railway. In addition, "electrification" of freight railway systems will reduce GHG emissions.
2. Applicability	○ After the project completes, the freight railway system will have its own rail-based infrastructure and will provide rapid transportation for a large volume of freight. ○The current baseline transport system should be road based (i.e., buses, private cars, taxies and bikes). Hence, the current transport system does not involve ships or civil aviation. ○Railway electrification projects are also targeted. In such cases, the current baseline transportation systems are non-electrified railways. ○The motive power of freight railways should be electricity or internal combustion (engine).
3. Methodology on Emission Reduction	GHG emissions reduction due to freight railway projects is calculated as the difference between the GHG emissions with the existing transport systems (baseline) and those after the success of the modal shift to a freight railway system (project emission). In addition, GHG emissions reduction due to railway electrification is calculated as the difference between the GHG emissions with the existing non-electrified railway (baseline) and those after the electrified railway (Project). $$ER_y = BE_y - PE_y \quad (\text{t-CO}_2/\text{y})$$ ER_y : GHG emissions reductions due to project activity in year y (t-CO_2/y) BE_y : GHG emissions with existing transport systems in year y (t-CO_2/y) (Baseline emissions) PE_y : GHG emissions after the success of modal shift to a freight railway system from the existing transport systems in year y (t-CO_2/y) (Project emissions) 

3. Methodology on Emission Reductions (Continuation)	(1) Baseline Emissions Estimation

1) Road-based Transportation Systems

In case the existing transport systems would share a similar volume of freights transported by the projected railway, baseline emissions for various types of vehicles are estimated by multiplying the shared volume of freights with the CO_2 emission factors per 1 ton of freight before the project starts.

$$BE_y = \sum_i \left(EF_{P,i,y} \times P_{PJ,i,j} \right)$$

Type	Items	Description
Output	BE_y	Baseline emissions： GHG emissions in the absence of the freight railway project (gr-CO_2/y)
Input	$EF_{P,i,y}$	CO_2 emission factor per 1 ton of freight for vehicle category i (gr-CO_2/passenger)
	$P_{PJ,i,y}$	Annual volume of freights transported by vehicle category i after the project has completed

<u>Determination of $EF_{P,i,y}$</u>

Involving parameters such as CO_2 emission factor per kilometer, average trip distance, and average loading ratio of vehicle before the project starts, the CO_2 emission factor per 1 ton of freight for each vehicle category is estimated by the following formula:

$$EF_{P,i,y} = \frac{EF_{KM,i} \times TD_i}{OC_i}$$

$EF_{KM,i}$ ：CO_2 emission factor per km for vehicle category i before the project starts（gr-CO_2/km）
TD_i ：Average daily trip distance driven by vehicle category i (km/vehicle)
OC_i ：Average daily loading for vehicle category i (ton/vehicle)

$EF_{KM,i}$ is calculated using the following formula:

$$EF_{KM,i} = \sum_x \left[\frac{(1-\alpha_{x,i})}{SEC_{x,i}} \times EF_{CO2,x} \times \left(\frac{N_{x,i}}{N_i} \right) \right]$$

$SEC_{x,i}$ ：Specific fuel consumption per vehicle category i (km/L)
$EF_{CO2,x}$ ：CO_2 emission factor of fuel category x (gr-CO_2/L)
$N_{x,i}$ ：Number of vehicle category i using fuel category x (vehicle)
N_i ：Number of vehicle category i (vehicle)
$\alpha_{x,i}$ ：Mixing rate of biofuel (ex. = 0.1 for biodiesel 10% mixing fuel)

2) Non-electrified railways

Baseline emissions are calculated by multiplying the total annual fuel consumption of non-electrified freight trains (diesel trains or internal-combustion locomotives) with the CO_2 emission factor of fuel.

$$BE_y = TC_{dt\,y} \times EF_{CO_2,x}$$

Type	Item	Description
Output	BE_y	Baseline emissions: GHG emissions of non-electrified trains (t-CO_2/y)
Input	$TC_{dt,y}$	Total annual fuel consumption of non-electrified trains (diesel trains or internal-combustion locomotives) after the project has completed (L/y)
	$EF_{CO2,x}$	CO_2 emission factor of fuel category x (gr-CO_2/L)

Determination of $EF_{P,i,y}$

The total annual fuel consumption of the non-electrified freight trains is estimated considering their specific fuel consumption multiplied by their total annual trip distance. By involving a mixing rate of biofuel in fuel consumption, the formula is as follows:

$$TC_{dt,y} = \frac{(1-\alpha_{x,bs})DD_y}{SEC_{x,dt}}$$

$SEC_{x,dt}$: Specific fuel consumtion (km/L)

DD_y : Total annual trip distance of freight trains (train km/y)

$\alpha_{x,bs}$: Mixing ratio of biofuel

(2) Project Emissions Estimation

1) Electric-powered Freight Trains

Project emissions are calculated by multiplying the total annual electricity consumption of freight trains (electric locomotive) after the project has completed (planned value) with the CO_2 emission factor of electricity.

$$PE_y = TC_y \times EF_{CO2,x}$$

Type	Item	Description
Output	PE_y	Project emissions: GHG emissions of freight trains (electric locomotive) after the project has completed (t-CO_2/y)
Input	TC_y	Total annual electricity consumption of freight trains after the project has completed (kWh/y)
	$EF_{CO2,x}$	CO_2 emission factor of electricity (gr-CO_2/kWh)

Determination of TC_y

The total electricity consumption of freight trains is estimated considering their electricity consumption rate multiplied by their total annual trip distance as follows:

$$TC_{et\,y} = DD_y \cdot SEC_{et,y}$$

$SEC_{et,y}$: Electricity consumption rate (kWh/km)

DD_y : Total annual trip distance driven by freight trains (train km/y)

2) Engine-powered Passenger Trains (Internal Combustion)

Project emissions are calculated by multiplying the total annual fuel consumption of freight trains (diesel train/internal-combustion locomotive) after the project has completed (planned value) with the CO_2 emission factor of fuel.

$$PE_y = TC_y \times EF_{CO_2,x}$$

Type	Item	Description
Output	PE_y	Project emissions： GHG emissions of freight trains (diesel train /internal-combustion locomotive) after the project has completed (t-CO_2/y)
Input	TC_y	Total annual fuel consumption of freight trains after the project has completed (L/y)
	$EF_{CO2,x}$	CO_2 emission factor of fuel category x (gr-CO_2/L)

Determination of TC_y

The total fuel consumption of freight trains is estimated considering their fuel consumption rate multiplied by their total annual trip distance.By involving a mixing rate of bio-fuel in the fuel consumption, the formula is as follows:

$$TC_{dt,y} = \frac{(1-\alpha_{x,bs})DD_y}{SEC_{x,dt,y}}$$

$SEC_{x,dt,y}$: Specific fuel consumtion (km/L)

DD_y : Total annual trip distance of freight trains (train km/y)

$\alpha_{x,dt}$: Mixing ratio of bio-fuel

4. Data Required for Estimation and Monitoring

Data Type		Description of Data	Data Acquisition Methods			
			Baseline Emissions		Project Emissions	
			Before the project starts	After project completion	Before the project starts	After project completion
Freights by existing transport systems (After : $P_{PJ,i,y}$)		Freights of existing transport systems that would be shared in the absence of the freight train project. The total freights of existing transport systems is equal to the freight carried by freight trains	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Total annual trip distance driven by unelectrified passenger trains (After:DD_y)		Total annual trip distance driven by unelectified passenger trains	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Specific fuel consumption of unelectirfied freight trains in fuel type x, vehicle category i, ($SEC_{x,dt}$)		Fuel consumption rate per liter (km/L)	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Total annual trip distance driven by freight trains (After:DD_y)		Total annual trip distance driven by freight trains	(Not necessary because data are not involved in the calculation)		Planned values	Measured values
Electricity consumption rate of freight trains ($SEC_{x,bs,s}$)		Electricity consumption rate of freight trains	(Not necessary because data are not involved in calculation)		Planned values	Measured values
CO_2 emissions factor	($N_{x,i}$) Total number of existing vehicles in fuel type x, and vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category and a fuel type	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Total number of existing vehicles in vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average trip distance driven by existing vehicles in vehicle category i,(OD_i)	Trip distance for each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average occupation rate of existing vehicles in vehicle category i, (OC_i)	Occupation rate of each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	

<table>
<tr><th colspan="2" rowspan="3">Data Type</th><th rowspan="3">Description of Data</th><th colspan="4">Data Acquisition Methods</th></tr>
<tr><th colspan="2">Baseline Emissions</th><th colspan="2">Project Emissions</th></tr>
<tr><th>Before the project starts</th><th>After project completion</th><th>Before the project starts</th><th>After project completion</th></tr>
<tr><td rowspan="3">CO_2 emissions factor</td><td>Specific fuel consumption of existing vehicles in fuel type x, vehicle category i, ($SEC_{x,i}$)</td><td>Fuel consumption rate per liter (km/L)</td><td colspan="2">It is best desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews with transport management authorities
ii) Published values in the country where the project exists
iii) Values based on IPCC database</td><td colspan="2">(Not necessary because data are not involved in the calculation)</td></tr>
<tr><td>CO_2 emission factor of fuel（$EFCO_{2,x}$）</td><td>CO_2 emission factor of fuel per liter, such as gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. with the transport management authorities
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<tr><td>Mixing ratio of biofuel</td><td>Mixing ratio of biofuel in gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. for the transport management authorities
ii) Published values in the country where the project exists</td></tr>
</table>

5. Others	(1) Project boundary The project delineation for GHG estimations is defined by the outreach of the MRT project. (2) Leakage Considering the life cycle assessment (LCA) related to the freight train project, the production and freight of raw materials needed for freight trains, and the energy consumed during construction and manufacturing of raw materials are expected as leakages of GHG emissions. However, these are significantly small as compared with the GHG emissions reduction caused by the project. Hence, these are not counted as leakages in this estimation methodology. Looking at five CDM registered projects, only the Bagota Bus Rapid Transit (BRT) Project took account of leakage, while the other projects counted leakage as zero. For reference, the estimated leakages of the Bogota BRT Project are shown in the appended Table B-3 attached herewith. The total volume of leakages is 0.8% as compared with that of the GHG emissions reduction due to the BRT project. (3) Relevant methodologies and their differences with this estimation methodology ACM0090：Modal shift in transportation of cargo from road transportation to water or rail transportation 【Differences】 ・At least 50% of investments for water or railway transport systems should be used for the cargo transportation systems including construction of facilities (i.e., railway stations) or purchase of equipments. ・The cargo is transported from the same origin (point A) to the same destination (point B); however, this condition is not considered in this estimation methodology. ACM0016：Baseline Methodology for Mass Rapid Transit Projects 【Differences】 ・All mass rapid transit (MRT) systems including not only rail-based systems such as subways and light rail transit (LRT) but also bus systems such as BRT; however, only freight train systems are considered in this estimation methodology. ・CH_4 and N_2O can be counted as GHG emissions other than CO_2; however, only CO_2 emission is counted in this estimation methodology. ・The effects of GHG emission reduction by the improvement of technology can be counted; however, these are not counted in this estimation methodology. ・The effects of GHG emission reduction due to the improvement of technology can be counted; however, these are not counted in this estimation methodology. In particular, a technology improvement factor is assumed 0.99/year (or 1%/year) and the GHG emissions are expected to reduce by 1% per year with the technology improvement. In 10th year, 0.99 to the 9th power equals 0.91, and so the baseline emissions from the existing transport systems becomes 0.91 times due to their technological improvement. Simply assuming annual GHG emissions is constant over 10 years, the difference between with and without the technology improvement factors is around 4%. Thus, the baseline GHG emissions over 10 years would reduce by 4% due to technology improvement, and so the effects of GHG emission reduction lessen by 4%, meaning it is on the safety side. In developing countries, however, it is reasonable to consider that old vehicles will be continuously used rather than acquiring brand-new vehicles. Because of this, the technological improvement factors are not considered in this estimation methodology. ・Once the freight railway system has been newly introduced, freight must utilize the freight stations that were not available before the project has started in order to reach their destinations. This results in producing additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・The reduction of traffic congestions after the project has started may reduce GHG emissions since vehicle operation will speed due to reduced traffic congestion. On the other hand, it may induce an increase in GHG emissions because of the increasing traffic caused by transport systems other than freight trains. These are involved in AM0016 but not considered in this estimation methodology. ・CO_2 emission factors for passenger cars and taxies are a function of speed; however, these are not considered as a function of speed (constant for average speed) in this estimation methodology.

	・ The changes in load factors of conventional buses and taxies after the MRT project has started are involved in its GHG emissions estimation; however, these factors are not considered in this estimation methodology. AMS-III-U：Cable Cars for Mass Rapid Transit Projects 【 Differences】 ・ Cable car projects can be the target for GHG emissions estimation; however, the freight railway project is the target in this estimation methodology. ・ CH_4 and N_20 can be counted as GHG emissions other then CO_2; however, only CO_2 emissions are counted in this estimation methodology. ・ The effects of GHG emissions reduction due to technology improvements can be counted; however, these are not counted in this estimation methodology. ・ Once the cable car system has been introduced, passengers must utilize the cable car stations which were not available before the project started in order to reach their destinations. This results in additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・ Cable cars are powered by electricity; however, both electricity and engine (internal combustion) is considered in this estimation methodology.

1. Typical Project Outline	The project intends to reduce GHG emissions by realizing "modal shift" from existing transport systems (i.e., buses, private cars, taxies and bikes) to a Mass Rapid Transit (MRT) system.
2. Applicability	○After the project completes, the MRT system will have its own rapid railways (a subway or elevated railway) infrastructures connecting a city center and its suburbs, and will provide rapid transportation for a large number of passengers. ○The baseline transport system should be road based, such as buses, private cars, taxies and bikes. Hence, the current transport system does not involve railways, ships, or civil aviation. ○The motive power of rapid railways should be electric-powered.

3. Methodology on Emission Reduction

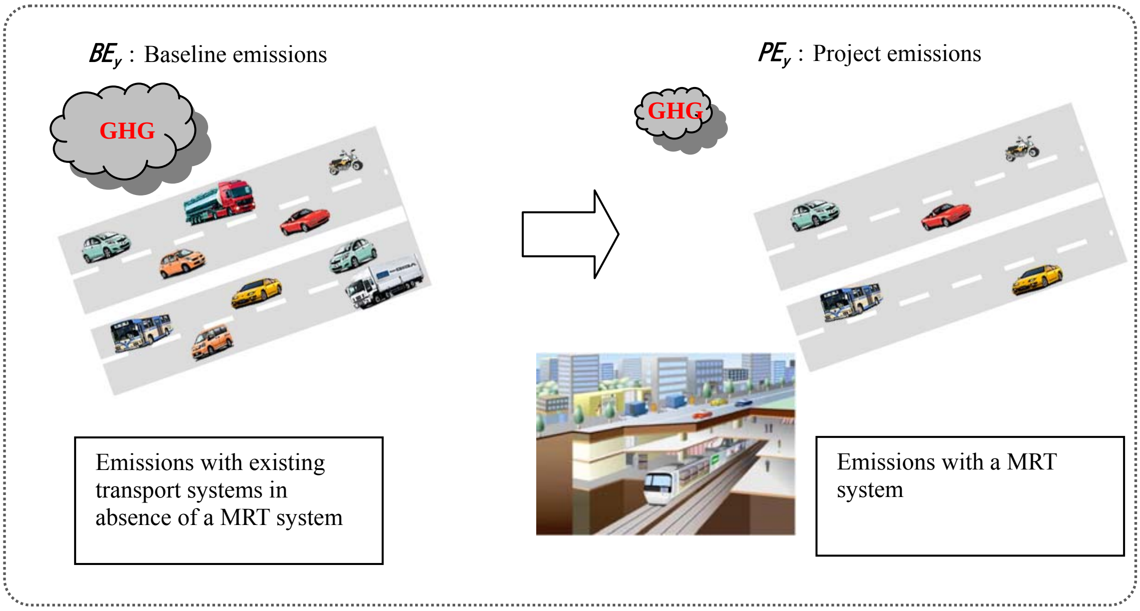
GHG emissions reduction due to MRT is calculated as the difference between the GHG emissions with the existing transport systems (baseline) and those after the success of the modal shift to MRT (project emission).

$$ER_y = BE_y - PE_y \quad (\text{t-}CO_2\text{/y})$$

ER_y : GHG emissions reduction due to project activity in year y (t-CO_2/y)

BE_y : GHG emissions with existing transport systems in year y (t-CO_2/y) (Baseline emissions)

PE_y : GHG emissions after the success of modal shift to MRT from the existing transport systems in year y (t-CO_2/y) (Project emissions)



(1) Baseline emissions estimation

In case the existing transport systems would share a similar number of passengers transported by the projected MRT, baseline emissions for various types of vehicles are estimated by multiplying their shared number of passengers with their CO_2 emission factors per passenger before the project starts.

$$BE_y = \sum_i \left(EF_{P,i,y} \times P_{PJ,i,j} \right)$$

Type	Items	Description
Output	BE_y	Baseline emissions : GHG emissions in the absence of MRT (gr-CO_2/y)
Input	$EF_{P,i,y}$	CO_2 emission factor per passenger for vehicle category i (gr-CO_2/passenger)
	$P_{PJ,i,y}$	Annual number of passengers transported by vehicle category i after the project has completed

3. Methodology on Emission Reductions (Continuation)	***Determination of $EF_{P,i,y}$*** Involving parameters such as CO_2 emission factor per kilometer, average trip distance, and average occupation rate of vehicle before the project starts, the CO_2 emission factor per passenger for each vehicle category is estimated by the following formula:

$$EF_{P,i,y} = \frac{EF_{KM,i} \times TD_i}{OC_i}$$

$EF_{KM,i}$: CO_2 emission factor per km for vehicle category i before the project starts (gr-CO_2/km)
TD_i : Average daily trip distance driven by vehicle category i (km/vehicle)
OC_i : Average daily occupancy rate for vehicle category i (person/vehicle)

$EF_{KM,i}$ is calculated using the following formula:

$$EF_{KM,i} = \sum_x \left[\frac{(1-\alpha_{x,i})}{SEC_{x,i}} \times EF_{CO2,x} \times \left(\frac{N_{x,i}}{N_i} \right) \right]$$

$SEC_{x,i}$: Specific fuel consumption per vehicle category i (km/L)
$EF_{CO2,x}$: CO_2 emission factor of fuel category x (gr-CO_2/l)
$N_{x,i}$: Number of vehicle category i using fuel category x (vehicle)
N_i : Number of vehicle category i (vehicle)
$\alpha_{x,i}$: Mixing rate of biofuel (ex. = 0.1 for biodiesel 10% mixing fuel)

(2) Project emissions estimation
Project emissions are calculated by multiplying the total annual electricity consumption of MRT trains (subways or elevated trains) after the project starts (planned value), with the CO_2 emission factor of electricity.

$$PE_y = TC_y \times EF_{CO_2,x}$$

Type	Items	Description
Output	PE_y	Project emissions: GHG emissions of MRT trains after the project starts (t-CO_2/y)
Input	TC_y	Total annual electricity consumption of MRT trains after the project has started (kWh/y)
	$EF_{CO2,x}$	CO_2 emission factor of fuel category x (gr-CO_2/l)

Determination of TC_y
The total annual fuel consumption of MRT trains is estimated considering their electricity consumption rate multiplied by their total annual trip distance as follows:

$$TC_{et\,y} = DD_y \cdot SEC_{et,y}$$

$SEC_{et,y}$: Electricity consumption rate (kWh/km)
DD_y : Total annual trip distance traveled by MRT trains (train km/y)

	For subway cars with electric power regeneration brake, a regeneration ratio is involved in their electrical consumption as follows: $$TC_y = DD_y \times SEC_{rt,y} \times (1 - \beta \times \gamma)$$ β : Ratio of electric power regeneration γ : Ratio of electrical power used for othare subway cars to total regenerateded power

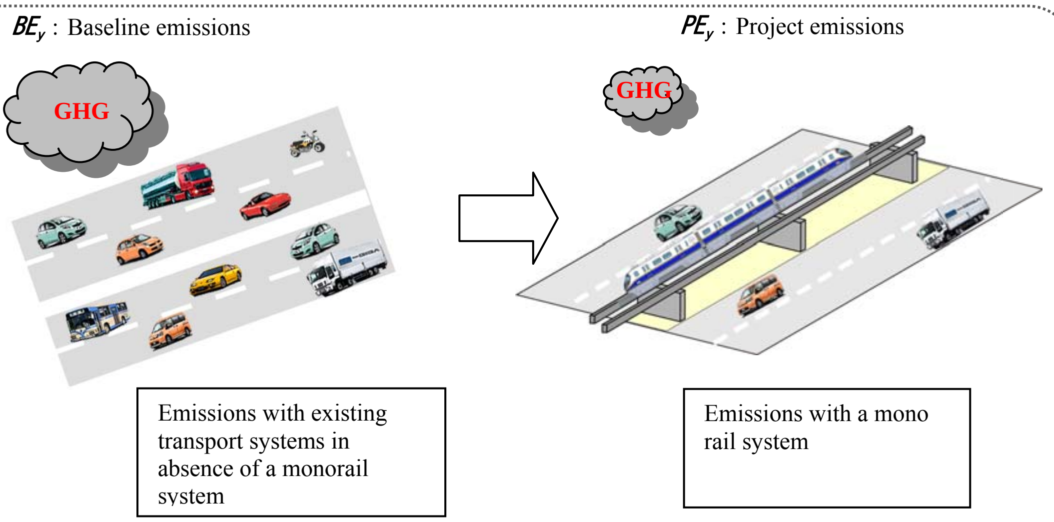
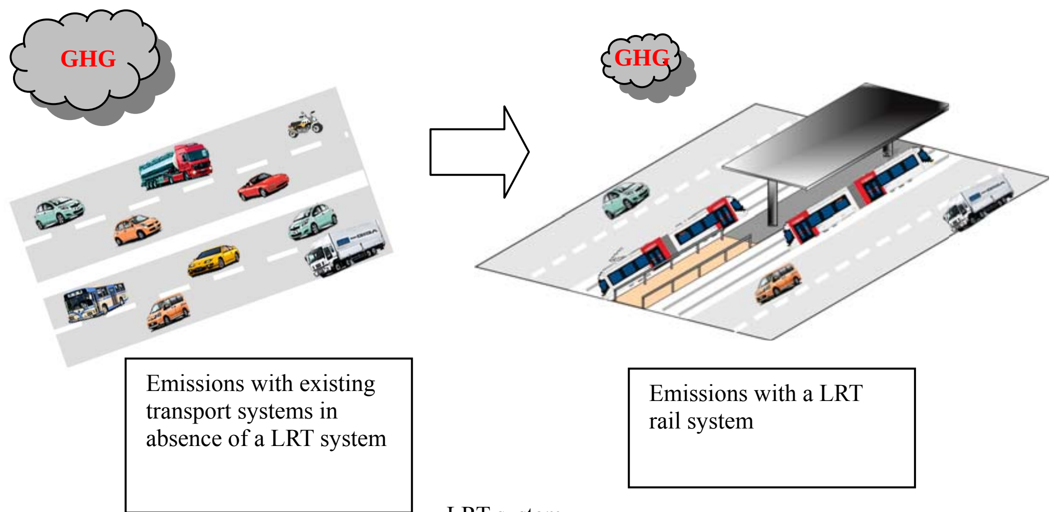
4. Data Required for Estimation and Monitoring

Data Type		Description of Data	Data Acquisition Methods			
			Baseline Emissions		Project Emissions	
			Before the Project Starts	After Project Completion	Before the Project Starts	After Project Completion
Passengers of existing transport systems (After : $P_{PJ,i,y}$)		Passengers of existing transport systems that would be shared in the absence of the MRT project. The total number of passengers of existing transport systems is equal to the passengers of MRT trains	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Total annual trip distance traveled by MRT trains（ After:DD_y）		Total annual trip distance traveled by MRT trains	(Not necessary because data are not involved in the calculation)		Planned values	Measured values
Electricity consumption rate of MRT trains （$SEC_{x,bs,s}$）		Electricity consumption rate of MRT trains	(Not necessary because data are not involved in calculation)		Planned values	Measured values
CO_2 emissions factor	（$N_{x,i}$） Total number of existing vehicles in fuel type x, and vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category and a fuel type	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Total number of existing vehicles in vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average trip distance driven by existing vehicles in vehicle category i,(OD_i)	Trip distance for each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average occupation rate of existing vehicles in vehicle category i, (OC_i)	Occupation rate of each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	

<table>
<tr><th colspan="2" rowspan="3">Data Type</th><th rowspan="3">Description of Data</th><th colspan="4">Data Acquisition Methods</th></tr>
<tr><th colspan="2">Baseline Emissions</th><th colspan="2">Baseline Emissions</th></tr>
<tr><th>Before the Project Starts</th><th>After Project Completion</th><th>Before the Project Starts</th><th>After Project Completion</th></tr>
<tr><td rowspan="3">CO_2 emissions factor</td><td>Specific fuel consumption of existing vehicles in fuel type x, vehicle category i, ($SEC_{x,i}$)</td><td>Fuel consumption rate per liter (km/L)</td><td colspan="2">It is best desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews with transport management authorities
ii) Published values in the country where the project exists
iii) Values based on IPCC database</td><td colspan="2">(Not necessary because data are not involved in the calculation)</td></tr>
<tr><td>CO_2 emission factor of fuel ($EFCO_{2,x}$)</td><td>CO_2 emission factor of fuel per liter, such as gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. with the transport management authorities
ii) Published values in the country where the project exists
iii) Values based on IPCC database</td></tr>
<tr><td>Mixing ratio of biofuel</td><td>Mixing ratio of biofuel in gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. for the transport management authorities
ii) Published values in the country where the project exists</td></tr>
</table>

5. Others	(1) Project boundary The project delineation for GHG estimations is defined by the outreach of the MRT project. (2) Leakage Considering the life cycle assessment (LCA) related to the passenger train project, the production and freight of raw materials needed for MRT facilities and trains, and the energy consumed during construction and manufacturing of raw materials are expected as leakages of GHG emissions. However, these are significantly small as compared with the GHG emissions reduction caused by the project. Hence, these are not counted as leakages in this estimation methodology. Looking at five CDM registered projects, only the Bagota Bus Rapid Transit (BRT) Project took account of leakage, while the other projects counted leakage as zero. For reference, the estimated leakages of the Bogota BRT Project are shown in the appended Table B-3 attached herewith. The total volume of leakages is 0.8% as compared with that of the GHG emissions reduction due to the BRT project. (3) Relevant methodologies and their differences with this estimation methodology ACM0016：Baseline Methodology for Mass Rapid Transit Projects 【Differences】 ・ All mass rapid transit (MRT) systems including not only rail-based systems such as subways and light rail transit (LRT) but also bus systems such as BRT; however, only subway and elevated train systems are considered in this estimation methodology. ・ CH_4 and N_2O can be counted as GHG emissions other than CO_2; however, only CO_2 emission is counted in this estimation methodology. ・ The effects of GHG emission reduction by the improvement of technology can be counted; however, these are not counted in this estimation methodology. ・ The effects of GHG emission reduction due to the improvement of technology can be counted; however, these are not counted in this estimation methodology. In particular, a technology improvement factor is assumed 0.99/year (or 1%/year) and the GHG emissions are expected to reduce by 1% per year with the technology improvement. In 10th year, 0.99 to the 9th power equals 0.91, and so the baseline emissions from the existing transport systems becomes 0.91 times due to their technological improvement. Simply assuming annual GHG emissions is constant over 10 years, the difference between with and without the technology improvement factors is around 4%. Thus, the baseline GHG emissions over 10 years would reduce by 4% due to technology improvement, and so the effects of GHG emission reduction lessen by 4%, meaning it is on the safety side. In developing countries, however, it is reasonable to consider that old vehicles will be continuously used rather than acquiring brand-new vehicles. Because of this, the technological improvement factors are not considered in this estimation methodology. ・ Once the MRT system has been newly introduced, passengers must utilize the MRT stations that were not available before the project has started in order to reach their destinations. This results in producing additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・ The reduction of traffic congestions after the project has started may reduce GHG emissions since vehicle operation will speed due to reduced traffic congestion. On the other hand, it may induce an increase in GHG emissions because of the increasing traffic caused by transport systems other than MRT trains. These are involved in AM0016 but not considered in this estimation methodology. ・ CO_2 emission factors for passenger cars and taxies are a function of speed; however, these are not considered as a function of speed (constant for average speed) in this estimation methodology. ・ The changes in load factors of conventional buses and taxies after the MRT project has started are involved in its GHG emissions estimation; however, these factors are not considered in this estimation methodology. AMS-III-U：Cable Cars for Mass Rapid Transit Projects 【Differences】 ・ Cable car projects can be the target for GHG emissions estimation; however, the MRT project is the target in this estimation methodology.

	・ CH_4 and N_20 can be counted as GHG emissions other then CO_2; however, only CO_2 emissions are counted in this estimation methodology. ・ The effects of GHG emissions reduction due to technology improvements can be counted; however, these are not counted in this estimation methodology. ・ Once the cable car system has been introduced, passengers must utilize the cable car stations which were not available before the project started in order to reach their destinations. This results in additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology.

1.Typical Project Outline	The project intends to reduce GHG emissions by realizing "modal shift" from existing transport systems (i.e., buses, private cars, taxies and bikes) to a light or medium transport system such as monorail and LRT(Light Rail Transit).
2.Applicability	○ After the project completes, the light or medium transport system will have its own rail-based infrastructure (monorail or LRT) infrastructures connecting a city center and its suburbs and will provide rapid transportation for a large number of passengers. ○The current baseline transport system should be road based, such as buses, private cars, taxies and bikes. Hence, the current transport system does not involve railways, ships, or civil aviation. ○The motive power of monorail and LRT should be electricity.
3. Methodology on Emission Reduction	GHG emissions reduction due to monorail or LRT systems is calculated as the difference between the GHG emissions with the existing transport systems (baseline) and those after the success of the modal shift to monorail or LRT systems (project emission). $ER_y = BE_y - PE_y$ $(t\text{-}CO_2/y)$ ER_y : GHG emissions reduction due to project activity in year y ($t\text{-}CO_2/y$) BE_y : GHG emissions with existing transport systems in year y ($t\text{-}CO_2/y$) (Baseline emissions) PE_y : GHG emissions after the success of modal shift to monorail or LRT from the existing transport systems in year y ($t\text{-}CO_2/y$) (Project emissions)  Monorail System  LRT system

3. Methodology on Emission Reductions (Continuation)

(1) Baseline emissions estimation

In case the existing transport systems would share a similar number of passengers transported by the projected monorail or LRT, baseline emissions for various types of vehicles are estimated by multiplying their shared number of passengers with their CO_2 emission factors per passenger before the project starts.

$$BE_y = \sum_i \left(EF_{P,i,y} \times P_{PJ,i,j} \right)$$

Type	Items	Description
Output	***BE_y***	Baseline emissions： GHG emissions in the absence of MRT (gr-CO_2/y)
Input	$EF_{P,i,y}$	CO_2 emission factor per passenger for vehicle category i (gr-CO_2/passenger)
	$P_{PJ,i,y}$	Annual number of passengers transported by vehicle category i after the project has completed.

Determination of $EF_{P,i,y}$

Involving parameters such as CO_2 emission factor per kilometer, average trip distance, and average occupation rate of vehicle before the project starts, the CO_2 emission factor per passenger for each vehicle category is estimated by the following formula:

$$EF_{P,i,y} = \frac{EF_{KM,i} \times TD_i}{OC_i}$$

$EF_{KM,i}$: CO_2 emission factor per km for vehicle category i before the project starts（gr-CO_2/km）

TD_i : Average daily trip distance driven by vehicle category i (km/vehicle)

OC_i : Average daily occupancy rate for vehicle category i (person/vehicle)

$EF_{KM,i}$ is calculated using the following formula:

$$EF_{KM,i} = \sum_x \left[\frac{(1-\alpha_{x,i})}{SEC_{x,i}} \times EF_{CO2,x} \times \left(\frac{N_{x,i}}{N_i} \right) \right]$$

$SEC_{x,i}$: Specific fuel consumption per vehicle category i (km/L)

$EF_{CO2,x}$: CO_2 emission factor of fuel category x (gr-CO_2/l)

$N_{x,i}$: Number of vehicle category i using fuel category x (vehicle)

N_i : Number of vehicle category i (vehicle)

$\alpha_{x,i}$: Mixing rate of biofuel (ex. = 0.1 for biodiesel 10% mixing fuel)

(2) Project emissions estimation

Project emissions are calculated by multiplying the total annual electricity consumption of monorail or LRT trains after the project has completed (planned value), with the CO_2 emission factor of electricity.

$$PE_y = TC_y \times EF_{CO_2,x}$$

Type	Items	Description
Output	***PE_y***	Project emissions： GHG emissions of monorail or LRT trains after the project has completed (t-CO_2/y)
Input	TC_y	Total annual electricity consumption of monorail or LRT trains after the project has completed (kWh/y)
	$EF_{CO2,x}$	CO_2 emission factor of fuel category x (gr-CO_2/l)

Determination of TC_y

The total annual electricity consumption of monorail or LRT trains is estimated considering their electricity consumption rate multiplied by their total annual trip distance as follows:

$$TC_{et\,y} = DD_y \cdot SEC_{et,y}$$

$SEC_{et,y}$: Electricity consumption rate (kWh/km)

DD_y : Total annual trip distance driven by MRT trains (train km/y)

4. Data Required for Estimation and Monitoring

<table>
<tr><th colspan="2" rowspan="3">Data Type</th><th rowspan="3">Description of Data</th><th colspan="4">Data Acquisition Methods</th></tr>
<tr><th colspan="2">Baseline Emissions</th><th colspan="2">Project Emissions</th></tr>
<tr><th>Before the Project Starts</th><th>After Project Completion</th><th>Before the Project Starts</th><th>After Project Completion</th></tr>
<tr><td colspan="2">Passengers of existing transport systems (After : $P_{PJ,i,y}$)</td><td>Passengers of existing transport systems that would be shared in the absence of the monorail/LRT project.
The total number of passengers of existing transport systems is equal to the passengers of monorail/LRT trains</td><td>Planned values</td><td>Measured values</td><td colspan="2">(Not necessary because data are not involved in the calculation)</td></tr>
<tr><td colspan="2">Total annual trip distance driven by monorail or LRT trains（After:DD_y）</td><td>Total annual trip distance driven by monorail/LRT trains</td><td colspan="2">(Not necessary because data are not involved in the calculation)</td><td>Planned values</td><td>Measured values</td></tr>
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<tr><td>Average trip distance driven by existing vehicles in vehicle category i,(OD_i)</td><td>Trip distance for each vehicle category before the project starts</td><td>Measured values</td><td>Measured values</td><td colspan="2">(Not necessary because data are not involved in the calculation)</td></tr>
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Data Type		Description of Data	Data Acquisition Methods			
			Baseline Emissions		Project Emissions	
			Before the Project Starts	After Project Completion	Before the Project Starts	After Project Completion
CO_2 emissions facto	Specific fuel consumption of existing vehicles in fuel type x, vehicle category i, ($SEC_{x,i}$)	Fuel consumption rate per liter (km/L)	It is best desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter): i) Specific data in the project obtained through interviews with transport management authorities ii) Published values in the country where the project exists iii) Values based on IPCC database		(Not necessary because data are not involved in the calculation)	
	CO_2 emission factor of fuel（$EFCO_{2,x}$）	CO_2 emission factor of fuel per liter, such as gasoline, diesel	It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter): i) Specific data in the project obtained through interviews, etc. with the transport management authorities ii) Published values in the country where the project exists iii) Values based on IPCC database			
	Mixing ratio of biofuel	Mixing ratio of biofuel in gasoline, diesel	It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter): i) Specific data in the project obtained through interviews, etc. for the transport management authorities ii) Published values in the country where the project exists			

5. Others	(1) Project boundary The project delineation for GHG estimations is defined by the outreach of the monorail or LRT project. (2) Leakage Considering the life cycle assessment (LCA) related to the monorail or LRT project, the production and freight of raw materials needed for monorail or LRT trains, and the energy consumed during construction and manufacturing of raw materials are expected as leakages of GHG emissions. However, these are significantly small as compared with the GHG emissions reduction caused by the project. Hence, these are not counted as leakages in this estimation methodology. Looking at five CDM registered projects, only the Bagota Bus Rapid Transit (BRT) Project took account of leakage, while the other projects counted leakage as zero. For reference, the estimated leakages of the Bogota BRT Project are shown in the appended Table B-3 attached herewith. The total volume of leakages is 0.8% as compared with that of the GHG emissions reduction due to the BRT project. (3) Relevant methodologies and their differences with this estimation methodology ACM0016：Baseline Methodology for Mass Rapid Transit Projects 【Differences】 ・ All mass rapid transit (MRT) systems including not only rail-based systems such as subways and light rail transit (LRT) but also bus systems such as BRT; however, only monorail and LRT systems are considered in this estimation methodology. ・ CH_4 and N_2O can be counted as GHG emissions other than CO_2; however, only CO_2 emission is counted in this estimation methodology. ・ The effects of GHG emission reduction by the improvement of technology can be counted; however, these are not counted in this estimation methodology. ・ The effects of GHG emission reduction due to the improvement of technology can be counted; however, these are not counted in this estimation methodology. In particular, a technology improvement factor is assumed 0.99/year (or 1%/year) and the GHG emissions are expected to reduce by 1% per year with the technology improvement. In 10th year, 0.99 to the 9th power equals 0.91, and so the baseline emissions from the existing transport systems becomes 0.91 times due to their technological improvement. Simply assuming annual GHG emissions is constant over 10 years, the difference between with and without the technology improvement factors is around 4%. Thus, the baseline GHG emissions over 10 years would reduce by 4% due to technology improvement, and so the effects of GHG emission reduction lessen by 4%, meaning it is on the safety side. In developing countries, however, it is reasonable to consider that old vehicles will be continuously used rather than acquiring brand-new vehicles. Because of this, the technological improvement factors are not considered in this estimation methodology. ・ Once the MRT system has been newly introduced, passengers must utilize the MRT stations that were not available before the project has started in order to reach their destinations. This results in producing additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・ The reduction of traffic congestions after the project has started may reduce GHG emissions since vehicle operation will speed due to reduced traffic congestion. On the other hand, it may induce an increase in GHG emissions because of the increasing traffic caused by transport systems other than monorail or LRT trains. These are involved in AM0016 but not considered in this estimation methodology. ・ CO_2 emission factors for passenger cars and taxies are a function of speed; however, these are not considered as a function of speed (constant for average speed) in this estimation methodology. ・ The changes in load factors of conventional buses and taxies after the MRT project has started are involved in its GHG emissions estimation; however, these factors are not considered in this estimation methodology. AMS-III-U：Cable Cars for Mass Rapid Transit Projects 【Differences】 ・ Cable car projects can be the target for GHG emissions estimation; however, the passenger railway project is the target in this estimation methodology.

	・ CH_4 and N_20 can be counted as GHG emissions other then CO_2; however, only CO_2 emissions are counted in this estimation methodology. ・ The effects of GHG emissions reduction due to technology improvements can be counted; however, these are not counted in this estimation methodology. ・ Once the cable car system has been introduced, passengers must utilize the cable car stations which were not available before the project started in order to reach their destinations. This results in additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology.

1.Typical Project Outline	The project intends to reduce GHG emissions by realizing “modal shift” from existing transport systems (i.e., buses, private cars, taxies and bikes) to Bus Rapid Transit (BRT) or trunk bus systems.
2.Applicability	○After the projects completes, the BRT or trunk bus system will have its own bus lanes, separating it from other transport systems, and will provide rapid transportation for a large number of passengers. ○The current baseline transport system should be road based (i.e., buses, private cars, taxies and bikes). Hence, the current transport system does not involve railways, ships, or civil aviation. ○The motive power of buses should be through an internal combustion (engine), meaning not electricity.
3. Methodology on Emission Reduction	See below

3. Methodology on Emission Reduction

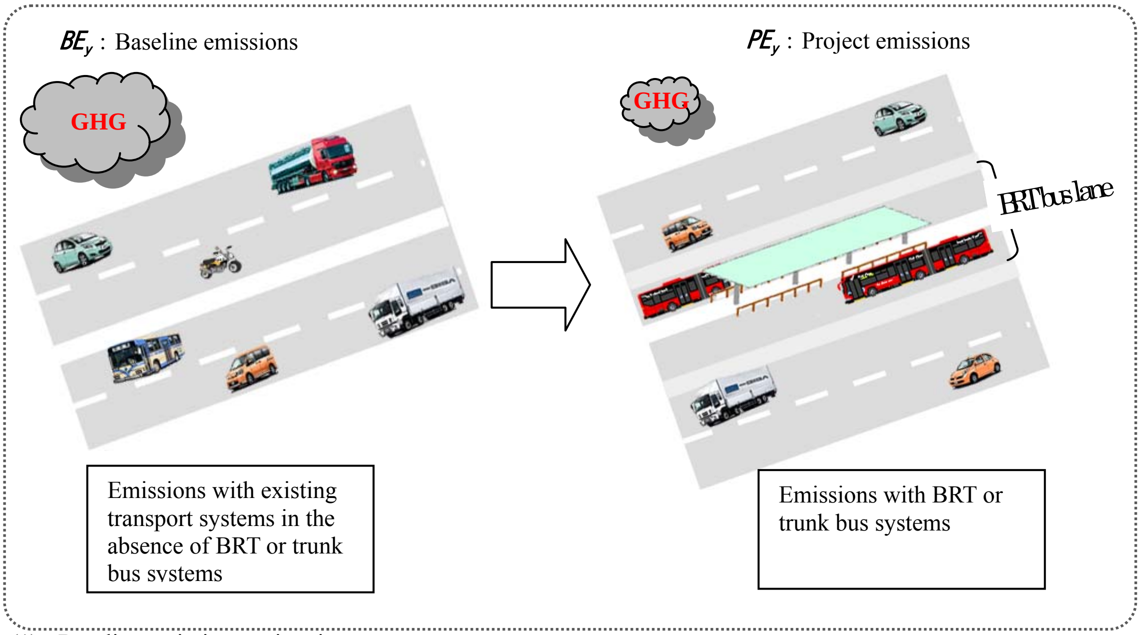
GHG emissions reduction due to BRT or trunk bus systems is calculated as the difference between the GHG emissions with the existing transport systems (baseline) and those after the success of the modal shift to BRT or trunk bus systems (project emission).

$$ER_y = BE_y - PE_y \quad (\text{t-CO}_2\text{/y})$$

ER_y : GHG emissions reduction due to project activity in year y (t-CO_2/y)

BE_y : GHG emissions with existing transport systems in year y (t-CO_2/y) (Baseline emissions)

PE_y : GHG emissions after the success of modal shift to BRT or trunk bus systems from the existing transport systems in year y (t-CO_2/y) (Project emissions)



(1) Baseline emissions estimation

In case the existing transport systems would share a similar number of passengers transported by the projected BRT, baseline emissions for various types of vehicles are estimated by multiplying their shared number of passengers with their CO_2 emission factors per passenger before the project starts.

$$BE_y = \sum_i \left(EF_{P,i,y} \times P_{PJ,i,j} \right)$$

Type	Items	Description
Output	BE_y	Baseline emissions : GHG emissions in the absence of BRT (gr-CO_2/y)
Input	$EF_{P,i,y}$	CO_2 emission factor per passenger for vehicle category i (gr-CO_2/passenger)
	$P_{PJ,i,y}$	Annual number of passengers transported by vehicle category i after the project completes

3. Methodology on Emission Reductions (Continuation)	

Determination of $EF_{P,i,y}$

The CO_2 emission factor per passenger for each vehicle category is estimated by the following formula, involving variables such as CO_2 emission factor per kilometer, average trip distance, and average occupation rate of vehicle before the project starts:

$$EF_{P,i,y} = \frac{EF_{KM,i} \times TD_i}{OC_i}$$

$EF_{KM,i}$: CO_2 emission factor per km for vehicle category i before the project starts（gr-CO_2/km）
TD_i : Average daily trip distance driven by vehicle category i (km/vehicle)
OC_i : Average daily occupancy rate for vehicle category i (person/vehicle)

$EF_{KM,i}$ is calculated using the following formula:

$$EF_{KM,i} = \sum_x \left[\frac{(1-\alpha_{x,i})}{SEC_{x,i}} \times EF_{CO2,x} \times \left(\frac{N_{x,i}}{N_i} \right) \right]$$

$SEC_{x,i}$: Specific fuel consumption per vehicle category i (km/L)
$EF_{CO2,x}$: CO_2 emission factor of fuel category x (gr-CO_2/L)
$N_{x,i}$: Number of vehicle category i using fuel category x (vehicle)
N_i : Number of vehicle category i (vehicle)
$\alpha_{x,i}$: Mixing rate of biofuel (i.e., = 0.1 for biodiesel 10% mixing fuel)

(2) Project emissions estimation

Project emissions are calculated by multiplying the total annual fuel consumption of BRT or trunk buses after the project starts (planned value), with the CO_2 emission factor of fuel.

$$PE_y = TC_y \times EF_{CO_2,x}$$

Type	Item	Description
Output	PE_y	Project emissions: GHG emissions of BRT or trunk buses after the project has completed (t-CO_2/y)
Input	TC_y	Total annual fuel consumption of BRT or trunk buses after the project has completed (L/y)
	$EF_{CO2,x}$	CO_2 emission factor of fuel category x (gr-CO_2/L)

Determination of TC_y

The total annual fuel consumption of BRT buses is estimated considering their specific fuel consumption multiplied by their total annual trip distance. By involving a mixing rate of biofuel in fuel consumption, the formula is as follows:

$$TC_y = \frac{(1-\alpha_{x,bs})DD_y}{SEC_{x,bs,y}}$$

$SEC_{x,bs,y}$: Specific fuel consumtion (km/L)
DD_y : Total annual trip distance driven by BRT buses (vehicle km/y)
$\alpha_{x,bs}$: Mixing ratio of biofuel

4. Data Required for Estimation and Monitoring

Data Type		Description of Data	Data Acquisition Methods			
			Baseline Emissions		Project Emissions	
			Before the project starts	After project completion	Before the project starts	After project completion
Passengers of existing transport systems (After : $P_{PJ,i,y}$)		Passengers of existing transport systems that would be shared in the absence of the BRT project. The total number of passengers of existing transport systems is equal to the passengers of BRT buses	Planned values	Measured values	(Not necessary because data are not involved in the calculation)	
Total annual trip distance driven by BRT buses（After:DD_y）		Total annual trip distance driven by BRT buses	(Not necessary because data are not involved in the calculation)		Planned values	Measured values
Specific fuel consumption rate of BRT buses （$SEC_{x,bs,s}$）		Specific fuel consumption of BRT buses	(Not necessary because data are not involved in calculation)		Planned values	Measured values
CO_2 emissions factor	Total number of existing vehicles in fuel type x, and vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category and a fuel type	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Total number of existing vehicles in vehicle category i, ($N_{x,i}$)	Total number of vehicles in a vehicle category	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average trip distance driven by existing vehicles in vehicle category i,(OD_i)	Trip distance for each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	
	Average occupation rate of existing vehicles in vehicle category i, (OC_i)	Occupation rate of each vehicle category before the project starts	Measured values	Measured values	(Not necessary because data are not involved in the calculation)	

<table>
<tr><th colspan="2" rowspan="3">Data Type</th><th rowspan="3">Description of Data</th><th colspan="4">Data Acquisition Methods</th></tr>
<tr><th colspan="2">Baseline Emissions</th><th colspan="2">Project Emissions</th></tr>
<tr><th>Before the project starts</th><th>After project completion</th><th>Before the project starts</th><th>After project completion</th></tr>
<tr><td rowspan="3">CO_2 emissions factor</td><td>Specific fuel consumption of existing vehicles in fuel type x, vehicle category i, ($SEC_{x,i}$)</td><td>Fuel consumption rate per liter (km/L)</td><td colspan="2">It is best desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews with transport management authorities
ii) Published values in the country where the project exists
iii) Values based on IPCC database</td><td colspan="2">(Not necessary because data are not involved in the calculation)</td></tr>
<tr><td>CO_2 emission factor of fuel ($EFCO_{2,x}$)</td><td>CO_2 emission factor of fuel per liter, such as gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. with the transport management authorities
ii) Published values in the country where the project exists
iii) Values based on IPCC database</td></tr>
<tr><td>Mixing ratio of biofuel</td><td>Mixing ratio of biofuel in gasoline, diesel</td><td colspan="4">It is desirable to use national or regional data and information of the project, so the availability of relevant data and information should be justified and used in the following order (see the tables hereinafter):
i) Specific data in the project obtained through interviews, etc. for the transport management authorities
ii) Published values in the country where the project exists</td></tr>
</table>

5. Others	(1) Project boundary The project delineation for GHG estimations is defined by the outreach of the BRT or trunk bus project. (2) Leakage Considering the life cycle assessment (LCA) related to the freight train project, the production and freight of raw materials needed for BRT or trunk buses, and the energy consumed during construction and manufacturing of raw materials are expected as leakages of GHG emissions. However, these are significantly small as compared with the GHG emissions reduction caused by the project. Hence, these are not counted as leakages in this estimation methodology. Looking at five CDM registered projects, only the Bagota Bus Rapid Transit (BRT) Project took account of leakage, while the other projects counted leakage as zero. For reference, the estimated leakages of the Bogota BRT Project are shown in the appended Table B-3 attached herewith. The total volume of leakages is 0.8% as compared with that of the GHG emissions reduction due to the BRT project. (3) Relevant methodologies and their differences with this estimation methodology AM0031：Methodology for Bus Rapid Transit Projects 【Differences】 ・ CH_4 and N_2O can be counted as GHG emission other then CO_2, while CO_2 emission is only counted in this estimation methodology. ・ The effects of GHG emission reduction by technology improvements can be counted; however, these are not counted in this estimation methodology. ・ GHG emissions including construction for BRT bus lanes and related facilities such bus stations with platforms, production of new BRT buses, scrap of conventional buses, and GHG emission reductions by decreasing fuel finery volume, are considered as leakages; however, these leakages are not considered in this estimation methodology. ・ Reduction of traffic congestions after the project has started may cause GHG emission reductions from speeding up vehicle operation due to reduced traffic congestion. On the other hand, it may induce an increase in GHG emissions because of the increasing traffic caused by transport systems other than BRT buses. These are involved in AM0016 but not considered in this estimation methodology. ・ The changes in load factors of conventional buses and taxies after the BRT project starts is involved in its GHG emissions estimation; however, these factors are not considered in this estimation methodology. ・ Biofuels cannot be considered in GHG emissions estimation; thus these factors are not suitable in this estimation methodology. ACM0016：Baseline Methodology for Mass Rapid Transit Projects 【Differences】 ・ All mass rapid transit (MRT) systems including not only rail-based systems such as subways and light rail transit (LRT) but also bus systems such as BRT; however, only BRT or trunk bus systems are considered in this estimation methodology. ・ CH_4 and N_2O can be counted as GHG emissions other than CO_2; however, only CO_2 emission is counted in this estimation methodology. ・ The effects of GHG emission reduction by the improvement of technology can be counted; however, these are not counted in this estimation methodology. ・ The effects of GHG emission reduction due to the improvement of technology can be counted; however, these are not counted in this estimation methodology. In particular, a technology improvement factor is assumed 0.99/year (or 1%/year) and the GHG emissions are expected to reduce by 1% per year with the technology improvement. In 10th year, 0.99 to the 9th power equals 0.91, and so the baseline emissions from the existing transport systems becomes 0.91 times due to their technological improvement. Simply assuming annual GHG emissions is constant over 10 years, the difference between with and without the technology improvement factors is around 4%. Thus, the baseline GHG emissions over 10 years would reduce by 4% due to technology improvement, and so the effects of GHG emission reduction lessen by 4%, meaning it is on the safety side. In developing countries,

	however, it is reasonable to consider that old vehicles will be continuously used rather than acquiring brand-new vehicles. Because of this, the technological improvement factors are not considered in this estimation methodology. ・ Once the freight railway system has been newly introduced, freight must utilize the freight stations that were not available before the project has started in order to reach their destinations. This results in producing additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・ The reduction of traffic congestions after the project has started may reduce GHG emissions since vehicle operation will speed due to reduced traffic congestion. On the other hand, it may induce an increase in GHG emissions because of the increasing traffic caused by transport systems other than BRT or trunk buses. These are involved in AM0016 but not considered in this estimation methodology. ・ CO_2 emission factors for passenger cars and taxies are a function of speed; however, these are not considered as a function of speed (constant for average speed) in this estimation methodology. ・ The changes in load factors of conventional buses and taxies after the MRT project has started are involved in its GHG emissions estimation; however, these factors are not considered in this estimation methodology. AMS-III-U：Cable Cars for Mass Rapid Transit Projects 【Differences】 ・ Cable car projects can be the target for GHG emissions estimation; however, the freight railway project is the target in this estimation methodology. ・ CH_4 and N_20 can be counted as GHG emissions other then CO_2; however, only CO_2 emissions are counted in this estimation methodology. ・ The effects of GHG emissions reduction due to technology improvements can be counted; however, these are not counted in this estimation methodology. ・ Once the cable car system has been introduced, passengers must utilize the cable car stations, which were not available before the project started in order to reach their destinations. This results in additional GHG emissions. These indirect GHG emissions can be counted; however, these are not considered in this estimation methodology. ・ Cable cars are powered by electricity; however, internal combustion is considered in this estimation methodology.

Annex Table B-1 Specific fuel consumption rates and CO_2 emission factors per liter for various types of vehicles

Vehicle Type	Fuel economy	CO_2/km traveled	$EF_{CO2,x}$
	L/100 km	gCO_2/km	gCO_2/L
New small gas/electric hybrid	4.2	100.1	2,383
Small gas auto, highway	7.3	175.1	2,399
Small gas auto, city	9.0	215.5	2,394
Medium gas auto, highway	7.8	186.8	2,395
Medium gas auto, city	10.7	254.7	2,380
Large gas automobile, highway	9.4	224.1	2,384
Large gas automobile, city	13.1	311.3	2,376
Medium Station wagon, highway	8.7	207.5	2,385
Med Station wagon, city	11.8	280.1	2,374
Mini Van, highway	9.8	233.5	2,383
Mini Van, city	13.1	311.3	2,376
Large Van, highway	13.1	311.3	2,376
Large Van, city	16.8	400.2	2,382
Mid size. Pick-up Trucks, highway	10.7	254.7	2,380
Pick-up Trucks, city	13.8	329.6	2,388
Large Pick-up Trucks, highway	13.1	311.3	2,376
Large Pick-up Trucks, cuty	15.7	373.5	2,379
LPG automobile	11.2	266	2,375
Diesel automobile	9.8	233	2,378
Gasoline light truck	16.8	400	2,381
Gasoline heavy truck	39.2	924	2,357
Diesel light truck	15.7	374	2,382
Diesel heavy truck	33.6	870	2,589
Light motorcycle	3.9	93	2,385
Diesel bus	35.1	1034.6	2,948

Sources：Miles per gallon for typical vehicles based on averages from US-EPA 2001 Guide.[1]

GHG mission activity	Fuel type	Unit	Values
Combustion of fuels	Gasoline	gr-CO_2/L	2,320
	Diesel	gr-CO_2/L	2,580

Source: A List for Estimation Methodologies and Emissions Factors in Regulations for Estimation, Reporting, and Publication[2]

Vehicle category (Fuel type)	CO_2 emission factor (gr-CO_2/L)
Passenger car and taxi (Gasoline)	2,313
Bus (Diesel)	2,661

Source: AM0031
(Original source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual[3])

[1] EPA : http://www.epa.gov/greenvehicles/Index.do
[2] Ministry of the Environment , Ministry of Economy,Trade and Industry : http://www.env.go.jp/earth/ghg-santeikohyo/material/itiran.pdf
[3] IPCC : http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.html

Annex Table B-2 Specific fuel consumption

Vehicle category		Fuel type	Specific fuel consumption (L/km)	Fuel consumption (km/L)
Commercial use	Normal	gasoline	0.19	5.26
		diesel	0.25	4.00
	Compact	gasoline	0.12	8.33
		diesel	0.12	8.33
	Special-purpose	gasoline	0.11	9.09
		diesel	0.23	4.35
	Light motor	gasoline	0.09	11.11
		diesel	-	-
Personal use	Normal	gasoline	0.15	6.67
		diesel	0.19	5.26
	Compact	gasoline	0.11	9.09
		diesel	0.11	9.09
	Special-purpose	gasoline	0.13	7.69
		diesel	0.19	5.26
	Light motor	gasoline	0.09	11.11
		diesel	-	-

Source: Year book of survey on motor vehicle transport, Ministry of Land, Infrastructure, Transport and Tourism, 2009[4]

Comparison between leakage and CO_2 emissions reduction effect in Bogota BRT project

Year	Estimation of project activity emissions (tCO_{2eq})	Estimation of baseline emissions (tCO_{2eq})	Estimation of leakage (tCO_{2eq}) [A]	Estimation of emisson reductions (tCO_{2eq}) [B]	Ratio of leakage [A]/[B]
2006	56,179	154,569	3,823	94,567	4%
2007	79,391	216,246	2,845	134,011	2%
2008	135,685	365,885	0	230,201	0%
2009	182,336	486,767	0	304,432	0%
2010	182,336	481,900	845	298,719	0%
2011	208,634	545,890	521	336,735	0%
2012	208,634	540,431	4,521	327,276	1%
Total (tCO_{2eq})	1,053,194	2,791,689	12,555	1,725,940	1%

Source: BRT Bogotá, Colombia: TransMilenio Phase II to IV[5]

[4] Ministry of Land, Infrastructure and Transport : http://www.mlit.go.jp/k-toukei/06/annual/06a0excel.html
[5] UNFCCC CDM http://cdm.unfccc.int/Projects/projsearch.html